Universitat de Girona

TRACING THE CREATION AND EVALUATION OF ACCESSIBLE OPEN EDUCATIONAL RESOURCES THROUGH LEARNING ANALYTICS

Cecilia AVILA GARZON

Universitat de Girona

DOCTORAL THESIS

TRACING THE CREATION AND EVALUATION OF ACCESSIBLE OPEN EDUCATIONAL RESOURCES THROUGH LEARNING ANALYTICS

CECILIA AVILA GARZON

2018

Universitat de Girona

Doctoral Thesis

TRACING THE CREATION AND EVALUATION OF ACCESSIBLE OPEN EDUCATIONAL RESOURCES THROUGH LEARNING ANALYTICS

Author: CECILIA AVILA GARZON

2018

Doctorate Program in Technology

Advisors:

Ph.D. RAMON FABREGAT GESA
Ph.D. SILVIA MARGARITA BALDIRIS NAVARRO
Ph.D. SABINE GRAF

Thesis submitted in partial fulfilment of the requirements for the degree of Doctor in Technology by the Universitat de Girona

The research reported in this thesis was carried out as part of the following projects:

- Augmented Reality in Adaptive Learning Management Systems for All (ARrELS project). Funded by the Spanish Science and Education Ministry (TIN2011-23930).
- Inclusive Learning - Supporting Teacher Training for an Inclusive Vocational Education. A transfer of innovation project funded by the European Commission (2012-1-ES1-LEOO5-49449).
- The Open Co-creation Project funded by the Spanish Ministry of Economy and Competitiveness (TIN2014-53082-R).
- The "Comunicacions i Sistemes Distribuïts" project funded by the University of Girona 2016-2018 (MPCUdG2016).

The research reported in this thesis was partially sponsored by:

- The research scholarship program of the University of Girona, reference BR2014.
- The mobility scholarship program of the University of Girona, reference MOB15. Under this mobility program the author of this thesis carried out a three-month research stay with the *Research Group on Intelligent, Adaptive and Analytics Systems* at the Athabasca University in Edmonton, Canada from March to June 2016.

The research work done in this thesis was carried out in the BCDS research group (ref. GRCT40) which is part of the DURSI consolidated research group Communicacions i Sistemes Intelligents (CSI) (ref. SGR-1469).

Universitat de Girona

Dr. Ramon Fabregat Gesa, Department of Computer Architecture and Technology, University of Girona

Dr. Silvia Margarita Baldiris Navarro, Fundación Universitaria Tecnológico de Comfenalco

Dr. Sabine Graf, Athabasca University

Declare:

That the thesis entitled "Tracing the creation and evaluation of accessible open educational resources through learning analytics" by Cecilia Avila Garzon to obtain the doctoral degree, has been completed under our supervision and meets the requirements to opt for an International Doctorate.

For all intents and purposes, we hereby sign this document.

Dr. Ramon Fabregat Gesa (Director)

Dr. Silvia Margarita Baldiris Navarro (Co-Director)

Dr. Sabine Graf (Co-Director)

Girona, January 22nd of 2018

To my lovely family and friends!

Acknoledgements

Each new experience in the life is an opportunity to grow up as a person and as a professional. I feel very grateful for those things happened while pursuing this PhD. I participated in different research activities, met new people (colleagues and friends), learnt new languages, kept in touch with new cultures, visited different places, etc.

First of all, thanks God for giving me the opportunity of living this educational experience at the University of Girona (UdG – Universitat de Girona). I feel enormously happy because I had the support from my lovely family in Colombia and from my friends all the way. My special thanks to Cecilia and Raul, they always treat me as a daughter and gave me their support during these years far from home. Jorge thank you for being alongside with me all the time, this would not had been the same without you.

My special thanks to my thesis supervisors Dr. Ramon Fabregat Gesa, Dr. Silvia Margarita Baldiris Navarro and Dr. Sabine Graf. Beyond their guide for the development of this thesis, I learnt lots of things from them. They always gave me good ideas for developing my research and opportunities to participate in different research and academic activities.

Thanks to my co-workers and friends from the BCDS research group and thanks to my research visit partners and people working at the Athabasca University.

Thanks to all the departments and people working at the UdG in the doctorate school, the Department of Computer Architecture and Technology (ATC), the Institute of Informatics and Applications (IIiA), and the Science Institute of Education (ICE) for all educational activities that allowed me to become a better researcher.

Thanks to all teachers who participated in the activities related to this research. Thanks to them and their participation I felt really motivated to develop this thesis.

Thanks to the funding from the UdG with the BR2014 scholarship and the mobility grant MOB2015 received to do the three-month research stay at the Athabasca University in 2016.

Thanks to the support given by the BCDS research group ((ref. GRCT40) which is part of the DURSI consolidated research group COMUNICACIONS I SISTEMES INTELLIGENTS (CSI). (ref. SGR-1469) for the financial support provided to attend to the conferences, meetings and courses.

I would like to thank the support provided by the projects in which this thesis was framed: “Inclusive Learning: - Supporting Teacher Training for an Inclusive Vocational Education”. A transfer of innovation project funded by the European Commission (2012-1-ES1-LEOO5-49449). The “Augmented Reality in Adaptive Learning Management Systems for All” funded by the Spanish Science and Education Ministry (TIN2011-23930) and the Open Co-creation Project “Collaborative creation of resources and educational practices opened to diversity” funded by the Spanish Ministry of Economy and Competitiveness (TIN2014-53082-R).

Last but no least, thanks to all friends I met during this process I really appreaciate your supportive words and those moments that we share together.

List of publications

Journal publications

Avila, C., Baldiris, S., Fabregat, R., & Graf, S. LAMTCE: Learning Analytics Model to Trace the Creation and Evaluation of Open Educational Resources. Computers in Human Behavior. [Submited].

Avila, C., Baldiris, S., Fabregat, R., & Graf, S. (2016). CoCreation and Evaluation of Inclusive and Accessible Open Educational Resources: A Mapping toward the IMS Caliper. IEEE RITA, 11(3), 167–176. doi:10.1109/RITA.2016.2589578.

Avila, C., Baldiris, S., Fabregat, R., & Graf, S. (2015). Co-Creación y Evaluación de Recursos Educativos Abiertos Inclusivos y Accesibles: un Mapeo hacia el IMS Caliper. VAEP-RITA, 3(4), 219–229.

Baldiris, S., **Avila, C.**, Fabregat, R., Potes, E., Cuesta, J., Muñoz, T. and Cardona, S. 2015. CO-CREARIA: Modelo de Co-Creación de REA Inclusivos y Accesibles. La experiencia de la maestría en TIC de la Universidad Pontificia Bolivariana. Revista Ingeniería E Innovación. 3, 2 (2015), 37–47.

Conference publications

Avila, C., Baldiris, S., Fabregat, R., & Graf, S. (2017). ATCE - An Analytics Tool to Trace the Creation and Evaluation of Inclusive and Accessible Open Educational Resources. 2017. Proceedings of the Seventh International Conference on Learning Analytics & Knowledge (LAK). Vancouver, Canada. dx.doi.org/10.1145/3027385.3027413.

Rodriguez, P., Méndez, N. D., Baldiris, S., **Avila, C.**, Fabregat, R., Jové, T., & Bacca, J. (2015). Guías para que profesores implementen la diversidad en sus aulas - Casos de estudio. X Latin American Conference of Learning Objects (LACLO) 10, p. 90.

Avila, C., Baldiris, S., Fabregat, R., & Graf, S. (2014). Open Educational Resources Evaluation in a Learning Management System. 7th International Conference of Education, Research and Innovation (ICERI). Seville, Spain.

Baldiris, S., Fabregat, R., Graf, S., Tabares, V., Duque, N., & **Avila, C.** (2014). Learning Object Recommendations Based on Quality and Item Response Theory. In IEEE 14th International Conference on Advanced Learning Technologies (pp. 34–36). IEEE. doi:10.1109/ICALT.2014.238

Avila, C., Baldiris, S., Fabregat, R., & Guevara, J. C. (2014). A Web Content Accessibility Evaluation process for Learning Objects in the context of a Virtual Learning Environment. In M. . S. peph. Elyira Popesqu., Qing Li., Ralf .Klamma, Ho.ward Leung (Ed.), The 2nd International Symposium on Knowledge Management and E-Learning (KMEL 2012) in conjunction with The 11th International Conference on Web-based Learning (ICWL 2012) (pp. 181–190). Sinaia, Romania: Springer-Verlag GmbH Berlin Heidelberg. doi:10.1007/978-3-662-43454-3_19

Baldiris, S., **Avila, C.**, Fabregat, R., Jové, T., Vilà, R., Rodríguez, P., & Duque, N. (2014). Inclusive Learning Handbook: un REA para Promover una Cultura de Aprendizaje Inclusivo. IX Latin American Conference of Learning Objects, 5(1).

Politis, Y., Deveril, D., Baldiris, S., **Avila, C.**, Lera, E. de, Monjo, T., & Goodman, L. (2014). Introducting the Inclusive Learning Handbook: an OER for Teachers and Policy Makers. 6th International Conference on Education and New Learning Technologies (EDULEARN).

Books

Baldiris, S., **Avila, C.**, Bacca, J., Fabregat, R., Vélez, G., Carmona, C. (2017). Acogiendo la diversidad en el sistema educativo a través de la co-creación de Recursos Educativos Abiertos. Universidad Pontificia Bolivariana. [in press].

Book chapters

Avila, C., Bacca, J., Baldiris, S., Fabregat, R., Sarraipa, J., Jardim-GonÇalves, R., … Aciar, S. (2014). Facilitando a los profesores el proceso de creación de objetos de aprendizaje accesibles. In Objetos de aprendizaje, repositorios y federaciones… Conocimiento para todos. Manizalez, Colombia: Editorial Universidad Nacional de Colombia. Sede Manizales.

Zervas, P., Kardaras, V., Baldiris, S., Bacca, J., **Avila, C.**, Politis, Y., Treviranus, J., Fabregat, R., Goodman, L., and Sampson, D. (2014). Digital Systems for Open Access to Formal and Informal Learning. In Digital Systems for Open Access to Formal and Informal Learning (pp. 57–68). Cham: Springer International Publishing. doi:10.1007/978-3-319-02264-2

Other publications

Baldiris, S., **Avila, C.**, Sarraipa, J., Aciar, S., Fabregat, R., Marcelino-Jesus, E., Bacca, J., & Jardim-Gonçalves, R. An Infrastructure to create, publish and recommend Accessible Open Educational Resources. Revista observatório. [Submited].

González, C., **Avila, C.**, Bacca, J., Baldiris, S., & Salas, D. (2013). Usabilidad y Accesibilidad en la gestión de comunidades virtuales de práctica en el contexto educativo. In XIV Encuentro Internacional Virtual EDUCA Colombia. 2013. Medellín, Colombia.

Oyola, J., Nuñez, R., **Avila, C.**, Bacca, J., Baldiris, S., & Salas, D. (2013). Objetos virtuales de aprendizaje para el trabajo colaborativo en el contexto de las comunidades virtuales de práctica. In XIV Encuentro Internacional Virtual EDUCA Colombia. 2013. Medellín, Colombia.

List of acronyms

ADDIE – Analysis, Design, Development, Implementation, and Evaluation

ATCE – Analytics Tool to Trace the Creation and Evaluation of OER

CO-CREARIA – Model for the co-creation of Inclusive and Accessible OER

ICT – Information and Communication Technologies

COL – Common wealth Of Learning

LAAM – Learning Analytics Acceptance Model

LAM – Learning Analytics Model

LAMTCE – Learning Analytics Model to Trace de Creation and Evaluation of OER

LMS – Learning Management System

LO – Learning Object

LORI – Learning Object Review Instrument

ODL – Open Distance Learning

OECD – Organization for Economic Co-operation and Development

OER – Open Educational Resource

QI – Quality Instrument

TAM – Technology Acceptance Model

UDL – Universal Design for Learning

UNESCO – United Nations Educational, Scientific and Cultural Organization

WAI – Web Accessibility Instrument

WCAG – Web Content Accessibility Guidelines

List of figures

List of tables

Contents

Abstract

The adoption of Open Educational Resources (OER) to support teaching and learning experiences has been continuously growing and with it the need to address the diversity of students' learning needs. However, when it comes to provide students with accessible and high quality learning contents teachers face some challenges in the sense they should acquire the knowledge and skills to create such contents and also to ensure that learning contents meet with accessibility and quality requirements. Moreover, when teachers are learning about or they get involved in the creation and evaluation of OER they carry out different activities and the information from these activities can be stored in a database. In this context, we identified the learning analytics as a way to support teachers in the creation and evaluation of OER. With these ideas in mind the research question that drives this thesis is: *How can learning analytics support teachers in the creation and evaluation of accessible open educational resources?*

In the review of the literature about OER, we also identified quality as an inherent and valuable characteristic of OER and that the evaluation of quality also involves the accessibility category considering that students may face content access barriers. Although some studies recommend considering accessibility standards, there is a need for further research on how teachers take part in the creation and evaluation of OER considering such characteristics (accessibility and quality). Web accessibility is the possibility of providing digital contents so that people can perceive, understand, navigate, and interact with the web. To ensure OER meet accessibility requirements we follow the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) provided by the W3C consortium. On the other hand, the quality concept refers to the suitability of OER to the learning and teaching context. As for quality we adopted the so-called Learning Object Review Instrument (LORI).

By conducting an exploratory study in which teachers participated in a training course about the creation and evaluation of OER considering both the accessibility and quality characteristics, we identified that training scenarios give teachers the knowledge and the power to develop their competences but still they require supporting tools that help them in these tasks. Topics in that training course were: inclusive learning, Universal Design for Learning (UDL), OER, web accessibility, and evaluation of OER.

Since in the creation of OER it should be promoted the addressing of students' learning needs, it is recommended to use a methodology for the creation of OER that provide authors with enough guidelines to achieve such commitment. That is why in the exploratory study we adopted the CO-CREARIA model, which is a model for the co-creation and evaluation of OER. This model involves the phases of analysis, design, development, evaluation, and implementation. Moreover, this model is based on the principles of the UDL framework which makes the model more valuable than other methodologies for the creation of OER because the resources are created considering that each student has unique qualities and therefore that there is a vast diversity of students' learning needs. Despite OER can be evaluated by experts, in the context of this thesis we proposed a peer review evaluation approach so that teachers could participate evaluating the accessibility and quality of an OER created by another teacher. This evaluation approach was integrated as part of the evaluation phase of CO-CREARIA. Then, in the exploratory study each teacher was asked to

create an OER and to evaluate an OER created by another teacher. OER were created as virtual courses in the ATutor Learning Management System (LMS).

Findings in the literature and lessons learned from that exploratory study allowed us to identify the elements to be considered in a learning analytics solution to support teachers in the creation and evaluation of accessible and quality OER. Thus, by analyzing in detail the WCAG 2.0 guidelines, considering the quality instrument used (an adaptation of LORI), and making a relation between these elements and the competences of teachers, we defined a user model to represent teachers' competences considering two domains: 1) the creation of accessible and quality OER and 2) the evaluation of accessibility and quality in OER. In that regard this thesis promotes the development of the teacher's competences, and particularly competences related to the creation and evaluation of OER.

The user model was used as part of one of the major contribution in this thesis which is *the Learning Analytics Model to Trace the Creation and Evaluation of OER (LAMTCE)* considering the web accessibility and quality characteristics. LAMTCE was built considering common steps in a learning analytics process: gathering of raw data, storing, analysis, and visualization. This model was implemented in a learning analytics tool we named ATCE (Analytics tool to Trace the Creation and Evaluation of OER). ATCE was integrated as a module within the ATutor LMS. Main functionalities of ATCE include: it stores the details of each HTML element added by an author in a OER, it checks some of the accessibility criteria that can be evaluated in an automatic way (automatic evaluation), it provides the instruments for the manual evaluation so that evaluators can answer questions related to the accessibility and quality of the OER, and it includes a dashboard with visualizations related to the accessibility and quality of the OER created so that teachers can use this information to improve the OER and therefore to improve their competences in the creation and evaluation of these resources.

To evaluate the LAMTCE model, we set up an evaluation scenario in which teachers participated in a training course which topics were the same from the training course followed in the exploratory study. The purpose of this evaluation was twofold. Firstly, it attempted to investigate whether ATCE (implemented based on the LAMTCE model) benefits teachers in the acquisition of competences in the creation and evaluation of OER. Secondly, it aims at identifying the perceptions of teachers with regard to the use of the ATCE tool. Results obtained highlight a positive effect on the acquisition of the teachers' competences in the creation and evaluation of OER and a positive attitude towards the use of our learning analytics tool because it allows teachers in their role of authors to be informed on how to improve the web accessibility and quality of the OER as well as on how to improve in their role as evaluators of OER.

Consequently, this thesis contributes to the knowledge in the fields of learning analytics and OER in the following aspects:

- The definition of an evaluation procedure for OER considering web accessibility and quality.
- The definition of a learning analytics model for helping teachers in the creation and evaluation of OER considering web accessibility and quality.
- The development of an analytics tool based on the proposed learning analytics model for supporting teachers in the creation and evaluation of OER while they adquire the competences to create and evaluate the web accessibility and quality of OER.

Resumen

La adopción de Recursos Educativos Abiertos (REA) para soportar las experiencias de aprendizaje ha venido aumentando y con ello la necesidad de atender la diversidad de necesidades de aprendizaje de los estudiantes. Sin embargo, cuando se trata de proveer a los estudiantes con contenidos de aprendizaje accesibles y de alta calidad, los profesores enfrentan algunos retos como adquirir el conocimiento y competencias para crear tales contenidos y también para asegurarse que cumplen con requerimientos de accesibilidad y calidad. Además, cuando los profesores están aprendiendo sobre o están involucrados en la creación y evaluación de REA llevan a cabo diferentes actividades y la información de estas puede ser almacenada en una base de datos. En este contexto, se identificó que una forma de analizar o procesar las trazas que provienen de los registros de actividad del profesor es haciendo uso de analíticas de aprendizaje. Con base en estas ideas, la pregunta de investigación que dirige esta tesis es: *¿cómo las analíticas de aprendizaje pueden proveer soporte a los profesores en el proceso de creación y evaluación de REA accesibles?*

En la revisión de literatura sobre REA también se identificó la calidad como una característica inherente y valiosa de los REA y que la evaluación de calidad también involucra la categoría de accesibilidad considerando que los estudiantes pueden enfrentarse a barreras de acceso en el contenido. Aunque algunos estudios recomiendan considerar estándares de accesibilidad, existe la necesidad de ir más allá en la investigación sobre cómo los profesores toman parte en la creación y evaluación de REA considerando tales características (accesibilidad y calidad). En el contexto de esta tesis el enfoque fue la creación y evaluación de REA considerando la accesibilidad web y la calidad. Accesibilidad web como la posibilidad que ofrecen los contenidos digitales para que las personas perciban, comprendan, naveguen e interactúen con la web. Para asegurar que los REA cumplen con requerimientos de accesibilidad se siguieron los lineamientos para accesibilidad en contenidos web conocidos como WCAG 2.0 (Web Content Accessibility Guidelines) que son provistos por el consorcio de la W3C. De otro lado, el concepto de calidad se refiere a la característica que hace que los REA se ajusten al contexto de enseñanza y aprendizaje. Con respecto a la calidad se adoptó el ya conocido instrumento para la revisión de objetos de aprendizaje o LORI (Learning Object Review Instrument).

En un estudio exploratorio en el cual los profesores participaron en un curso de formación sobre la creación y evaluación de REA accesibles considerando ambas características la accesibilidad y la calidad, se identificó que los escenarios de formación dan a los profesores el conocimiento y el potencial para desarrollar sus competencias, pero ellos aun requieren herramientas de soporte que les ayude a desenvolverse en estas tareas. Los temas del curso de formación fueron: aprendizaje inclusivo, Diseño Universal para el Aprendizaje (DUA), REA, accesibilidad web y evaluación de REA.

Dado que en la creación de REA se debe promover la atención de las necesidades de aprendizaje de los estudiantes, se recomienda hacer uso de una metodología para la creación que provea los lineamientos suficientes para que los autores logren este cometido. Es por esto que en el estudio exploratorio se adoptó el modelo CO-CREARIA, el cual es un

modelo para la co-creación y evaluación de REA. Este modelo incluye las fases de análisis, diseño, desarrollo, evaluación e implementación. Adicionalmente, este modelo está basado en los principios del marco de trabajo del Diseño Universal para el Aprendizaje (DUA) lo cual hace que el modelo adoptado sea más valioso que otras metodologías de creación en el sentido en que los recursos son creados considerando que cada estudiante tiene cualidades únicas y por ende que existe una gran diversidad de necesidades de aprendizaje. Aunque los REA pueden ser evaluados por expertos, en el contexto de esta tesis se propuso un enfoque de evaluación par para dar a los profesores la oportunidad de participar en la evaluación de la accesibilidad y calidad de REA creados por otros profesores. Este enfoque fue integrado como parte de la fase de evaluación del modelo CO-CREARIA. Por ello, en este estudio exploratorio se pidió a cada profesor que creara un REA y que evaluara un REA creado por otro profesor. Los REA fueron creados a manera de cursos virtuales dentro del sistema de gestión de aprendizaje ATutor.

Los hallazgos en la literatura y las lecciones aprendidas del estudio exploratorio permitieron identificar los elementos a ser considerados en una solución de analíticas de aprendizaje para brindar soporte a los profesores en la creación y evaluación de REA accesibles y de calidad. Así, analizando en detalle los lineamientos de las WCAG 2.0, considerando el instrumento de calidad utilizado (una adaptación del LORI) y haciendo una relación entre estos elementos y las competencias del profesor, se definió un modelo de usuario para representar las competencias del profesor considerando dos dominios: 1) la creación de contenidos accesibles y de calidad y 2) la evaluación de accesibilidad y calidad. De esta forma, esta tesis promueve el desarrollo de las competencias del profesor, y particularmente las competencias relacionadas con la creación y evaluación de REA.

El modelo de usuario definido fue utilizado como parte de una de las principales contribuciones de esta tesis que es el modelo de analíticas de aprendizaje para hacer seguimiento a la creación y evaluación de REA, considerando las características de accesibilidad web y calidad. Este modelo se denominó LAMTCE (Learning Analytics Model to Trace the Creation and Evaluation of OER). LAMTCE fue construido siguiendo los pasos comunes en un proceso analítico: colección de datos brutos, almacenamiento, análisis y visualización. Este modelo de analíticas de aprendizaje fue implementado en una herramienta de analíticas que se denominó ATCE (Analytics Tool to Trace the Creation and Evaluation of OER). ATCE fue integrada como un modulo dentro de ATutor. Las principales funcionalidades de ATCE incluyen: guardado de los detalles de cada elemento HTML agregado por un autor en un REA, revisión de los criterios de accesibilidad que pueden ser verificados de forma automática (evaluación automática), provisión de los instrumentos para la evaluación manual permitiendo que los evaluadores respondan preguntas relacionadas con la accesibilidad y calidad de los REA e incluye un tablero de analíticas con visualizaciones relacionadas con la accesibilidad y calidad de los REA para que los profesores puedan utilizar esta información para mejorar los REA y por ende sus competencias en la creación y evaluación de estos recursos.

Para evaluar el modelo LAMTCE, se llevó a cabo un escenario de evaluación en el cual los profesores participantes siguieron las lecciones de un curso de formación cuyos tópicos fueron los mismos del curso seguido en el estudio exploratorio. Esta evaluación tuvo un doble propósito. Primero se pretendía analizar si la herramienta ATCE (implementada con base en el modelo LAMTCE) beneficiaba a los profesores en la adquisición de las competencias en la creación y evaluación de REA. Segundo, el estudio pretendía identificar las percepciones de los profesores con respecto al uso de la herramienta ATCE. Los resultados destacan un efecto positivo en la adquisición de las competencias del profesor en la creación y evaluación de REA y una actitud positiva con respecto al uso de nuestra herramienta de analíticas porque permitió a los profesores, en su rol de autores, estar informados sobre cómo mejorar la accesibilidad web y la calidad de los REA al mismo tiempo que les proveió información sobre cómo mejorar en su rol de evaluadores de REA.

En consecuencia, esta tesis contribuye al conocimiento en las áreas de analíticas de aprendizaje y REA en los siguientes aspectos:

- La definición de un procedimiento de evaluación para REA considerando accesibilidad web y calidad.
- La definición de un modelo de analíticas para ayudar a los profesores en la creación y evaluación de REA considerando la accesibilidad y calidad de los REA.
- El desarrollo de una herramienta basada en el modelo de analíticas de aprendizaje propuesto para soportar a los profesores en la creación y evaluación de REA mientras adquieren competencias para crear y evaluar la accesibilidad web y calidad de los REA.

Resum

L'adopció de Recursos Educatius Oberts (REO) per suportar les experiències d'aprenentatge ha anat augmentant i amb això la necessitat d'atendre la diversitat de les necessitats d'aprenentatge dels estudiants. No obstant això, quan es tracta de proveir als estudiants amb continguts d'aprenentatge accessibles i d'alta qualitat, els professors s'enfronten amb alguns reptes atès que han d'adquirir el coneixement i competències per crear tals continguts i també per assegurar-se que compleixen amb els requeriments d'accessibilitat i qualitat. A més, quan els professors estan aprenent o estan involucrats en la creació i avaluació de REO duen a terme diferents activitats i la informació d'aquestes activitats pot ser emmagatzemada en una base de dades. Llavors, vam identificar que una forma d'analitzar o processar les traces que provenen dels registres d'activitat és fent ús de l'enfocament d'analítiques d'aprenentatge. Amb base en aquestes idees, la pregunta d'investigació que dirigeix aquesta tesi és: com les analítiques d'aprenentatge poden proveir suport als professors en el procés de creació i avaluació de REO accessibles?

En la revisió de literatura sobre REO també identifiquem la qualitat com una característica inherent i valuosa dels REO i que l'avaluació de qualitat també involucra la categoria d'accessibilitat considerant que els estudiants poden enfrontar-se a barreres d'accés al contingut. Encara que alguns estudis recomanen considerar estàndards d'accessibilitat, hi ha la necessitat d'anar més enllà en la investigació sobre com els professors prenen part en la creació i avaluació de REO considerant aquestes característiques (accessibilitat i qualitat). En el context d'aquesta tesi, ens hem enfocat en la creació i avaluació de REO considerant l'accessibilitat web i la qualitat. L'accessibilitat web és la possibilitat que ofereixen els continguts digitals perquè les persones percebin, comprenguin, naveguin i interactuïn amb el web. Per assegurar que els REO compleixen amb els requeriments d'accessibilitat nosaltres seguim les directrius per accessibilitat en continguts web coneguts com WCAG 2.0 (Web Content Accessibility Guidelines) que són proveïdes pel consorci de la W3C. D'altra banda, el concepte de qualitat es refereix a la característica que fa que els REO s'ajustin al context d'ensenyament i de l'aprenentatge. Llavors, pel que fa a la qualitat, nosaltres adoptem el ja conegut instrument per a la revisió d'objectes d'aprenentatge o LORI (Learning Object Review Instrument).

Portant a terme un estudi exploratori en el qual els professors van participar en un curs de formació sobre la creació i avaluació de REO accessibles considerant ambdues característiques, l'accessibilitat i la qualitat, identifiquem que els escenaris de formació donen als professors el coneixement i el potencial per desenvolupar les seves competències, però ells encara requereixen eines de suport que els ajudi en aquestes tasques. Els temes del curs de formació van ser: aprenentatge inclusiu, Disseny Universal per a l'Aprenentatge (DUA), REO, accessibilitat web i avaluació de REO.

Atès que en la creació d'REO s'ha de promoure l'atenció de les necessitats d'aprenentatge dels estudiants, es recomana fer ús d'una metodologia per a la creació que proveeixi les directius suficients perquè els autors aconsegueixin aquesta comesa. És per això que en l'estudi exploratori adoptem el model Co-Crearia, el qual és un model per a la co-creació i

avaluació de REO. Aquest model inclou les fases d'anàlisi, disseny, desenvolupament, avaluació i implementació. Addicionalment, aquest model està basat en els principis del marc de treball del Disseny Universal per a l'Aprenentatge (DUA) la qual cosa fa que el model adoptat sigui més valuós que altres metodologies de creació en el sentit en què els recursos són creats considerant que cada estudiant té qualitats úniques i per tant que hi ha una gran diversitat de necessitats d'aprenentatge. Tot i que els REO poden ser avaluats per experts, en el context d'aquesta tesi vam proposar un enfocament d'avaluació per parells per donar als professors l'oportunitat de participar en l'avaluació de l'accessibilitat i qualitat de REO creats per altres professors. Aquest enfocament va ser integrat com a part de la fase d'avaluació del model Co-Crearia. Llavors, en aquest estudi exploratori es va demanar a cada professor que creés un REO i que avalués un REO creat per un altre professor. Els REO van ser creats a manera de cursos virtuals dins el sistema de gestió d'aprenentatge ATutor.

Les troballes en la literatura i les lliçons apreses de l'estudi exploratori ens van permetre identificar els elements a ser considerats en una solució d'analítiques d'aprenentatge per brindar suport als professors en la creació i avaluació de REA accessibles i de qualitat. Així, analitzant en detall les línies de les WCAG 2.0, considerant l'instrument de qualitat utilitzat (una adaptació del LORI) i fent una relació entre aquests elements i les competències del professor, vam definir un model d'usuari per representar les competències del professor considerant dos dominis: 1) la creació de continguts accessibles i de qualitat i 2) l'avaluació d'accessibilitat i de qualitat. D'aquesta manera, aquesta tesi promou el desenvolupament de les competències del professor, i particularment de les competències relacionades amb la creació i avaluació de REO.

El model d'usuari definit va ser utilitzat com a part d'una de les contribucions principals d'aquesta tesi que és el model d'analítiques d'aprenentatge per fer el seguiment a la creació i avaluació de REO considerant les característiques d'accessibilitat web i qualitat. Aquest model l'anomenem LAMTCE (analítiques d'aprenentatge Model to Trace the Creation and Evaluation of OER). LAMTCE va ser construït seguint els passos comuns en un procés analític: col·lecció de dades brutes, emmagatzematge, anàlisi i visualització. Aquest model d'analítiques d'aprenentatge va ser implementat en una eina d'analítiques que anomenem ATCE (Analytics Tool to Trace the Creation and Evaluation of OER) que vaser integrada com un mòdul dins d'ATutor. Les principals funcionalitats d'ATCE inclouen: guardar els detalls de cada element HTML agregar per un autor en un REO, revisió dels criteris d'accessibilitat que poden ser verificats de forma automàtica (avaluació automàtica), provisió dels instruments per a l'avaluació manual permetent que els avaluadors responguin preguntes relacionades amb l'accessibilitat i qualitat dels REO i inclou un tauler d'analítiques amb visualitzacions relacionades amb l'accessibilitat i qualitat dels REO perquè els professors puguin utilitzar aquesta informació per millorar els REO i per tant les seves competències en la creació i avaluació d'aquests recursos.

Per avaluar el model LAMTCE, portem a terme un escenari de validació en el qual un grup de professors van participar en un curs de formació amb els mateixos tòpics que els del curs seguit en l'estudi exploratori. Aquesta avaluació va tenir un doble propòsit. Primer es pretenia analitzar si l'eina ATCE (implementada amb base en el model LAMTCE) beneficiava als professors en l'adquisició de les competències en la creació i avaluació de REO. Segon, l'estudi pretenia identificar les percepcions dels professors respecte a l'ús de l'eina ATCE. Els resultats destaquen un efecte positiu en l'adquisició de les competències del professor en la creació i avaluació de REO i una actitud positiva pel que fa a l'ús de la nostra eina d'analítiques perquè permet als professors en el seu rol d'autors estar informats sobre com millorar la accessibilitat web i la qualitat dels REO al mateix temps que els proveeix informació sobre com millorar en el seu rol d'avaluadors de REO.

En conseqüència, aquesta tesi contribueix al coneixement en les àrees d'analítiques d'aprenentatge i REA en els següents aspectes:

- La definició d'un procediment d'avaluació per REO considerant accessibilitat web i qualitat.
- La definició d'un model d'analítiques per ajudar els professors en la creació i avaluació de REO considerant l'accessibilitat i qualitat dels REO.
- El desenvolupament d'una eina de analíticas basada en el model d'analítiques d'aprenentatge proposat per suportar als professors en la creació i avaluació de REO mentre adquireixen competències per crear i avaluar l'accessibilitat web i qualitat dels REO.

PART 1
CONTEXTUALIZATION

CHAPTER 1
INTRODUCTION

This chapter describes the motivations and the main problems in the creation and evaluation of Open Educational Resources (OER) which led us to carry out the research work of this thesis (section 1.1). Likewise, we present in this chapter the formulation of the research question (section 1.2) and the objectives (section 1.3) defined for this thesis. We also describe the phases followed in the methodology applied in this thesis (section 1.4). This chapter concludes with a general description of the structure of this document and some comments on the style of writing of this thesis (section 1.5).

1.1 Motivation and research problem

Nowadays, a vast majority of learning contents is published on the web and this digital nature makes them more available for everyone with access to the digital world. Particularly, students who attend virtual classes from home or students who access learning contents using the computer are the main users in this digital age. Learning contents can be represented with different levels of granularity (Wiley, 2000): as single digital resources (images, videos, games, etc.), learning units or complete courses. Those educational resources known as learning objects and since 2002 as Open Educational Resources (OER) are "*teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and repurposing by others*"(Atkins, Brown, & Hammond, 2007). Besides, one of the statements declared in the guidelines for OER in higher education promotes the use and adoption of tools to "*facilitate the creation and use of adaptable, inclusively designed educational resources*" (Commonwealth of Learning., 2011) to address the diversity of students' learning needs.

When it comes to create OER that address the diversity of students' learning needs, teachers should consider characteristics such as the web accessibility to avoid content access barriers, and the quality to make learning contents more appropriate to the learning context for which the OER are intended. Moreover, the creation process also involves an evaluation process which can be taken as a strategy to ensure that an OER meets with accessibility and quality requirements.

Web accessibility means that all people can perceive, understand, navigate, and interact with the web (W3C, 2005). Thus, international accessibility recommendations such as the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) provide a set of best practices to make web contents more accessible for all people. Thereby, OER 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(Hoyer & Hoyer, 2001) and thus it makes OER appropriated for a learning context. To evaluate the quality of OER we adopted LORI (Learning Object Review Instrument) (Leacock & Nesbit, 2007) which has been widely used to evaluate the quality of learning objects (Yuan & Recker, 2015).

Despite the multiple benefits attributed to OER, Prasad and Usagawa (2014) stated that

inadequate trainings, uncertainties about copyright, or difficulties to select appropriate learning contents are some of the teachers' perceived barriers to use and adopt OER. Moreover, research on how to support teachers in the achievement of accessible and quality OER is limited. According to Iniesto, McAndrew, Minocha, & Coughlan (2016) "accessibility does not appear to have been considered in a consistent way when designing online learning resources". Indeed, teachers may find that getting OER that address the diversity of students' learning needs and that meet with quality requirements requires too much time and effort. Thereby, creating such OER is not straightforward, especially when teachers do not have enough information, specialized competences, feedback or supporting tools to make decisions on how to create and improve their learning contents.

Furthermore, Learning Management Systems (LMS) such as ATutor, Blackboard, dotLRN. Moodle, etc., have emerged as powerful platforms for creating digital learning contents in the form of virtual courses, publishing contents and designing learning activities. However, the support offered by such systems is rather limited in the sense that teachers may need to acquire specialized knowledge and skills to use them for creating OER.

In this research we consider the creation and evaluation of OER as part of the teachers' competences. A competence "means 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" (European Commission, 2008). Since OER include different digital contents (e.g. HTML elements), teachers require the acquisition of specialized knowledge and skills to create and evaluate OER in terms of web accessibility and quality.

As part of the work done in different European and national projects within the BCDS[1] research group, we have had the opportunity to organize training sessions with teachers involving the use of the ATutor LMS to develop their competences in the creation of OER in the form of virtual courses. For instance, in the ALTER-NATIVA project[2] (ALFA III - DCI-ALA/19.09.01/10/21526/245-575/ALFA III (2010)88), teachers learnt how to create accessible contents considering the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) and using the web editor of the ATutor LMS. Similarly, in the Inclusive Learning project[3] (Supporting Trainers for an Inclusive Vocational Education and Training) (2012-1-ES1-LEO05-49449), teachers learnt how to create accessible OER. As a result, we identified that for most of the teachers it was the first time dealing with the topics addressed in those projects (e.g. inclusive learning, web accessibility, evaluation of educational resources). In inclusive learning environments teachers are required to provide their students with learning contents that pay attention to the diversity of learning needs. Currently we are working in the Open Co-creation (TIN2014-53082-R) national funded project in which the focus is the co-creation of accessible OER. The expertise gained from the work in these projects is a solid background and also motivated the research conducted in this thesis.

Another aspect that motivated the research conducted in this thesis was that in the literature review about OER (presented in CHAPTER 2) we identified that little research has been conducted on the support given to teachers to create and evaluate accessible and quality OER. Some studies recommend guidelines, methodologies or standards so that teachers create learning contents based upon pedagogical or technological approaches but few studies analyze or mention the attention to the diversity of students' learning needs or issues related to the accessibility and quality of OER. Thereby it is worth noting the need for

[1] BCDS' web site: http://bcds.udg.edu/

[2] ALTER-NATIVA project web site: http://titanic.udg.edu:8000/www_alternativa/

[3] Inclusive Learning project web site: http://www.inclusive-learning.eu/

further research on how such issues can be addressed in a real experience with teachers as the authors and evaluators of OER.

Based upon these ideas, one of the challenges for today's teachers is to create and evaluate accessible and quality OER to address the diversity of students' learning needs. Consequently, teachers are expected to be able to create and evaluate accessible and quality OER, and this is the focus of attention in this research work.

On the other hand, there is a growing trend towards learning analytics solutions in the field of educational technology. Learning analytics "is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs"(Siemens, 2011). The majority of learning analytics solutions so far have focused on informing teachers whether the results from the interactions of students with learning activities or learning contents correspond with or meet the expected learning outcomes (e.g. De Freitas et al., 2015; Fernandez-Delgado et al., 2014b; Lori Lockyer et al., 2013; María Jesuś Rodríguez-Triana et al., 2012). Moreover, a key concept in such analytics solutions is the feedback given to teachers so that they can make decisions of improvement in the learning activities, learning contents or learning paths using the learning traces of their students. Nevertheless, we did not found studies dealing with how to exploit learning analytics to trace data coming from actions carried out by teachers at the creation or evaluation time and how teachers can use such information to improve the learning contents before the OER are implemented in a real scenario with students.

As can be observed, learning analytics not only inform teachers about student's interactions, but also teachers can be informed on how appropriated their educational resources are for the target audience. This idea is supported by Bodily, Nyland, & Wiley (2017), who state that the use of learning analytics contributes to the continuous improvement of educational content through the analysis of course evaluation data. Furthermore, learning analytics may allow us to provide teachers with meaningful information regarding the creation and evaluation of OER. Such information can be presented through a learning analytics dashboard also known as learning dashboard which is defined as "a single display that aggregates different indicators about learner (s), learning process(es) and/or learning context(s) into one or multiple visualizations" (Schwendimann et al., 2017, p. 37)

In summary and based on the discussion presented earlier in this section, the motivation of this thesis focused on the latent need of analyzing the support that learning analytics can bring to teachers in the creation and evaluation of accessible OER with particular focus on the accessibility and quality characteristics. Thus, we defined a learning analytics model to trace the activities done by teachers when they create and evaluate OER considering the web accessibility and quality characteristics as a major contribution of this thesis in the field of OER and learning analytics.

1.2 Research question

The concern about the attention to the diversity of students' learning needs, lessons learnt from our experience working with teachers in the creation of OER in different research projects, and the benefits that learning analytics could bring to support teachers in the creation and evaluation of accessible OER motivated us to pose the following research question:

How can learning analytics support teachers in the creation and evaluation of accessible open educational resources?

1.3 Objectives

The main aim of this thesis is to define a learning analytics model for supporting teachers in the creation and evaluation of accessible open educational resources. To achieve this objective, we have defined the following specific objectives (SO):

- **SO1**: To conduct a literature review on open educational resources and monitoring mechanisms to support teachers in the creation of open educational resources.
- **SO2**: To conduct an exploratory study to identify aspects that provide a better support in the creation and evaluation of accessible open educational resources.
- **SO3:** To define a user model to represent the teachers' competences in the creation and evaluation of accessible open educational resources.
- **SO4**: To define a learning analytics model to trace the creation and evaluation of accessible open educational resources.
- **SO5**: To develop a learning analytics tool based on the proposed learning analytics model.
- **SO6**: To conduct an evaluation for the proposed learning analytics model and the learning analytics tool.

1.4 Research methodology

Based on the methodology described by Kothari (2012), the phases for the development of a research work can include: literature review, exploratory studies, implementation tasks, evaluation, and reporting. The phases and activities defined for this thesis are depicted in Figure 1-1.

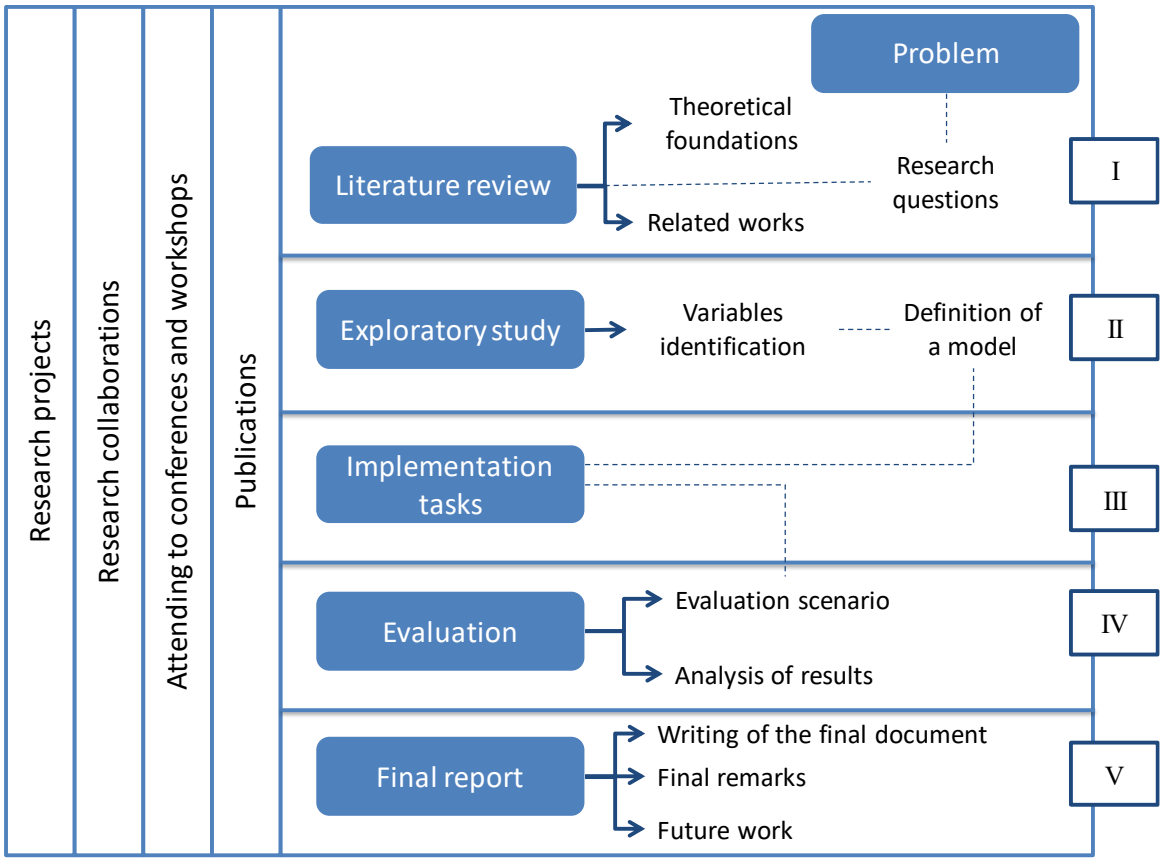


Figure 1-1. Phases of the methodology followed in this thesis

These phases are described as follows:

- **Phase I:** in this phase the theoretical foundations were defined by means of a literature review about the current research on OER. As a result, we could identify that accessibility and quality are two of the most valuable characteristics of OER. Then, it was needed to broaden information about other specific topics related to this thesis that were not covered at all in the studies analyzed. These topics are: web accessibility, quality in educational resources, ICT competences for teachers, user modelling, and learning analytics. All these topics are connected with the research problem and objectives we tackle in this thesis.
- **Phase II:** this phase is divided into two main activities. The first one is to conduct an exploratory study with teachers in order to allow them to participate in the creation and evaluation of OER considering characteristics such as the accessibility and quality. From this exploratory study we identified some aspects to be considered as part of our Learning Analytics Model to Trace the Creation and Evaluation of OER (LAMTCE). Then, the second main activity consisted in defining and documenting the LAMTCE model considering findings from the exploratory study and the definition of a user model to represent the teachers' competences in the creation and evaluation of accessible and quality OER.
- **Phase III:** contributions of this thesis are connected with the educational technology research field, thus as part of the technological contribution in this phase we carried out some software implementation tasks in order to implement the LAMTCE model in a learning analytics tool to support teachers in the creation and evaluation of OER (ATCE).
- **Phase IV:** this phase is focused on the definition of the evaluation scenario for the LAMTCE model and the ATCE tool. This evaluation scenario is based on the findings and outputs from the previous phases.
- **Phase V:** the main aim of this phase is to compile the final report by contextualizing the motivation, main problem and the research objectives. Moreover, this final report describes all activities and findings coming from the analysis of the literature review, the exploratory study, the definition of the LAM, the development of the learning analytics tool, and the deployment of the evaluation scenario. The last part of the final report includes final remarks related to the conclusions from the research work done and lines for future work.

Activities that were carried out in parallel with the development of all phases in the research methodology include:

- To write and publish papers (at least one for a Journal)
- To participate in related international conferences..
- To work with other research group.
- To participate in the research projects leaded by the BCDS research group.
- To attend meetings with supervisors to follow the advances in the thesis.

1.5 Structure of the document

This document is divided into four parts that contain seven chapters including this introduction part, and the references.

- PART 1 – CONTEXTUALIZATION
    - **CHAPTER 1 – INTRODUCTION**: this chapter presents the main elements that drove the development of this thesis: motivations and research problem, research question, objectives, methodology and the outline of this document.

- **CHAPTER 2 – LITERATURE REVIEW:** this chapter presents the literature review of open educational resources. This literature review was complemented with an overview of other topics addressed in this thesis such as web accessibility, quality in educational resources, ICT competences for teachers, user modelling, and learning analytics.

- PART 2 – EXPLORATORY STUDY
  - **CHAPTER 3 - EXPLORATORY STUDY:** this chapter describes an exploratory study conducted to identify aspects that provide a better support in the creation and evaluation of OER.

- PART 3 –LEARNING ANALYTICS MODEL
  - **CHAPTER 4 – DEFINITION OF THE LEARNING ANALYTICS MODEL:** this chapter describes all the elements considered to build the learning analytics model from the perspective of the four common steps in a learning analytics process: gathering of raw data, storing, analysis, and visualization.
  - **CHAPTER 5 – LEARNING ANALYTICS TOOL TO TRACE THE CREATION AND EVALUATION OF OER:** this chapter briefly describe the main outcomes from the learning analytics model, the design decisions that came up to implement the LAMTCE model into a learning analytics tool, the description of the tool developed together with a description of the visualizations that can be obtained after using the tool.
  - **CHAPTER 6 – EVALUATION OF THE LEARNING ANALYTICS MODEL:** this chapter presents the evaluation scenario for the learning analytics model. It describes the research design of the evaluation including research questions, methods, participants, materials, procedure and analysis. The last two parts of this chapter deal with the results, discussion and conclusions of the study.

- PART 4 – FINAL REMARKS
  - **CHAPTER 7 – CONCLUSIONS, CONTRIBUTIONS AND FUTURE WORK:** this chapter presents a general overview of the document, the contributions, the conclusions of the research work done in this thesis and some ideas for future work.

- REFERENCES

1.6 Writing style

Regarding the writing style of this thesis, we adopted the use of the first person of the plural "we", hereinafter used to refer to the author of this thesis, supported by her supervisors (PhD. Ramon Fabregat, PhD. Silvia Baldiris and PhD. Sabine Graf) in an effort to present the research in active voice instead of passive voice to facilitate reading. This choice is a matter of writing style. The aim of using the first person of the plural is also to avoid confusions when talking about the work of other authors or researchers and to maintain simplicity. This means that, within the text, any expressions like "authors" or "researchers" always refer to other authors and researchers that are neither the author of this thesis nor her supervisors.

Despite the fact that the use of the first person of the plural refers to the author supported by her supervisors, this research was completely conducted by the author of this thesis which means that the contributions of this thesis are the result of her work. The supervisors of this thesis guided, revised and provided suggestions, ideas and experience for the correct development and orientation of this thesis.

In short, some the activities conducted in this thesis and developed by the author with the

guide, orientation, revision, suggestions and inputs of her supervisors are:

- The abstract, acknowledgements, motivation, the research questions, the objectives, the research methodology and the structure of this document. All of these are reported at the beginning of this thesis and in CHAPTER 1.
- The analysis of the studies and findings in the literature review reported in CHAPTER 2.
- The definition of the model and the web tool for the evaluation of OER described in CHAPTER 3.
- Participation in the development tasks and installation of the ATutor LMS instance used in the exploratory study reported in CHAPTER 3.
- Participation in the development tasks and installation of the Inclusive Learning Handbook platform, the development of the web accessibility examples and video tutorials included in the handbook, as well as the installation and adjustments of the ATutor instance that teachers used in the training sessions described in CHAPTER 3.
- The statistical analysis of data collected and the analysis of the results from the exploratory study reported in CHAPTER 3.
- The definition of the analytics model described in CHAPTER 4.
- The development and installation of the ATutor LMS instance and the analytics tool described in CHAPTER 5.
- The recording and edition of the video tutorials used to introduce the training sessions of the virtual course carried out as part of the evaluation reported in CHAPTER 6.
- The evaluation of the OER created by teachers and the verification of the evaluations done by teachers in the evaluation of analytics model and the analytics tool reported CHAPTER 6.
- The statistical analysis of data collected and the analysis of the results from the evaluation study reported in CHAPTER 6.
- Participation as one of the virtual tutors in the courses carried out in the exploratory study reported in CHAPTER 3 and also in the evaluation reported in CHAPTER 6.
- The summary of the thesis including general conclusions, contributions, publications and the future work reported in CHAPTER 7.

Regarding the citation style of this thesis, we followed the APA citation style.

CHAPTER 2
LITERATURE REVIEW

This chapter presents a literature review conducted to present an overview of Open Educational Resources (OER) describing characteristics, benefits, challenges, and initiatives of OER, as well as to describe the elements surrounding the creation of OER such as actors, phases, standards, technologies and methodologies. Findings from this review in OER led us to broaden the theoretical underpinnings on other research topics related to this thesis such as web accessibility, quality in educational resources, ICT competences for teachers, user modeling, and learning analytics.

Following the **Phase I** in the research methodology defined for this thesis, findings and challenges identified in this thesis are supported by the literature review in the field of OER and the other topics mentioned above. Moreover, this literature review contributes to achieve the first specific objective of this thesis (***SO1*** – *To conduct a literature review on open educational resources and monitoring mechanisms to support teachers in the creation of open educational resources*).

This chapter is organized as follows: section 2 is mainly focused on the topic of OER, and the remaining sections correspond with the other topics studied in this literature review, namely: web accessibility (section 2.2), quality in educational resources (section 2.3), ICT competences for teachers (section 2.4), user modelling (section 2.5), and learning analytics (section 2.6). The last section (section 2.7) of this chapter presents the main conclusions derived from the theoretical findings reported in the previous sections.

2.1 Open Educational Resources

The literature review presented in this section is focused on OER since this is one of the most important topics of this thesis. We investigate on OER because this kind of resources may include learning contents and materials that support the teaching process and teachers need to acquire competences to be able to create and evaluate such OER. This literature review about OER contains two main parts an introduction to OER (subsection 2.1.3) and an overview of the creation of OER (subsection 2.1.4).

2.1.1 Literature review - research questions

The literature review presented in this chapter was focused mainly on an introduction to OER and the state of the art in the creation of OER. The ***Literature Review - Research Questions (LR-RQs)*** are described as follows:

- **LR-RQ1 -** Which are the methodologies for the creation of OER (including: characteristics of OER, actors, standards, technologies, phases)? **Scope:** this question will allow us to identify which the characteristics of OER are, actors, standards, technologies, and phases considered in the creation of OER. Besides, it is important to identify the modality of each methodology in terms of collaborative methodologies and those that are not. **Topics:** creation of OER, teacher training.
- **LR-RQ2 -** *How have learning needs and student preferences been considered in the*

creation of OER? **Scope:** the purpose of this question is to check in which phases of the creation of OER special needs of access and student preferences have been considered, and how they have been addressed. **Topics:** creation of OER, accessibility, inclusion.

- **LR-RQ3 -** *What are the mechanisms, systems or strategies considered to monitor the creation OER?* **Scope:** with this question we aim to know if there are some mechanisms, systems or strategies (e.g. dashboards) that trace the creation and use of OER. **Topics:** creation of OER, monitoring.

2.1.2 Methodology

- Step 1 – Databases and general search: this step describes a general search and the tendency of publications related to "open educational resources".
- Step 2 – Studies selection: in this step the selection is based on a set of exclusion and inclusion criteria and each reference selected is saved in the Mendeley references management tool.
- Step 3 – Reading, coding and memoing: in this step the papers selected are read and coded in order to identify a classification per topics. Regarding the memoing Birks & Mills (2011), in their practical guide of grounded theory, point out that memos are records of thoughts and ideas related to the research project. For that reason, while reading and coding it is useful to write some memos to support our ideas of findings. To do this, we used Atlas.ti[4], which is a software that allow users to allocate, code and annotate findings on the materials analysed in this case papers and articles.
- Step 4 – Complementing findings: different topics emerged from the codification of papers and then we included other studies we considered relevant to complement the review. We repeat step 2 and step 3 with these extra papers.
- Step 5 – Writing: in this step we took the reports from the codification phase in order to describe findings on literature review according to the LR-RQs.

2.1.2.1Step 1 – Databases and general search

This literature review is based on studies gathered from Web of Science (Wos) and ScienceDirect which cover a wide variety of fields and retrieve studies from other databases such as ERIC, Elsevier, IEEE, Springer, Taylor & Francis and Wiley, among others. On the other hand, "open educational resources" is the main term to address in this analysis. Thereby we made a general search in order to observe the publication tendency of this term from 2004 to the first half of 2015. Table 2-1 shows the results retrieved from the general search including: database name (Database), text of the query (Query) total number of records obtained in each query (Total records), records classified by the timespan (2004-2015) (Timespan), and the average of publications in each database (Average). As a result of this general search 442 records were found: 162 in ScienceDirect and 280 in WoS. Figure 2-1 shows a graphical representation of this general search and according to this, publications related to "open educational resources" have grown over time and so far, 2013 in Wos and 2015 in ScienceDirect are the years with more publications in this research topic.

[4] Atlas.ti website: http://atlasti.com

Table 2-1. Results retrieved with "open educational resources"

Database	Query	Total records	Timespan											
			2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ScienceDirect	pub-date > 2003 and ("open educational resources")	162	0	1	1	0	3	3	10	18	12	37	31	46
Web of Science (Wos)	TS=("open educational resources") Timespan: 2004-2015. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH.	280	0	0	0	3	13	14	24	37	56	72	48	13
	Total	442	0	1	1	3	16	17	34	55	68	109	79	59

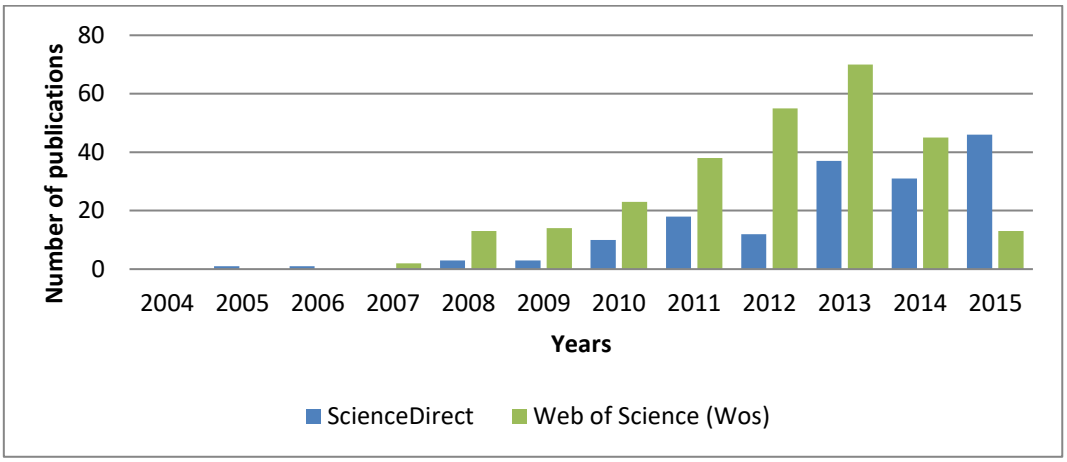


Figure 2-1. Publication tendency of "open educational resources"

2.1.2.2Step 2 – Studies selection

In this step we considered the following inclusion and exclusion criteria to select the papers:

Inclusion criteria

- Studies related to experiences in the creation, use or adoption of OER.

Exclusion criteria

- The term "open educational resources" or "OER" is just mentioned and not used in depth or only appears in the bibliography section.
- Front pages, book abstracts, or authors biographies which do not cover the topics of interest in this literature review.
- There is a similar study from the same author.
- The text of the study is not available.

After applying these criteria, 131 studies were selected from WoS and 39 from ScienceDirect. Then, from those studies there were 9 duplicates obtaining at the end a total of 161.

2.1.2.3Step 3 – Reading, coding and memoing

To codify the papers selected we chose the Atlas.ti software which is used mostly to analyse qualitative data and also to make literature reviews. Data to analyse may come from different sources or documents such as: text files (plain text, Word, PDF, etc.), image files, and video files, among others. In this literature review we analysed the articles and papers in PDF format. The options used in Atlas.ti to develop this literature review were:

- Primary documents: in this case a primary document is an article/paper in PDF format.

- Codes: tags created to codify the primary documents. A text or image in the PDF document should be selected to add a code. While reading each PDF, different codes were created. Step 5 presents a structure with the codes used in this literature review.
- Memos: texts that are written according to the findings in each primary document. One memo was created for remarkable elements such as: actors, benefits, challenges and issues, characteristics, claims and assertions, contributions, creation of OER, types of OER.
- Comments: each comment belongs to a unique document, code or quotation. In this literature review a comment was added in each PDF in order to summarize the article/paper.
- Quotations: selected text or section within a primary document. Different text were selected and marked with one or more codes.
- Families: this element allows us to make groups of documents, codes or memos. We organized the PDF documents in families according the books, conferences, and journals.

2.1.2.4Step 4 – Complementing searches

Finishing step 3, we search in the Scopus database including the terms *open educational resources*, *creation* and *instructional design* as follows:

Search 1: ***(TITLE-ABS-KEY ("open educational resources") AND TITLE-ABS-KEY (creation)) AND PUBYEAR > 2003.***

Search 2: ***(TITLE-ABS-KEY ("open educational resources") AND TITLE-ABS-KEY (instructional design)) AND PUBYEAR > 2003.***

As a result, a total of 63 records were obtained from both searches in the Scopus database. Then, we applied inclusion and exclusion criteria (step 2 - Studies selection) obtaining 32 studies and from those we removed 16 that were duplicated in the studies selected from WoS and ScienceDirect. After that, we followed the step 3 (Reading, coding and memoing).

At the end 176 studies were selected to do the literature review (161 from both WoS and ScienceDirect, and 15 from Scopus). Figure 2-2 illustrates the flow diagram of the papers selected in each step.

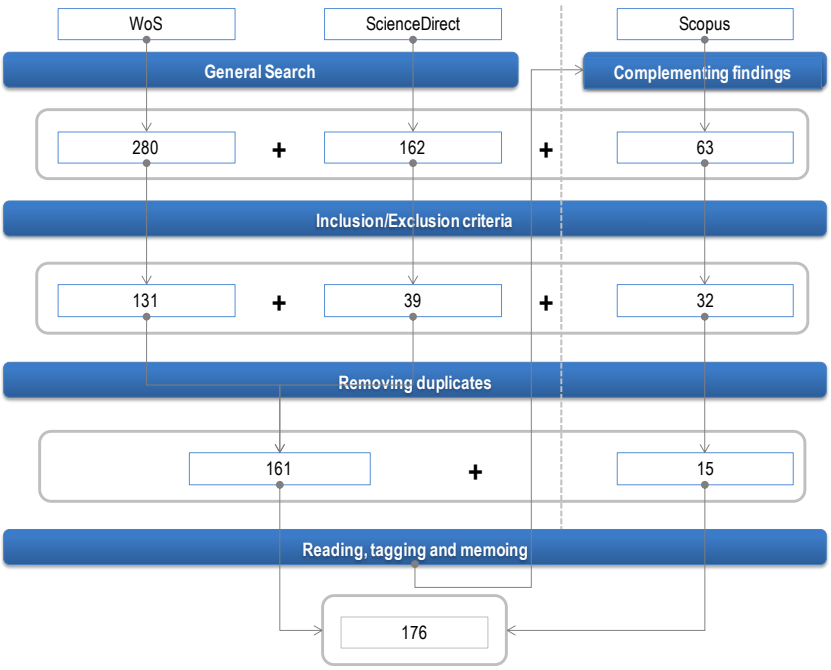


Figure 2-2. Flow diagram of the studies selected

2.1.2.5Step 5 – Writing

Figure 2-3 shows the structure of topics including categories and sub-categories. This structure was created taking into account the codes and memos used in the Atlas.ti. All codes were classified in different categories. These categories were generated as a result of the codification process in Atlas.ti. The structure was divided into two main categories: the introduction to OER category for general topics and creation of OER category to tackle specific topics in the creation of OER. The introduction to OER category includes: definitional basis, characteristics, benefits, challenges and issues and initiatives. As for the creation of OER category, it includes the lifecycle of OER, actors, standards, technologies, methodologies, monitoring and evaluation.

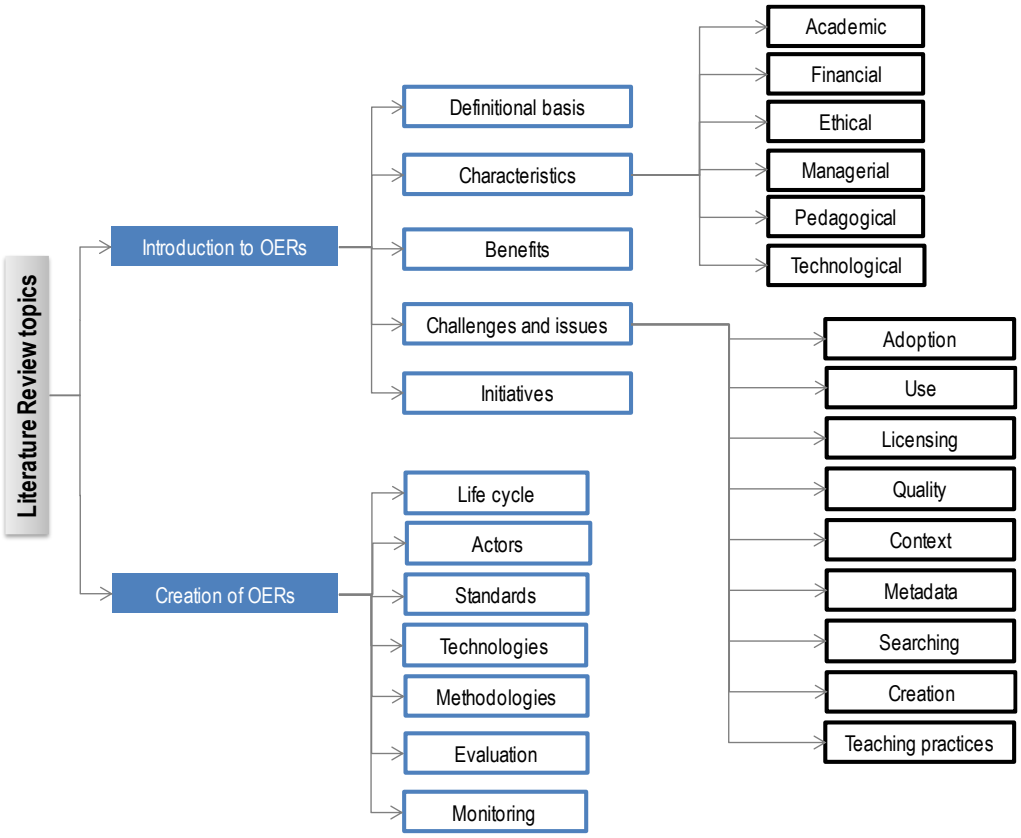


Figure 2-3. Literature review topics

2.1.3 Introduction to OER

The first part of this literature review about OER deals with the definitions of OER that have been introduced by different authors (subsection 2.1.3.1), characteristics of OER (subsection 2.1.3.2) classified by categories (academic, ethical, managerial, pedagogical, technological and financial), benefits (subsection 2.1.3.3), challenges and issues of OER (subsection 2.1.3.4) with regard to the adoption, use, copyright and licensing, quality, context, metadata, searching, creation, and teaching practices, and the last subsection of this part deals with national and international initiatives carried out to promote OER (subsection 2.1.3.5).

2.1.3.1Definitional basis

During decades, teaching and learning have been supported by different sort of resources that can be delivered in digital or printed formats in a wide variety of contexts. With a noticeable change in educational practices, the open movement has set up a revolution with teachers creating a vast pool of educational resources free for all to use, as reported in the Cape Town Open Education Declaration in 2008 (as cited in Stacey, 2013). Currently Open

Educational Resources (OER) is a concept mostly used when people refer to digital and learning contents. Although the concept was coined in a forum held by UNESCO in 2002, three definitions of OER have been attributed to UNESCO:

- OER refer to an "open provision of educational resources, enabled by information and communication technologies, for consultation, use and adaptation by a community of users for non-commercial purposes" (as cited in Angell, Hemingway, & Hartwell, 2011, p. 2; Çakmak, Özel, & Yılmaz, 2013, p. 2; K. I. Clements & Pawlowski, 2012, p. 1; DeVries, 2013, p. 1; Dinevski, 2008, p. 3; Hart, Chetty, & Archer, 2015, p. 2; Hawkridge, Armellini, Nikoi, Rowlett, & Witthaus, 2010, p. 3; Llamas-Nistal & Mikic-Fonte, 2014, p. 1; Pawlowski & Bick, 2012, p. 1; Piedra, Chicaiza, Lopez, & Tovar Caro, 2014, p. 1; Pirkkalainen, Jokinen, & Pawlowski, 2014, p. 2; Rosell-Aguilar, 2013, p. 2; Toetenel, 2014, p. 4; Tovar, Piedra, Chicaiza, Lopez, & Martinez-Bonastre, 2012, p. 2; Tuomi, 2013, p. 3, Zervas & Sampson, 2014, p. 1)
- OER are "any type of educational materials that are in the public domain or introduced with an open license. The nature of these open materials means that anyone can legally and freely copy, use, adapt and re-share them" (as cited in Caeiro, Santos, Llamas, & Lama, 2014, p. 1).
- In the Paris OER declaration in 2012 OER were defined as "teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions" (as cited in Marcus-Quinn & Diggins, 2013, p. 1; Tovar & Piedra, 2014, p. 2; Abeywardena, Chan, & Tham, 2013, p. 2; Hart et al., 2015, p. 3)

The last definition is quite similar to the adopted by the William and Flora Hewlett Foundation, which was proposed by Atkins, Brown, & Hammond (2007), in which OER are described as "teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others" (as cited in Arimoto & Barbosa, 2013, p.1; Blyth, 2013, p. 3; Chiappe & Arias, 2015, p. 3; Connolly, 2013, p. 1; Deimann & Farrow, 2013, p. 3; Hilton III, Wiley, & Lutz, 2012, p. 3; Jameson (Eds.), 2013, p. 1; Lane & McAndrew, 2010, p. 1; Llamas-Nistal & Mikic-Fonte, 2014; Maina, Pérez-Mateo, Guàrdia, & Sangrà, 2015; Olcott, Jr., 2013, p. 8; Okonkwo, 2012, p. 5; Prasad & Usagawa, 2014; Robinson, Fischer, Wiley, & Hilton, 2014, p. 1; Tuomi, 2013, p. 4).

As noted by Tuomi (2013) the definition of OER comes from open source software perspectives as well as the idea of working collaboratively to create peer-produced resources. Dinevski (2008) supports this idea arguing that the root of OER is the use of open source educational tools such as Learning Management Systems (LMS), Learning Content Management Systems (LCMS), and authoring tools, among others. Besides, other authors or institutions have adopted their own definition of OER. For instance, the Organisation for Economic Co-operation and Development (OECD) defines OER as "digitised materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning and research" (OECD, 2007) (as cited in Hilton III et al., 2012, p. 2; Khanna & Basak, 2013, p. 3; Mtebe & Raisamo, 2014, p. 2; Okonkwo, 2012, p. 5; Rennie, Johannesdottir, & Kristinsdottir, 2011, p. 8; Rosell-Aguilar, 2013, p. 1; Tovar & Piedra, 2014, p. 2).

From the perspective of textbooks, the Florida Distance Consortium defines OER as "freely accessible digital textbooks [resources] that can be read online, self-printed or download via any computer with Internet access at no or low cost" (as cited in Prasad & Usagawa, 2014, p.12). Other authors cite definitions focused on educational resources freely available for educators and students without license fees (as cited in Khanna & Basak, 2013, p. 3).

Other definitions are focused on the intellectual property and licenses of a resource. In this

regard, Downes (2011) states that OER are "materials used to support education that may be freely accessed, reused, modified and shared by anyone" (as cited in McKerlich, Ives, & McGreal, 2013, p. 2; Okonkwo, 2012, p. 5) (Van Acker, Vermeulen, Kreijns, Lutgerink, & van Buuren, 2014) (Tovar & Piedra, 2014, p. 2). In the same vein, OER are defined as "teaching, learning, and research resources with an intellectual property license that permits them to be reused, reworked, remixed, and redistributed" (as cited in Khanna & Basak, 2013, p. 3; Okonkwo, 2012, p. 5; Wright & Reju, 2012, p. 4). According to Rennie et al. (2011), OER are "digital materials that are able to be easily accessed, shareable, and freely available for reuse within the very broad constraints of Creative Commons licensing for use in the construction of educational lessons" (Rennie et al., 2011, p. 8). Okonkwo (2012) anticipated that OER are "tools to enable viable outreach in higher education systems in general, and Open Distance Learning (ODL) in particular, incorporating innovative strategies in teaching and learning. OER are also capable of enriching learning much more than the materials that we have in the face-to-face institutions, which hitherto have been handicapped by a lack of resources" (Okonkwo, 2012, p. 4).

Tonks, Weston, Wiley, & Barbour (2013) state that OER are: "educational materials whose copyright license freely permits copying, revising, remixing, and sharing. In other words, open educational resources are educational materials whose copyright licenses are compatible with the broader goals of education" (Tonks et al., 2013, p. 7).

Open and open content definitions are also connected with the definition of OER. Open means the ability to apply the 4Rs framework: reuse, revise, remix, and redistribute (Amiel, 2013; J. Hilton III et al., 2012; Tonks et al., 2013) and to complement the above definitions of OER, some authors have been focused in other concepts such as openness, open content, or open access. Openness can be defined in terms of access (content provided free of charge), licensing (content liberally licensed for reuse), format (content designed for easy reuse), and software (content produced with open source software) (Lane, 2009).

According to Wiley (1998) (as cited in Cobo 2013, p . 2) open content refers to the use of licenses that permit the free use of information. Moreover, the Budapest Open Access Initiative (2002) (as cited in Cobo, 2013, p. 2) defines open access as the free availability of online contents that can be read, downloaded, copied, distributed, printed, searched, or linked taking into account the acknowledgement to the authors of the contribution.

Overall, these definitions highlight characteristics of OER that should be considered to create, use, reuse, remix, repurpose and share OER. Although most of the definitions reported in the literature have common elements, in the context of this research we take OER as 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 o redistribute them.

Next subsection describes the characteristics of OER identified in this literature review.

2.1.3.2 Characteristics

In the literature authors highlight characteristics of OER such as: quality, copyright-licensing, accessibility, availability, metadata, social networking, contextualization, pedagogical approaches, and interoperability, among others. Characteristics identified in the literature review were grouped by the dimensions laid out by Khanna & Basak (2013) in their OER architecture framework: academic, ethical, financial, managerial, pedagogical, and technological. Taking into account these dimensions, we grouped the characteristics of OER identified in this literature review. Figure 2-4 shows the characteristics grouped in each dimension.

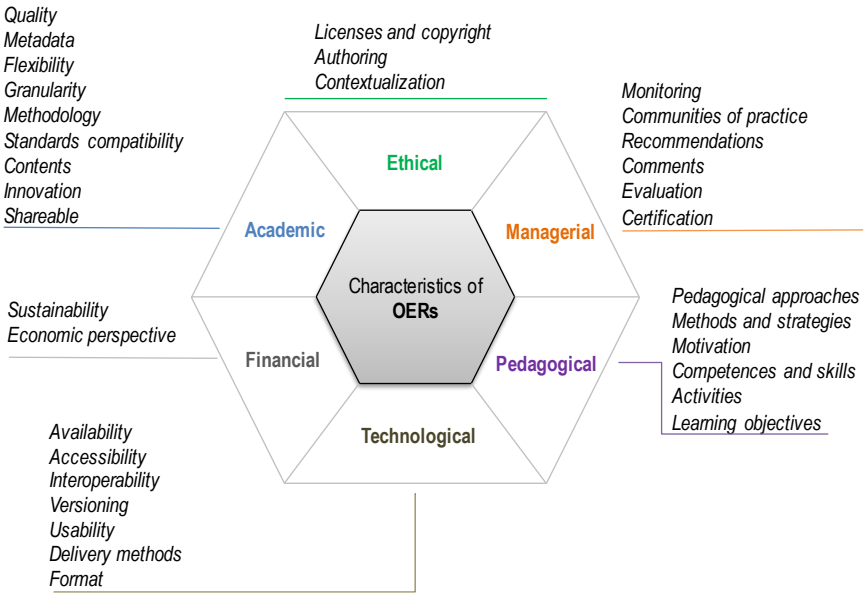


Figure 2-4. Characteristics of OER

2.1.3.2.1 Academic

This dimension refers to the "creation and use of online courses and programmes, and teaching and learning materials and techniques" (Khanna & Basak, 2013, p. 72). OER could be a difficult concept to understand (Prasad & Usagawa, 2014), especially if actors are not involved in the creation and use of OER. Thus, characteristics within this category are related to the creation and use of OER.

- *Quality*

To start with, Long & Håklev (2012) state that quality in resources is related to an educational philosophy, teaching teams, teaching materials, teaching methods and approaches, and teaching management and assessment. Some teachers are suspicious of the quality of OER because of the need to adapt them to specific contexts (Mtebe & Raisamo, 2014) and relate quality to things that improve the resources but things they are not able to do by themselves (Sinclair, Joy, Yau, & Hagan, 2013). Then, quality may be considered from the following points of view:

  - Sharing and revising: quality increases by sharing and revising OER (Llamas-Nistal & Mikic-Fonte, 2014).
  - Supporting authors: to ensure the quality of OER it is necessary to provide support to authors so that they improve them (Ros et al., 2014).
  - Evaluating quality: quality can be evaluated according to aspects such as pedagogical, technical, and usability (Sinclair et al., 2013). To achieve this, peer review has been identified as a strategy to evaluate the quality of OER (Hemingway, Angell, Hartwell, & Heller, 2011). The study by Constantinescu & Vladoiu (2013) presents a quality model that consists of four categories related to the content, the instructional design, the technology-related, and the learning assessment.

- *Metadata*

All in all, quality is associated to more productive students and educators (Thoms & Thoms, 2014). Quality is also associated with the "incorporation of metadata to allow adequate indexing and course [resources] description" (Ros et al., 2014, p. 3). Metadata is the semantic information added to an OER to simplify its discovery and re-utilization (Cueva

Carrion, Morales Rodriguez, & Pelaez Romero, 2010). Several studies have reported contributions in this regard. For instance, Kinshuk and Jesse (2013) introduce a mobile authoring tool for OER that allows learners to create real-life examples and to incorporate some characteristics of OER such as: interaction with mobile device sensors, metadata information, availability in learning platforms, and the possibility of sharing the examples with other co-learners. Kerres & Heinen (2015) propose a model in which a strong OER approach is based on the contributions of teachers who return new or modified resources or metadata to the system. Mohamed Nour, Williams, & Suleman (2012) developed a desktop application called Open Educational Resources Depositor (ORchiD) for depositing OER remotely in a repository. This tool contains a metadata entry form based on the nine categories of the Learning Object Metadata (LOM) specification.

Due to the complexity in metadata specifications, metadata can be suggested by staff (Sancho Vinuesa, Villalonga Pons, Carboneil, & Sanchez-Bonvehi, 2014). This view is supported by Kerres & Heinen (2015) who wrote that metadata can come from editorial staff, contents generated by users or the automated extraction of metadata from web contents.

Social tagging is a strategy used to enrich the description of OER. In this regard, Zervas & Sampson (2014) differentiate between two tagging approaches, on one hand the use of educational metadata based on LOM and on the other hand the use of "social tagging" concept as the process in which users add key words or known tags to any resource.

- *Flexibility*

An OER is flexible when educational resources fit in the needs and context of independent learners (Hatzipanagos, 2012). For instance, recorded lectures are flexible resources that complement in-class interactions and provide students with more control of the time and learning pace (Llamas-Nistal & Mikic-Fonte, 2014). Sapire & Reed (2011) developed a module for mathematics as an OER for teaching in diverse classrooms. The module was used in a mixed-mode with self-study spaces and short face to face sessions. As a result, teachers and students really appreciated the flexibility they had for working with different populations and managing their own time.

- *Granularity*

An OER can be a composition of different single or composed resources. This characteristic is defined as granularity. It allows a resource to contain other resources so the language of the container and the contained resource may be different (Leinonen, Purma, Põldoja, & Toikkanen, 2010). According to Kerres & Heinen (2015) the granularity is represented by the most typical types of OER as follows:

    - Textbook: it is a collection of learning units and additional materials.
    - Learning unit: it addresses topics, competences, or learning objectives.
    - Learning material: it addresses a single learning objective or activity.
    - Learning asset: it is a document that may be used for instruction.

- *Methodology*

From the perspective of the creation of OER, an appropriate approach or methodology should support the design and development of OER (Arimoto & Barbosa, 2012). According to Conole & Weller (2008) a better design and reuse of OER is possible thanks to the adoption of a learning design methodology (as cited in Kinshuk & Jesse, 2013). Methodologies are required in different stages of the OER's lifecycle. As suggested by Chikh (2014), a methodology is required for the analysis and creation of a learning scenario.

- *Standards compatibility*

Not all resources fit in all students profiles (Sinclair et al., 2013). This may be due to difficulties in applying standards. In learning design, compatibility refers to the use of standards that allow resources to be used outside their current deployment environment and by different types of users. Standards compatibility can be considered as part of: competences and educational objectives (Sicilia, 2007); compliance of accessibility standards (Ros et al., 2014); character encoding (Wagner, 2012); learning designs (Sicilia, Lytras, Sánchez-Alonso, García-Barriocanal, & Zapata-Ros, 2011); course development (Long & Håklev, 2012); learning object description (Chikh, 2014); metadata schemas (Dietze et al., 2013); packaging of resources (Kinshuk & Jesse, 2013; Sicilia et al., 2011); quality approaches ((Clements & Pawlowski, 2012); Vladoiu, Constantinescu, & Moise, 2013); reusability and interoperability features (Rodriguez M., Cueva Carrion, & Tovar Caro, 2011); specific metadata for multimedia (Little, Ferguson, & Rüger, 2012); and the OER lifecycle (Glahn, Kalz, Gruber, & Specht, 2010).

- *Contents*

To date, several studies have highlighted the use of single units of content or resources as an essential part of OER (e.g. Boyle & Ravenscroft, 2012; Raposo-Rivas, Martínez-Figueira, & Sarmiento-Campos, 2015; Kaosaiyaporn, Na-Songkhla, & Boonthong, 2015; Maina et al., 2015; Ye, Recker, Walker, Leary, & Yuan, 2015). Similarly, *topics covered*, *structure*, *keywords*, *target group* and time *schedules* (in the case of courses) are elements included as part of learning or instructional designs applied to create OER. OER with a large amount of contents or units to cover can be modularized and redistributed in small parts (Petrides, Nguyen, Kargliani, & Jimes, 2008). As the use of OER is immersed in formal and informal learning (H. Kelly, 2014), it is necessary to classify them by *type* according to the user's context or the educational setting (Long & Håklev, 2012; Read, Ros, Pastor, Hernandez, & Rodrigo, 2011).

- *Innovation*

OER as innovations need teachers to support students using them (Raman, Achuthan, Nedungadi, Diwakar, & Bose, 2014). OER as innovative resources may have positive or negative effects for learners, for that reason it is needed to analyze which are the factors that influence the use of OER (Kim, Lee, Lee, & Shon, 2015) in a particular context. Many studies have conducted surveys in order to identify general and particular factors in the use and adoption of OER (e.g. Kelly, 2014; Kim et al., 2015; Mtebe & Raisamo, 2014; Okonkwo, 2012). In this context, the use and reuse are related to the level of openness, the level of access in terms of technical requirements, and the level of relevance for users according to their needs (Abeywardena, Tham, & Raviraja, 2012).

- *Shareable*

An OER is shared when it is published in a public domain and people can use it for different purposes. In this context, web environments are a good opportunity to share knowledge (Tovar & Piedra, 2014), but it is necessary to add a copyright declaration or license that allows users to know how a specific OER was shared and how it can be used. Besides, an open license enables the sharing of OER (Cobo, 2013).

2.1.3.2.2 Ethical

This dimension includes "geographical diversity, learner diversity, legal issues (such as licensing), and information accessibility as related to the general institutional information" (Khanna & Basak, 2013, p. 72).

- *Licenses and copyright*

Licensing and copyright is a controversial topic in the OER field because not all authors publish contents with an open license hindering the reuse of those contents. David Wiley was one of the first researchers in mentioning the term "reuse" but it was oppressed due to the traditional licensing and copyrighting ways (H. Kelly, 2014). As copyright is a concern for authors, Creative Commons is an appropriate way to share OER by selecting a specific Creative Commons License (CCL).

To date, a wide range of resources have applied or have considered applying a Creative Commons License (Ives & Pringle, 2013). As an example the NZGOAL (New Zeland Goverment's Open Access and Licensing) framework pretends to standardize the use of Creative Common Licenses in New Zeland (Stacey, 2013). Those who use existing resources have to attribute to the original creators (Amiel, 2013). Moreover the attribution of a license to a specific resource emerges at the moment of creating or publishing resources (Ivanova, Grosseck, & Holotescu, 2014). According to Amiel (2013), it is better to choose a less restrictive license in order to make the resources more open.

- *Authoring*

Attributions to authors allow resources to be shared in order to modify them or create new ones. One resource can be attributed to one or more authors. This may be due to the interactions stablished between different actors during the creation process. In this regard, working alone and collaborating with others are strategies for authoring learning contents (Muñoz Arteaga, Reyes, Collazos Ordoñez, & González-Calleros, 2015).

- *Contextualization*

Contextualization can be defined as the adaption or modification of resources in order to use them in other deployment environments or with other users. Petrides et al. (2008) stated that the viability of OER is related to issues of contextualization and that is a key concern around the reuse of OER. In the literature, contextualization is commonly associated with cultural aspects such as language or multilingual settings (e.g. Anderson & McGreal, 2012; Hemingway et al., 2011; Leinonen et al., 2010; Ngimwa & Wilson, 2012; Pawlowski & Bick, 2012; Xia, 2012) and others deal with the social context (Toven-Lindsey, Rhoads, & Lozano, 2015), granularity (Q. Chen, 2010), and licensing (Rennie et al., 2011).

Boyle & Ravenscroft (2012) divide learning into three layers: psychological, cognitive and interactional. They situate the context as the main key of the interactional layer and assert that instructional designers are challenged to create contexts for effective learning.

2.1.3.2.3 Financial

This dimension involves “sustainable and cost-effective business model, educational systems, and processes for the associated OER initiatives” (Khanna & Basak, 2013, p. 72).

- *Sustainability*

It is noteworthy that *not cost* is not necessarily a synonym of free as well as *openness* is not a synonym of access (Tuomi, 2013). To ensure the sustainability of OER, it is important to know who are involved in the process of creation (Ives & Pringle, 2013). Moreover governments should decide the best use of public funds related to open initiatives and open licenses can be used to transform educational resources funded by governments into OER (Stacey, 2013).

Mulder (2013) points out that many countries are considering national approaches in order to stimulate the sustainability and use of OER. In this regard, Kelly (2014) asserts that governments are supporting the creation, development, and maintenance of OER. However, Hemingway et al. (2011) state that sustainability depends on factors such as the active use

of OER. This means that sustainability not only depends on governmental efforts but depends on the active use and creation of OER in local contexts such as universities, colleges or schools. The study by Llamas-Nistal & Mikic-Fonte (2014) describes an experience in a university in which teachers record and publish videos in a public domain for free access. This is an example on how universities are working on going with open policies for the development of OER.

- *Economic perspective*

From an economic perspective, Tuomi (2013) defines four types of OER as follows:

  - I: resources with access and accessibility.
  - II: resources that are free and open source.
  - III: resources that can be modified to add some value.
  - IV: resources that are redistributed

OER type I means that a resource can be read or watched, while OER type II means that a resource can be used in order to obtain revenue (e.g. a certificate). In the case of OER type III, users can modify and add value to the resource. Finally, OER type IV represents those resources in which users participate in the resource development.

2.1.3.2.4 Managerial

This dimension refers to "framing educational policies and decision making with regard to development and maintenance of a good learning environment, delivery of quality distance education, distribution of associated information" (Khanna & Basak, 2013, p. 72).

- *Monitoring*

Monitoring refers to the process of tracking information to make decisions. In the field of OER there are two types of monitoring: monitoring students as users of OER and monitoring the adoption and creation of OER. Regarding the former, Anderson & McGreal (2012) describe the concept of "teaching presence" by stating that web conferencing and participation of teachers in asynchronous systems and the monitoring of the student activity using learning analytics lead to a better teaching presence. Monitoring is also considered as an strategy to avoid students drop out of online courses (Hernández-Carranza, Romero-Corella, & Ramírez-Montoya, 2015). The latter is discussed in the study conducted by Hernández-Leo et al. (2014) in which almost all participants agreed that monitoring the creation of learning designs allows them to think about the development stages of the educational design. Although behavior of teachers in learning environments have been hardly systematically analyzed, Ye et al. (2015) describe a log system for capturing data related to the teacher's' online activities within an online curriculum customizable service.

- *Communities of practice*

Algers, Silva-Fletcher, Gregory, & Hunt (2013) use the Wenger's definition and describe communities of practice as "groups of people who share a concern or passion about a topic and who deepen their knowledge by interacting" (p. 672). There is a need of creating communities to carry out collaborative activities in which participants learn from others (Toven-Lindsey et al., 2015). According to Murphy & Wolfenden (2013) "learners become more central members of a community if they can deepen their participation in the practices of that community" (p. 265).

Communities of practice are suitable in different contexts and some technological tools support the management and development of these communities. For instance, in the creation of OER, Leinonen et al. (2010) present a collaborative platform in which teachers can create communities of practices to create and share resources.

- *Recommendations*

Recommendations or recommender systems are applied to improve the user experience in online learning environments. According to Vladoiu et al. (2013) recommender systems use the information to predict whether a particular user needs something. In the case of OER, Ruiz-Iniesta, Jimenez-Diaz, & Gomez-Albarran (2014) introduce a knowledge-based recommendation strategy, based on the description and contextual information of the OER in order to enhance the searching task. Other strategies take into account a classification of resources by their relevance for users (Shelton, Duffin, Wang, & Ball, 2010), actions recommended based on actions of previous learners (Daradoumis, Bassi, Xhafa, & Caballe, 2013), and recommendations from users (Cabrera, Almagro, & Ruano, 2014).

- *Comments*

Commenting on published OER is useful to improve their quality (Wright & Reju, 2012). In online environments, comments can be managed in terms of privacy or visibility. As Massive Open Online Courses (MOOCs) can contain different kind of resources, learners have the possibility to comment on others' work (Ventura, Bárcena, & Martín-Monje, 2014).

- *Evaluation*

Evaluation methods are used to assess the academic performance achieved by students in a particular course (Khanna & Basak, 2013) or activity. Methods such as surveys, questionnaires, quizzes, exams, or problem sets are an evidence of the achievement of academic tasks carried out individually or in pairs (Raposo-Rivas et al., 2015).

- *Certification*

An academic certification is the acknowledgment to the achievements of students in learning activities from contexts such as online courses that include the use of OER. Tovar, Dimovska, Piedra, & Chicaiza (2013) differentiate between two types of certification of knowledge and skills through final evaluation: one with zero cost and other in which costs depend on the policy of each institution. In some cases, to obtain a certification students have to pay a representative cost (Ros et al., 2014), whereas Rosell-Aguilar (2013) conducted a study with 1981 participants and found that 69.1% of them would be interested in taking some form of assessment for a fee. Other studies report offering courses for free (Anderson & McGreal, 2012; Hernández-Carranza et al., 2015).

The future of certifications is addressed to obtain international accreditations because the use of OER in formal studies will allow institutions to offer international degrees so that students can choose courses from various institutions (Ros et al., 2014).

2.1.3.2.5 Pedagogical

This dimension is related to "content analysis, goal analysis, design approach, organisational methods, and ODL strategies" (Khanna & Basak, 2013, p. 71). Pedagogical, administrative, social, and personal aspects, in terms of applications, are part of OER concept (Khanna & Basak, 2013).

- *Pedagogical approaches*

OER are characterized by the pedagogic value they can offer to transmit the knowledge (Atenas-Rivera, Rojas-Sateler, & Pérez-Montoro, 2012; Lane & McAndrew, 2010). Teacher-learner interactions improve when learner-centered pedagogy is applied (Wolfenden & Buckler, 2013). Contrary to what many might think, learners are primarily attracted to learn and gain skills by using OER instead of seeking formal recognition (Gillani & Eynon, 2014).

Lin, Lin, & Hung (2015) state that for achieving specific learning results designers should include teaching philosophies in virtual learning environments. In the same vein, the study

by Dimitriadis, McAndrew, Conole, & Makriyannis (2009) describes design representations and pedagogical patterns as mediating artifacts used to create and repurpose OER. Pedagogical knowledge of the domain can be applied to define learning paths (Ruiz-Iniesta et al., 2014).

Toven-Lindsey et al. (2015), advocate the critical pedagogy used to connect resources, contents or curriculum to personal and social experiences in real world contexts. Other authors mention specific pedagogical theories such as:

- *Instructional theories* offer guidance for the development of learning resources (Sicilia et al., 2011). Design theories provide general guidelines that must be considered in the creation of new learning activities or resources (Sicilia et al., 2011). A pedagogical framework involves training about the proposed strategy for learning design (Fragou & Kameas, 2013). Constantinescu & Vladoiu (2013) describe a set of criteria for quality assurance of Open Course Ware and OER. Those criteria include a category related to instructional design considering elements such as: learning objectives, learning outcomes, instructional activities, evaluation, learning theory, instructional design model, and reflective learning opportunities. According to Rule (2006) "authentic learning is an instructional theory focused on learning in context, or real life application of knowledge" (as cited in Kinshuk & Jesse, 2013, p. 32). Authentic learning seeks to engage learners by creating meaningful learning contexts (Boyle & Ravenscroft, 2012; Murphy & Wolfenden, 2013).
- MOOCs are based on the connectivist theory (Raposo-Rivas et al., 2015; Tovar et al., 2013). This theory was introduced by George Siemens in 2005 and emphasizes in the role of cultural and social contexts (Frydenberg & Andone, 2014).
- Constructivism is another pedagogical orientation considered in the production of quality materials (Sapire & Reed, 2011). This approach encourage the engagement of students in learning processes (Toven-Lindsey et al., 2015).
- Carneiro (2010) introduced the generativism in which learning is represented as an integral part of meaning making (as cited in Steffens, 2015). The generative learning expands capabilities, enhances creativity, addresses underlying causes, anticipates future, and rewards knowledge re-construction.

- *Methods and strategies*

Collaboration influences the pedagogy in OER. According to Toetenel (2014) when OER include collaborative elements the pedagogy shifts from products used by students to processes in which students drive their own learning path. This is possible when contents are structured with a self-learning method (Tovar et al., 2013). Likewise, when OER are presented as courses, those should encourage collaborative activities (Abeer & Miri, 2014). In this context, Maina et al. (2015) present a methodology for the participatory design process of a training course about principles and strategies for the open educational practices. The pedagogical approach of that methodology combines individual and collaborative work to enhance the interaction of teachers when they learn about open educational practices.

Another strategy used to integrate open materials or contents is the Problem-Based Learning (PBL) (Gurell, Kuo, & Walker, 2010; Davinia Hernández-Leo et al., 2014). In PBL learners have to identify their learning needs and collect resources related to the assigned problem (Gurell et al., 2010). Besides that, Connolly (2013) proposes the visualization mapping as a method for the definition of institutional plans related to OER, for designing

and producing OER, and for the design of a navigation interface.

- *Motivation*

Ensuring persistence among participants in an online course is not an easy task, but information comprehensible to everybody motivates students to achieve their learning goals in a *self-regulated* way (Hernández-Carranza et al., 2015; Ros et al., 2014). OER are means of communication that engage the participation of students in a learning process (Ponti, 2014). Student's motivation is enhanced by interactive learning (Ives & Pringle, 2013), thus educational resources should include a level of interactivity.

Motivation in the active learning approach is the result of the participation of students in problem solving and in the development of learning resources (Algers, Lindström, & Pajor, 2010).

- *Competences and skills*

In 2006 the European council established eight key competences for lifelong learning that individuals need for personal fulfillment and development, active citizenship, social inclusion and employment (as cited in Steffens, 2015, p. 44). Those competences are:

  - Communication in the mother tongue.
  - Communication in foreign languages.
  - Mathematical competence and basic competences in science and technology.
  - Digital competence.
  - Learning to learn.
  - Social and civic competences.
  - Sense of initiative and entrepreneurship.
  - Cultural awareness and expression.

In OER, competences are focused on both students and teachers. Teachers should become learning facilitators so that students develop their competences, knowledge, and skills (Santos-Hermosa, 2012). According to Pedraza, Farías, Lavín, & Torres (2013), basic knowledge about Information and Communication Technologies (ICTs), deepening knowledge, and generating knowledge are basic skills for teachers.

- *Activities*

Activities are considered an essential part of OER and can be defined as actions carried out by actors participating or interacting in learning processes. In learning design, activities can be described through metadata specifications (Sicilia et al., 2011).

Regarding the type of activities, Ventura et al. (2014) stated that activities, in the form of writing and oral tasks, are the key element in course design and they foster collaborative learning. In the same vein, Abeer & Miri (2014) pointed out that MOOCs allow participants to collaborate in many activities such as sharing knowledge, providing peer-assessment, and working on final projects. Ravenscroft et al. (2010) propose the approach of digital dialogue games in which an activity, a curriculum requirement and web-based content are linked to generate a discussion space (as cited in Boyle & Ravenscroft, 2012, p. 1228).

- *Learning objectives*

Learning objectives are a key element to define if an OER is appropriate for reuse (DeVries, 2013). According to Sicilia et al. (2011), learning objectives are part of metadata sets. However, Sinclair et al. (2013) argue that sometimes it is hard to identify learning objectives within a learning resource. In learning design, learning objectives should be defined in a clear way and match with the content, activities and assessment (Lane & McAndrew, 2010). In terms of student satisfaction related to the definition of learning objectives, Morris et al. (2005) state that students feel more satisfied and successful when teachers provide clear

objectives and requirements for the course (as cited in Toven-Lindsey et al., 2015, p. 3).

Previous studies have identified different strategies to define learning objectives. For instance, Lin et al., (2015) highlight the use of pre-lecture surveys as a way to anticipated learning objectives. Zervas & Sampson (2013) analyzed the reuse of mobile assisted language learning applications evaluating the correlation between the reuse of those applications and the educational objectives (defined according to the Common European Framework of Reference levels). They found a positive correlation between the number of times of reuse and the number of educational objectives. This is an insight into the usefulness of common frameworks to define learning objectives as a strategy to foster reusability in educational resources.

2.1.3.2.6 Technological

This dimension includes "infrastructure planning, designing hardware and software, and technical design for learning programs, such as page and site design, content design, animation, multimedia, navigation, and usability testing" (Khanna & Basak, 2013, p. 71).

- *Availability*

Finding OER in a public domain is a strategy that helps teachers to improve the quality of existing resources or to create new ones. According to UNESCO's recommendations, OER should be available to anyone (Ives & Pringle, 2013) as well as their copyright information (Khanna & Basak, 2013). Despite the wide availability of OER, some authors report a lack of awareness on the use of OER (Maina et al., 2015). In one study by Prasad & Usagawa (2014), participants pointed out that educational materials available online can be used by the general public for teaching and learning purposes as well as for researching.

- *Accessibility*

According to Amiel (2013), accessibility is a common topic in OER' guides but in the literature the term "accessibility" is frequently used to talk about the access to OER instead of the accessibility as such. Sicilia (2007) points out that one starting point for creating resources is that the designs should address particular learning needs. Thus, the study by Fenton (2014) is focused in the creation of high accessible resources that applied the W3C accessibility guidelines and worked across browsers and mobile devices. Presenting resources (e.g. videos) in multiple formats can improve the accessibility for learners with different needs (Young & Hung, 2014). Ros et al. (2014) describe a platform of Open Course Ware (OCW) in which the attainment to quality requirements includes the compliance of accessibility standards. Moreover, Kourbetis & Konstantinos (2014) describe the design of accessible educational and instructional material for students with disabilities. The materials were videos and its accessibility was addressed by including subtitles, interactive transcripts, easy to read texts, sign language, symbols, pictograms and audio descriptions.

- *Interoperability*

Transferring contents among different platforms is considered an alternative way of reuse (Lane & McAndrew, 2010). For instance, the Distributed Learning Environments (DLE) integrate diverse platforms and external tools (Prieto et al., 2014) in which OER can be included or shared. Wright & Reju (2012) stated that interoperability should be considered to interconnect data, software and services. Interoperability in data is referred to the interpretation, sharing and processing of information through different systems (Sicilia et al., 2011). Information can be managed with metadata sets to enable that interoperability (Lane & McAndrew, 2010; Sinclair et al., 2013).

Platforms and tools should ensure interoperability so it is applied to enable the exchange and reuse of learning designs across different platforms (Kinshuk & Jesse, 2013). Besides that, digital resources can be packaged attending to technological specifications (Sicilia et

al., 2011) or saved in a specific format (e.g. PDF) (Davinia Hernández-Leo et al., 2014) to ensure their portability. In the study by K. I. Clements & Pawlowski (2012), teachers trust resources because of their interoperability between repositories and LMS.

- *Versioning*

Versioning systems are used to do a revision of all modifications made in a specific resource. Those systems bring advantages such as to know who modify a resource or to retrieve past versions of a resource. For instance, Leinonen et al. (2010) describe an open learning object repository and collaborative authoring platform in which versions are managed as both private drafts and published resources. Moreover, a template for versioning OER, considering contextual information, facilitates their adaptation in local contexts (Murphy & Wolfenden, 2013). Arimoto & Barbosa (2013) propose a model for developing OER with different practices such as the collective ownership. In their model any member can modify resources; thereby they suggest managing and maintaining a repository of versions. This kind of versioning systems promote the co-editing of resources. Such is the case of the study by Davinia Hernández-Leo et al. (2014), in which participants highlighted the resource revision history as a strategy to see the contributions made different editors.

- *Usability*

Usability in user interfaces facilitates the adoption of OER (H. Kelly, 2014). In their review of learning objects, Sinclair et al. (2013) identified different models to assess quality in learning objects, two of them include the category of *usability* with criteria such as easy of navigation, predictability of the user interface, clear instructions and the quality of user interface help features. In the same vein, Van Rosmalen, Boon, Bitter-Rijpkema, Sie, & Sloep (2014) carried out an evaluation by applying 19 heuristics based on: general usability heuristics; heuristics for creativity support tools; design heuristics for computer supported collaborative creativity; and interference protection. In that evaluation, authors identified issues regarding the interface design, terminology used, and common interface elements.

- *Delivery methods*

Delivery methods vary according to the characteristics of the learning context which can be influenced by economic, social or technological factors. Publishing contents in open access makes the information more visible and accessible to learners (Anderson, 2013). Thus, most open universities have been facing a transformation from a distance learning education using print-based materials to online environments (e.g. Ives & Pringle, 2013; Ros et al., 2014). Despite the emerging of economic crisis in some countries, introducing institutions with online delivery methods is a strategy to face those economic issues (Rennie et al., 2011).

Using multimedia resources and web 2.0 tools foster interaction among students and teachers and increase their social presence. In this regard, Millard, Borthwick, Howard, McSweeney, & Hargood (2013) highlight the use of a delivery service including web presence through the use of user profiles, metadata, comments, and reuse tools. Xia (2012) asserts that the delivering of resources in entertainment websites will engage the young generation to learn in open courses. It involves the use of interactive resources (e.g. videos) that are usually delivered through online or mobile tools. Another example is embedding contents within an eBook which is a good strategy for delivering contents by taking advantage of mobile devices (Rodriguez-Triana et al., 2014). According to Wagner (2012), mobile devices are an alternative to support the delivery of open educational resources.

- *Format*

One of the guidelines for OER in higher education, provided by UNESO-COL is to "consider adopting open format standards" (as cited in Stacey, 2013). The concept of open formats refers to present or deliver contents that can be accessed without restrictions or without

using additional tools to open them. OER can be accessible in different file types (Abeywardena et al., 2013) or formats depending on the kind of resource (document, webpage, media, etc.).

All characteristics discussed in this subsection give an idea of the power that OER have for educational settings. Teachers also need to be aware of the benefits brought with the use of OER which are discussed in the following subsection.

2.1.3.3Benefits

The evolution of learning and teaching processes has been influenced by social, technological, and economical factors. Thus, new approaches and strategies are applied in educational settings to improve characteristics such as the accessibility, quality, and usability of learning contents. Publishing in public domains, sharing educational resources, and authoring resources are some of the strategies applied to adopt and use OER. Since OER emerged as a concept, educational institutions and governmental organizations have made good use of the opportunities offered by this innovative concept. For instance, universities such as the Open University in UK has benefited in terms of (Lane, 2009, p. 955):

- Enhancing the reputation of the Open University.
- Extending the reach to new users and communities.
- Recruitment of students from those who come to see OpenLearn.
- Supporting widening participation.
- Providing an experimental base of material for use within the university.
- Accelerating uptake and use of new technologies.
- Acting as a catalyst for less formal collaborations and partnerships.

The enhancing of reputation at institutional and personal levels has been widely mentioned in different studies (Algers et al., 2010; Cobo, 2013; Hawkridge et al., 2010; Khanna & Basak, 2013; Lane & McAndrew, 2010; Mtebe & Raisamo, 2014; Prieto et al., 2014; Stacey, 2013; Van Rosmalen et al., 2014; Xia, 2012). Moreover, Hylén (2008) highlights other benefits in the adoption of OER such as the wide spread of knowledge, the fostering of research, the technical development, and the decentralization of knowledge (as cited in Atenas-Rivera et al., 2012; Lane & McAndrew, 2010).

OER also contribute to the development of lifelong learning opportunities (Kim et al., 2015) because the use of OER in teacher training programs makes future teachers to understand that OER can be ease to use (H. Kelly, 2014).

On the other hand, the collaboration among actors participating in the creation of OER makes OER more high quality because of the feedback and improvements provided by those actors. Similarly, Arendt & Shelton (2009) identified that the use of OER moves authors to gain community support, personal monetary, commerce, and convenience in the open publication of resources. Besides that, collaboration and further developments are fostered when OER are shared with open licenses (Khanna & Basak, 2013).

Reducing cost is another benefit of OER that increases the opportunities to access to the education system (Khanna & Basak, 2013) with the use of low cost or free of charge educational resources. In this regard, Mtebe & Raisamo (2014) assert that OER are described as one of the solutions to support institutions in the acquisition of free of charge and quality learning resources.

As discussed before, OER bring many benefits at personal and at institutional level. However, there are still some open issues to address when working with OER. Some of such challenges and issues in the adoption, use, licensing, quality, context, metadata, searching, creation of OER and in teaching practices are discussed below.

2.1.3.4 Challenges and issues

Almost all studies reviewed report challenges and issues regarding the creation, use or sustainability in the adoption of OER, likewise insecurities about legal aspects, quality, and the not-invented-here syndrome (Pawlowski & Bick, 2012) are some factors surrounding OER. In the review presented by Arimoto & Barbosa (2012) some limitations in the adoption of OER were identified: little use of web 2.0 tools and semantic web; lack of authoring rights and intellectual properties; and little use of tools to support the automation of tasks. Challenges and issues were classified into nine categories, namely: adoption of OER, use of OER, copyright and licensing, quality of OER, context, metadata, searching of OER, creation of OER, and teaching practices.

2.1.3.4.1 Adoption of OER

To date, a number of studies have investigated the effects of including Information and Communication Technologies (ICT) as part of teaching and learning processes. The acceptance of a new technology is measured through existing or adapted instruments such as the Technology Acceptance Model (TAM) (Kelly, 2014; Kim, Lee, Lee, & Shon, 2015). TAM is the most common model used to explore adoption in a variety of contexts (H. Kelly, 2014). In some cases people are reluctant to embrace the use of new technologies such as OER (Ives & Pringle, 2013). According to Cobo (Cobo, 2013), in developing countries, learners and educators do not have the skills needed to use, develop, or repurpose OER. Moreover, when people feel unfamiliar with a specific subject it might hinder their desire to share knowledge (Van Acker et al., 2014). Some studies report issues regarding limited access to a stable and reliable Internet connexion as well as limited access to computers especially in rural settings (Ngimwa & Wilson, 2012).

One socio-cultural issue, which is related to the adoption of OER, is the OER concept awareness (Ngimwa & Wilson, 2012; Ezz, Loureiro-Koechlin, & Stergioulas, 2012). As happen with other ICT implementations, sometimes people who create or use OER are not aware or have not heard about this term. Hatzipanagos (2012) carried out a study about the perspectives on OER, and 80% of the participants did not have prior knowledge about OER. Thereby, actors in the open movement need to empower educational resources, guidelines for designing resources, and information about the gains of this type of resources, among others (Constantinescu & Vladoiu, 2013).

2.1.3.4.2 Use of OER

Usage and sustainability should be considered in solutions to support learning design from the perspective of teacher or other actors in the role of designer (Prieto et al., 2014). Teacher's self-efficacy needs to be sufficiently high to use digital resources (Kreijns, Van Acker, Vermeulen, & van Buuren, 2013). The level of granularity in a resource may represent a barrier in terms of reuse (Sinclair et al., 2013) because it seems to more granularities, less reuse effect. Sustainability depends on multiple factors among which are the costs and revenue regarding the production and distribution of open resources. J. L. Hilton III & Wiley (2011) analyzed the sustainability of the open model used by the Flat World Knowledge Company which takes into account the factors mentioned above, but in spite of this kind of initiatives they stated that it will always be so hard to compete with the upcoming prices of textbooks.

Use of OER sometimes depends on the user's perspective (Sinclair et al., 2013) because not all users expected the same from an OER. For instance, Ros et al. (2014) argue that students demand more open content and social networking interactions.

2.1.3.4.3 Copyright and licensing

Complexity in licensing makes more difficult the remixing of OER (Amiel, 2013) and the

desirability to publish resources is blurred because faculty do not know how to protect them legally (Kursun, Cagiltay, & Can, 2014). It is well-known that ownership of OER is a concern at institutional level and copyright policies influence the decision to publish or use OER (Hemingway et al., 2011). Although the use of Creative Commons licenses have alleviated the sharing of resources, there are still some difficulties regarding intellectual property because some institutions own the resources with limitations in their use (Ives & Pringle, 2013). Moreover, institutional policies include constraints about when and how staff should publish and share resources in a public domain.

It is a pending task for institutions to be aware of copyrighting issues that currently hinder the appropriate use of resources (Mtebe & Raisamo, 2014). Besides, limitations in licensing are different in each country (Amiel, 2013) because of the legal statements related to copyright licensing. Institutions should reconsider policies and roles (Tuomi, 2013) so that open movement takes effect in the whole educational process.

Copyright and licensing also affect the creation of OER. Although it takes considerable time to produce or create digital resources from scratch (Tovar & Piedra, 2014), some creators of OER prefer create resources from scratch more than remixing them due to the decisions they have to make related to attributions (Amiel, 2013).

As the establishment of copyright licenses may be a little complex (DeVries, 2013), it would be useful that creators of OER can define what kind of content they are including in their OER. New iterations of OER should ensure that licensing includes a "share-alike" from the original resource (DeVries, 2013). Thus, the question of how can a new OER maintain the licensing terms from the original?

On the other hand, there are experiences in which teachers report to know about Creative Commons Licences (CCL) but they do not to use them (Banzato, 2012). For instance in Romania different projects related to the open educational practice have been carried out with the philosophy of OER, but the resources that are protected under the copyright law are still an issue (Pavel, Manolea, Bucur, Voicu, & Constantinescu, 2014). When authors use CCL they can update and change the type of license at any time, which causes that those authors who include resources under CCL to be in trouble (Ivanova et al., 2014). Another issue connected to CCL is the inappropriate use of resources copyrighted with CCL, because original authors may not agree with their use (Ivanova et al., 2014).

Hawkridge et al. (2010) describe another perspective about the relationships between curriculum, OER and Intellectual Property Rights (IPR) by stating that: “academics, in protecting their IPR, may restrict the curriculum; they may also limit those OER that may become part of the curriculum in their university and beyond. Individual authors may have the power to include their books and articles in the curriculum or to exclude them”.

2.1.3.4.4 Quality of OER

As quality is one of the most relevant characteristics of OER, to obtain resources from known repositories and designing resources with a particular methodology or standards, are considered as quality factors (Sinclair et al., 2013). It is a challenge to improve quality on existing resources (Ives & Pringle, 2013). Notwithstanding, some authors of OER are reluctant to use resources created by others (Ngimwa & Wilson, 2012) because of their unawareness about quality.

With the big amount of resources available in web environments the need of quality controls increases (Clements & Pawlowski, 2012). In this sense, Sinclair et al. (2013) suggest providing evaluations from experts and users, but there is no a model which allows projects or institutions to hire experts for revising the quality of OER (Clements, Pawlowski, & Manouselis, 2015). Experts’ participation may provide valuable insights to make decisions and solve problems (Ponti, 2014). For this, it is necessary to specify a way so that resources

could be assessed in terms of their learning outcomes (Sinclair et al., 2013), as well as, to update and improve quality, creators may require support through the publishing platforms (e.g. repositories) (Hemingway et al., 2011) or the authoring tools.

2.1.3.4.5 Context

Context can be managed by using descriptions with examples on how to use the resource (Leinonen et al., 2010), but if OER include detailed context features, it could be difficult to reuse them in other contexts Wiley (2001) (as cited in Sinclair et al., 2013). Sinclair et al. (2013) state that "the more contextualized and targeted the resource, the more useful for teachers in a similar context but the more difficult to repurpose for others" (p. 8).

On the other hand, there are some few explored areas regarding the use of OER, such is the case of second language learning and teaching Thoms & Thoms (2014). In the same vein, Cobo (2013) identifies sociocultural barriers, especially in the context of languages from non-English speaking countries. Besides, a considerable amount of resources or non-OER digital materials are invisible in the sense they are not available in a public domain and most of the contents in academic platforms tend to be created in English, while there is a growing of other non-English contents in non-academic platforms (Cobo, 2013). Similarly, Amiel (2013) found that English language is an often-ignored barrier to the remix and revision, and why not to say the creation of OER. Sometimes educational context is not evident and not all resources can be edited (Sinclair et al., 2013).

The findings of the research conducted by Xia (2012) confirms the fact that, for some learners, to read contents written in their mother tongue is less frustrating that found contents written in other languages. It is noticed when learners only view and comment in those contents rather than interact with them (Xia, 2012). Access to materials in other languages has been a disadvantage especially for Spanish-speaking countries such as the case of Latin America countries (Muñoz Arteaga et al., 2015).

2.1.3.4.6 Metadata

Collecting metadata automatically facilitates the task of teacher when they are fulfilling metadata forms or when they want to search for a specific resource (Leinonen et al., 2010). Leinonen et al. (2010) suggest using less technical vocabulary for metadata items so that teachers find it profitable. Moreover, metadata applied to OER have issues regarding the copyright options or quality factors because it is focused on content more than use (Dichev & Dicheva, 2012).

2.1.3.4.7 Searching OER

Some resources are difficult to find and this is due to the lack of mechanisms to find appropriate resources, the fact that universities do not provide public access to resources produced inside (Sinclair et al., 2013) and the amount of resources that have been produced so far (Dicheva & Dichev, 2014). Although some years ago there was no a central index of repositories (Sinclair et al., 2013), so far some initiatives have been adopted to allow linking with most of the existing repositories.

To find the appropriate resources is one of the most difficult tasks when people is introducing with open content (Tonks et al., 2013). Sinclair et al. (2013) differentiate between skills for instructors such as to locate and contribute with learning materials and skills for students such as to locate learning resources to complement those provided by instructors. To support this idea, Thoms & Thoms (2014) point out that finding an appropriate resource takes a lot of time. While the amount of resources grows, it becomes more difficult to find the needed contents (Dichev & Dicheva, 2012).

2.1.3.4.8 Creation of OER

Nowadays, teachers are involved in the age of digital resources and have the challenge of transforming learning ideas into digital resources based on learning design theories. It means to represent resources and activity designs in a digital format following learning design specifications (Sicilia et al., 2011). In this context, the lack of expertise and experience hinders the task of actors immersed in the creation of OER (Mtebe & Raisamo, 2014). A major concern for teachers in the creation of new learning designs is the lack of understanding on how to use resources (Fragou & Kameas, 2013). Arimoto & Barbosa (2012) identified a lack of systematic methods for the appropriate creation and adoption of OER. Other authors stated that lack of time influences the willingness to create OER (Thoms & Thoms, 2014;Sancho Vinuesa, Villalonga Pons, Carboneil, & Sanchez-Bonvehi, 2014; Ngimwa & Wilson, 2012).

On the other hand, time limitations, inadequate training about OER, insufficient multimedia skills to use OER, uncertainties about copyright, and difficulties to select appropriate and high quality OER, are other issues that teachers deal with (Prasad & Usagawa, 2014). In addition to this, complex creation processes imply an investment of time and effort by teachers (Dimitriadis et al., 2009). Hence, motivational strategies should be applied to engage teachers and other stakeholders to participate in this process. The challenge here is to provide scaffolds, support and examples on how teachers can use technologies in different educational settings (Conole & Culver, 2010) as well as to provide flexible, extendable and easily adaptable open tools to support the access, creation, use and reuse of OER (Sellami, 2013). Elements considered as challenges and issues in the creation process are described as follows:

- *Access*: issues related with access to contents can be covered by strategies such as applying responsive design in the creation of contents or platforms to create those contents (e.g. Young & Hung, 2014). Moreover, learners can reach OER through their mobile devices beyond the classroom, but there are some drawbacks in using this kind of devices, for instance the screen size and the computational power (Young & Hung, 2014).
- *Accessibility*: behaviors in traditional learning environments might not be the same on online learning environments and therefore it is important to take into account the learner characteristics and requirements (Kim et al., 2015). Such is the case of user models which are instruments that allow gathering all information regarding general and specific data from users. Another approach that teachers or creators of OER should take into account to meet accessibility requirements is the inclusive design. According to Treviranus & Coombs (2000), the attention to inclusive design involves the use of elements such as a simple navigation or the captioning of multimedia contents (as cited in Ives & Pringle, 2013).
- *Authoring*: Students can become co-authors (Robinson et al., 2014) when they participate in conjunction with teachers to improve educational resources. One of the main challenges of methodologies, strategies, authoring tools, among others, is the support for instructors (Chikh, 2014) or teachers as authors of their own resources.
- *Costs*: creating resources free of charge does not mean that the process of creating is free of charge too. For this reason the creation of OER should be part of institutional processes (Tovar & Piedra, 2014) and some institutions rely on raising contributions from different sources including those assigned specifically for the development of national plans (Long & Håklev, 2012). Costs of print contents are becoming in costs to maintain digital device (Robinson et al., 2014) so that digital contents and resources can be available to all.
- *Skills*: to create a unit of content or an educational resource leads teacher to invest time, put interest and demonstrate or acquire certain skills. For instance, UNESCO promotes the development of communication skills (Richter & McPherson, 2012). There is a need

to improve and foster the ICT skills of people who create OER (Algers et al., 2013). Moreover, ICT skills include: planning and design, communication and interaction, instruction and learning, management and administration, and ICT usage (Hernández-Carranza et al., 2015). Regarding to this, some studies reflect that teachers or instructors do not have enough time, interest or the skills needed to create new contents (Amiel, 2013). Teachers also deal with the complexity of technological tools because sometimes they have to know specific procedures to manage such tools (Limongelli, Sciarrone, & Temperini, 2015).

- *Reuse*: OER are not created with the reuse in mind (DeVries, 2013). To counter this issue, creators need to be aware that new educational resources could be used in other contexts.
- *Collaboration*: according to Mtebe & Raisamo (2014), working in communities facilitates the acquisition of skills in the creation of OER. OER should promote collaborative conversation to cope the need to build new knowledge (Toetenel, 2014). To ensure quality of OER, teachers should create OER in a collaborative way, where students also participate (Tovar & Piedra, 2014). The contribution of stakeholders, in collaborating or repurposing, should be acknowledged and recognized (Hemingway et al., 2011).
- *Training*: the literature has emphasized the importance of training teachers in ICT to transform them into bespoke content developers as well as the need for teachers to be engaged in training processes which allow them to acquire knowledge about the use of open education strategies and OER for teaching and learning (Okonkwo, 2012). Moreover, the use of OER has not been integrated as part of the curriculum in teacher's training (H. Kelly, 2014) and the creation or development of OER required to integrate OER into the curriculum (Thoms & Thoms, 2014). According to this, the main recommendation is to train teachers in specific competences to reuse OER and get them feel aware of strategies for quality assurance (Clements & Pawlowski, 2012). Besides that, Limongelli et al. (2015) state that few studies deal with the support for teachers in the creation of contents and therefore training should include real cases to encourage teachers to practice in real environments (Algers et al., 2013).
- *Monitoring*: experiences in the use of OER represent new opportunities for the development of solutions based on learning analytics (Giovanni Fulantelli & Taibi, 2014).

2.1.3.4.9 Teaching practices

New advantages in technology means teachers are challenged to change their teaching practices including other strategies to delivery learning contents. One of the technological breakthroughs was the introduction of the concept of OER because the publication of this kind of resources brings new ways of accessing to learning content. Moreover, new approaches could be useful to support teachers in their multi-task labor when they create courses (Limongelli et al., 2015) or educational resources. Despite the multiple boundaries of OER (sharing, reuse, collaboration, etc.), some challenges in teaching practices still remain. For instance:

- It is necessary to analyze how OER can be incorporated in learning and teaching practices because the mere use of OER does not ensure constructive and collaborative learning beyond bringing access to learners (Ponti, 2014).
- Prieto et al. (2014) highlight the role of teachers and poses four important challenges to the orchestration of Computer Supported Collaborative Learning (CSCL): deployment of learning activities, run-time flexibility, time-effective and usage by teacher in authentic practice.
- The use of flexible methodologies to ensure the creation of quality OER (Arimoto & Barbosa, 2013).

- Not all resources are appropriate for all learners (Ros et al., 2014) for this reason there is the need of making easy for users to find resources that fit their learning needs or styles.
- Initiatives aimed to change teaching practices and methods, should involve a training process (as cited in Algers et al., 2013).
- According to Bruni (2014), teaching practices should be combined with the production of OER.
- The emergence of OER and social media alleviate the transition among learning scenarios (Peña López, 2013).
- Teachers should "explore how OER facilitate new ways of learning such as self-directed learning, cooperative learning, and inquiry learning etc." (Q. Chen, 2010, p.p. 348).

To overcome such challenges and issues, different initiatives have been carried out which seek to promote OER in the international community. Next subsection presents a compilation of the most important initiatives around the globe.

2.1.3.5Initiatives

Different initiatives of OER have been created around the globe. Initiatives go from projects for developing specific supporting tools for creating or adapting OER to the foundation of national projects that promote the adoption and use of OER in the Open Distance Learning (ODL). Each country defines its own open policies and makes decisions regarding the funds for open initiatives. For instance, Kursun et al. (2014) state that OER initiatives in Turkey are organized in three levels: nationwide, institution-based, and personal. Romania forwards projects in the open movement by training teachers in courses related to OER (Pavel et al., 2014).

In a concern to address the challenges surrounding OER lots of initiatives have been identified in this literature review. Other initiatives exist beyond this review but those reported here are considered important promoters of OER in the open movement. Initiatives are presented according to their focus as follows:

- Documents and declarations (Table 2-2): general statements defined by international organisms.
- Legal (Table 2-3): initiatives related with legal issues especially with copyright and licensing.
- Institutions and projects (Table 2-4): organisms or universities that have adopted OER as their mainstream in learning and teaching processes.

Table 2-2. Documents and declarations

International documents and declarations of OER		
Name	**Year**	**Description**
1st Global OER Forum in 2002	2002	UNESCO. In conjunction with the William and Flora Hewlett Foundation, a group of experts met in 2002 to discuss about the participation of countries as producers and consumers of open courseware resources. This forum adopted the term OER. The report of this forum was entitled "Forum on the Impact of Open Courseware for Higher Education in Developing Countries". Website: http://portal.unesco.org/ci/en/ev.php-URL_ID=2492&URL_DO=DO_TOPIC&URL_SECTION=201.html
Education Program – strategic plan	2002	This document describes the strategic program of The William and Flora Hewlett Foundation for supporting OER in education programs. Website: http://www.hewlett.org/uploads/documents/Education_Strategic_Plan_2010.pdf

International documents and declarations of OER		
Name	**Year**	**Description**
The Cape Town Open Education Declaration	2007	This declaration pursuits three strategies to: Encourage educators and learners to actively participate in the emerging open education movement. Call on educators, authors, publishers and institutions to release their resources openly. Call governments, school boards, colleges and universities to make open education a high priority. It can be signed in an online mode by anyone. Website: http://www.capetowndeclaration.org/read-the-declaration
Giving Knowledge for Free, the emergence of open educational resources.	2007	OECD - Organisation for Economic Co-operation and Development. This document addresses the following questions: How can sustainable cost/benefit models for OER initiatives be developed? What are the intellectual property rights issues linked to OER initiatives? What are the incentives and barriers for universities and faculty staff to deliver their materials to OER initiatives? How can access and usefulness for the users of OER initiatives be improved? Website: www.oecd.org/edu/ceri/38654317.pdf
Guidelines for Open Educational Resources (OER) in Higher Education.	2011	Commonwealth of Learning. This document outlines key issues and make suggestions for integrating OER into higher education. Website: http://oldwebsite.col.org/resources/publications/Pages/detail.aspx?PID=364
Paris OER Declaration	2012	UNESCO. This declaration provides a set of international statements promoted by OER. Foster awareness and use of OER. Facilitate enabling environments for use of Information and Communications Technologies (ICT). Reinforce the development of strategies and policies on OER. Promote the understanding and use of open licensing frameworks. Support capacity building for the sustainable development of quality learning materials. Foster strategic alliances for OER. Encourage the development and adaptation of OER in a variety of languages and cultural contexts. Encourage research on OER. Facilitate finding, retrieving and sharing of OER. Encourage the open licensing of educational materials produced with public funds. Website: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CI/WPFD2009/English_Declaration.html

Table 2-3. Legal initiatives

Legal initiatives about OER		
Name	**Year**	**Description**
Creative Commons (CC)	2001	• CC is a not-for-profit organisation that expands the range of creative works available for others to build upon legally and to share. This organisation defined a set of six licenses to share contents in public domains, namely: Attribution, Attribution-ShareAlike, Attribution-NoDerivs, Attribution-NonCommercial, Attribution-NonCommercial-ShareAlike, and Attribution-NonCommercial-NoDerivs. Website: http://creativecommons.org/

Legal initiatives about OER		
Name	**Year**	**Description**
NZGOAL	2010	• New Zealand Government Open Access and Licensing framework. This framework proposes the use of three components: The six Creative Commons licenses. A no known rights statement. Creative Commons Plus (CC+) protocol. Website: https://www.ict.govt.nz/guidance-and-resources/open-government/new-zealand-government-open-access-and-licensing-nzgoal-framework/

Table 2-4. Institutions and projects

Institutions and projects related to OER		
Name	**Year**	**Description**
OER Africa	1992	This is the main institution in Africa that supports the development and use of OER. This institution was established by the South African Institute for Distance Education (SAIDE). Their contributions in OER revolve around: increase availability; reduce costs; encourage the participation of learners and educators; foster collaborative partnerships and communities of practices. ***Website***: http://www.oerafrica.org/
JISC	1993	Joint Information Systems Committee. It is a UK not-for-profit organisation in the sectors of further education and skills and brings support for digital services and solutions. They managed the project "Open education" with the aim of enabling free and open access to learning and teaching resources licensed in ways that permit reuse and repurposing in the UK and worldwide. ***Website***: https://www.jisc.ac.uk/rd/projects/open-education
MIT Open Courseware	2001	"The idea is simple: to publish all of our course materials online and make them widely available to everyone." Dick K.P. Yue, Professor, MIT School of Engineering. ***Website***: http://ocw.mit.edu/about/our-history/
BOAI	2003	The Budapest Open Access Iniative. An initiative to stablish policies and recommendations for a peer-review strategy for open access contents. This initiative is related to the Open Access movement ***Website***: http://www.budapestopenaccessinitiative.org/
TESSA	2005	Teacher Education in Sub-Saharan Africa "is a network of teachers and teacher educators working alongside The Open University, UK, to improve the quality of classroom practice and access to teacher education resources across sub-Saharan Africa". ***Website***: http://www.tessafrica.net/
VCILT	2006	VCILT is the Virtual Centre for Innovative Learning Technologies. ***Website***: http://vcampus.uom.ac.mu/vcilt/home.php
OLCOS	2006	The Open eLearning Content Observatory Services (OLCOS) aims to build an online information and observation center for promoting the adoption of educational resources. ***Website***: http://www.olcos.org/
Japan OCW Consortium	2006	This is a consortium of Japanese universities that offer online courses. The JOCW member universities are involved in open content production and users of OER. ***Website***: http://www.jocw.jp/Members.htm
ACEMaths	2006	ACEMath foster the collaborative selection, adaptation and use of OER in the Mathematics field. ***Website***: http://www.saide.org.za/african-teacher-education-oer-network-aten/acemaths
OERu	2009	OERu was stablished with the aim of using open education as a means to provide leadership and international networking, as well as supporting educational institutions to achieve their strategic objectives. This initiative has a network of recognized universities, polytechnics and community colleges collaborating for widening access to OER. ***Website***: http://oeru.org/about-oeru/

Institutions and projects related to OER		
Name	**Year**	**Description**
Athabasca University	2009	"Initiatives in course development using OER commenced with an external grant (2009–2011) that funded the development of 25 digital enhancements for 17 high-enrolment" (Ives & Pringle, 2013). ***Website***: http://www.athabascau.ca/
CORE	2009	China Open Resources for Education is a non-for-profit organization that promotes the open sharing of educational resources. ***Website***: http://www.core.org.cn/cn/jpkc/index_en.html
Wikiwijs	2009	This initiative that aims to offer a mix of open and closed educational materials, information on teaching methods and professional development materials on the use and application of teaching materials. It was launched as a joint initiative of Kennisnet, the Open Universiteit and the Dutch Ministry of Education, Culture and Science. ***Website***: http://www.wikiwijsleermiddelenplein.nl/
OER Foundation	2009	This is a non-profit company which aims to provide leadership in support of open education. ***Website***: http://wikieducator.org/OERF:Home
OTTER	2009	The aim of the Open Transferable and Technology-enabled Educational Resources (OTTER) project was to improve the quality of existing teaching materials to create new OER. ***Website***: http://www2.le.ac.uk/departments/beyond-distance-research-alliance/projects/otter
TAACCCT OER	2011	Trade Adjustment Assistance Community College and Career Training (TAACCCT) grantees. The Open Professionals Education Network (https://open4us.org/services/) provides support to the TAACCT grantees for meeting OER, accessibility, and quality requirements. ***Website***: http://creativecommons.org/tag/taaccct
POERUP	2011	The Policies for OER Uptake (POERUP) initiative is mainly focused on developing policy recommendations by promoting the uptake of OER in the educational setting. ***Website***: http://www.poerup.info/index.html
BC Open Textbook Project	2012	"The goal of the project is to make higher education more accessible by reducing student cost through the use of openly licensed textbooks" ***Website***: http://open.bccampus.ca/about-2/
LATin	2012	The Latin American open text books Initiative which is focused on the creation and dissemination open text books encouraging and supporting local professors and authors to contribute with individual sections or chapters in each book. Open text books are created in the Booktype platform ***Website***: http://www.proyectolatin.org/

2.1.4 Creation of OER

In recent years, authors have begun to describe the creation of OER in terms of actors, standards, technologies, methodologies and evaluation. In their review of methods for developing OER, Arimoto & Barbosa (2012) noticed a lack of appropriate methods for the creation and adoption of OER. Apart from an appropriate methodology, the particular contexts in which OER are adopted allow creators to define what they have to take into account when creating OER.

To date, several studies have suggested that the use of social tools facilitates the creation of learning contents. Collaborative environments and collaborative learning techniques guide the design of educational resources (Dimitriadis et al., 2009) and help them to share experiences and feed systems for the selection of new resources (Limongelli et al., 2015). Moreover, the social authorship strategy allows educators and students to work collaboratively in the creation of learning contents. As a result, there could be a significant reduction in the creation time (Cueva Carrion et al., 2010).

On the other hand, design of OER may be addressed with the use of methodologies such as

the research based design. According to Ives & Pringle (2013) "design-based research provides several methodological advantages for the design and assessment of innovations in education. It is systematic and iterative, in line with emerging understanding of how people learn; it is based in real-life educational situations and is therefore relevant to teaching and design practitioners; and it encourages researchers and practitioners to work collaboratively to create and assess the impact of solutions to learning problems".

Other important elements to consider in the creation of OER are:

- Social learning dimension is considered through the use of social learning platforms to foster discussions regarding the use of OER (Ives & Pringle, 2013).
- Creation is like a production chain with different actors participating and performing activities such as editing, assembling, annotating, tagging, commenting or linking information resources (Kerres & Heinen, 2015).
- Open the design process allow actors to learn how to create new designs and compare the effectiveness between different existing designs (Sicilia, 2007).
- In this context, the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional design model is one of the most widely-used in educational settings (Cueva Carrion et al., 2010). Although ADDIE has been a criticized model because of the long time it takes to implement this model in real environments as cited by Fragou & Kameas (2013), there is no an empirical study that demonstrates such argument, on the contrary, there are studies which propose methodologies based on the ADDIE instructional design model (Cueva Carrion et al., 2010; Sicilia et al. 2011).
- Numerous studies have introduced methodologies and approaches to create OER. Mitros & Sun (2014) present a distributed course model in which instructors and students collaborate to create, use and share a course in various classrooms.
- A wiki read/write approach enables users to co-create designs (Davinia Hernández-Leo et al., 2014).

The remaining of this subsection describes the findings in this literature review regarding the creation of OER by describing: the lifecycle of an OER (subsection 2.1.4.1); the actors involved in the creation of OER (subsection 2.1.4.2); standards, instruments or protocols reported by different studies (subsection 2.1.4.3); technologies associated with the use, adoption and creation of OER (subsection 2.1.4.4); methodologies for the creation of OER (subsection 2.1.4.5); evaluation experiences (subsection 2.1.4.6); and monitoring strategies (subsection 2.1.4.7).

2.1.4.1 Lifecycle

From its conception as an idea to cope with learning needs, OER go through different states which can be represented by means of a lifecycle. This lifecycle is then understood as a set of possible states that an OER can take since it is created. The main actions regarding the adoption and use of OER that were identified in this literature review should be discussed to define those states.

To start with, an OER can be created by using authoring tools (Davinia Hernández-Leo et al., 2014; Kinshuk & Jesse, 2013; Leinonen et al., 2010; Sicilia et al., 2011) or other technological tools that support individuals or groups in creating new OER. During or after the creation process, an OER can be described by using tools which support metadata standards (Mohamed Nour et al., 2012) or enriching the metadata with web semantic technologies (Ruiz-Iniesta et al., 2014; Shelton et al., 2010). According to DeVries (2013), open licensing schemes such as the Creative Commons will be needed to analyze OER for reuse. For this reason, the description of an OER should include the license adopted so that others know how they can use a specific resource.

An OER is ready for being published when at least it has been created and described

properly. After that, others can comment on the quality of an OER and provide useful feedback in order to improve it (Wright & Reju, 2012). Moreover, OER should be published in an appropriate format to facilitate their downloading. For instance, to facilitate printing and adaptation of OER, in the OER Africa initiative, resources were revised and then made freely available for downloading in two formats: PDF and Microsoft word (Sapire & Reed, 2011). Some authors suggest the use of standards for packaging OER to facilitate their transportability and reuse in other contexts.

On the other hand, redistribution is understood as the process of sharing resources with others (J. Hilton III et al., 2012). Due to that redistribution, OER become units of content ready to be adapted to other contexts or to be combined with other resources to generate new ones.

Together these ideas led us to identify some possible states of an OER in its lifecycle. This lifecycle is depicted in Figure 2-5. The initial state is *created*. When an OER is *created*, it can be *described* and then *licensed*; with an accurately description and licensing definition, an OER can be *published* in a public domain; an OER *published* could be also *redistributed* (*shared*) to others, *downloaded* (sometimes *packaged*) *tagged*, or *evaluated*; once an OER is *downloaded* or *redistributed*, it can be *reused*; finally, an OER *reused* can become in a *remixed* or *revised* (*modified*, *adapted*) OER in order to generate a new OER. In this lifecycle an OER is always alive while the state "*reused*" remains active.

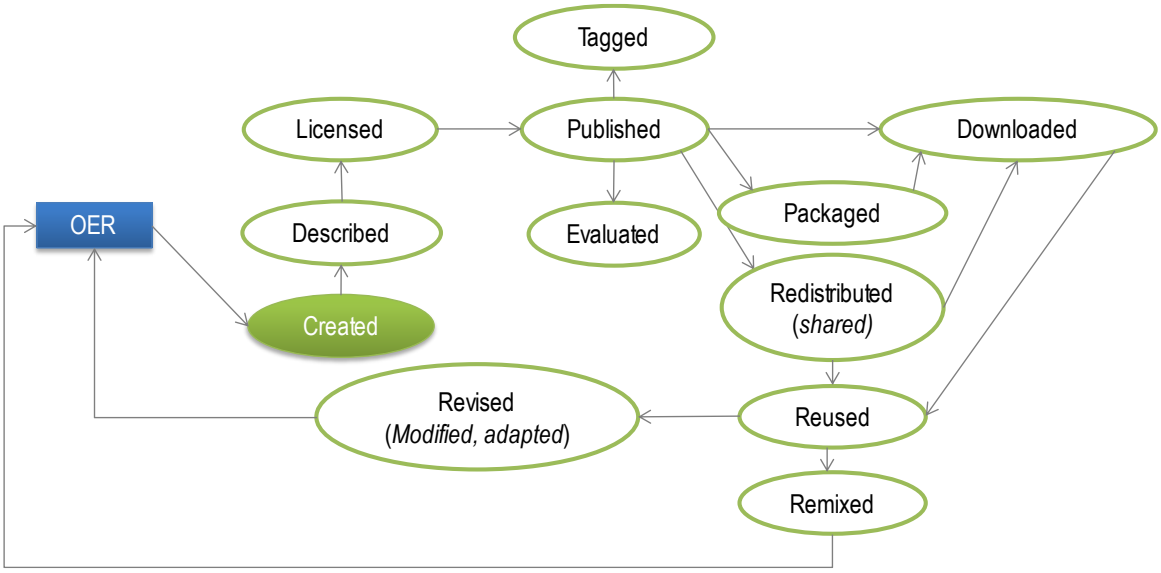


Figure 2-5. OER's lifecycle

Once an OER is created, it is ready to take all the other states in the lifecycle and because of that the creation process should guarantee that an OER is ready to take all the other states. Thus, an incomplete or poor quality OER can be described, licensed, published, and downloaded/packaged/redistributed but when it comes to reuse, the OER may not be usable or even suitable for all learning needs or learning settings.

2.1.4.2Actors

The creation of OER involves the participation of different actors such as teachers, students, experts, and institutions, among others. A methodology for creating OER should describe the role that each participant plays. Because of their interaction in different activities related to the creation of OER, teachers are considered the protagonists in this process. According to Lane & McAndrew (2010) , teachers play the main role in the design of teaching activities, experiences or modules. One of the aims of teachers is to structure and support learning experiences by providing students with learning contents and tools. In this regard, Kerres &

Heinen (2015) introduce the concept of "informational ecosystems for education" in which teachers should be able to: search for educational resources, link resources, and provide contents for learning platforms. Other studies also analyse how teachers take part in the use and adoption of OER. For instance, in the study conducted by Kelly (2014) to analyse the adoption of OER, participants were classified into three groups, namely: K-12 educators, higher education professionals, and those involved in workplace training. As a result of that study, K-12 educators found OER more useful than those working in higher education or other settings.

Despite the importance of teachers as creators or authors of OER, students can also take part in this process. Students can participate actively in the creation process due to their motivation to contribute with more resources (Ives & Pringle, 2013). Besides, in the study by Llamas-Nistal & Mikic-Fonte (2014), authors identified the wide acceptance of students regarding the recording lectures (generated as OER) to the extent that it encouraged authors to produce more. This may be due to the active use of OER, not just by students but also other users, as a key factor to determine their effectiveness.

In the study by Chikh (2014), instructors are associated with roles such as designer and learners are called consumers of educational resources. However, consumers are not just learners or students. Different studies use the terms consumers as users of OER and producers as designers or creators of OER. According to Thoms & Thoms (2014) consumers may become producers if they interact with OER. Moreover, Atenas-Rivera et al. (2012) assert that administrative, academic staff, librarians, and content designers (as producers) are responsible for creating educational resources that are included in educational repositories.

Governments and decision makers take an active role in the whole process of the creation of OER by launching funded initiatives (Stacey, 2013). For instance, the Paris OER declaration encourages governments to create and adapt OER to local language and diverse contexts (Amiel, 2013).

Together, these actors and all denominations identified in the literature review were classified into five categories as follows:

- **Teacher**: this is considered the main actor in the creation, use and adoption of OER. This category includes those denominations of actors who take part in teaching processes and in the creation of OER. Teachers are present in all learning activities taking place at school or on virtual environments.
- **Student**: a student can take part in the learning process and interact with OER. Appreciations coming from this actor are useful to assess the usefulness and usability of OER as a way of contributing in the creation process.
- **Technical team**: a technical team can support teachers in the creation of OER from a technical point of view.
- **Academic staff, managers, and institutions**: support the labour of teachers as main creators of OER by defining open policies, making decisions, or launching OER initiatives.
- **Other stakeholders**: participate from an external and internal point of view in the creation of OER. Actors in this category are interested in working collaboratively with teachers in order to create or adapt new OER.

The aim of this classification is to show the diversity of actors who participate in the creation of OER and in the related activities such as adoption or reuse. Table 2-5 shows the categories of actors mentioned above with their corresponding denominations identified in this literature review. Such denominations were obtained from the codes used during the reading of the research studies analysed in this literature review.

Due to the prominence of the role of teachers in the creation of OER, we can conclude that

giving teachers the appropriate support to create OER may help them to the achievement of better educational resources. Moreover, in the creation process learners, technical team, academic staff, and other stakeholders can contribute with their support to the creation or even to improve the OER.

Table 2-5. Actors of OER

Category	Denominations in studies
Teacher	Academic teacher, assistant lecturer, corresponding teacher, associate professor, educator, instructor, k-12 educator, non-expert teachers, Open Distance Learning (ODL) practitioners, practitioner, primary school teacher, producer, professor responsible, retired teacher, senior lecturer, staff training, school teacher working at home, trainer, workplace training.
Student	Adult learner, busy student, classmate, co-learner, college student, consumer, course participant, end-user, external learner, fellow students, graduate, independent learners, individual learner, internal student, lifelong learner, older student, self-learner, part-time students, fulltime students, undergraduate.
Technical team	Animation expert, content developer, course developer, designer, developer of OER, designer of templates, faculty adopters, faculty members graphic designer, programmers, providers, software engineer, teaching teams, technical staff.
Academic staff, managers and institutions	Academic staff, administrative guidance, coordinator, copyright officer, course team, decision maker, department, director, district officials, education leaders, government leaders, higher education professional, institution, media professionals, officials of the institution, opinion leaders, policymakers, policy and decision maker, private organizations, role of government, teams of academics, universities.
Other stakeholders	Accreditor, author's auxiliary, co-editor, co-author, commentator, content organizer, content writer, course designer, course writer, creator, creator of OER, curator, digital librarian, editor, educational researcher, educational technologist, end-user, evaluator, expert, facilitator, generator of ideas, individual, group organizer, instructional designer, learning designer, moderator, multidisciplinary lab team, OER user, parents, participant, partner, pedagogical researcher, producers, researcher, re-user, repository user, retired people, review committee, reviser, savvy user, starter, subject matter experts, supervisor, support service, teams of learning designers, translator.

2.1.4.3Standards, instruments or protocols

Different studies in this literature review have reported the use of standards as a way of improving the quality, accessibility, interoperability, and other characteristics of OER. Table 2-6 summarizes the standards, instruments or protocols for OER identified in this literature review. The following subsections describe them in terms of metadata, content, interoperability, format, web semantic, accessibility, quality and use of OER.

Table 2-6. Standards, instruments or protocols for OER

Type	Standard, instrument or protocol
Metadata	→IEEE Learning Object Metadata (LOM) Website: https://standards.ieee.org/findstds/standard/1484.12.1-2002.html Cited in: (Arimoto & Barbosa, 2013; Chikh, 2014; H. C. Davis et al., 2010; Glahn et al., 2010; Kinshuk & Jesse, 2013; Leinonen et al., 2010; Mohamed Nour et al., 2012; Rodriguez M. et al., 2011; Ruiz-Iniesta et al., 2014; Santos-Hermosa, Ferran-Ferrer, & Abadal, 2012; Sicilia, 2007; Sicilia et al., 2011; Sinclair et al., 2013; Zervas & Sampson, 2013, 2014)
	→Dublin Core (DC) Website: http://dublincore.org/ Cited in: (Sellami, 2013)

Type	Standard, instrument or protocol
Content	→IMS Learning Design (LD) Website: http://www.imsglobal.org/learningdesign/index.html Cited in: (Chikh, 2014; Dodero, del Val, & Torres, 2010; Lane & McAndrew, 2010; Leinonen et al., 2010; Sicilia, 2007)
	→ Shareable Content Object Reference Model (SCORM) Website: http://www.adlnet.org/scorm Cited in: (Arimoto & Barbosa, 2012; Q. Chen, 2010; Chikh, 2014; H. C. Davis et al., 2010; Dietze et al., 2013; Dinevski, 2008; Dodero et al., 2010; Glahn et al., 2010; Kinshuk & Jesse, 2013; Leinonen et al., 2010; Limongelli et al., 2015; Read et al., 2011; Rejas-Muslera, Cuadrado, Abran, & Sicilia, 2008; Sánchez-Alonso, Sicilia, García-Barriocanal, Pagés-Arévalo, & Lezcano, 2011; Santos & Jorge, 2013; Sicilia, 2007; Sinclair et al., 2013)
Interoperability	→ Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) Website: https://www.openarchives.org/pmh/ Cited in: (Leinonen et al., 2010)
	→ALOCOM Website: http://jelenajovanovic.net/ontologies/loco/alocom-core/spec/ Cited in: (Boyle & Ravenscroft, 2012; Leinonen et al., 2010; Sinclair et al., 2013)
	→Simple Web-service Offering Repository Deposit (SWORD) Website: http://swordapp.org/ Cited in: (Glahn et al., 2010)
Format	→MPEG-7 Website: http://mpeg.chiariglione.org/standards/mpeg-7 Cited in: (Daradoumis et al., 2013)
Semantic web	→Linked Data Website: http://www.w3.org/DesignIssues/LinkedData.html http://linkeddata.org/ Cited in: (Dietze et al., 2013; Piedra et al., 2014)
	→ Link Open Course Ware Data (LOCWD) Website: http://presentations.ocwconsortium.org/ind2013_tovar_locwd/ Cited in: (Piedra et al., 2014)
Accessibility	→IMS accessibility specification Website: http://www.imsglobal.org/activity/accessibility Cited in: (Sicilia, 2007)
	→Web Content Accessibility Guidelines (WCAG) 2.0 Website: http://www.w3.org/TR/WCAG20/ Cited in: (Cueva Carrion et al., 2010; Fenton, 2014)
	→Authoring Tool Accessibility Guidelines (ATAG) Website: http://www.w3.org/TR/ATAG20/ Cited in: (Cueva Carrion et al., 2010; Rodriguez M. et al., 2011)
	→User Agent Accessibility Guidelines (UAAG) Website: http://www.w3.org/TR/UAAG20/ Cited in: (Cueva Carrion et al., 2010)
Quality	→Learning Object Review Instrument (LORI) Website: http://www.transplantedgoose.net/gradstudies/educ892/LORI1.5.pdf Cited in: (Constantinescu & Vladoiu, 2013; Sinclair et al., 2013)
	→ Learning Object Attribute Metric (LOAM) Website: http://www.nottingham.ac.uk/nmp/sonet/projects/loam/ Cited in: (Sinclair et al., 2013)
	→ Learning Object Evaluation Metric (LOEM) Website: http://eric.ed.gov/?id=EJ829899 Cited in: (Sinclair et al., 2013)

Type	Standard, instrument or protocol
	→ ISO/IEC 25000:2014 Website: http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=64764 Cited in: (Constantinescu & Vladoiu, 2013)
Use	→Technology Acceptance Model (TAM) Website: Cited in: (H. Kelly, 2014)
	→ Unified Theory of Acceptance and Use of Technology (UTAUT) Website: http://www.vvenkatesh.com/organizations/Theoretical_Models.asp Cited in: (Mtebe & Raisamo, 2014)
	→OER Readiness Tool Website: http://auspace.athabascau.ca/bitstream/2149/3296/1/OER%20Readiness%20Tool-1.pdf Cited in: (Mtebe & Raisamo, 2014).
Evaluation (learning)	→IMS Question and Test Interoperability (QTI) Website: http://www.imsglobal.org/question/index.html Cited in: (Glahn et al., 2010; Rejas-Muslera et al., 2008; Rodriguez M. et al., 2011; Santos-Hermosa et al., 2012; Sicilia, 2007; Sicilia et al., 2011)

2.1.4.3.1 Standards related to metadata

OER can be described by using the *IEEE Learning Object Metadata (LOM)* which is a predominant standard used to describe resources and allow them to be selected, evaluated and reused (Sinclair et al., 2013). Although LOM is a complete standard, some people do not comprehend this standard at all (Mohamed Nour et al., 2012). That is why some authors have introduced adaptations to this standard in order to improve its use. For instance, Chikh (2014) describes "LOM+" which is divided into two parts the "LOM category" and the "LD category". The former contains the nine categories of LOM, namely: general, lifecycle, meta-metadata, technical, educational, rights, relation, annotation, and classification. The latter is related to the knowledge of reuse in the concept of Learning Design Object (LDO) and authors defined ten categories, namely: LDO nature, LDO type, LDO form, LDO credibility, LDO goal, LDO granularity, LDO constraint degree, LDO customization degree, LDO formalization degree, and LDO reification degree.

Although the Dublin Core standard is applied for generic resources descriptions, it is also used for describing OER (Sellami, 2013). Dublin Core includes 15 elements: title, creator, subject, description, publisher, contributor, date, type, format, identifier, source, language, relation, coverage, and rights.

2.1.4.3.2 Standards related to the content

The *Shareable Content Object Reference Model (SCORM)* is a set of standards from organizations such as IEEE, AICC, Ariadne, and IMS Global (Santos & Jorge, 2013). Resources packaged with SCORM are stand-alone web file packages or PDF booklets than can be imported in other platforms that support this standard as well (Leinonen et al., 2010). In their review of methods for developing OER, Arimoto & Barbosa (2012) identified that most studies use SCORM as the specification for content packaging. The use of SCORM for packaging OER facilitates their reuse in other contexts.

2.1.4.3.3 Standards related to interoperability

The Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) is a protocol that facilitates the interoperability among repositories by collecting metadata that allows one platform or repository to have as much information as possible about a specific OER. For instance, in the authoring platform described by Leinonen et al. (2010) OER can be

harvested with the OAI-PMH by using LOM or DC. In the study by Shelton et al. (2010), metadata is harvested from data sources such as OAI-PMH endpoints. (Dietze et al., 2013) mention OAI-PMH as part of interface mechanisms exploited by repository providers for interoperability purposes.

On the other hand, ALOCOM is described as a model for supporting reusability and interoperability among learning contents (Sinclair et al., 2013). According to Leinonen et al. (2010), ALOCOM has been used by plugins in the Microsoft Office software such as PowerPoint in order to retrieve smaller content fragments that can be part of the resources created by teachers in that software. Boyle & Ravenscroft (2012) introduce a model for dealing with the reuse and re-integration of OER and use ALOCOM as a reference model in the classification of learning objects for reuse.

Another solution for publishing contents is the Simple Web-service Offering Repository Deposit (SWORD) (as cited in Glahn et al., 2010) which is an interoperability standard applied to repositories to accept the deposit of contents in different formats.

2.1.4.3.4 Standards related to the format

Format defines the way of representing a resource and is an indicator of what kind of content is included in a specific resource. In this context, standards such as MPEG-7 are used for describing educational resources (Sellami, 2013) and more exactly for defining the structure of multimedia (Little et al., 2012).

2.1.4.3.5 Standards related to semantic web

Semantic web aims to making links between data published on the web. Based on this idea the *Linked Data* was introduced by Berners-Lee (2006) and it is an approach that addresses the interoperability and integration of systems for sharing, connecting and discovering information related to OER (Tovar & Piedra, 2014). Based on this approach, the linked open data initiatives engage different institutions in order to provide open access to the data of their educational resources. In the study by Dietze, Sanchez-Alonso, et al. (2013), linked data principles are used to model and expose metadata for educational resources, services and APIs.

Piedra et al. (2014) introduce the Link Open Course Ware Data (LOCWD) model which contains a vocabulary based on a semantic representation through the W3C RDF technology and is used to publish metadata of courses that come from different educational sources. They also point out that the aim of this model is to link information related to OER, open licenses, OCW repositories, and other academic information.

2.1.4.3.6 Standards related to accessibility

The *IMS accessibility specification* addresses accessibility barriers that hinder the learning process such as the access to specific devices (Sicilia, 2007). Moreover, the World Wide Web Consortium (W3C) through the Web Accessibility Initiative (WAI) works on guidelines for web accessibility at three levels: at content level with the *Web Content Accessibility Guidelines (WCAG) 2.0*; at authoring tools level with the *Authoring Tool Accessibility Guidelines (ATAG)*; and at tools for user level with the *User Agent Accessibility Guidelines (UAAG)* (REF CUE10).

2.1.4.3.7 Standards related to quality

In their practice-oriented review of learning objects, Sinclair et al. (2013) mention about three instruments for assessing the quality of educational resources. To start with, the Learning Object Review Instrument (LORI) allow evaluators to rate and comment resources subjectively in terms of content quality, learning goal alignment, feedback and adaptation, motivation, presentation, interaction usability, accessibility, reusability, and standards

compliance. Another one is the Learning Object Attribute Metric (LOAM) tool which presents a set of criteria based on the IMS Learning Design framework. Categories in this tool are: environment, learner role, and activity. Finally, the Learning Object Evaluation Metric (LOEM) is also a model for evaluating educational resources that consists of these five categories: interactivity, design, engagement, usability, and content.

On the other hand, Constantinescu & Vladoiu (2013) introduce a quality model with four categories, namely: content related, instructional design, technology related, and courseware evaluation. To define this model, authors considered the quality characteristics related to the internal and external quality of a product according to the ISO/IEC 25000 SQuaRE standard. The model covers user needs such as effectiveness, efficiency, satisfaction, reliability, security, context coverage, learnability, and accessibility.

2.1.4.3.8 Standards related to use

The *TAM (Technology Acceptances Model)* is the most common used models to explore the adoption in the context of OER (H. Kelly, 2014).

The *Unified Theory of Acceptance and Use of Technology (UTAUT)* proposed by Venkatesh et al. (2003) was applied in the study by Mtebe & Raisamo (2014) in order to identify challenges and instructors' intention to adopt and use OER. "This model consists of four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. These four constructs are direct determinants of usage intention and behaviour. Moreover, the variables gender, age, experience, and voluntariness of use moderate the key relationships in the model" (as cited in Mtebe & Raisamo 2014).

The *OER Readiness Tool* has been applied to analyse the creation and use of OER among higher education teachers (Mtebe & Raisamo, 2014).

2.1.4.4 Technologies

For years, educational resources have been created with a wide variety of tools. Although openness in OER does not depend on the tool, most of the studies have mentioned different tools and platforms which are technologies for supporting creators of OER. Thus, authoring tools provide different functionalities to alleviate the labour of creators when they create or edit OER. Some tools also provide support for collaborative tasks. Another example of these tools are the educational repositories because some of them allow users to create, edit, share, and asses OER. A complete list of the technologies for OER identified in this literature review can be found at: https://goo.gl/7WVt0d. That table presents the information of all software tools listed including: launching year, description, website, license, type, and services.

2.1.4.5 Methodologies

This subsection presents an analysis of the methodologies identified in the literature review for the creation, publishing, reuse or adaptation of OER. Each methodology has been described in terms of name, actors, phases, standards, tools, and additional characteristics. A list with all the methodologies and their characteristics can be found at: https://goo.gl/khyVbF. Table 2-7 presents a relation of the methodologies and its components in terms of actors, phases, standards, tools and the purpose (create, publish, reuse, adapt). The following is the relation of name and reference of the methodologies listed in Table 2-7.

- ***M1*** – Model of reuse (cited in K. I. Clements & Pawlowski, 2012)
- ***M2*** – Sharing levels in the design of OER (Sicilia, 2007)
- ***M3*** - Creation and repurposing of OER with mediating artefacts (Dimitriadis et al., 2009)

- ***M4*** – Social authoring and semantic tools in the OER'S Production cycle (Cueva Carrion et al., 2010)
- ***M5*** – OER lifecycle authoring and re-authoring with open standards (Glahn et al., 2010)
- ***M6*** – Scaffolding authoring of OER (the LeMill model) (Leinonen et al., 2010); ***M7*** – FLEXO LD visual language (Dodero et al., 2010)
- ***M8*** – Course design using OER (Rennie et al., 2011)
- ***M9*** – Model for publishing and using OER (Hemingway et al., 2011)
- ***M10*** – Reusability and interoperability in the creation of OER (Rodriguez M. et al., 2011)
- ***M11*** – OER's production cycle in the UTPL (Tovar et al., 2012)
- ***M12*** – Model of development for China's national quality course plan (Long & Håklev, 2012)
- ***M13*** – Ritcher's learning adaptation model (Richter & McPherson, 2012)
- ***M14*** – IMS-LD Best practice guide by Koper et, al. (2013) (Cited in Chikh, 2014)
- ***M15*** – Creation of OER as reusable learning objects by using a mobile authoring tool (Kinshuk & Jesse, 2013)
- ***M16*** – Collaborative development cycle for OER according Pawlovsky's model (cited in McKerlich et al., 2013)
- ***M17*** – OpenLearn OER production process (Connolly, 2013)
- ***M18*** – dScribe (cited in Connolly, 2013)
- ***M19*** – CORRE: A framework for transforming teaching materials into OER (cited in Connolly, 2013)
- ***M20*** – Methodology for knowledge sharing (Algers et al., 2013)
- ***M21*** – Agile method for OER (Arimoto & Barbosa, 2013)
- ***M22*** – Creation of OER using boundary objects (Fragou & Kameas, 2013)
- ***M23*** – IDEA Model - Instructional Design Model for Integrating Information Literacy (Mullins, 2014)
- ***M24*** – The process of developing digital didactic competences in the open movement (cited in Hernández-Carranza et al., 2015)
- ***M25*** – Collaborative production of open textbooks (Muñoz Arteaga et al., 2015)
- ***M26*** – Model for OER in the Rajabhat University (Chanayotha & Na-songkhla, 2015)
- ***M27*** – Open educational resources development model for an inquiring cultural skill of higher education students (Kaosaiyaporn et al., 2015).

According to the analysis presented in Table 2-7, in most of the methodologies identified in this literature review teacher is considered as one of the actors who can take part in the creation of OER. Likewise, the methodologies specify some phases or steps to create, publish, reuse or adapt OER. Regarding the use of standards, few of these methodologies state the application or use of specific standards such as SCORM, IEEE LOM, IMS QTI, IMS LTI, and IMS Accessibility (*M2, M4-M7, M10, M14, M15,* and *M17-M22*). Some of the tools considered to apply the methodologies are authoring tools, LMS, mobile applications, web sites, or the use of specific contents such as videos. Moreover, almost all methodologies focus on the creation of OER and only some of them focus on publishing OER, reusing OER or adaptating OER.

Table 2-7. Methodologies for OER

Methodology	Actors		Phases	Standards	Tools	Create OER	Publish OER	Reuse OER	Adapt OER
	Teacher	Others							
M1	x		x					x	x
M2	x		x	x	x	x		x	
M3	x	x	x		x	x	x		
M4	x	x	x	x	x	x			
M5		x	x	x		x	x	x	
M6	x	x	x	x	x	x		x	
M7	x	x	x	x	x				x
M8		x	x		x	x			
M9	x		x			x	x		
M10			x	x		x			
M11	x	x	x		x	x	x	x	x
M12	x		x			x			
M13			x						x
M14		x	x	x		x			
M15	x	x	x	x	x	x			
M16		x	x			x		x	
M17		x	x		x	x	x		
M18		x	x		x	x	x		
M19	x	x	x		x		x		x
M20	x	x	x		x	x		x	
M21	x	x	x	x	x	x	x		
M22	x	x			x	x			
M23		x				x			
M24	x		x			x	x		
M25		x	x		x	x	x		
M26		x				x	x		
M27	x		x		x	x			

Due to the fact that few of the methodologies analyzed consider the attention to the learning needs of students or the web accessibility issue, it is worth noting the need for further research on how such topics can be addressed in a real experience with teachers as the creators of OER. In this sense, we emphasize that teachers need supporting guide and tools that consider the attention to the diversity of students' learning needs.

2.1.4.6Evaluation

The literature has emphasized in the importance of delivering high quality educational resources. Quality may be evaluated during or after the creation of OER. This evaluation consists in analyzing the compliance of requirements and characteristics that allow an OER to be delivered in a specific educational setting. Another aim of the evaluation of OER is to compare new resources with traditional materials (Robinson et al., 2014). Thile (2008) suggests that an ongoing evaluation, feedback from users, and pedagogical considerations are essential elements for the growing of the open education (as cited in Toven-Lindsey et al., 2015). Regarding the strategies applied to evaluate OER, peer review is the most common strategy to evaluate aspects such as the quality and completeness of learning contents. One of the advantages of peer reviews are the improvements that authors can apply to their resources (Kelty, Burrus, & Baraniuk, 2008). Moreover, DeVries (2013) assert that in a course review is mandatory to apply an appropriate academic peer review to identify gaps and other problems in the content.

As noted in previous subsections, teachers are one of the main actors in the creation of learning designs or educational resources and are involved in an ongoing evaluation of resources because the adoption of OER requires teachers to select resources and evaluate them (Tonks et al., 2013). Students can also participate in the evaluation of educational resources. For instance, in the study by Abeer & Miri (2014) students were asked to evaluate a MOOC in terms of educational goals, course structure, teaching methods, course requirements, and the role of the lecturer. In the approach proposed by Arimoto & Barbosa (2013) for an agile development of OER, customers (users of OER) carry out an evaluation in each delivery of the OER release. With this evaluation customers can identify changes or improvements for the new OER in short periods of time minimizing the cost of change.

Some studies have reported methods or strategies for the evaluation of OER. In their review about learning objects, Sinclair et al. (2013) highlight the users' view as part of the evaluation of reusable learning objects. Thus, users can provide ratings, peer reviews or comments. Moreover, in the same study authors report three evaluation instruments, namely: LORI, LOAM, and LOEM (mentioned before in subsection 2.1.4.3), which include criteria for the evaluation of quality in OER in terms of content, pedagogical elements, design, usability, and accessibility. Santos-Hermosa et al. (2012) mention some indicators to evaluate the quality in OER including metadata, the usage of OER, and the experts' points of view. According to Long & Håklev (2012), the Ministry of Education in China publishes each year a set of quality criteria for courses including elements such as: teaching team, educational research, contents, planning of the course, teaching materials, instructional elements (design, approach, practice, learning outcomes), and evaluation methods. K. I. Clements & Pawlowski (2012) conducted two surveys with 80 and 66 teachers respectively from different countries who participated in two summer schools organized by two European Union funded projects (Aspect and Cosmos). The aim of the surveys was to understand the reuse and quality of educational resources among teachers. To the question about which kind of functionalities in repositories could help the teachers to increase the reuse, 55% of the respondents considered that reviews and evaluations are factors to foster the reuse of educational resources.

Q. Chen (2010) highlights three elements to take into account in the evaluation of the design and development of OER: 1) the great educational value of resources that are part of other resources or learning activities, 2) the contextual information related to authentic learning tasks and situated learning, and 3) the feedback information about the use of OER. Similarly, Sapire & Reed (2011) describe five dimensions from an OECD study for the evaluation of OER initiatives: 1) scope to know how focused is a project, 2) authorship to define OER were create as a result of a collaborative effort, 3) licensing to define how an OER can be reused in other contexts, 4) granularity to know the size of OER, 5) teaching duration referring to the actual teaching time needed for the use of the materials.

A schema of the elements considered in the evaluation of OER is depicted in Figure 2-6. This schema was created based upon the elements identified in this literature review such as the actors involved in the evaluation process (*Who?*), the evaluation instruments (*How?*) and the common dimensions that are considered when an OER is evaluated in terms of quality (*What?*).

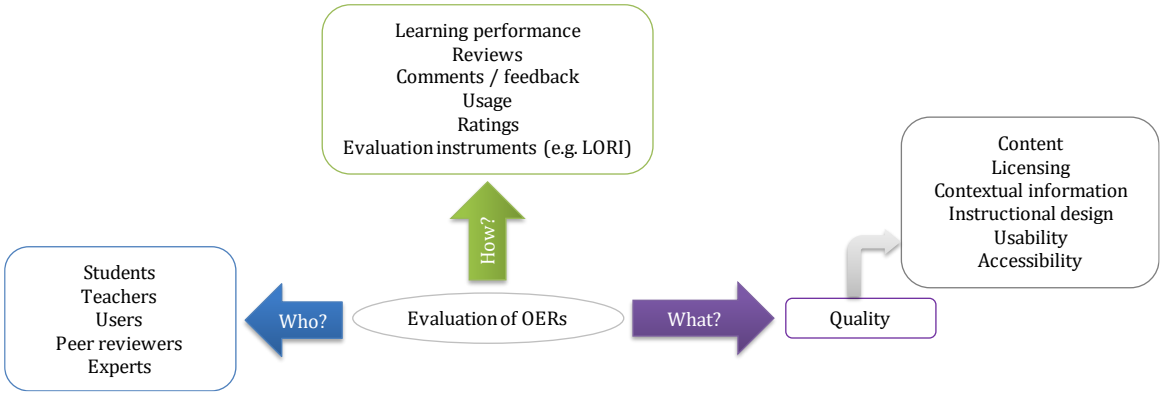


Figure 2-6. Evaluation of OER

2.1.4.7Monitoring the creation of OER

None of the studies analyzed have reported a broad research regarding how to monitor the process of creating OER. However, some of them apply or report strategies to make history revisions or stablish relationships with other actors in this process. The use of social networking platforms is the most common way to keep in touch with people when creating educational resources. Thus, the study by Hernández-Leo et al. (2014) focuses on a platform called LdShake which enables the co-creation of learning designs and provides tools for promoting and monitoring the interactions among co-creators such as revision graphs of the learning designs, information of co-editors and history browsing. Regarding the history browsing service, "participants agreed that monitoring the joint creation of learning designs using the LdShake history facility was largely useful. It was used in a significant number of learning designs to reflect on the development stages of the educational designs performed by the team members".

On the other hand, the field of OER monitoring is focused more on the students' progress. In this context, learning analytics is one of the strategies suggested to follow the behavior of students in certain activities such as watching videos (Llamas-Nistal & Mikic-Fonte, 2014). The use of learning analytics may also assure the quality in open resources (Tonks et al., 2013). Moreover, the use of learning analytics solutions makes that stakeholders (course designers, managers, tutors, participants and policy-makers) appreciate the information they can obtain regarding the profile, preferences and learning styles of students (Daradoumis et al., 2013).

Further analysis is needed to understand how monitoring techniques such as the learning analytics can be used to support teachers in the creation of learning contents.

2.1.5 Summary of the findings about OER

The findings from this literature review that contributed to answer our LR-RQs are described as follows:

- **LR-RQ1 -** Which are the methodologies for the creation of OER (including: characteristics of OER, actors, standards, technologies, phases)?

  The introduction to OER (described in subsection 2.1.3) provides an overview of the definitions, characteristics, benefits, challenges and issues, and initiatives tackled in the research about OER. Moreover, the creation of OER (described in subsection 1.1.1) involves the states of an OER (lifecycle), the people who take part in the stages or phases of the creation process, the standards applied, the technologies used, the main elements in a methodology for the creation of OER, the perspectives on the monitoring of OER, and the kind of evaluations that can be performed during or after the creation process. Since all these elements are involved in the methodologies for the creation of

OER, the main findings in this regard are:

- So far, teachers have had to cope with different pressures and changes proper of this digital age. In the creation of OER the lack of time, the lack of appropriated training processes, the lack of knowledge and skills, and the lack of technological support are some of those pressures. Subsection 2.1.3.4 describes some challenges and issues regarding the creation of OER that are also related with such pressures.
- An appropriate methodology for the creation of OER should consider the characteristics of OER depicted in Figure 2-4 and described in subsection 2.1.3.2. Although some of those characteristics may result challenging to achieve, there are supporting tools or standards that guide creators in this task. A methodology should be also somehow aligned with the ICT competences that teachers need to acquire in order to provide their students with better learning contents.
- Some studies recommend applying accessibility standards as a way to address content access barriers. However, in this literature review we identified that in some cases the accessibility concept was used in terms of the medium for giving students access to the learning contents (e.g. a robust technological infrastructure). The most appropriate term in such case could be *access* instead. This misuse of the accessibility concept and the few studies dealing with the OER accessibility gave us some hints to answer the LR-RQ2.
- Since quality has been highlighted as one of the most challenging characteristic to achieve when creating OER, the analysis of all the elements related to OER allowed us to identify that there are few studies that describe how OER meet quality requirements. Moreover, in the description of the states in the OER's lifecycle (subsection 2.1.4) we stated that poor quality OER represent a problem when it comes to reuse or share them.
- Teachers were identified as the main actors in the creation of OER. The fact that teachers create OER increases the awareness on their use. All denominations given to actors who create, use, reuse, or share OER are presented in subsection 2.1.4.2.
- The fact that teachers get involved in the creation of OER implies also an evaluation process to verify whether an OER has the enough characteristics that make it a high quality resource or if the OER complies the standards stablished in the methodology used for creating them.

- **LR-RQ2 -** How have learning needs and student preferences been considered in the creation of OER?

  As noted in subsection 2.1.3.4, one of the challenges in teaching practices is to select or create the appropriate learning contents because not all resources are appropriate for all students. This can be achieved by providing students with learning contents that consider the diversity of learning needs. To help authors of OER make their contents more accessible for all, there are some standards such as the Web Content Accessibility Guidelines (WCAG) that can be used to avoid content access barriers and give a better access to the learning contents. In this sense, and as mentioned in the LR-RQ1, we identified a misuse of the accessibility concept. Thus, when creators of OER deal with how to avoid content access barriers, it refers to the web accessibility concept. Some of the studies analysed recommend the use of accessibility standards, but we identified only one empirical study about OER that reports how videos used as learning materials are created considering accessibility characteristics. Moreover, we did not find studies dealing with the accessibility of OER with a more complex granularity (e.g. a complete course).

- **LR-RQ3 -** What are the mechanisms, systems or strategies considered to monitor the creation OER?

  None of the studies analysed considered a monitoring strategy to support teachers at the creation of OER. Some authors pointed out that learning analytics can be used to provide a better support for teachers in the creation of OER but those studies are focused on how teachers use, analyse and interpret leaners interactions and not regarding data collected from the creation process itself. Further research may contribute to identify to what extent learning analytics can support teachers in the creation of OER.

Taking into account the aforementioned findings about OER and the specific objectives **SO3** and **SO4** of this thesis (**SO3** – To define a user model to represent the teachers' competences in the creation and evaluation of accessible open educational resources and **SO4** – To define a learning analytics model to trace the creation and evaluation of accessible open educational resources), in the following sections we broadened the discussion on the following topics of interest for this research:

- Web accessibility
- Quality in educational resources
- ICT competences for teachers
- User modelling
- Learning analytics

2.2 Web accessibility

As discussed in different studies instruments used for evaluating OER consider also the web accessibility of OERs. This is why in this thesis we considered both web accessibility and quality for the creation and evaluation of OER. This section deals with the concept of Web accessibility (subsection 2.2.1), an overview of the international standard for web accessibility known as WCAG (subsection 2.2.2), web accessibility evaluation (subsection 2.2.3) and how web accessibility is addressed in educational settings (2.2.4).

2.2.1 What is web accessibility?

As highlighted in the section 2, web accessibility is one of the characteristics of OER that should be considered so that all students can access to the learning contents without content access barriers. Web accessibility means that all people can perceive, understand, navigate, and interact with the web (W3C, 2008). Thus, international accessibility recommendations such as the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) (W3C-WAI, 2008) provide a set of guidelines to make web contents more accessible for all people.

On the other hand, the evaluation of web accessibility is a process in which experts, developers or teachers should guarantee all web contents to have a minimum level of accessibility for users with or without disabilities. In order to understand this process it is important to describe the WCAG 2.0 and how the evaluation process is carried out.

2.2.2 Web Content Accessibility Guidelines (WCAG)

The accessibility guidelines provided by the W3C were published for first time in 1999 as the Web Content Accessibility Guidelines (WCAG) 1.0 and in 2008 the WCAG 2.0 version was released. The former was widely applied in past years but these days most of the web sites are required to apply the WCAG 2.0. This standard is divided into four principles: perceivable, operable, understandable, and robust. Likewise, these principles contain a total of 12 guidelines and each principle provides us with some criteria to make digital contents more accessible for everyone. The full structure of the WCAG 2.0 is depicted in Figure 2-7.

Following the description of each one of the WCAG 2.0 principles:

- Perceivable - Information and user interface components must be presentable to users in ways they can perceive. This means that users must be able to perceive the information being presented (it can't be invisible to all of their senses).
- Operable - User interface components and navigation must be operable. This means that users must be able to operate the interface (the interface cannot require interaction that a user cannot perform).
- Understandable - Information and the operation of user interface must be understandable. This means that users must be able to understand the information as well as the operation of the user interface (the content or operation cannot be beyond their understanding).
- Robust - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies. This means that users must be able to access the content as technologies advance (as technologies and user agents evolve, the content should remain accessible).

Each criterion is associated to a level of conformity including level A, level AA and level AAA (WAI, 2011). These levels are an indicator of the level of conformity for each guideline. Most important aspects in the WCAG 2.0 can be summarized as follows:

- Perceivable principle:
    - To provide text alternatives to the non-textual contents.
    - To provide subtitles and other alternatives for the multimedia contents.
    - To create contents that can be represented in different ways including assistive technologies without missing the meaning.
    - To facilitate listen and watch the contents.
- Operable principle:
    - To make all functionalities operable by means of the keyboard.
    - To give users enough time to read and use the content.
    - Avoid contents that provoke seizures.
    - To provide users with help information about how to operate and locate contents.
- Understandable principle:
    - To provide texts that can be read and understood by the user.
    - To make contents more predictable.
    - To advise users and help to correct errors in the input of data.
- Robust principle:
    - To maximize the compatibility with current and posterior versions of the tools.

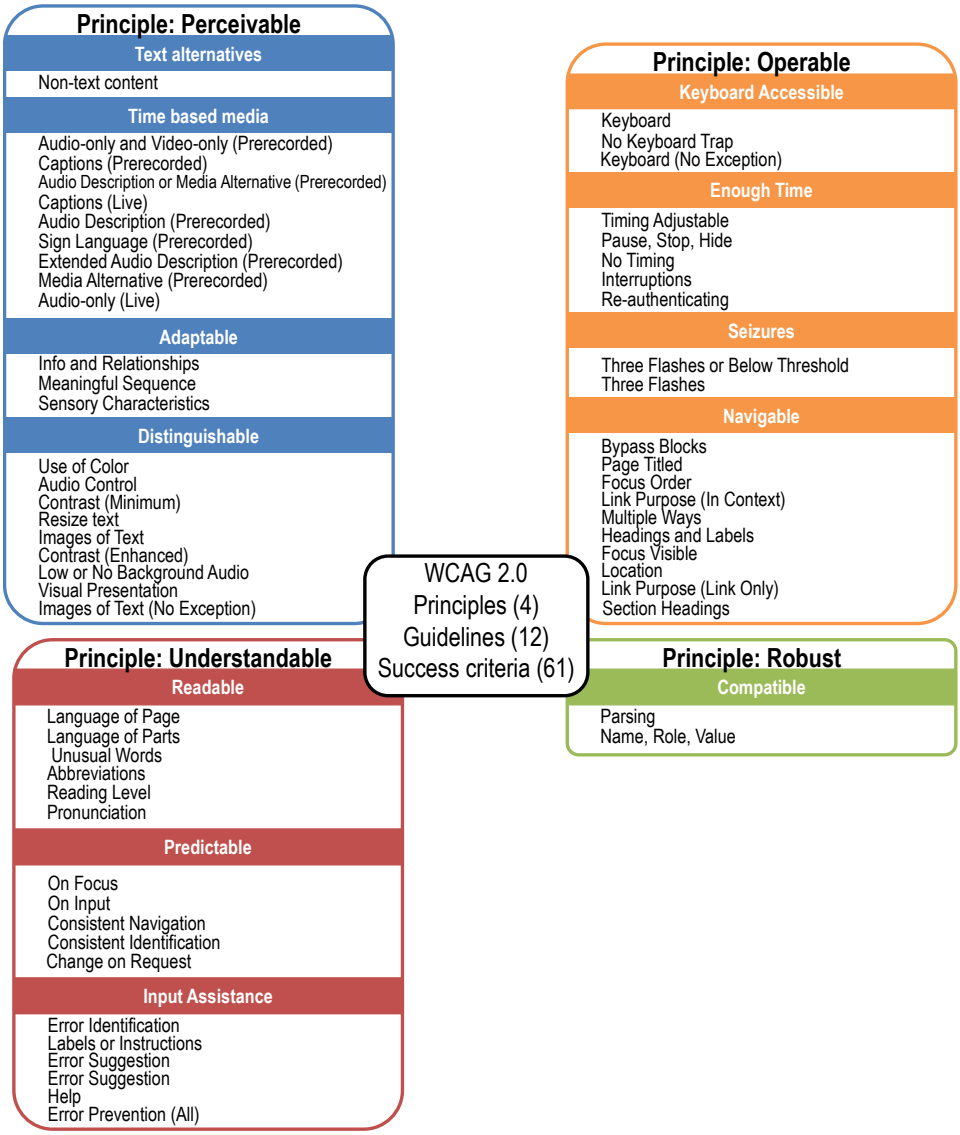


Figure 2-7. Structure of the WCAG 2.0

On the other hand, most of the international legislations in web accessibility are based on the WCAG 2.0. In the same vein other organizations have proposed initiatives for making web contents more accessible for all. For instance, the IMS provides a set of recommendations, taking into account the WCAG 2.0. The accessibility recommendations from IMS (IMS, 2015) consider other elements and IMS standards taking into account that the content creation is surrounded by: inclusive design and assessment; interoperability and personal needs and preferences; platforms, third party software and digital products; assistive technologies and accessibility settings; and legal requirements and international standards. The IMS schema for accessibility is depicted in Figure 2-8.

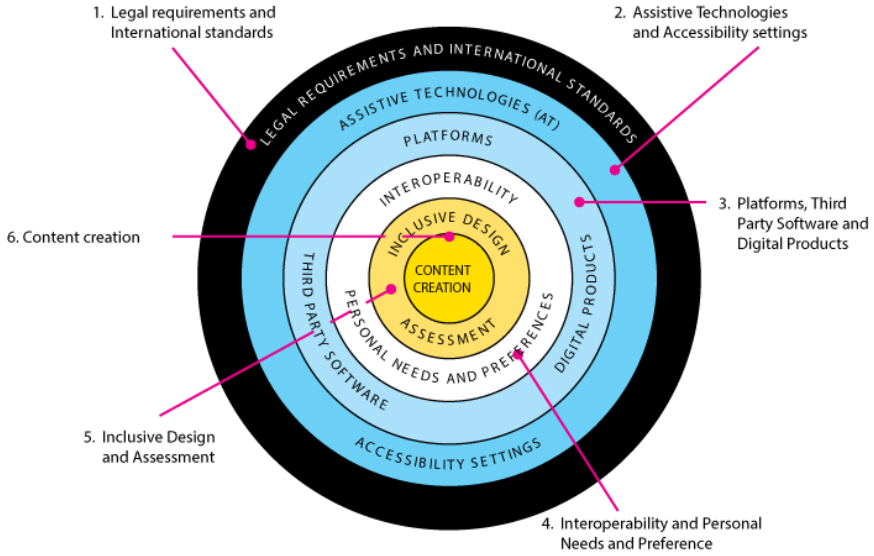


Figure 2-8. IMS accessibility (IMS, 2015)

2.2.3 Web accessibility evaluation

According to the WAI (Web Accessibility Initiative), the web content accessibility evaluation is defined as the process that verifies and determines whether a web site complies with the WCAG 2.0. This evaluation may be performed in a manual or in an automatic way as is depicted in Figure 2-9.

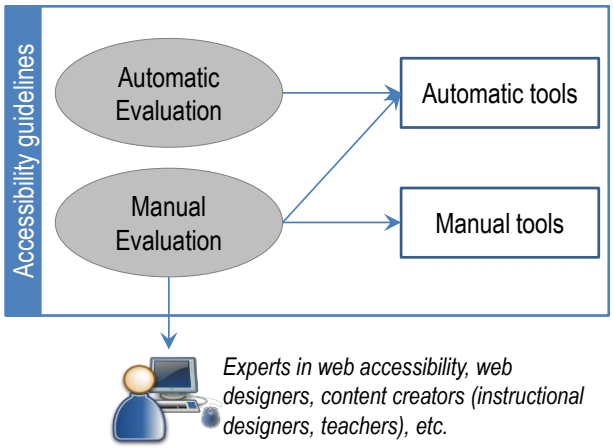


Figure 2-9. Types of web accessibility evaluation

The Web accessibility evaluation process requires knowledge and understanding of the following aspects:

- How do people with disabilities perform in a web environment?
- What types of assistive technologies does the user require to properly surf through web content?
- Which are the limitations of the technology resources used by consumers when surfing the web?
- How can users interact with other type of technologies?

One hand, the **automatic evaluation** is supported by software that analyzes the internal labeling of webpages, it means elements like the code marking HTML (HyperText Marckup Language) and the style sheets CSS (Cascading Style Sheets) and delivering validation reports according to the selected features. Some of the tools used in the automatic

evaluation are:

- AChecker is a tool that is often used to validate accessibility for errors in the HTML code. Validation can be performed using the URL (Uniform Resource Locator), attaching the file that contains the HTML code or copying the page code source. In AChecker three types of problems are identified. Known issues that represent barriers to accessibility, probable problems that can be accessibility barriers and potential problems which are those that AChecker cannot identify and they require an expert' decision.
- TAW is an online service that allows users to check the availability for a given URL by means of a web accessibility test based on the WCAG. One goal of TAW is to check the level of accessibility achieved by a webpage. It is a tool, like the other ones, recommended for the use of professionals such as developers and web designers.
- Hera is a tool that is available on the web which automatically validates the accessibility of webpages allowing users to select the points that they want to review. This tool is available in Spanish.
- EXaminator is a free-online tool that reviews the HTML pages and conducts a series of tests that relate to techniques and faults associated with web accessibility guidelines, WCAG 2.0 specifically.
- TotalValidator is a desktop tool that validates the HTML code. This tool is based on the WCAG 1.0, WCAG 2.0 and the standard of the 508 section. Morevoer, it reviews the broken links on pages tested and identifies spelling errors in the text content.
- SortSite is a tool that checks any broken link pages and identifies spelling errors, problems with the browser compatibility, accessibility, web standards and aspects of SEO (Search Engine Optimization).

On the other hand, the **manual evaluation** is performed by human evaluators (expert in web accessibility, web developer, teacher, etc.) who use different strategies to validate the accessibility of web contents. Examples of these strategies are:

- To apply a particular methodology: for instance the Web Accessibility Conformance Evaluation Methodology (WCAG-EM). This methodology was adopted by Rodríguez, Pérez, Cueva, & Torres (2017) who present a methodology for assessing accessibility and usability in Open CourseWare (OCW) sites.
- To use automated tools: using computer programs that are also part of the automatic evaluation.
- To use a web accessibility validation format: the use of a format that contains the guidelines and criteria for web accessibility. It allows to control over what is correct and what has to be corrected to ensure that content is accessible.
- To conduct tests with users: a sample of a group of people is taken. These people, through some planned activity, use web content and give their assessment on the problems that arise in the interaction with it.
- To do tests with other programs such as: screen readers, screen magnifiers, accessible browsers, alternative browsers, text assessors, color assessors, among others.
- Sometimes the evaluation of accessibility is also combined with usability considerations (Navarrete & Lujan-Mora, 2015).

Rodrigo & García-Serrano (2015) introduce another way of carrying out the evaluation of accessibility through an approach they call "social accessibility" referring to the fact that a group of people work together in the improvement of the accessibility of OER. This approach emerged from the experience they had in the improvement of the accessibility of the videos that teachers commonly used in their classes at the National Distance Education University (UNED) in Spain. In that experience a group of volunteers (students from the same university) participated in tasks such as: transcriptions of videos, creation of subtitles, definition of metadata, and creation of accessible documents as text-based alternatives for the videos.

2.2.4 Web accessibility in education

To date, several studies have highlighted the factors that are associated to the use of accessibility frameworks and standards in the educational context. For instance, Nevile & Treviranus (2006) describe how the interoperability works in the AccessforAll approach. Such approach takes into account the learning needs and preferences of learners as well as the description of educational resources. They also state that accessibility can be promoted when educational resources are prepared to interoperate with others.

B. Kelly et al. (2007) propose the Accessibility 2.0 framework. This framework combines what they call the tangram metaphor as an extensible solution to accessibility that vary depending on situation and the stakeholder model which is focus on how stakeholders in higher education respond to external drivers for accessibility (legislation, guidelines, and standards). They defined the framework on the basis that the WCAG do not tackle variations on the context especially when users face analysis and interpretation processes.

Sampson & Zervas (2008) present the framework and results from the eAccess2Learn project. Results include a learning design toolkit, an accessible learning objects metadata authoring toolkit, and a repository of eTraining resources and eTraining course suppliers. This framework includes accessibility requirements in the production of educational resources.

Moreno, Iglesias, Martínez, & Ruiz-Mezcua (2008) present a case study in which two prototype interfaces were created in order to provide students with a multi-modal interaction of the multimedia educational resources. In the first interface students had access to different audio and text alternatives of the multimedia content. The second interface provided students with, captioning, audio description and transcription of the multimedia content.

In their literature review about standards and trends for OER, Morales & Carrión (2010) point out three aspects for future research in the field of OER, namely accessibility standards, social components, and semantic web. As for accessibility standards they highlight the use of metadata, web accessibility (e.g. WCAG, ATAG, UAAG, WAI-ARIA), IMS and content packaged standards.

In 2011-2013 the BCDS research group participated in the ALTER-NATIVA project ("Alter-Nativa Project," 2013) as the leader of the technical work package (including the participation of the author of this thesis and UdG supervisors). The main aim of this team was to technologically support teachers in the creation accessible educational resources. Contributions to this project in terms of web accessibility included:

- An accessible infrastructure composed by: authoring tools, educational repository, a knowledge base (user profile, assistive technology, thesaurus), and a collaborative platform.
- Training sessions for teachers and in-service teachers on how to create accessible contents including the use of the accessible infrastructure and the application of the WCAG 2.0. These training sessions were supported by accessible video tutorials created also by the team.
- Accessible educational resources created by teachers participating in the training sessions.
- Accessibility tests with users including blind and deaf people.

All in all, these research studies and projects have pointed out some factors that should be considered to address web accessibility issues in the educational context such as:

- The diversity of students' learning needs (variability of the educational context).
- The influence of stakeholders (institutions, educators/teachers, students, etc.).

- Web accessibility legislations and the use of accessibility standards.
- Supporting tools for teachers and other stakeholders in charge of creating accessible educational resources.

2.3 Quality in educational resources

Quality is one of the main characteristics highlighted in the literature review about OER. Therefore, this section describes how quality is addressed in OER (subsection 2.3.1) and how quality is evaluated in OER (subsection 2.3.2).

2.3.1 Quality in open educational resources

Quality is referred to as the set of inner properties of a product or service which enables to meet the design specifications (Hoyer & Hoyer, 2001). Quality also refers to the features and characteristics of a product or service that satisfy customer needs (Pawlowski, 2007).

Based on these definitions, in the context of OER, quality is associated to the suitability of such resources for the teaching practice (Clements, Pawlowski, & Manouselis, 2014). In the same vein, Mishra & Kanwar (2015) point out that quality is associated to the relationship of the user to the OER. According to Romero & Morocho (2016), to observe the characteristics of OER is directly related to the quality of the resource. With regard to the reuse, Piedra, Chicaiza, Lopez, & Caro (2016) highlight quality as one of the factors influencing the reuse of digital material and thereby as an opportunity to improve the quality in education.

On the other hand, quality can be a subjective concept because of its relation with different factors. Cechinel & Ochoa (2014) give an overview of the quality inside learning object repositories and state that quality depends on the alignment between the user, the learning setting, and the purpose of the educational resources. These contextual elements help to understand "how useful are such resources for various actors involved in educational processes" (Vladoiu & Constantinescu, 2013).

2.3.2 Evaluation of quality

With the big amount of resources available in web environments, the need of quality controls increases (Clements & Pawlowski, 2012). An evaluation of quality can serve to know whether a product, part, organization or service meets specified requirements (Kurilovas, Bireniene, & Serikoviene, 2011). In the context of OER, the evaluation of quality is focused on certain characteristics of OER that make them appropriated for a learning context. Some studies deal with the evaluation of quality in educational resources in terms of elements such as the metadata (Ochoa & Duval, 2006) (Tabares, Duque, Ovalle, Rodríguez, & Moreno, 2013), reusability (Clements & Pawlowski, 2012; Kurilovas et al., 2011), and learning styles (J. Moreno & Defude, 2010), among others.

Considering that quality is a very subjective concept and difficult to measure (Kalayanapan, Wuwongse, & Dittawit, 2014), the increasing number of OER available in educational repositories results in the need to know how the quality of these resources is. Some studies propose different approaches or instruments to evaluate OER. For instance, Cochrane (2005) evaluates four OER by adopting the MERLOT peer review process. Kurilovas et al., (2011) introduce a quality evaluation criteria including domains such as technological (considering web accessibility criteria), pedagogical and intellectual property rights. Baldiris et al. (2014) propose an evaluation approach which consists of components (elements of the OER), dimensions (evaluation perspectives), and categories (quality metrics). Moreover, some authors state that the quality of an OER may increase when users have an active interaction with it (McGreal, Kinuthia, & Marshall, 2013).

There are different instruments to evaluate the quality in OER. For instance, Leacock and Nesbit (2007) present a framework to evaluate the quality of multimedia learning resources

defining LORI (Learning Object Review Instrument) and claiming that investing little effort and few time an evaluator can provide a meaningful and an informative review by including comments. LORI includes the following categories: content quality, learning goal alignment, feedback and adaptation, motivation, presentation and design, usability, accessibility, reusability, and standards compliance. Moreover, Sinclair et al. (2013) describe three of the most well-known instruments namely: the above mentioned LORI, the Learning Object Attribute Metric (LOAM) tool, and the Learning Object Evaluation Metric (LOEM). Particularly, LORI has been widely used to evaluate quality in educational resources because of its coverage of different criteria (e.g. Cechinel & Ochoa, 2014; Gordillo et al., 2014; Sinclair et al., 2013; Vladoiu et al., 2013; Yuan & Recker, 2015a).

Although there are some empirical studies that describe how OER meet quality requirements, these studies are not focused on how teachers evaluate those resources and how the evaluation of those resources can be used as a feedback to improve the OER. Then, further research need to be conducted to identify how teachers acquire and develop competences with respect to the evaluation of OER.

2.4 ICT competences for teachers

One direction of this research is the support that teachers require to acquire or strength their competences in the creation and evaluation of OER. This section introduces the definition of competence (subsection 2.4.1) and gives an overview of models of ICT competences for teachers (subsection 2.4.2).

2.4.1 Definition of competence

It is useful to know the elements of a competence in order to understand what a competence is. In this regard, Miller (1990) proposed a pyramid for the professional development. Although it was defined in a clinical context, it can be generalized to other contexts. The bottom of the pyramid is the *knowledge* that a person acquires in his/her professional career. Then, it is important to *know how to* use that knowledge by developing searching skills. The next step is to *demonstrate how* the knowledge is used when the professional performance is evaluated. Finally, the top of the pyramid represents the action in workplace-based experiences.

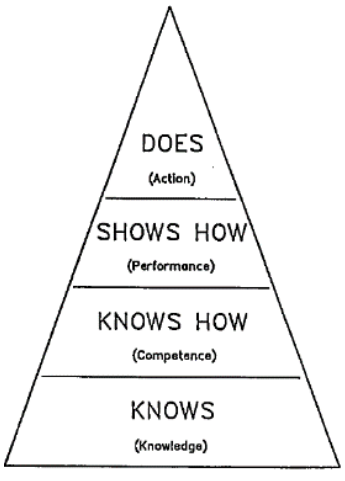


Figure 2-10. Miller's pyramid for professional development (Miller, 1990)

Definitions of competence take into account the above elements. For instance, competence "means 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" (European Commission, 2015). Another definition states that a competence

can be defined as a set of knowledge, skills, attitudes, and understandings and cognitive, social, emotional, and psychomotor dispositions related among them to facilitate the flexible and effective performance with a sense of an activity in novelty and challenging contexts (MEN, 2013). Baldiris, Graf, Fabregat, & Duque (2012) point out that a competence "defines the appropriate knowledge that a person should possess and show in a specific context". In the Information and Communication Technology (ICT) context, digital competence is the commonly term used. According to Ferrari (2012), a digital competence is "the 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".

2.4.2 Models of ICT competence for teachers

So far, the review of the literature has highlighted the role played by teachers in the creation of OER. According to Güler & Altun (2010), teachers participating as the main authors or content creators somehow increases the awareness of individual users or students about the learning contents. Thereby, teachers should acquire certain ICT competences in order to create meaningful learning contents and experiences supported by ICT tools.

According to the UNESCO ICT competence framework for teachers (ICT-CFT) (UNESCO and Microsoft, 2011), competences are related to six aspects of the work of teachers namely: understanding ICT in education, curriculum and assessment, pedagogy, ICT, organization and administration, and teacher professional learning. These aspects are tackled by means of the three approaches to teaching based on human capacity development which are: technology literacy, knowledge deepening, and knowledge creation. Table 2-8 presents the modules included in the ICT-CFT. This framework was released for first time in 2008 and then updated in 2011.

Table 2-8. UNESCO ICT competence framework for teachers (UNESCO and Microsoft, 2011)

	Technology literacy	Knowledge deepening	Knowledge creation
Understanding ICT in education	Policy awareness	Policy understanding	Policy innovation
Curriculum and assessment	Basic knowledge	Knowledge application	Knowledge society skills
Pedagogy	Integrate technology	Complex problem solving	Self-management
ICT	Basic tools	Complex tools	Pervasive tools
Organization and administration	Standard classroom	Collaborative group	Learning organizations
Teacher professional learning	Digital literacy	Manage and guide	Teacher as a model learner

Since then, some ICT competence models have been created (Table 2-9) taking into account elements such as: content creation, adaptation, learning by doing, legal issues, search of information, communities of practice, diversity, critical and reflective thinking, and learning strategies among others.

Table 2-9. Some ICT competence models

Competence Model	Description
Standards for teachers (ISTE, 2008)	This model includes performance indicators related to the role of teacher in the classroom including the use of digital tools. Aspects included are: creativity and learning of students, learning experiences and assessments in the digital era, learning and work in the digital era, digital citizen and responsibility, professional development and leadership.
Techers 2.0 (Alonso, 2010)	This model presents a list of competences related to the skills of teachers in the use of digital tools to promote collaboration among students, the teacher's autonomy, the learning by doing approach, and the sharing of educational resources.
Tasks of today's teachers (Marquès, 2011)	This model includes four dimensions: techniques, professional updating, teaching methodology, and attitudes.
Inclusive teachers profile (European Agency for Special Needs and Inclusive Education, 2012)	The core values and areas of competence in this profile are: valuing learner diversity, supporting all learners, working with others, and personal and professional development.
Common framework of the digital competence for teachers V 2.0 (INTEF, 2013)	This profile defines a set of indicators related to information, communication, content creation, information security, and problem solving.
ICT competences for the teacher's professional development (MEN, 2013)	Competences included as part of this model are: technological, pedagogical, communicative, of management, and research.
The 20 Digital Skills Every 21st Century Teacher should have (EdTech, 2015)	Main focus of these skills is the use, finding, and creation of digital contents by using digital tools.

These competence models promote that teachers should be able to use and adopt ICT tools to support learning and teaching processes as part of learning activities or in the development of innovative teaching ideas. However, very few of them have considered competences related to the creation of educational or digital contents with particular attention to the diversity of students' learning needs.

2.5 User modelling

Characteristics of teachers in terms of their competences in the creation and evaluation of OER can be represent through a user model. This section gives a standard definition of user model (subsection 2.5.1) and describes elements that are considered in the user modelling process (subsection 2.5.2).

2.5.1 Definition of user model

A user model represents essential information about each user (Brusilovsky & Millán, 2007). Baker & Yacef (2009) sate that user models represent information regarding characteristics or states such as current knowledge, motivation, meta-cognition, and attitudes.

2.5.2 User modelling process

Brusilovsky & Millán (2007) state that five aspects commonly modeled in user models are: *knowledge, interests, goals, background, and individual traits*. This topic has gained the interest of researches in the last decades and other aspects have been considered to be represented in a user model. For instance, the competences of a person in a specific context or learning domain can be represented by means of a user model. Baldiris (2012) presents a complete description of the modelling process highlighting user model types, user modelling approaches, stages of the user modelling process, and different aspects that are being modeled. Figure 2-11 summarizes her findings on the user and context modelling process.

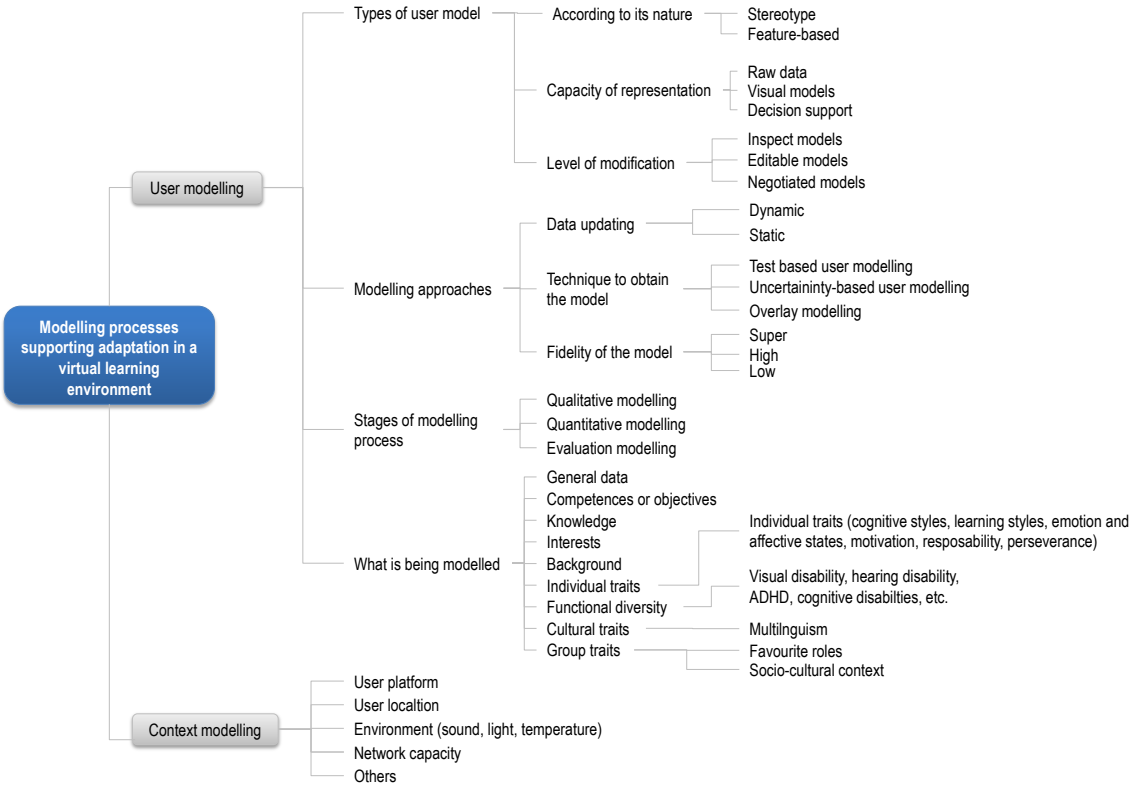


Figure 2-11. User and context modelling process (Baldiris, 2012)

The way in which the information of a user model is delivered to the user vary depending on the design of the model, the main purpose of the model, the ICT tools used, etc. For instance, when a user model aims to be used in a learning context, and the information of this model is viewed or somehow accessed by the learner, or by other users (e.g. teachers, peers, etc.), then it becomes an open user model or also known as Open Learner Model (OLM) (Susan Bull & Kay, 2010). According to Mejía (2013), the learning analytics approach can be used to give access to the learner to their user. In the same vein Chatti, Dugoija, Thus, & Schroeder (2014) state that a complete learner profile can be combined with the learning analytics approach for purposes such as intervention, adaptation, personalization, or recommendation.

In the context of user models to represent competences applying learning analytics, Chou et al. (2015) identified a lack of sufficient systematic evaluative information on students' proficiencies in core competences and this led them to introduce an open student model of core competences using learning analytics for student reflection based on competences and records of student's courses and grades. This approach can be extended to other contexts such as the ICT competences of teachers. Next section gives an overview of the learning analytics research field.

2.6 Learning Analytics

Learning analytics is the key element of the model presented in this thesis. We seek to investigate on how learning analytics can support teachers in the acquisition of competences for the creation and evaluation of OER. Thus, this section starts by giving an introduction of what learning analytics are (subsection 2.6.1), following by context of applications (subsection 2.6.2) in the creation of OER (subsection 2.6.2.1) and the monitoring of competences (subsection 2.6.2.2), and finally it describes learning analytics models reported in the literature to identify elements that are considered in such models.

2.6.1 An introduction to learning analytics

Learning analytics is a tool to measure, collect, analyze and report data about learner and his/her context (Siemens et al., 2011) and is part of the Technology-Enhanced Learning (TEL) field (Ferguson, 2013). Learning analytics serves to understand and optimize learning and teaching processes through data analysis from activities carry out by learners in a virtual environment (Van Harmelen & Workman, 2012; Vetter, 2012). An integrated system for learning analytics is presented by Siemens et al. (2011) which highlights the use of analytics to identify and process data from different modules. Although the work is oriented to learners it can also consider data management at micro level (students and their context using learning analytics) or macro level (institutional advantages considering data from learners profile, academic performance, etc., using academic analytics) (Vetter, 2012). Thus, learning analytics can be also used by academic institutions to address needs of improvement in the teaching and learning processes, and to identify if the material of learning activities also support the progress of the learner (Graf, Ives, Rahman, & Ferri, 2011).

When research is focused on learning analytics solutions, as Ferguson (2013) defines, there are four key factors when people decide to work with learning analytics: 1) to think on working with a big dataset; 2) in the online learning it is needed that teacher and learner have a way to follow or to trace the learning and teaching processes in order to define improvements; 3) institutional decisions that can be guided taking into account the individual or the institutional context; and 4) to think on who is the target population?. Moreover, there is a wide variety of techniques to generate these analytics, from statistical analysis to the use of specialized machine learning algorithms (Papamitsiou & A. Economides, 2014).

An influencing factor for the adoption of analytics is the use of visualizations of data gathered from learners' interactions on the enactment of learning scenarios (Ali, Hatala, Gašević, & Jovanović, 2012). In this regard, dashboards allow systems to show a behavioral pattern (Siemens et al., 2011) to provide learner, teacher or other stakeholders with reports used to make decisions on how to enhance learning activities (Brown, 2012).

Beyond the benefits in the adoption of the learning analytics approach, there are some issues that still remain. Slade & Prinsloo (2013) highlight different issues related with ethical concerns. They state that learning analytics can be defined when there is a clear purpose in terms of the data that is being collected and the management of these data should be transparent. It entails that stakeholders take an active role and use learning analytics results to serve learning. Moreover, they point out that the financial cost of implementation of learning analytics solutions is a big concern.

2.6.2 Contexts of application for learning analytics

Studies in the literature about learning analytics are focused in some key educational contexts such as: MOOCs (Khalil & Ebner, 2015; Lebron & Shahriar, 2015; Martínez et al., 2015), recommendation systems (Corbi & Burgos, 2015; Manso-Vázquez & Llamas-Nistal, 2015; Niemann & Wolpers, 2015), Social Network Analysis (SNA) (Casquero, Ovelar, Romo, & Benito, 2014; Hernández-García, González-González, Jiménez-Zarco, & Chaparro-Peláez, 2015; Nistor et al., 2014), learning design (Fernández-Gallego, Lama, Vidal, & Mucientes, 2013; D Hernández-Leo & Pardo, 2016; Kennedy et al., 2014; Lockyer et al., 2013; María Jesuś Rodríguez-Triana et al., 2012), retention (De Freitas et al., 2015; Goldsmith, Fulton, Witherill, & Espeleta, 2014; Slade & Prinsloo, 2013), mobile learning (N. Aljohani & Davis, 2012; G Fulantelli, Taibi, & Arrigo, 2013; Stylianidis, 2015; Tabuenca, Kalz, Drachsler, & Specht, 2015), open learner model (S Bull & Kay, 2016; Ginon, Johnson, Turker, & Kickmeier-Rust, 2016; Vatrapu, Teplovs, Fujita, & Bull, 2011), text analysis (Gašević, Mirriahi, & Dawson, 2014; Hoppe, Erkens, Clough, Daems, & Adams, 2013; Lei, Man, & Ting,

2014), and virtual worlds (Cruz-Benito et al., 2014; Cruz, Costa, Martins, Gonçalves, & Barroso, 2015; Fernández-Gallego et al., 2013) among others.

This search led us to some studies into learning analytics or monitoring solutions focused on supporting the decision-making of teachers at the creation or design time in the field of learning design. We analyzed some of those studies to identify main applications of learning analytics to support teachers and also to identify if there are studies dealing with the analytics solutions in the creation of OER. This analysis is presented in the following subsection.

2.6.2.1 Learning analytics in the creation of open educational resources

There is a growing trend towards analytics solutions in the field of educational technology. The majority of those solutions have focused on informing teachers about the interactions of their students with learning activities or learning contents (e.g Brooks, Erickson, Greer, & Gutwin, 2014; De Freitas et al., 2015; Fernandez-Delgado et al., 2014; Lockyer et al., 2013; Persico & Pozzi, 2015; María Jesuś Rodríguez-Triana et al., 2012). Besides that, learning analytics solutions provide teachers with feedback so that they can make decisions of improvement in the learning activities, learning contents, learning paths or learning strategies using the students' learning traces. A more recent study introduces the RISE (Resource Inspection, Selection, and Enhancement) framework (Bodily et al., 2017), which is focused on the continuous improvement of OER by using a metric that combines elements such as the use of the resource and the student's assessment.

According to Lori Lockyer & Dawson (2011) the integration of ICT tools and strategies in the teaching practice has created complexity in terms of implementation and evaluation learning experiences. They also state that recent research has been focused on how teachers create, share, adapt and implement educational design ideas and that teaching and research responsibilities are time consuming activities that represent a time barrier in the adoption of new ideas (Lockyer & Dawson, 2011). Thereby, a challenge is to alleviate teacher's workload by integrating learning analytics solutions that provide teachers with pedagogical recommendations and a better understanding of the learning interactions.

Nevertheless, to the best of our knowledge none of the studies on learning analytics deal with how to trace the actions carried out by teachers during the creation and evaluation of educational resources and how teachers can use such information to improve the learning contents before delivering them in a real scenario with students. The adoption of learning analytics solutions in the creation of educational resources entails providing teachers with feedback about the learning context and to consider the institutional pressures and time shortages that teachers face day-to-day (Holtham, Martin, Brown, Jawaheer, & Dove, 2012). According to Haya, Daems, Malzahn, Castellanos, & Hoppe (2015), learning analytics allows teachers to have an analytic thinking and constitutes a key tool for supporting teacher inquiry.

Some approximations towards learning analytics solutions to support teachers at the creation or design of educational resources or learning experiences are those related to monitoring mechanisms. For instance, Dyckhoff, Zielke, Bültmann, & Chatti (2012) present a learning analytics toolkit for teachers (eLAT) which is a conceptual toolkit to support teachers in the analysis of interventions and improvements for the learning scenario taking into account graphical information with regard to the content usage, students' behavior and assessment results. Lockyer et al. (2013) analyze how checkpoints and process analytics can facilitate pedagogical actions on learning designs. Such analytics provide teachers with information about student engagement which is used to redesign the learning contents when they run a course again or in a different context. In the study presented by Ruiperez-Valiente, Munoz-Merino, Gascon-Pinedo, & Kloos (2016), instructors are supported using a tool called ANALYSE that helps them to detect problems in students, educational resources,

and sections of a course by providing information regarding the students' performance inside a MOOC platform. A recent study in learning analytics solutions for OER, and particularly for open textbooks, highlights that "learning analytics for open textbooks can provide new insights into important questions such as how to assess learning outcomes based on textbook impact" (Prasad, Totaram, & Usagawa, 2016b). The conceptual framework they propose includes an analytics system that monitor students' activity in elements such as: contents viewed, usage patterns, annotations, bookmarks, etc. and then authors, teachers, learning designers, funders, etc. take this information to improve open textbooks contents.

Other studies include:

- The analysis of student behavior data (e.g. Brooks et al., 2014; Dawson & Siemens, 2014; Graf et al., 2011).
- Rodríguez et. al. (2012) 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 found such information useful to identify improvements on their learning designs.
- Lockyer et al. (2013) 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.
- Drachsler, Stoyanov, & Specht (2014) present a group concept mapping study in which they identify the impact of learning analytics in the Dutch education system according to the following areas: 1) student empowerment, 2) personalization, 3) research and learning design, 4) teacher empowerment, 5) feedback and performance, 6) risks, and 7) management and economics.
- Karkalas, Mavrikis and Labs (2016) 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. (2016) 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 different type of analytics (temporal, comparative, tool specific, cohort dynamics and contingency) related to learning events so that teachers may adapt the learning designs by analyzing students' behaviors when they use learning contents and participate in learning activities.

Overall, these studies highlight the need for providing teachers with information that help them to improve their learning contents or learning activities. There is a trend on a retrospective analysis in which teachers are informed regarding the learning traces from students' interactions with the learning activities and contents. However, there is a lack of research on how learning analytics solutions support teachers at the creation of OER using information from the creation process itself. According to Avramides, Hunter, Oliver, & Luckin (2015) little research has been done on analytics solutions to support teachers and "*the effectiveness of learning analytics tools in a school context depends on the extent to which the tools meet the teachers' inquiry requirements* " (p. 250). In the same vein Persico & 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.

On the other hand, some elements that can be considered in learning analytics solutions to support teachers in decision-making are:

- Time information is crucial to obtain a view of a person at a particular time and place (Slade & Prinsloo, 2013).
- Externalizing learning analytics to teachers may result in a good strategy to support teachers in the development of learning design activities (Tzelepi, 2014).
- Potential beneficiaries from learning analytics should be engaged with the use of analytic tools, otherwise information provided will be ignored or misinterpreted (Mor, Ferguson, & Wasson, 2015).
- Most of the LMS have storing systems to collect data related with the interaction of students with learning activities and contents, but such information is not easy to interpret by teachers. One strategy to face this issue is the adoption of learning analytics visualizations (Lockyer et al., 2013). When analytical data is given to teachers in the form of reports, teachers may claim for the use of visual representations for a better understanding on the feedback given in such reports as in the case of the LOCO-Analyst tool presented by Ali et al. (2012). But visualizations also represent a barrier when they are overloaded with information or when users need to be experts to interpret such information.
- When teachers use learning analytics tools (e.g. dashboards) they get informed on how to refine or redesign their learning activities or contents. Results from such experiences could be shared with peers as an example of good research-based educational practices (Mor et al., 2015).

Consequently, the learning analytics can be used to provide teachers with technological support in the creation and also in the evaluation of OER.

2.6.2.2 Learning analytics to support the monitoring of competences

The creation and the evaluation of OER involve a learning process and therefore the development of certain teacher's competences. In the literature, we identified some learning analytics solutions dealing with the monitoring of competences by providing solutions that allow reflection on personal knowledge, skills, or attitudes. Most of the studies conducted so far have focused on the support provided by learning analytics in the monitoring of student's competences rather than teacher's competences.

For instance, the learning analytics infrastructure for gathering data at scale introduced by Shum & Crick (2012) monitors students' competences in seven dimensions: changing and learning, critical curiosity, meaning making, creativity, resilience, learning relationships, and strategic and awareness) and authors found that the visualizations they provided allowed students to reflect on their strengths and weaknesses from such dimensions. Florian-Gaviria, Glahn, & Fabregat Gesa (2013) developed a software solution for the monitoring of the student's competences in any domain taking into account the European qualifications framework. This software provides visualizations related to the formative assessment of competences including information about the self-assessment, peer-assessment, and teacher-formative-assessment. Another example is the SCALE framework (Boulanger, Seanosky, Clemens, Kumar, & Kinshuk, 2016) which outlines a methodology to apply competence analytics in generic competences considering information from the monitoring of learning activities and student's interactions. Authors applied this framework to quantitatively assess the competence level reached by students in an English writing class and provided information related to the progress of each student and the progress in a group.

The examples mentioned above show how learning analytics solutions serve to monitor the development of student's learning competences but there are no learning analytics solutions focused on observing the teachers' competences when they are creating or evaluating OER. Thus, further research is needed to determine if learning analytics might help teachers to improve in their competences as authors and evaluators of OER.

2.6.3 Learning analytics models

Most of the learning analytics processes have a learning analytics model immersed. A learning analytics model can represent structural or procedural aspects. For instance, Chatti et al. (2012) introduce a reference model for learning analytics considering four dimensions: 1) what referring to the kind of data to gather, manage and use, 2) who considering stakeholders such us learners, teachers, tutors, mentors, researchers, systems designers, etc., 3) why defining the objectives or reasons to analyze the collected data such as monitoring and analysis, prediction and intervention, tutoring and mentoring, assessment and feedback, adaptation, personalization and recommendation, reflection, etc., and 4) how specifying the ways or strategies used to do the analysis such as statistics, visualizations, data/web mining, or social analysis network, etc.

Another example is the learning analytics cycle presented by Clow (2012), which includes four steps: 1) learners participating in a learning process, 2) capture of data from learners, 3) metrics or analytics (e.g. visualizations, dashboards, lists of 'at risk' students, comparisons of outcome measures with benchmarks or previous cohorts, aggregations, etc.) which provide some insights into the learning process, and 4) carrying out interventions as the scenarios for using the above mentioned metrics.

Greller and Drachsler (2012) introduce a generic framework for learning analytics with six dimensions namely: stakeholders, objectives, data, instruments, external limitations and internal limitations. In this framework authors also highlight the importance of describing contextual environment and expectations from the users such as the competences required.

Aljohani and Davis (2012) describe a ubiquitous learning analytics model in the mobile learning context. This model's aim is to facilitate the enhancing of learning taking into account contextual information on the student's interactions. It includes four parts: learning activities, mobile learner's data, analysis and new knowledge.

Rayon, Guenaga, & Nunez (2014) present a model for the Scalable Competence Assessment through a Learning Analytics approach (SCALA). Components of this model are: 1) data sources to collect data from learning activities, 2) a data integration system to integrate data from different sources, 3) a database to store and maintain datasets, and 4) a dashboard to display information related to the indicators of competence.

Bae, Cho, & Lee (2015) designed a reference model for learning analytics interoperability. The abstract workflow of that model includes the following parts: data collection, data storing and processing, analyzing, visualization.

Wu, Zhong, Zhou, & Ma (2016) define a dataflow for the analysis of learning data with learning analytics. This dataflow involves recording learning log data, producing learning data, and a learning analytics system engine processing, producing and using learning analytics data (e.g. visualizations in a dashboard).

Based on these studies, we considered the following as common steps in a learning analytics process:

- *Step 1 – Gathering of raw data*: data is collected from various educational systems or data sources.
- *Step 2 – Storing*: data collected is stored in a database with a data model previously defined.
- *Step 3 – Analysis*: data is retrieved from data storage systems and then passed through algorithms based on statistical analysis or machine learning techniques.
- *Step 4 - Visualization*: users are provided with reports including textual descriptions, tables or visualizations with charts that show information coming from the analytics process. These reports are commonly presented as dashboards.

We focused on these steps to define a learning analytics model to support teachers in the creation and evaluation of OER considering the accessibility and quality characteristics. This model is further described in CHAPTER 4.

2.7 Conclusions of the chapter

The first sections of this chapter presented a literature review bringing the state of the art about OER with particular attention to the creation of OER. It was divided into two parts in order to provide a general overview about OER and the elements to take into account for the creation of OER. The first part presented the most cited definitions identified in the literature regarding the concept of OER (subsection 2.1.3). After that, this chapter discussed the main characteristics of OER (subsection 2.1.3.2) taking into account the dimensions of the framework for OER proposed by Khanna & Basak, (2013): academic, financial, ethical, managerial, pedagogical, and technological. Moreover, it highlighted the benefits obtained with the adoption and use of OER (subsection 2.1.3.3) as well as challenges and issues (subsection 2.1.3.4) surrounding processes related to OER such as adoption, use, licensing, quality, context, metadata, searching, creation, and teaching practices. The last subsection of this first part (subsection 2.1.3.5) collects all initiatives reported in the literature review in order to show the growing of OER in different contexts. Those initiatives were chronologically organized.

The second part of the literature review in OER (subsection 2.1.4) is focused mainly on the creation of OER in terms of: the lifecycle of states that an OER may have (subsection 2.1.4.1); actors involved in this process (subsection 2.1.4.2); standards, instruments or protocols that have been used in the creation of learning designs or educational resources (section 2.1.4.3); the description of technologies (software tools) that are commonly used in the creation of OER (subsection2.1.4.4); an analysis of the actors, phases, tools, standards, and additional characteristics of the methodologies for the creation, use or adaptation of OER (subsection 2.1.4.5); strategies for the evaluation of OER (section 2.1.4.6); and insights from the monitoring of the creation of OER (subsection 2.1.4.7).

Latter sections of this chapter give an overview of other research topics related to this thesis, namely: web accessibility (section 2.2), quality in educational resources (section 2.3), ICT competences for teachers (section 2.4), user modelling (section 2.5) and learning analytics (section 2.6).

Some conclusions derived from this chapter are:

- *Teachers* as deliverers of learning contents are required to create educational resources considering the diversity of students' learning needs.
- When it comes to create OER that address the diversity of students' learning needs, teachers should consider characteristics such as the *web accessibility* to avoid content access barriers, and the *quality* to make learning contents more appropriate to the learning context for which the OER are intended.
- In the literature review we found that some studies recommend the use of web accessibility standards, but only one of them reports how videos used as learning materials are created considering accessibility characteristics. Moreover, we did not find studies in the creation of OER with a more complex granularity (e.g. a complete course) and that consider accessibility characteristics.
- Since quality has been highlighted as one of the most challenging characteristic to achieve when creating OER, the analysis of all the elements related to OER allowed us to identify that there are few studies that describe how OER meet quality requirements.
- The creation process also entails an evaluation process to ensure that an OER meets *web accessibility* and *quality* requirements. However, there is a lack of studies that

explore how teachers create OER considering accessibility and quality characteristics and how these resources are evaluated.

- *ICT competence* models for teachers promote the use and adoption of ICT tools to support learning and teaching processes as part of learning activities or in the development of innovative teaching ideas. However, very few competence models have considered competences related to the creation of educational or digital contents with particular attention to the diversity of students' learning needs.
- Actions in both the creation and the evaluation of OER can be included as part of the *ICT competences* for teachers. These competences can be represented by means of a *user model*. Thus, this user model can be framed into the knowledge (competence-based) associated to that particular learning context of the creation and also the evaluation of OER.
- We agree that open user models empower users to make decisions and to be more aware of their actions in learning and teaching processes.
- *Learning analytics* are being used as monitoring solutions to support teachers in the enactment of learning activities. However, such solutions are focused on the analysis of students' interactions and not on aspects related to the creation of OER itself.
- The use of monitoring solutions based on the learning analytics approach can serve to make teachers more aware of their actions and thus they can become into actionable decision-makers to improve learning contents. This can be achieved if teachers are provided with supporting tools that help them to make informed decisions.

As observed in the literature review, different studies have been carried out in the field of OER. For instance, some authors seek to analyze the impact of using open resources by comparing them with traditional printed materials and taking into account the student's interaction (Robinson et al., 2014). Other studies deal with the evaluation of quality in educational resources in terms of metadata (Tabares, V., Duque, N., Ovalle, D., Rodríguez, P., & Moreno, J., 2013), reusability (Clements & Pawlowski, 2012; Kurilovas et al., 2011), and learning styles (J. Moreno & Defude, 2010), among others.

However, to the best of or knowledge no empirical studies have been carried out that analyze data coming from the evaluation of OER while they are created. Both processes have been treated in a separate way, which means that information gathered from external evaluations of OER or from the interaction of students-OER is used for improving the OER after they are ready for production or after they have been delivered in real scenarios with students. The research conducted in this thesis differ from other studies because its focus is on teachers as authors and evaluators of OERs considering the web accessibility and quality characteristics as well as on the support that teachers may require for acquiring competences in the creation and evaluation of OER.

In terms of technologies and tools, it is also important to note that technologies such as LMS, repositories and authoring tools that provide users with options to create and evaluate OER, do not guide content creators on how to improve characteristics like the web accessibility or quality of OER while they are being created. We found only one accessibility checker plugin for web contents that enables users to check the web accessibility in vivo, which works similarly to the check accessibility option of text processors such as Word, but for web contents, showing possible accessibility errors and recommendations on how to fix them. However, that tool is a paid tool, is only based on automatic web accessibility checks, and it does not store a record of fails encountered in the web contents.

Findings from the literature review about OER and discussions about the other topics studied in this chapter opened up the possibilities for further research in this thesis. There is a need to conduct empirical studies to observe how teachers create and evaluate OER considering the web accessibility and quality characteristics of those resources and also to analyze how teachers could be supported in this process through the use of a learning

analytics solution.

The second phase in the research methodology defined for this thesis is related to the implementation of an exploratory study to identify aspects that provide a better support in the creation and the evaluation of OER when teachers are the main actors participating in this process. CHAPTER 3 presents the deployment and main conclusions derived from this exploratory study.

PART 2
EXPLORATORY STUDY

CHAPTER 3
EXPLORATORY STUDY

As concluded in the literature review (CHAPTER 2), there is a need to conduct empirical studies to observe how teachers create OER considering the web accessibility and quality characteristics of those resources and also to analyze how teachers could be supported in this process through the use of a learning analytics solution. This exploratory study focuses on four main points: 1) providing teachers with a model to create and evaluate Open Educational Resources (OER); 2) describing the evaluation scenario for this exploratory study; 3) analyzing the results obtained from the creation and the evaluation of OER in terms of accessibility and quality; and 4) presenting a theoretical mapping of the main components and actions in the creation and evaluation of OER towards an existing learning analytics framework. The study took place in 2014, within the context of a Master's degree in ICT at the Bolivarian Pontifical University in Colombia, with the participation of 72 teachers and 5 instructors. These instructors also performed as experts by giving feedback to the authors of OER during the creation and evaluation processes.

Following the **Phase II** in the research methodology applied in this thesis, this chapter presents the deployment of the exploratory study. Moreover, this exploratory study contributes to achieve the second specific objective of this thesis (***SO2*** – *To conduct an exploratory study to identify aspects that provide a better support in in the creation and evaluation of accessible open educational resources*).

The following sections describe the model to create and evaluate OER (section 3.1), the deployment (section 3.2) and results (section 3.3) from this exploratory study, and as first approximation of a learning analytics solution, section 3.4 describes a theoretical mapping towards an existing learning analytics framework. In the conclusions of this exploratory study (section 3.5) we discuss the elements to consider in a learning analytics solution and how these elements could support teachers in the acquisition of their competences in the creation and evaluation of OER.

3.1 The creation and evaluation of OER

In the study by Güler y Altun (2010), besides giving a perspective about the difficulties in the creation of digital resources, they state that the teachers' training should include the creation of educational resources and the evaluation of those resources as a relevant aspect. Moreover, apart from teachers there are other actors participating in the creation of OER. For that reason, in this exploratory study we adopted a model for the creation of OER to allow teachers to interact in a collaborative way with other teachers, experts, academic staff, students and those involved in the learning and teaching processes.

The active participation of teachers in the creation of OER fosters the advancement of different initiatives ranging from the development of authoring tools (e.g. Amara ("Amara," n.d.), Compendium ("Compendium," 2013), GLOMaker ("GLOMaker," 2009), GLUE!-PS ("GLUE!-PS," 2012), LabSpace ("LabSpace," 2012), LdShake ("LdShake," 2010), OERPub ("OERPub," 2012), OpenTapestry ("OpenTapestry," 2012), etc.) to the definition of a set of standards or guidelines that support new knowledge generation and the quality

improvement in OER (e.g. Common core – OER rubrics (Achieve Inc, 2011), OER in higher education (Commonwealth of Learning., 2011), etc.).

As discussed in CHAPTER 2, when it comes to create an OER, that addresses the diversity of students' learning needs, 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 OER are intended. Such creation process also entails an evaluation process to ensure that an OER meets such characteristics. Since OER can be created as virtual courses which include webpages with different HTML elements, the main issue in this context is that sometimes teachers require technical knowledge to identify problems on the accessibility and quality of the OER. Thereby, teachers require tools that support them in the creation and evaluation of OER.

In this exploratory study we adopted a model for the creation of OER named CO-CREARIA (described in subsection 3.1.1) and we proposed a schema for the evaluation of OER (described in subsection 3.1.2).

3.1.1 Model adopted for the creation of OER

The model we adopted for this exploratory study was CO-CREARIA[5] (by its name in Spanish) (Baldiris et al., 2015). CO-CREARIA was created during the execution of the Inclusive Learning project ("Inclusive Learning Project," 2014) by an interdisciplinary group of teachers from different European countries and specialized in fields such as design, pedagogy, informatics, and psychopedagogy. This model is based on the phases of ADDIE (Analysis, Design, Development, Implementation, and Evaluation) (Branson et al., 1975).

Other studies have also taken ADDIE as a reference to the creation of OER. For instance, in the study by Cueva, Rodríguez y Peláez (2010), authors introduce a cycle for the production of OER. This cycle extends ADDIE and includes social authorship and sematic web features. Moreover, the study by Rodríguez, Cueva y Tovar (2011) presents a set of specifications based on reusability and interoperability standards for OER. Those specifications include four phases: design, development, implementation and evaluation.

In contrast to other studies, the CO-CREARIA model suggests a creative collaboration among different actors of the creation process. This model also enriches ADDIE including features from the UDL (Meyer, Rose, & Gordon, 2014) and the Web Content Accessibility Guidelines 2.0 (W3C-WAI, 2008), establishing guidelines and clear processes to achieve the creation of OER truly inclusive and accessible.

Main actors in such creative process are: teachers or learning designers, students, decision-making institutions (e.g. government, universities, ONGs, etc.), experts in attention to diversity (e.g. psychologist, psych pedagogues, etc.), parents, among others. These actors participate in the creation of OER to favor the collective creativity and innovation to obtain OER which emerged as part of the cleverness of a team beyond individual efforts.

Following items describe Actors we considered for this exploratory study and the Phases of CO-CREARIA.

Actors

- **Author**: person who creates OER.
- **Evaluator**: evaluates the web accessibility and quality of OER.

[5] CO-CREARIA's web site: http://www.co-crearia.technology

- **Expert**: professional with knowledge in inclusion, web accessibility, and quality in educational settings who is in charge of evaluating the OER and providing feedback for authors.
- **Student**: when an author implements the OER in a real scenario with students can access to it, use it and give comments to the author for improving the learning contents and activities.

Phases of CO-CREARIA

- **Analysis**: in this phase authors define contents and the context in which the OER will be used. Besides that, the students' profile is defined including their strengths, weakness and preferences according to the UDL networks (recognition, strategic, affective) (Meyer et al., 2014).
- **Design**: in this phase authors identify possible barriers and opportunities according to the student's profile, and the detailed description of materials and methods to be included in the OER. For each material and method, authors should define: name, description, reasons for use, type of material (video, document, webpage, audio file), and accessibility elements to be included.
- **Development**: in this phase contents are developed and materials defined in the design phase are prepared. This phase suggests the use of an accessible platform such as ATutor (ATutor, 2002) in which each author creates the OER taking into account elements defined in previous phases.
- **Evaluation**: in this phase each author evaluates, in terms of accessibility and quality, the OER from other author. A web instrument was developed for each type of evaluation (accessibility and quality) linking the OER data. This evaluation process is detailed in the next subsection (3.1.2. Model for the Evaluation of OER).
- **Implementation**: in this phase the author describes the deployment scenario for the use of the OER taking into account the context features addressed in the analysis phase. Besides that, the author reports and presents results of the scenario in order to analyze the students' experience in the use of OER.

Figure 3-1 depicts the deliverables associated to the activities in each phase of CO-CREARIA.

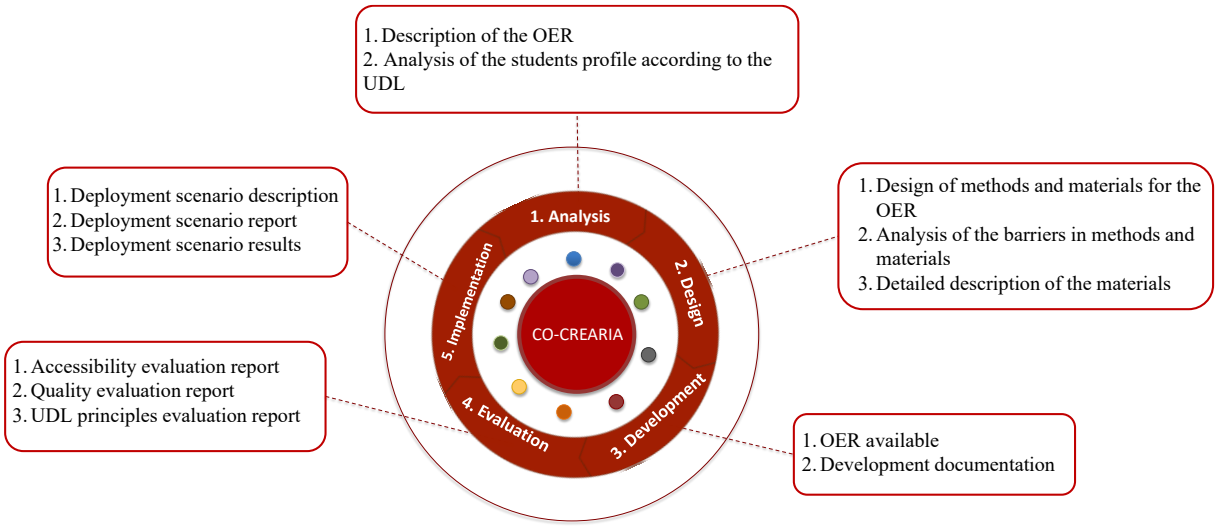


Figure 3-1. CO-CREARIA: phases and deliverables

3.1.2 Model for the Evaluation of OER

The main target of the evaluation phase, in the CO-CREARIA model, is to evaluate the OER in terms of accessibility, quality and UDL principles. Taking advantage of the collaborative vision suggested by CO-CREARIA, peer revision was the strategy adopted for the evaluation of OER in which one evaluator can evaluate one or more OER.

The evaluation of educational resources has been addressed in some studies that introduce different ways to evaluate educational resources and that can be applied for OER (Baldiris, Fabregat, et al., 2014; Cochrane, 2005; Kurilovas et al., 2011; Leacock & Nesbit, 2007) taking into account elements such as technology, pedagogy, contents, etc.

The evaluation approach we propose is an alternative for teachers to technologically support them in the evaluation process. This evaluation approach focuses on two of the main components of an OER, web accessibility and quality. Taking into account the roles in the CO-CREARIA model, teachers can play two differentiated roles. On the one hand, the role of "evaluator" (OER's evaluator), the person who evaluates an OER – created by other author – in terms of web accessibility and quality. On the other hand, the role of "author", the person who is informed with the comments/suggestions provided by the evaluators in order to make decisions on the improvement of the OER.

For the purposes of this thesis we designed and developed a tool to support the Quality and Web Accessibility Evaluation (QWAE) (Avila, Baldiris, Fabregat, & Graf, 2014). QWAE has two evaluation instruments, namely: The Web content Accessibility evaluation Instrument (WAI) and the Quality Instrument (QI). These instruments were included as part of the ATutor LMS. Figure 3-2 shows the flow chart of our evaluation approach including the use of our tool. The process begins when a teacher goes into an OER within ATutor. After that, the system validates if the teacher is the evaluator or the author of the OER. In the case of the evaluator, the system provides an access to the WAI and QI instruments. For the WAI, evaluators should select between Yes, No or Not applicable for each question, and for the QI, evaluators should assign a rating from 1 to 5 stars in each question. When an evaluator has completed an evaluation process, the system generates a report with the answers and comments given in the evaluation process. Otherwise, the system provides a link to access or download the evaluation report in a PDF format. Such evaluation report contains the results from both instruments the WAI and the QI including the question, the answer and the evaluator's comments.

The evaluation model was implemented using ATutor LMS as the virtual environment where the teacher can interact with the QWAE tool. Figure 3-3 depicts the elements of the schema of implementation for the QWAE tool.

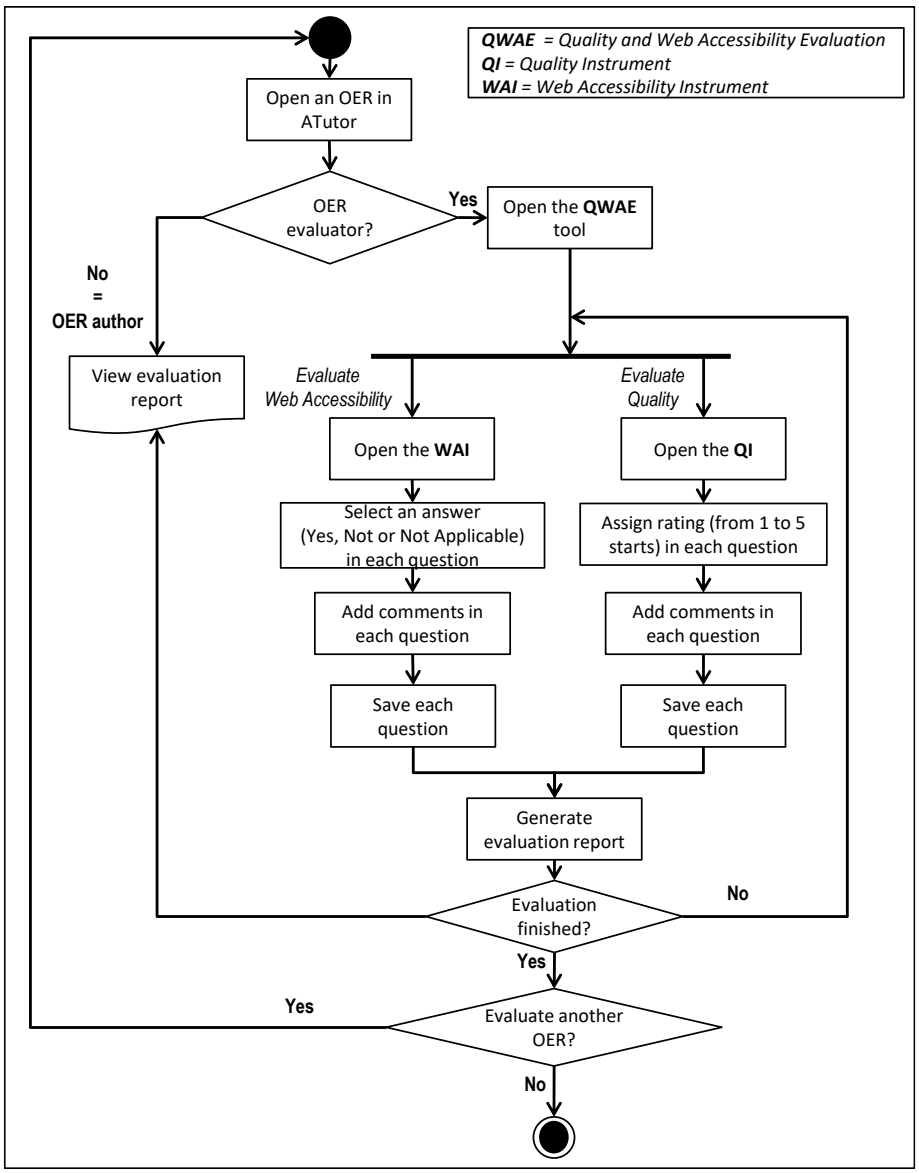


Figure 3-2. Diagram process: model for the evaluation of OER

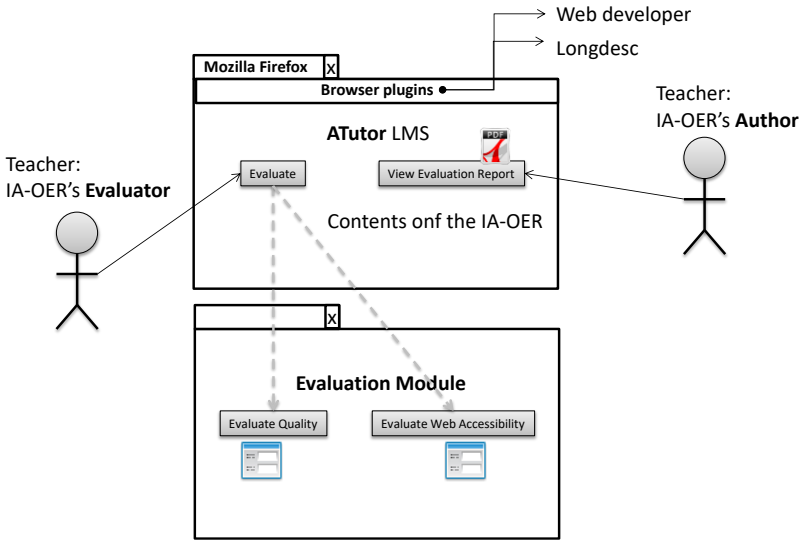


Figure 3-3. Schema of implementation for the QWAE tool

The evaluation phase was divided into two parts: an accessibility evaluation (supported by the WAI) and a quality evaluation (supported by the QI).

On the one hand, the WAI (see Figure 3-4) allows evaluators to check the compliance of the WCAG 2.0 with regard to elements that teachers included as part of the OER. The evaluation is carried out by means of a questionnaire designed for novice evaluators and it has 21 questions organized in 8 categories as presented in Table 3-1. Each category of questions corresponds with a type of web element included in the OER: headings, images, tables, links, lists, videos, abbreviations and acronyms, and definitions lists. These types of web element were selected because they are mostly used by teachers in the creation of OER. The possible answers for each question were: Yes, No, and Not Applicable. Apart from this, a field to write comments and indicate which particular content presented accessibility failures was included. To answer each question, evaluators had a guide with an explanation on how to do each step of the accessibility evaluation process. They also used other tools such as the Web Developer and Longdesc plugins, which allow evaluators to check in detail the properties in all the web elements included as part of the OER.

Although each category has more than one question, an element is considered to be accessible in a specific category when it meets the criteria evaluated in all questions of that category. For that reason, the author of an OER should pay special attention to those categories which have criteria evaluated as not accessible.

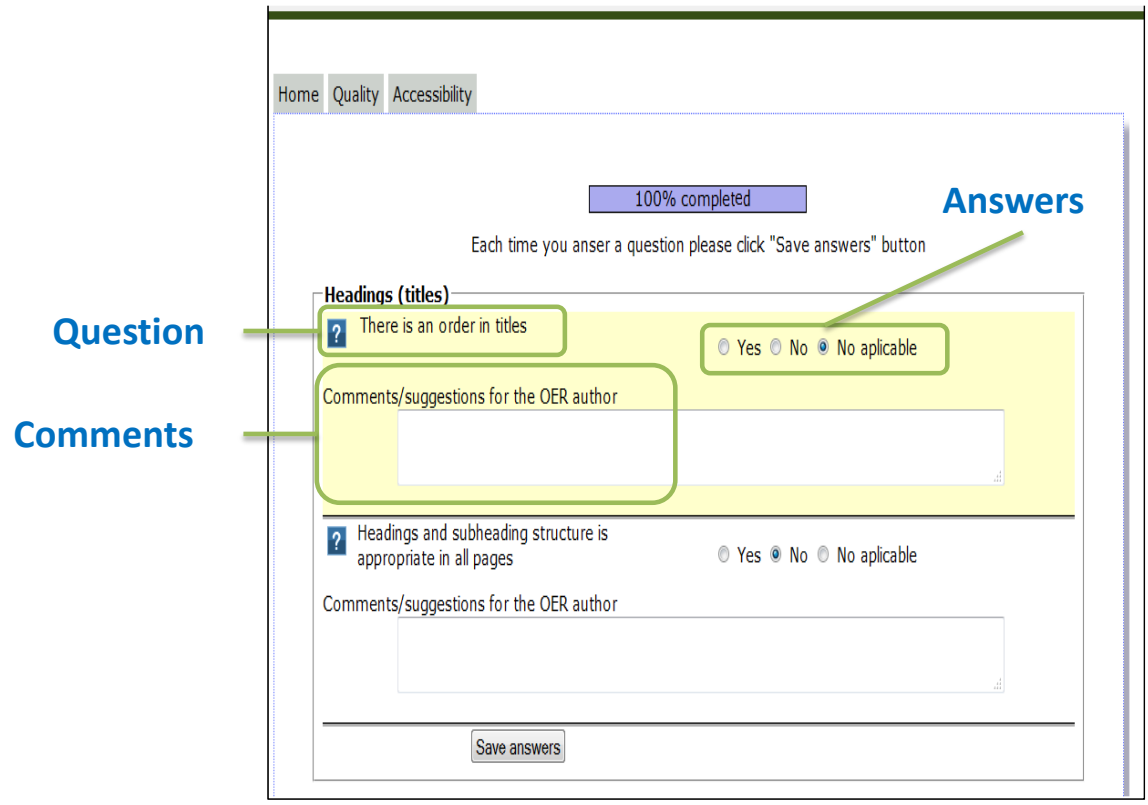


Figure 3-4. Screenshot of the Web Accessibility Instrument (WAI)

Table 3-1. Accessibility evaluation questions

Category	Question
1. Headings	1. ¿Is the order of titles respected?
	2. ¿Is the titles' hierarchy appropriated?
2. Images	3. ¿Do images have alternative text?
	4. ¿Do complex images have a long description?
	5. ¿Are those images without alternative text decorative?
3. Tables	6. ¿Do all tables have title?
	7. ¿Do all tables have summary?
	8. ¿Is appropriated the tables' summary?
	9. ¿Are there tables with decorative purposes?
	10. ¿Are headings well defined in tables?
4. Links	11. Reading the text of the links ¿is it easy to understand the purpose of links?
	12. ¿Are titles of links clear and guidance the student?
	13. ¿Are there broken links?
5. Lists	14. ¿Are lists well defined?
	15. ¿Is the use of lists justified?
6. Videos	16. ¿Is the purpose or objective of the video textually described in pages with videos?
	17. ¿Do videos have subtitles?
7. Abbreviations and acronyms	18. ¿Are abbreviations defined?
	19. ¿Are acronyms defined?
8. Definition lists	20. ¿Are terms of definition lists linked (anchor) to the main content?
	21. ¿Are definitions of terms in definition lists understandable?

On the other hand, the QI (see Figure 3-5) has 8 out of the 9 categories defined in the LORI (Learning Object Review Instrument) (Leacock & Nesbit, 2007): content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, usability, reusability, and standards compliance. The accessibility category was removed as it was incorporated as part of the WAI. A question was created for each category and the evaluator assigned a mark from 1 to 5 stars according to the criteria presented in Table 3-2. Besides that, for each question there was a field to add comments about the OER's quality.

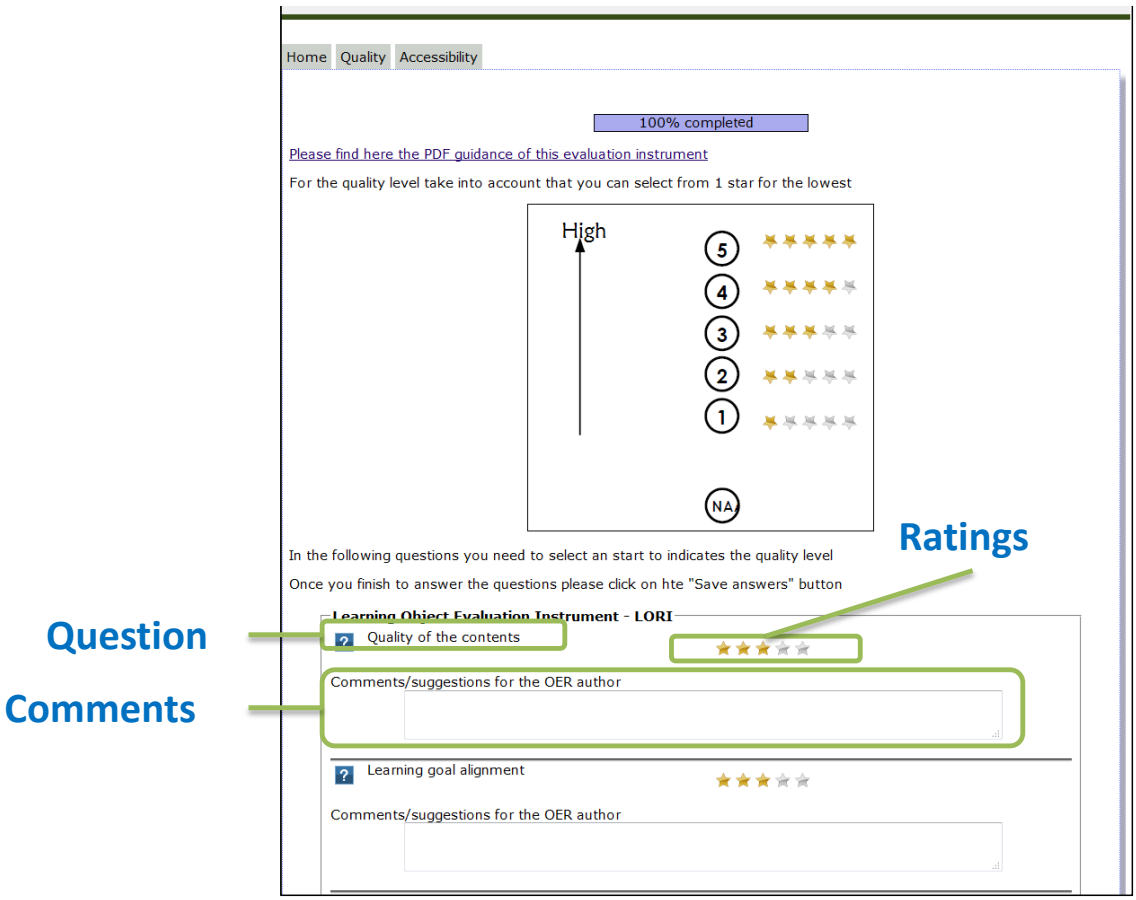


Figure 3-5. Screenshot of the Quality Instrument (QI)

Table 3-2. Quality evaluation questions

Item	Description
1. Content quality	Veracity, accuracy, balanced ideas, and appropriate level of detail.
2. Learning goal alignment	Learning goal alignment regarding to: activities, assessments, and learner characteristics.
3. Feedback and adaptation	Adaptive content or feedback according learner inputs or learning styles.
4. Motivation	Ability to motivate and engage learners.
5. Presentation design	Design of auditory and visual information for enhanced learning and efficient mental processing.
6. Usability	Ease of navigation, predictability, and interface help features.
7. Reusability	Capacity to be used in different learning settings and with diverse learners.
8. Standards compliance	Compliance of international standards and specifications.

3.2 Research design

The purpose of this exploratory study was to analyze how teachers create and evaluate OER considering the accessibility and quality characteristics. The evaluation scenario of this study was a training course delivered in the context of the Master's degree in ICT at the Bolivarian Pontifical University in Colombia. This evaluation involved the use of the CO-CREARIA model for the creation of the OER and the QWAE tool with the WAI and QI instruments by following the peer-review evaluation model we proposed in this thesis. The following subsections describe the participants in this study as well as the instruments and

procedure.

3.2.1 Participants

This study was conducted with 72 teachers (46 male y 26 female) who teach in primary and secondary grades that took the role of authors and evaluators of the OER created during the training course mentioned above. Contents of this course were developed in the context of the Inclusive Learning European Project ("Inclusive Learning Project," 2014). As the creation of OER involves the use of ICT tools, at the beginning of the training process teachers were asked about their experience in the use of ICT tools (computer, Internet, etc.). Over half of those surveyed reported to have an intermediate domain in the use of both the computer (13% expert, 77% intermediate, 10% beginner) and the Internet (8% expert, 83% intermediate, 10% beginner). Regarding the use of other tools, the most used tools are: e-mail (99%) and chat (93%), following by social networks (89%), forums (82%), blogs (78%), wikis (67%), professional networks (42%), and mobile apps (40%). Moreover, the main motivation of participants was to learn strategies for the use of ICT that allow them to improve their teaching practices and consider the inclusion of students in diversity contexts.

On the other hand, the training course had 5 instructors who also performed as experts by giving feedback to the OER authors during the creation and evaluation processes.

3.2.2 Materials

This subsection describes the materials used to collect data and carried out different activities in this study.

- Training course

  Contents of the training course were divided into the following 5 units: Unit1 – Inclusive Learning; Unit 2 – Universal Design for Learning (UDL); Unit 3 – Open Educational Resources (OER); Unit 4 – Web Accessibility; and Unit 5 – evaluation of OER. Table 3-3 presents each activity proposed for each unit of the training course with its corresponding estimated time. These activities, the learning contents of this training course and the tools used in the training course were defined and organized by the team of experts participating in the Inclusive Learning Project[6].

Table 3-3. Activities of the training course

Topic	Activity	Estimated time
Pre-test	To solve a case study related to diversity in the educational context	10 minutes
Unit 1: Inclusive Learning	To read the contents of the unit 1 and participate in the forum about inclusive learning. To select one use case from the Inclusive learning handbook and provide a new solution.	60 minutes
Unit 2: Universal Design for Learning	**CO-CREARIA: Analysis** To read the contents of the unit 2 and develop the Analysis template.	60 minutes
Unit 3: Open Educational Resources	**CO-CREARIA: Design** To read the contents of the unit 3 and develop the Design template.	60 minutes

[6] Inclusive Learning Project website: http://www.inclusive-learning.eu/

Topic	Activity	Estimated time
Unit 4: Web Accessibility	**CO-CREARIA: Development** To read the contents of the unit 4 and develop the Web Accessibility exercises. To create an OER as a virtual course in the ATutor platform.	180 minutes
Unit 5: Evaluation of OER	**CO-CREARIA: Evaluation** To participate in a peer-review evaluation by evaluating the OER created by other partner using the instruments to evaluate the accessibility (WAE) and quality (QI) of the OER.	120 minutes
Final presentation	To expose the OER in front of the group	120 minutes

- ATutor LMS

  The training course was implemented as a virtual course in the ATutor LMS and ATutor was also used as the platform in which teachers created their OER.

- Handbook

  As part of the training course teachers had access to other tools such as the Inclusive Learning Handbook for Teachers[7] (Baldiris, Avila, et al., 2014; Politis et al., 2014; Rodriguez et al., 2015). Contents of this handbook give teachers an overview of the inclusive learning topic, present some use cases related to diversity in the educational context, and include some video tutorials on how to create accessible contents using the web editor of the ATutor platform.

- Initial survey

  An initial survey was created to gather information related to the experience of teachers in the use of ICT tools.

- QWAE tool

  The QWAE tool with the WAI and QI instruments (described in subsection 3.1.2) was developed and integrated with the ATutor LMS to support teachers in the evaluation of OER.

3.2.3 Procedure

Firstly, we created an instructor account for each participant in the ATutor LMS. Then all participants were enrolled as students in the virtual training course. Sessions of this course were carried out by means of Skype.

The main target was that each teacher created and evaluated an OER in the ATutor LMS by following the phases of the model adopted for the creation (CO-CREARIA) and the model we proposed for evaluation of OER.

The training course was carried out into seven sessions described as follows:

- First session
  - Each teacher was asked to solve a case study in which a hypothetical teacher should design a learning unit for their students considering their diversity of learning needs.

[7] Inclusive Learning Handbook website: http://handbook.inclusive-learning.eu/

  - Each teacher was asked to answer the initial survey about their experience in the use of ICT tools (computer, Internet, etc.).
  - Instructors described the objective of the course and the methodology.

- Second session
  - Instructors explained to teachers the contents of the *Unit 1: Inclusive Learning*.
  - Each teacher was asked to participate in the forum of the unit 1 and to answer the question: Do you consider it is important to foster inclusive learning and teaching processes? (Explain your answer).

- Third session
  - Instructors explained to teachers the contents of *Unit 2: Universal Design for Learning (UDL)*.
  - Teachers were asked to visit the Inclusive Learning Handbook website and to choose a use case and then provide a new solution for the case.
  - Instructors explained the phases of the CO-CREARIA model and the activities on each phase.
  - Each teacher was asked to develop the template of the Analysis phase of CO-CREARIA.

- Fourth session
  - Instructors explained to teachers the contents of *Unit 3: Open Educational Resources (OER)*.
  - Each teacher was asked to develop the template of the Design phase of CO-CREARIA.

- Fifth session
  - Each teacher was asked to start with the Development phase of CO-CREARIA by creating the OER in the ATutor LMS. To do so teachers were given with a video tutorial.
  - Each teacher added a Creative Commons License to the OER.
  - Instructors explained to teachers the contents of *Unit 4: Web Accessibility*.
  - Each teacher was asked to develop web accessibility exercises which allowed them to learn how to create accessible contents in ATutor (*1. Structure of a page, 2.Enphasis in texts, 3. Footnotes and Block quotes, 4. Tables, 5. Lists of elements, 6. Styles, 7. Videos with subtitles, and 8. Text alternatives*). To do so teachers were given with a video tutorial for each exercise.

- Sixth session
  - Instructors explained to teachers the contents of Unit 5: Evaluation of OER.
  - Teachers observed a video tutorial about how to do the evaluation of an OER by following our evaluation approach.
  - Each teacher was asked to evaluate the OER created by another teacher.
  - After the evaluation, the teachers in their role of authors could access to the web accessibility and quality results through the evaluation report available in the ATutor LMS in a PDF document.

- Seventh session
  - Each teacher was asked to present the OER created in front of the group. Key points of the presentation included: a general description of the OER, the description of the learning units included in the OER, the description of the web accessibility characteristics considered and improved after the

evaluation, and the future work for the implementation phase of CO-CREARIA.

3.3 Analysis and results

This section deals with the analysis and results coming from the information gathered in the evaluation process.

3.3.1 Results from the creation of OER

The resources created by teachers (a total of 72) were focused on different thematic fields. Figure 3-6 shows the distribution of resources created by field: Social sciences (3%), English (4%), Oral communication (6%), Grammar (7%), Nature (14%), Reading (17%), Technology (15%), Math (19%), and Others (15%) related to topics such as marketing, didactics of learning, and pedagogical tools, among others. Each teacher as author selected the topic according to his/her preferences and area of expertise, and the problem identified at classroom or institution.

Although it was desirable that teachers implemented the OER with their students (the phase of implementation in CO-CREARIA), just 4 of them achieved this objective. Thus, they observed the student interactions with the OER. The rest of teachers did not use the OER with their students because of the limitations in time and physical space. Those who used the OER with their students observed an active participation and an increased interest in using the learning contents (particularly images and videos). Moreover, in the final report of the implementation scenario teachers pointed out that although the investment of time that is required to the creation of OER, they could achieve a clear understanding in the features of contents that are presented to students and in how to implement strategies focused on the strengths and weaknesses of all students.

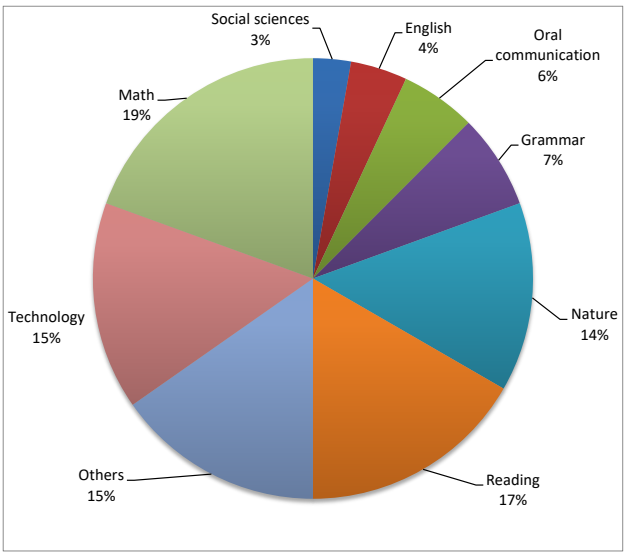


Figure 3-6. Distribution of resources created by subject

Another aspect to highlight is that teachers were always interested in improving their OER in terms of accessibility and quality by using the feedback obtained from the comments provided by the instructors, other authors, and some from the experience with their own students. Furthermore, the supporting task of instructors was a key point so that teachers received feedback in each of the phases in the creation and evaluation of OER.

3.3.2 *Results from the evaluation of accessibility*

During the evaluation process each teacher performed as evaluator of an OER created by another teacher. Figure 3-7 shows the general results obtained from the 21 accessibility questions (see Table 3-1) for the 72 OER created. Results in questions 9 and 13 were reversed because the statement of those questions is written as a negative sentence.

As mentioned before, the possible answers in these questions were "Yes", "No" or "Not Applicable". Some of the questions were not answered for some OER and this option is identified as "Without answer". Ideally the "Yes" option should cover the 100% of all OER which applied the criteria of each of the 8 accessibility categories. It would mean that according to the evaluation carried out by evaluators, all OER would be completely accessible.

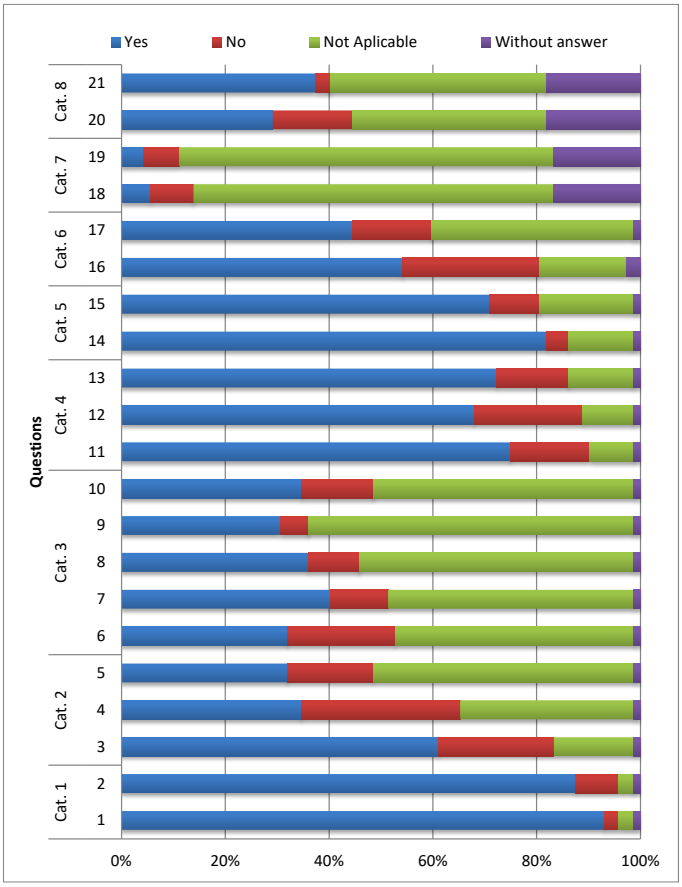


Figure 3-7. Results: evaluation of accessibility

As observed in Figure 3-7 results are positive. Results in each category are described as follows:

a) Headings (Cat. 1): headings are used to organize contents in a hierarchical way. Results indicate that 69 OER have headings. 67 out of 69 meet the order of headings and 63 out of 69 use an appropriate headings structure.

b) Images (Cat. 2): accessible images should include a short descripting text (alternative text). If an image has complex elements that require a more detailed description then a long description should be used. Moreover, those images that are used with decorative purposes should not include an alternative text. According to the results, 60 OER have images. 44 out of 60 include alternative text. Besides that, 47 OER have complex images; 25 out of 47 include a long description. The last result is due to de complexity in the process of adding a long description to an image.

Although images used with decorative purposes should not include alternative text, 29 out of 38 that have decorative images meet this criterion.

c) Tables (Cat. 3): an accessible table should include a title, a comprehensible summary, and well defined table headings indicating column or row headings. Results indicate that 38 OER have tables. 23 out of 38 have a title, 29 have a summary, 26 have a comprehensible summary, and 25 have well defined table headings. Tables are elements that allow users to present tabular information but tables must not be used with decorative purposes. According to this, just 4 OER have tables with decorative purposes.

d) Links (Cat. 4): links are accessible when they have a comprehensible text and a title that indicates the link purpose. Results indicate that 65 OER have links. 54 out of 65 have a comprehensible text, 49 have titles is a clear an advisory text and just 10 have broken links.

e) Lists (Cat. 5): lists (ordered and unordered) can be created by adding bullets in a manual way (i.e. using special characters such as asterisks and hyphens) or creating an accessible list with the editor tool provided in the platform used to create the OER. Moreover, an ordered list refers to elements that should be presented as a sequence. According to the results 62 OER include lists. 59 out of 62 have lists created by using the above mentioned tool, and in 51 lists were used properly.

f) Videos (Cat. 6): an accessible video should include subtitles and a textual description that guide users about its content and purpose. Apart from the textual description, an audio description is another element that can be included as part of a video to improve its accessibility and allow those who cannot visually perceive the characters, places, and other elements included in the video. Due to the fact that most of the teachers had little or no experience working with videos, in this evaluation scenario they work on the two first elements: subtitles and textual description. To subtitle videos teachers learnt how to use the Subtitle Edit tool, which allowed them to create a file with the subtitles that are attached when the video is added into the OER. According to the results, 58 OER have videos. 39 out of 58 have a textual description that defines its purpose, and 32 include subtitles. The OER that do not include subtitles are videos without an audio track.

g) Abbreviations and acronyms (Cat. 7): abbreviations and acronyms are the least used web element in the OER. Results indicate that 10 of the OER have abbreviations. 4 out of 10 have appropriate definitions. In the case of acronyms, 8 OER have this element, which of 3 have properly definitions.

h) Definition lists (Cat. 8): definition lists are similar to glossaries because they present the definition of different terms. In a web context definitions should be linked to the main content. Results indicate that 32 OER have definition lists. 21 out of 32 link definitions to the main content and 27 have accurate definitions.

We also analyzed web accessibility evaluation results regarding the OER thematic area (see Figure 3-8). Social sciences (54%) and grammar (61%) have the least percentage of accessible resources; meanwhile the others exceed the 70% of accessible resources.

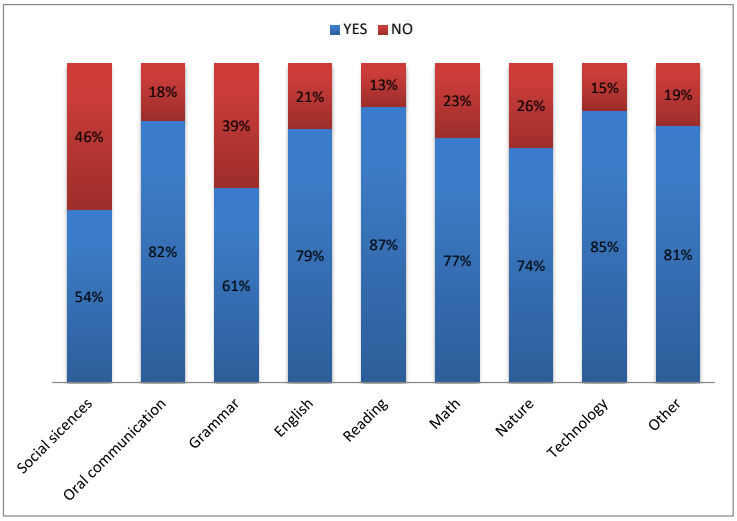


Figure 3-8. Accessibility evaluation results by topic

Table 3-4 presents an example of the comments provided by a teacher when evaluated the web accessibility of an OER.

Table 3-4. Results of the accessibility evaluation: a use case

Question	Answer			Comments
	Yes	No	NA	
1	X			Titles have a hierarchical order.
2	X			I think headings are well defined and it is not necessary to add more.
3	X			Describes the purpose of the image.
4			X	I do not see complex images, so they do not require a long description.
5			X	All images have alternative text.
6		X		Any table has a title: the first one do not have contents; the second one was used just to highlight the heading.
7		X		No, any table has the summary.
8			X	There is no summary in the tables.
9	X			Just the second table because was used to highlight a title.
10		X		This case is applied just in tables 3 and 4, but they do not have the table headings.
11	X			The text of the link highlights its purpose, but not for those links in which the text is an URL.
12	X			Titles of links, which have title, are clear.
13		X		All links redirect to the corresponding webpages.
14	X			
15		X		In those cases in which there is a list the order is not required for the items included in the lists.
16			X	There are not videos. Just links to external sites.
17			X	
18			X	I do not see abbreviations.
19			X	I do not see acronyms.
20			X	I do not see definition lists.
21			X	

3.3.3 Results from the evaluation of quality

Apart from the accessibility evaluation, teachers, in their role of evaluators, were asked to

evaluate the quality of an OER created by another teacher. Although evaluators and authors knew each other, they were sensitized that the idea was to identify those issues to improve in the OER, instead of giving the best qualification to their colleagues.

Figure 3-9 presents the results of the quality evaluation. According to these results, it can be concluded that teachers (in their evaluator role) positively evaluated the quality of the OER in each of the 8 questions because they gave between 4 and 5 stars to most of the resources and very little were evaluated with one or two stars.

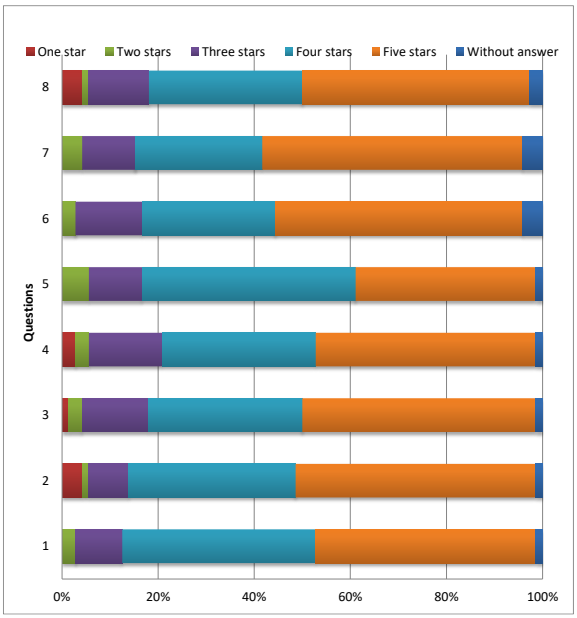


Figure 3-9. Quality evaluation results

3.3.4 Analysis of the comments provided by evaluators

A total of 775 comments were provided during the evaluation of the accessibility (279 comments) and the quality (496 comments) of the OER. Those comments were provided by evaluators after using both instruments QI and WAI, and then we classified the comments into 4 categories according to the intention of each comment. Categories were defined as follows:

- Single: phrases without detailed or extra information (e.g. “well done”, “very good”, “congratulations”, etc.)
- Reflexive: comments with detailed or extra information (e.g. “I suggest you to do an introduction about the course and presenting the objectives to achieve”).
- Lack of: comments which refers to a lack of some elements in the content without mentioning details (e.g. “There are not tables”)
- Misunderstood question: evaluators had the possibility to write something like “I don’t understand the question” for those questions they did not understand.

Each comment was labeled with one of these categories. Table 3-5 presents the results obtained in each category separated by evaluation instrument. According to these results most of comments were reflexive in both quality (81%) and accessibility (62,9%). In reflexive comments, teachers provided further information about the name of pages or specific location in which they observed some improvements for the OER.

Table 3-5. Categories of comments in the evaluation of OER

Category	QI		WAI	
	Count	%	Count	%
Single	37	13,26	89	17,94
Reflexive	226	81	312	62,90
Lack of	10	3,58	94	18,95
Misunderstood question	6	2,15	1	0,20
Total	279	100	496	100

3.3.5 Teachers' evaluation vs expert's evaluation

Since the OER created by teachers are based on web contents, teachers applied what they learnt about the WCAG 2.0 during the training course. Besides, as mentioned before each teacher evaluated the accessibility of an OER created by another teacher in a peer review process. An expert was subsequently asked to evaluate 49 out of the 72 OER by following the steps proposed by the Website Accessibility Conformance Evaluation Methodology (WCAG-EM) (W3C, 2014). This methodology allowed us to identify the level at which the OER created by teachers meet the accessibility requirements according to the expert criteria, and also to compare both the expert's evaluation and the teachers' evaluation. Each step is described as follows:

- ***Step 1 – Scope of the evaluation***

  This evaluation was focused on the web accessibility of the OER created by teachers. To evaluate the OER both teachers and the expert used a web accessibility instrument that we defined with 21 questions based on the WCAG 2.0 (see Table 3-1).

- ***Step 2 - Explore the OER***

  As mentioned before, all OER were created in the form of virtual courses in the ATutor LMS. Each OER consists of a set of webpages and each webpage has different HTML elements (paragraphs, links, tables, images, videos, etc.).

- ***Step 3 – Select a representative sample***

  We randomly selected 49 out of the 72 OER for this sample. All these OER have from 4 to 17 webpages with different HTML elements.

- ***Step 4 – Evaluate the selected sample***

  After each teacher evaluated an OER created by another teacher in a peer review process, an expert in web accessibility was asked to evaluate the web accessibility of the 49 OER in this sample by using the web accessibility instrument and the same tools used by teachers in the peer review evaluation to check some accessibility features (plugins: WebDeveloper and Longdesc).

- ***Step 5 – Report the evaluation findings***

  As a result of the expert evaluation we analysed two main aspects: the level of accessibility reached in the 49 OER according to the expert evaluation and a comparison of the answers given by both the teachers and the expert.

  On the one hand, Figure 3-10 shows the level of accessibility of the 49 OER in each category of the web accessibility instrument. The possible answers in the web accessibility instrument were Yes (YES), No (NO) and Not Applicable (NA). As observed in Figure 3-10, results from the accessibility evaluation conducted by the expert are positive.

  Results in each category are described as follows:

- Headings (Cat. 1): headings are used to organize contents in a hierarchical way. Results indicate that 89,80% of the OER meet the order of headings (Q1) and 87,76% use an appropriate headings structure (Q2).
- Images (Cat. 2): accessible images should include a short descripting text (alternative text). If an image has complex elements that require a more detailed description then a long description should be used. Moreover, those images that are used with decorative purposes should not include an alternative text. According to the results 67,35% of the OER include the alternative text in the images. Besides that, 18,37% of the images have a long description (Q4) and 40,82% do not require to have a long description. The last result is due to the complexity in the process of adding a long description to an image. Taking into account that images used with decorative purposes should not include a text in the alternative text attribute; 14,29% of the OER with decorative images (Q5) meet this criterion while 83,67% of the OER do not use decorative images.
- Tables (Cat. 3): an accessible table should include a title, a comprehensible summary, and well defined table headings indicating a scope in columns or rows accordingly. Results indicate that more than a half of the OER do not include tables, 34,69% of the OER have tables with a title (Q6) and with 36,73% of the OER have tables with an appropriate summary (Q7, Q8). However, 6,12% of the OER have tables that are used with decorative purposes (Q9) and 26,53% of the OER have tables that do not have an scope defined (Q10).
- Links (Cat. 4): links are accessible when they have a comprehensible text and a title that indicates the link purpose. Results indicate that 65,31% of the OER have links with an appropriate text (Q11), 53,06% of the OER have links with an appropriate title (Q12) and 83,67% of the OER have no broken links (Q13).
- Lists (Cat. 5): lists (ordered and unordered) can be created by adding bullets in a manual way (i.e. using special characters such as asterisks and hyphens), which is not correct in terms of accessibility or creating an accessible list with the editor tool provided in the platform used to create the OER, which is the correct way to do it. Moreover, an ordered list refers to elements that should be presented as a sequence. According to the results, 75,51% of the OER have lists of elements correctly defined (Q14) and in 61,22% of OER the ordered lists are used appropriately (Q15).
- Videos (Cat. 6): an accessible video should include at least subtitles and a textual description that guide users about its content and purpose. To subtitle videos teachers learnt how to use the Subtitle Edit tool to create a file with the subtitles that can be attached when the video is added into the OER. According to the results, 44,90% of the OER have a textual description (Q16) near to the videos and 63,27% of the OER have videos with subtitles (Q17).
- Abbreviations and acronyms (Cat. 7): abbreviations and acronyms were the least used web element in the OER. Results indicate that 87,76% of the OER did not include abbreviations and 4,08% of the OER have properly definitions for the abbreviations (Q18), similarly 75,55% of the OER did not include acronyms and 8,16% of the OER have properly definitions for the acronyms (Q19).
- Definition lists (Cat. 8): definition lists are similar to glossaries because they present the definition of different terms. In a web context, definitions should be linked to the main content. Results indicate that 83,67% of the OER did not include definition lists, 16,23% of the OER linked the terms to the main

content (Q20), and 14,29% of the OER have definitions lists with understandable definitions (Q21).

On the other hand, Figure 3-11 shows a comparison between the percentage of answers given by both the expert and the teachers. The ideal result would be that the percentage of answers given by teachers had the same percentage as the answers given by the expert. According to the results depicted in Figure 3-11 the difference between the two is not very large. The percentage in the YES answer is higher in teachers (8,47% more than in the expert). The percentage in the NO answer is lower in teachers (3,89% less than in the expert). The percentage in the NA answer is lower in teachers (9,42% less than in the expert). Although the ideal situation would be a cero percent of difference, these results are an indicator that teachers and experts agreed that OER have a good level of accessibility (YES answer) and they identified also some accessibility failures (NO answer). Thereby, the adoption of the WCAG 2.0 somehow contributed so that teachers could evaluate and identify accessibility failures in the web accessibility of the OER obtaining similar results to the expert evaluation.

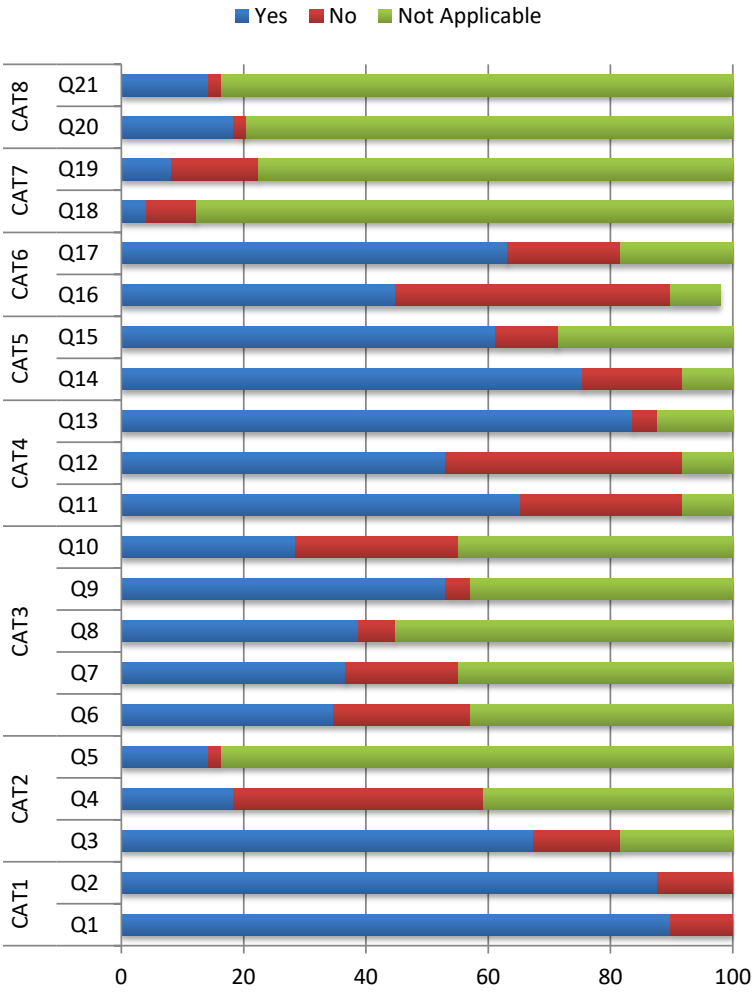


Figure 3-10. Expert's Evaluation - Overall Accessibility Results

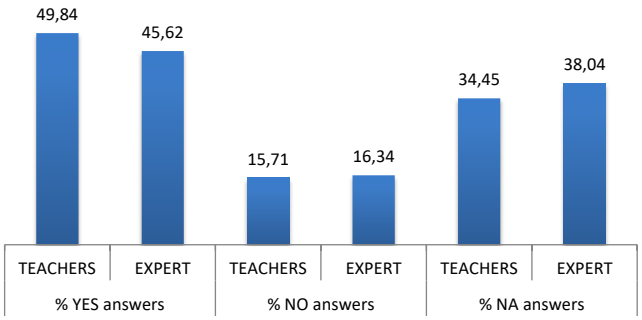


Figure 3-11. Expert's Evaluation vs Teachers Evaluation

3.3.6 Lessons learned from the evaluation

To offer truly inclusive learning processes is a current need of the educational system that is naturally diverse and which should place special emphasis on taking into account the preferences and educational needs of all students. The evaluation process of the CO-CREARIA model allow us to highlight the challenge for teachers to provide their students with inclusive, accessible and quality learning resources, coping with the access barriers that those resources may put for students. In this sense, results from the evaluation of the CO-CREARIA model suggest that teachers were able to create inclusive and accessible learning resources by following the model. They started from doing an analysis focused on the students learning needs, then designing the more appropriated methods and materials according to the learning needs identified and preferences and specifying this in the development of an OER that meets, in a technical level, the web accessibility criteria.

On the other hand, the implementation phase of the model adopted for the creation of OER fosters the delivering of learning contents in real scenarios with students. This serves so that teachers can improve their OER with the feedback of students who interact with the resources. Besides that, the evaluation of accessibility and quality of the OER gave teachers, in their role of authors, ideas for improving their own resources. However, they expected to have a more detailed report on the failures identified on their OER after the evaluation process.

3.4 Theoretical mapping the model towards the IMS Caliper analytics framework

The creation and evaluation of OER have different elements related to the context in which teachers learn how to create and evaluate OER. Likewise, a big dataset should be managed in a way that would be useful in different stages of the learning process. According to the exploratory study described in the previous section, we present a theoretical mapping of the creation and evaluation of OER towards the IMS Caliper Analytics Framework (IMS Global, 2013). This theoretical mapping is presented in Figure 3-12 and includes the following components:

1. LTI Enabled Provided/Consumers.
2. Learning Metric Profiles.
3. Representative Analytics Services/Solutions.

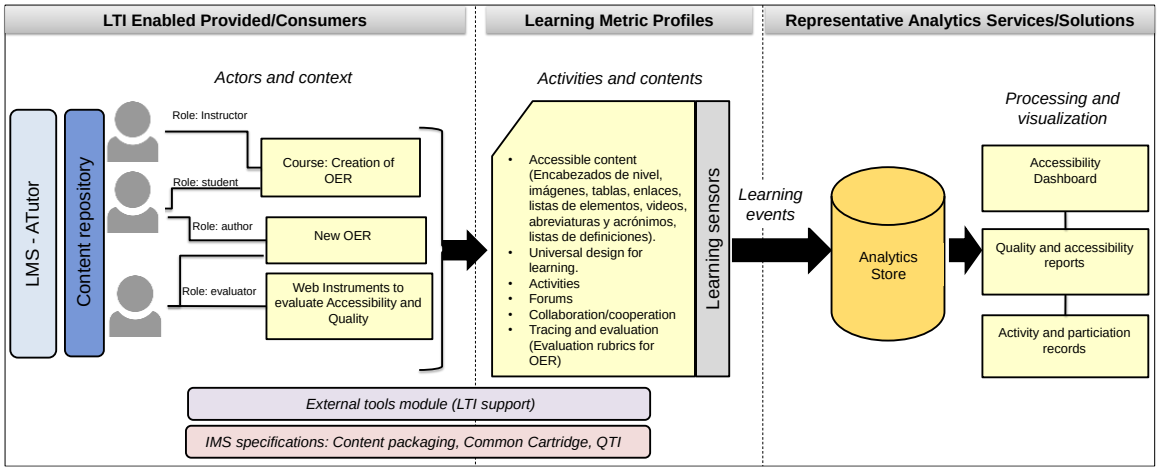


Figure 3-12. Creation and evaluation of OER: a mapping towards the IMS Caliper.

3.4.1 LTI Enabled Provided/Consumers

This component deals with the interoperability among learning tools. In this sense, the ATutor platform was used as the learning management system. This platform supports IMS specifications like the Content packaging, Common cartridge, and QTI. It has also a module for the inclusion of external tools upon the IMS LTI standard. Moreover, different participation roles were considered in the context of creation and evaluation of OER. The teacher performs the role of author to create OER. Likewise, the same teacher performs the role of evaluator when checking the accessibility and quality of an OER created by a peer.

3.4.2 Learning Metric Profiles

Activities and contents for the training of teachers are related to the creation and evaluation of OER. The interaction among teachers and other actors is a co-creation process which can be carried out through the participation in discussion forums and evaluation activities. Results from those activities act as sensors to facilitate the gathering of data in a specific context. Those sensors are activated by learning events such as the interactions in the development of learning activities.

3.4.3 Representative Analytics Services/Solutions

Learning events lead to the storage of data obtained during the development of the learning activities, in this case activities are related to the co-creation and evaluation of OER. Those data are processed and can be retrieved through the evaluation reports or the activities log.

Taking into account that one of the components proposed by the IMS Caliper are the visualization services for analytics, we developed a module for the ATutor platform called “Accessibility dashboard” which allows teacher (in the role of author) to visualize information related to the accessibility categories described in the evaluation phase: headings, images, tables, links, lists, videos, definition lists, abbreviations and acronyms (see Figure 3-13). Another section of the “Accessibility dashboard” presents analytics of the accessibility evaluation results considering the quantity of evaluations carried out and results obtained in each category regarding the other OER created (see Figure 3-14). In this section of the dashboard, each category has a specific color according to the type of answer (green for “Yes”, red for “No” and gray for “No Applicable”) so that teachers can identify those web elements that were not evaluated positively and require some improvements. Results presented in the “Accessibility dashboard” correspond with the information of the OER presented in Table 3-4. Figure 3-13 and Figure 3-14 present “Accessibility dashboard” screenshots.

Teacher can also get the evaluation report with the comments provided by the evaluators of OER. To obtain visualizations we analised data from the accessiblity evaluation considering the amount of elements, the quantity of elements, the quatity of revisions done in the OER and the answers provided by evaluators through the web instrument. To generate the graphics we use a generic function that receives the results from the accessibility evaluation in each category of the web elements. This function also use the jqPlot library ("jqPlot," n.d.) to draw the graphic.

By means of the "Accessibility dashboard" developed, teachers have a supporting tool that allow them to, from a descriptive and graphic perspective, make desicions for improving the OER in terms of accessibility.

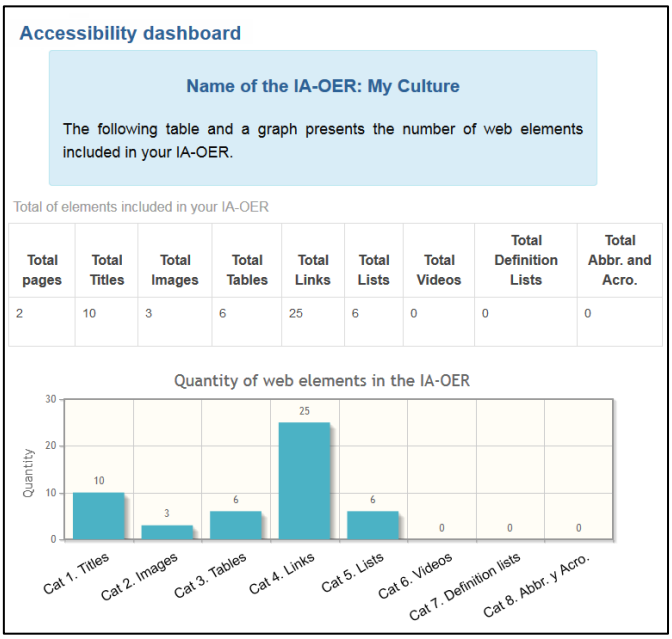


Figure 3-13. Accessibility dashboard screenshot – Information of the OER

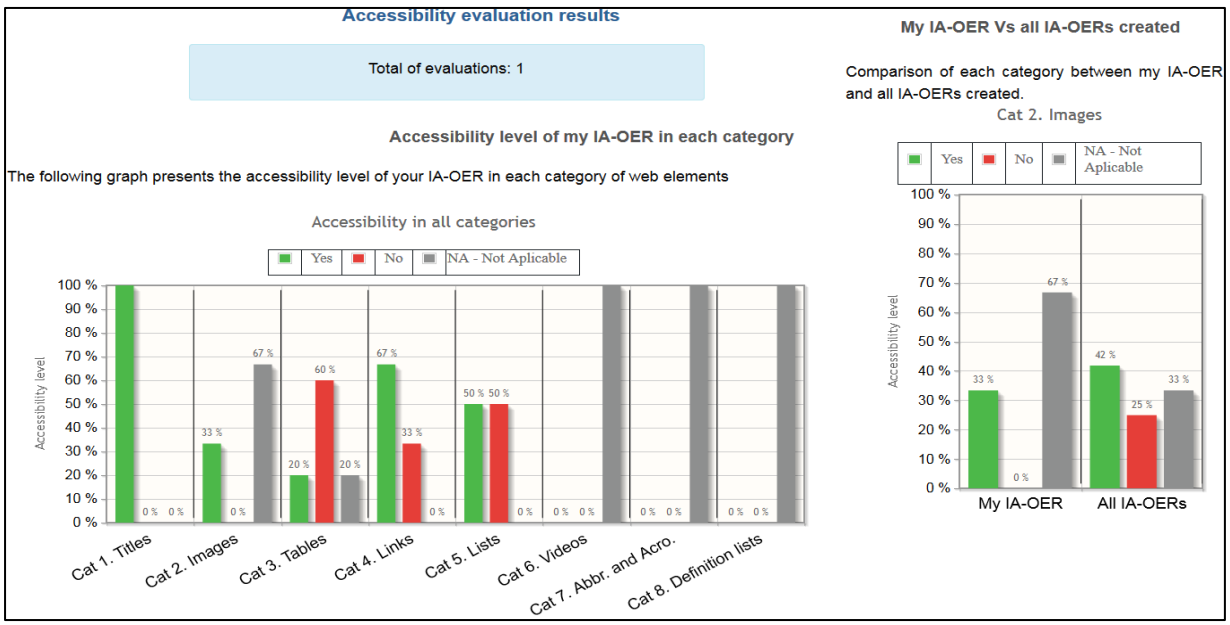


Figure 3-14. Accessibility dashboard screenshot – Accessibility evaluation results

3.5 Conclusions of the chapter

This chapter described the model we adopted for the creation of OER and the evaluation approach we defined to evaluate the OER. We also described the results obtained from the exploratory study and a theoretical mapping towards an existing learning analytics framework. Results and lessons learned from the exploratory study provides us with an initial insight into the aspects we should take into account to offer a technological support to trace the teachers' activities in the creation and evaluation of OER.

For the creation process we adopted the CO-CREARIA model which takes into account the UDL principles and the WCAG 2.0 to make the OER more inclusive and accessible. CO-CREARIA is a flexible model in which teachers are one of the main actors in the creation and evaluation of OER, and therefore activities and contents of the training process were selected and designed to help teachers in addressing the needs and preferences of all students.

As for the evaluation of OER, we presented our evaluation approach which focuses on two characteristics of an OER, accessibility and quality. It also involved the participation of teachers from two main roles: evaluator and author. This evaluation approach includes two evaluation instruments, namely WAI for the web accessibility and QI for the quality. By using these instruments, teachers answered questions related to the accessibility and the quality of OER, as well as they provided comments on each question. The fact that teachers have instruments to evaluate an OER is a way to encourage them to reflect about the need to offer OER which fits for all students and with the possibility that others could use and reuse this kind of resources to support their learning lessons. The evaluation process itself facilitated teachers to reaffirm the main characteristics they need to take into account when they are creating an OER and according to the teacher's experience accessibility and quality are not an option but are a need.

During the training course, teachers learnt and practiced on how to create OER in the form of virtual courses within the ATutor LMS. OER were created applying the phases of the CO-CREARIA model and evaluated using our evaluation approach. Teachers also highlighted several times the importance to acquire such competences as a way to address the learning needs and preferences of their students. In this context, we encourage educational institutions to include lessons about the creation and evaluation of OER as part of their curriculums in teachers' training programs. Moreover, teachers felt motivated to learn the topics of the training course and pointed out that the methodology followed to create and evaluate the OER let them to be more aware of the learning context in which they were involved.

Although teachers could see textual reports from the evaluation of the web accessibility and quality of their OER, we identified that such information could be also represented in a graphical mode. Therefore, we developed an accessibility dashboard prototype, which was integrated in the ATutor platform to facilitate the visualization of results from the accessibility evaluation. The text-based reports and the dashboard prototype allow teachers (in their role of authors) to identify improvements on the accessibility of the OER.

One of the most significant findings that emerged from this exploratory study was that the methodology used for the creation and evaluation of OER helped teachers to create OER that have a good level of accessibility and quality. Moreover, by analyzing the comments provided by teachers (as evaluators of OER), it was possible to identify that most of them felt more confident giving a reflexive comment to the OER authors rather than giving only the answer to the questions. Those comments may help authors to improve their OER.

The theoretical mapping towards the IMS Caliper learning analytics framework allowed us to identify the elements from this framework that we were considering in our approach. The

elements represented were: LTI Enabled Provided/Consumers, Learning Metric Profiles and Representative Analytics Services/Solutions.

As a result of this exploratory study we identify the following aspects that can be improved for providing teachers with a better support in the creation and evaluation of OER:

- The evaluation of web accessibility involves the use of automated tools that in most of the cases use a technical language that required some level of expertise in the use of these tools. In fact, these tools are oriented to web developers and not to teachers. Teachers could use the tools but after being instructed for using them.
- Teachers perceived that the use of these tools helped them to check if the webpages had accessibility failures but these tools do not provide assistance or guidance in the evaluation process. Doubts in the use of the tools were solved by the instructors of the training course.
- In the case of web accessibility evaluation, each question was referred to the whole OER and not to a particular element of the OER. Because of that, evaluators had to explain in detail which page of the OER had a problem, but in some cases evaluators just answered the questions without providing comments.
- Teachers (in their role of authors) received text-based reports regarding the accessibility and quality of their OER after the evaluation process, but teachers in their role of evaluators received feedback from the instructors on how they did the evaluation task. For evaluators, it is important to know how well they are doing this task and what aspects they need to improve.
- As mentioned before, in the training process teachers acquired competences in the creation and evaluation of OER but they did not have clear hints on how they were advancing in the acquisition of those competences.

Finally, the QWAE tool with the evaluation instruments (WAI and QI) and the prototype of the dashboard serve as a starting point to extend the tool to do learning analytics on the teacher competences in the creation and evaluation of OER considering the accessibility and quality characteristics. Moreover, such extension should integrate new functionalities to make a more detailed tracing of the activities derived from both the creation and evaluation of OER.

PART 3
LEARNING ANALYTICS MODEL

CHAPTER 4
DEFINITION OF THE LEARNING ANALYTICS MODEL

In the exploratory study presented in CHAPTER 3, we reported results in the creation and evaluation of OER considering web accessibility and quality as two featured characteristics of OER. The creation and the evaluation of OER are processes that involve different activities and the outcomes of such activities serve to represent the teacher's competences. Thus, we defined a learning analytics model to trace the actions carried out by teachers when they create and evaluate accessible and quality OER. In this chapter we present the definition of the Learning Analytics Model to Trace the Creation and Evaluation of OER (LAMTCE).

Following the **Phase III** in the research methodology defined for this thesis, this chapter presents the definition and documentation of the LAMTCE model. Moreover, the definition of this model contributes to achieve the third and fourth specific objectives of this thesis (***SO3*** *– To define a user model to represent the teacher's competences in the creation and evaluation of accessible open educational resources.* And ***SO4*** *– To define a learning analytics model to trace the creation and evaluation of accessible open educational resources*).

The following sections present the definition of the model describing some open issues (Section 4.1), a contextualization of the model with the roles, data sources, the flowchart of actions in the creation and evaluation of OER, and the user model of the teacher's competences defined in LAMTCE (Section 4.2), a general overview of LAMTCE (Section 4.3), and the description of each step for the analytics process in LAMTCE (Sections 4.4 – 4.7).

4.1 Introduction

Based on the findings in the literature, we found that there is a lack of research on supporting teachers in the creation and evaluation of OER before delivering them to students in a real course. Furthermore, we found that learning analytics might benefit teachers by tracing their actions in the creation and evaluation of OER considering the web accessibility and quality characteristics.

In addition to the findings from our literature review, in a previous exploratory study with teachers participating in the creation and evaluation of accessible and quality OER (Avila, Baldiris, Fabregat, & Graf, 2016) we identified the following open issues:

- The use of specialized tools to evaluate the web accessibility requires teachers to be experts. In this case we identified that teachers would benefit from supporting tools that alleviate their workload in the evaluation of OER.
- After teachers, in their role of evaluators, evaluated the web accessibility of an OER, they answered a questionnaire with web accessibility questions that were focused on all contents of the OER evaluated and give comments for each answer. However, when

the teachers who created the OER looked at the feedback from the evaluators, they could not easily identify which specific elements of the OER needed to be improved. In this regard, a more detailed evaluation, focusing on each HTML element of an OER might help to provide teachers with more detailed feedback about the accessibility of the OER.

- With the existing tools to evaluate the web accessibility, teachers in their role of evaluators only receive technical reports with the results of the evaluation but they do not have access to information on how to improve in their role as evaluators. It is important for evaluators to know how well they are doing this task and what aspects they should improve for future evaluations.

Taking into account the findings in the literature and the above mentioned open issues, we defined the Learning Analytics Model to Trace the Creation and Evaluation of OER (LAMTCE).

4.2 Contextualization

The LAMTCE model aims to trace actions carried out by teachers when they create and evaluate OER considering the web accessibility and quality characteristics. In LAMTCE the creation and evaluation of OER represent the teachers' competences. In this subsection we explain the roles, the data sources, the creation and evaluation of OER, and the user model of the teachers' competences in the LAMTCE model.

4.2.1 Roles

Each role in the LAMTCE model plays specific actions in the creation and evaluation of OER that are described as follows:

- *Author*: person who creates OER. In this context, teachers are assumed to be authors of OER.
- *Evaluator*: person who carries out the evaluation of an OER in terms of web accessibility and quality. In this context, teachers are assumed to be also evaluators of OER they have not created.
- *Expert*: person who verifies how well an evaluator evaluated an OER by verifying the answers given by the evaluator. The expert also verifies how well an author created an OER. In this case, the expert takes on the role of an evaluator to evaluate the web accessibility and quality of the OER.

4.2.2 Data sources

The data sources that are considered in the LAMTCE model are:

- *Web editor*: is an authoring tool integrated into an LMS. An author uses the web editor to create and edit the webpages of an OER. Each OER consists of one or more webpages. Within each webpage authors can add different HTML elements (text, images, links, tables, lists of elements, videos, etc.). Figure 4-1 shows the basic structure of an OER.
- *Evaluation module*: this module is divided into two parts namely accessibility evaluation and quality evaluation. Each part consists of a set of questions and each question has its answer options and a space for typing comments. An evaluator is asked to use this module to answer those questions and also to provide comments on each answer.
- *Verification module*: this module presents the answers and comments given by an evaluator to the web accessibility questions and the quality items for a specific OER, provided through the evaluation module. The verification module also has some questions to evaluate if each answer and comment given by the evaluator was

appropriate or not. An expert is asked to verify answers given by the evaluators using the verification module.

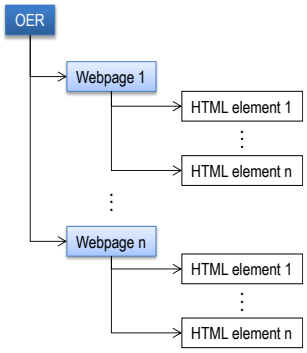


Figure 4-1. Structure of an OER.

4.2.3 The Creation and Evaluation of OER

The flowchart of actions identified in the creation and evaluation of OER is depicted in Figure 4-2.

In the LAMTCE model an author can create an OER or open and edit/delete an existing one. Once OER are created, authors add webpages to the OER and use the web editor for editing those webpages as many times as they want. During the creation, authors should consider web accessibility and quality characteristics to address the diversity of students' learning needs and to provide students with learning contents with good quality. As mentioned earlier, participating in the creation of OER might help authors to acquire and improve their competence in the creation of OER. In this regard, authors need supporting tools that help them to reflect on how well they perform as authors and one of the contributions of the LAMTCE model is to provide authors with information (by using learning analytics) about the web accessibility and quality of their OER, on one hand while they are creating the OER and on the other hand, once they have completed the creation of the OER (or the first version of them).

In the LAMTCE model, an evaluator evaluates the web accessibility and quality of an OER. An evaluator is asked to evaluating one or more OER by using the evaluation module. The evaluation process consists of an *automatic evaluation* and a *manual evaluation*. In the *automatic evaluation* the system checks the web accessibility of some properties in the HTML elements that can be verified in an automatic way. This *automatic evaluation* is carried out once the author stores changes in a webpage of the OER. 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 allow teachers to save time and work. The *manual evaluation* requires the intervention of a human evaluator. In the *manual evaluation,* an evaluator uses the evaluation module to answer a group of questions to evaluate both the web accessibility and the quality of the OER.

The web accessibility questions are based on the WCAG 2.0. We analyzed the WCAG 2.0 criteria in order to define the questions for the manual and the automatic accessibility evaluation. Table 4-1 shows the list of accessibility questions classified by WCAG 2.0 principle, HTML tag and the evaluation type. HTML tags are: *a*=links, *h*=headings, *img*=images, *object*=videos, *p*=paragraphs, *table*=tables, *ol*/*ul*=lists of elements, *abbr*=abbreviations, *acronym*=acronyms, *dl*=definition lists. The column *Evaluation type* indicates if the question is evaluated automatically by the system (*Automatic*) or by a human evaluator in the *manual evaluation* process (*Manual*). Questions related to the robust principle were not included because criteria in this principle are related to the HTML source code of the webpages and teachers do not work directly with the source code of the

webpages. Possible answers for each question are Yes, No and Not applicable. Moreover, for each accessibility question we provide a help option with further explanation and examples so that the evaluator can better understand the question.

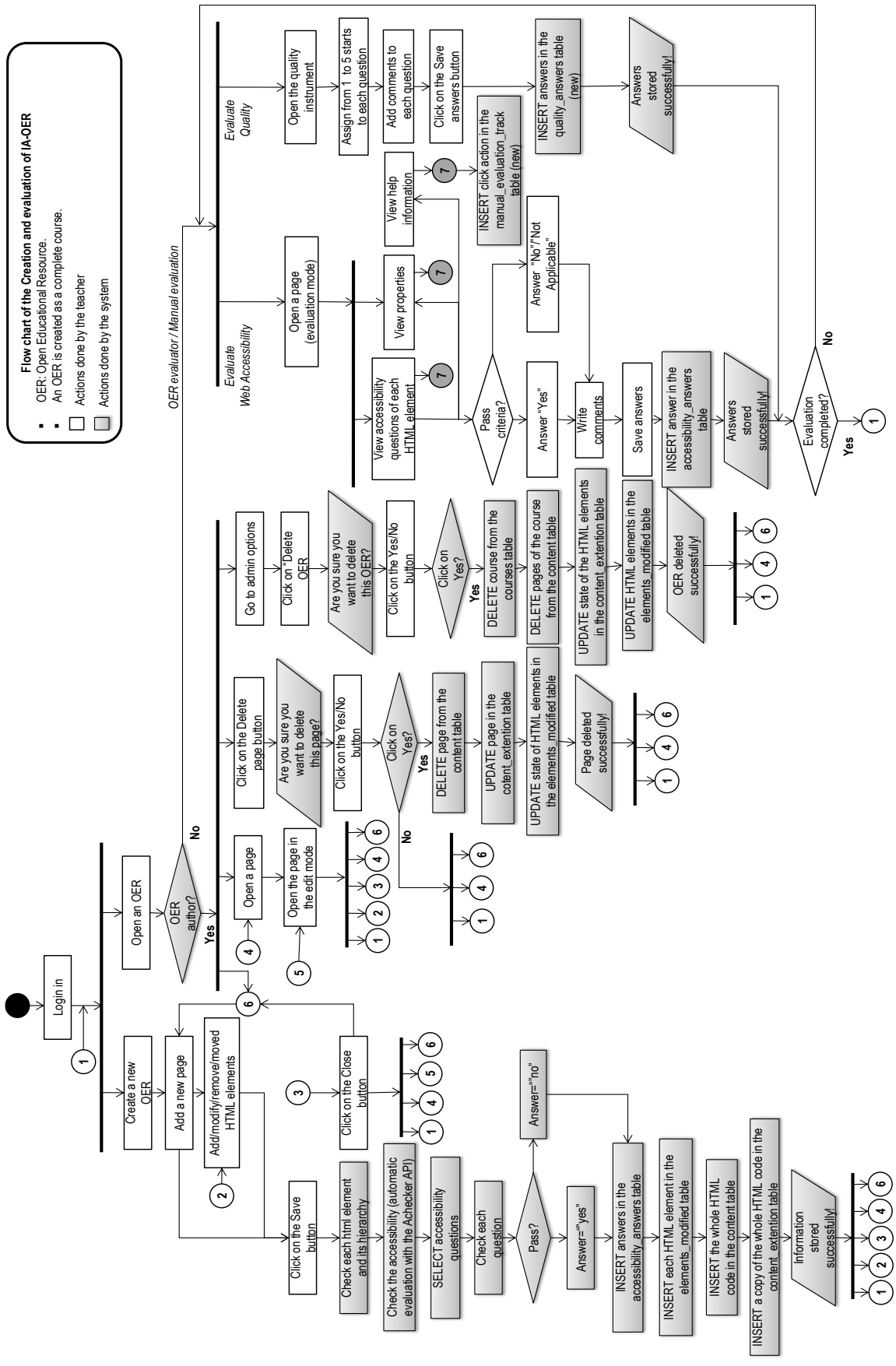


Figure 4-2. Flowchart of actions in the creation and evaluation of OER

Table 4-1. Accessibility questions – WCAG 2.0

Code	Question	HTML tag	Evaluation type
	Principle: Perceivable		
PQ1	Can the link be visibly distinguished from the rest of the text?	a	Manual
PQ2	Are the headings appropriate for the contents?	h	Manual
PQ3	Are the headings after the [H1, H2, H3, H4, H5, H6] heading correct?	h	Automatic
PQ4	Does the alternative text properly describe the main idea that is conveyed with the image?	img	Manual
PQ5	If the image is complex, does it have a long description?	img	Manual
PQ6	Does the long description describe details of the content presented in the complex image?	img	Manual
PQ7	Is this image appropriately defined as a decorative image?	img	Manual
PQ8	If the image contains text, do the text and its background have a minimum contrast ratio of 4.5:1? (contrast minimum)	img	Manual
PQ9	If the image contains text, do the text and its background have a minimum contrast ratio of 7:1? (contrast enhanced)	img	Manual
PQ10	Does the image have an alternative text?	img	Automatic
PQ11	Is the alternative text longer than 100 characters?	img	Automatic
PQ12	Is there any textual description for the video or its purpose in the paragraphs before or after the video?	object	Manual
PQ13	Does the video have subtitles?	object	Manual
PQ14	Does the video have an audio description or a link to the video transcript?	object	Manual
PQ15	If the video has an audio description, are the pauses in the audio track enough to allow the audio description to convey the information about the video?	object	Manual
PQ16	Is there any link to the subtitles file or the full description of the video?	object	Manual
PQ17	The audio of the video has no or very low background noise so the audio can be easily distinguished	object	Manual
PQ18	Is the use of the given type of list appropriate to present the information?	ol/ul	Manual
PQ19	Do the text and its background have a minimum contrast ratio of 4.5:1? (contrast minimum)	p	Manual
PQ20	Do the text and its background have a minimum contrast ratio of 7:1? (contrast enhanced)	p	Manual
PQ21	Should this text be presented as a heading?	p	Manual
PQ22	Does the table have a title?	table	Automatic
PQ23	Does the table have a summary?	table	Automatic
PQ24	Is the title appropriate for this table?	table	Manual
PQ25	Is the summary appropriate for this table?	table	Manual
PQ26	Are the column or row headers for the table properly defined?	table	Manual
PQ27	Is the table summary different from the table title?	table	Automatic
PQ28	Does the table have the headers TH?	table	Automatic
	Principle: Operable		
OQ1	Is the text of the link presented as a URL?	a	Manual
OQ2	When you read the text of the link, do you understand the purpose of the link?	a	Manual
OQ3	Does the title of the link indicate where the link redirects?	a	Manual
OQ4	Is the text of the link meaningful when it is read out of context?	a	Manual
OQ5	Does the link contain text in either in the link itself, in the title attribute of the link or in the alternative text attribute of an image used within the link?	a	Automatic
	Principle: Understandable		
UQ1	Does the title of the link describe the type of content that students will find when they open the link?	a	Manual
UQ2	Is the abbreviation well defined?	abbr	Manual
UQ3	Is the acronym well defined?	acronym	Manual
UQ4	Are the definition terms and descriptions of the definition list easy to understand?	dl	Manual
UQ5	Does the text require a specialized reading level?	p	Manual
UQ6	Is there any word that requires additional information about its pronunciation, but this information is not given?	p	Manual

As for the quality of OER we adopted the so-called Learning Object Review Instrument (LORI) (Leacock & Nesbit, 2007). LORI has 9 items namely content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, usability, accessibility, reusability, and standards compliance. In the LAMTCE model, we removed the accessibility item of LORI because the model considers the web accessibility questions presented in Table 1 which are based on the WCAG 2.0 and those questions are more detailed. In the quality evaluation, the evaluator is asked to assign 1 (lowest level of quality) to 5 (highest level of quality) stars for each item presented in Table 4-2. Moreover, for each quality item we provide a help option with a more detailed description so that the evaluator can better understand the item.

Table 4-2. Quality Items – adapted from LORI

Item	Description
1. Content quality	Veracity, accuracy, balanced ideas, and appropriate level of detail.
2. Learning goal alignment	Learning goal alignment regarding to: activities, assessments, and learner characteristics.
3. Feedback and adaptation	Adaptive content or feedback according to learner inputs or learning styles.
4. Motivation	Ability to motivate and engage learners.
5. Presentation design	Design of auditory and visual information for enhanced learning and efficient mental processing.
6. Usability	Ease of navigation, predictability, and interface help features.
7. Reusability	Capacity to be used in different learning settings and with diverse learners.
8. Standards compliance	Compliance of international standards and specifications.

4.2.4 User model: teachers' competences in the creation and evaluation of OER

The main aim of this user model is to represent the teachers' competences in the creation and evaluation of OER. These competences were defined based on the actions that teachers carry out in the creation and evaluation of OER. The competences were divided into two domains: Domain 1 (Creation of accessible and quality contents) and Domain 2 (Evaluation of the accessibility and quality of OER). For each competence domain we defined the competences including three expertise levels (beginner, intermediate, and advanced) and the required percentage of competence for each level. Table 4-3 and Table 4-4 present the competences and levels for each competence domain.

Table 4-3. Competence Domain 1: Creation of accessible and quality contents

Competence	Description	Expertise Level		
		Beginner	Intermediate	Advanced
Ability to create accessible OER	The HTML elements in the webpages of the OER meet accessibility requirements.	0%-33%	34%-66%	67%-100%
Ability to create quality OER	Contents of the OER have good quality.			

Table 4-4. Competence Domain 2 – Evaluation of the accessibility and quality of OER

Competence	Description	Expertise Level		
		Beginner	Intermediate	Advanced
Ability to evaluate the web accessibility of OER	Answers and comments given in the web accessibility evaluation are appropriate.	0%-33%	34%-66%	67%-100%
Ability to evaluate the quality of OER	Ratings and comments given in the quality evaluation are appropriate.			

4.3 General overview

In order to give a general overview of the LAMTCE model, we answered to the questions posed by Chatti et al. (Chatti et al., 2012) in their learning analytics reference model:

- *What?* – The context of application of the LAMTCE model is the process of creation and evaluation of OER considering the web accessibility and quality characteristics. The OER are created as virtual courses using the web editor of an LMS and these OER are evaluated in terms of web accessibility and quality. Data collected to do learning analytics come from the actions carried out by teachers in the creation and evaluation of OER. Such actions also represent the teachers' competences in the creation and evaluation of OER.
- *Who?* – The analytics model is focused on actors who participate in the creation and evaluation of OER including teachers, participating as authors and evaluators of OER, and experts.
- *Why?* – Teachers have the challenge to overcome the diversity of students' learning needs by providing them with accessible and quality OER. Thereby, teachers need supporting tools that help them to achieve this. The main purpose of the analytics model is to trace the activities done by teachers in the creation and evaluation of OER, and to provide feedback to teachers in their role of authors on how to improve the web accessibility and quality of the OER as well as on how to improve in their role as evaluators of OER.
- *How?* - The techniques considered to be included in the analytics model are statistics and visualizations. As for the statistics we defined a set of metrics based on the teachers' competences in the creation and evaluation of OER and based on these metrics we defined a set of visualization to be included in a dashboard.

Figure 4-3 shows the four steps of the learning analytics process for the LAMTCE model (*Step 1 - Gathering of raw data; Step 2 - Storing; Step 3 - Analysis; Step 4 - Visualization*). These steps are described in detail in subsections 4.4 – 4 .7.

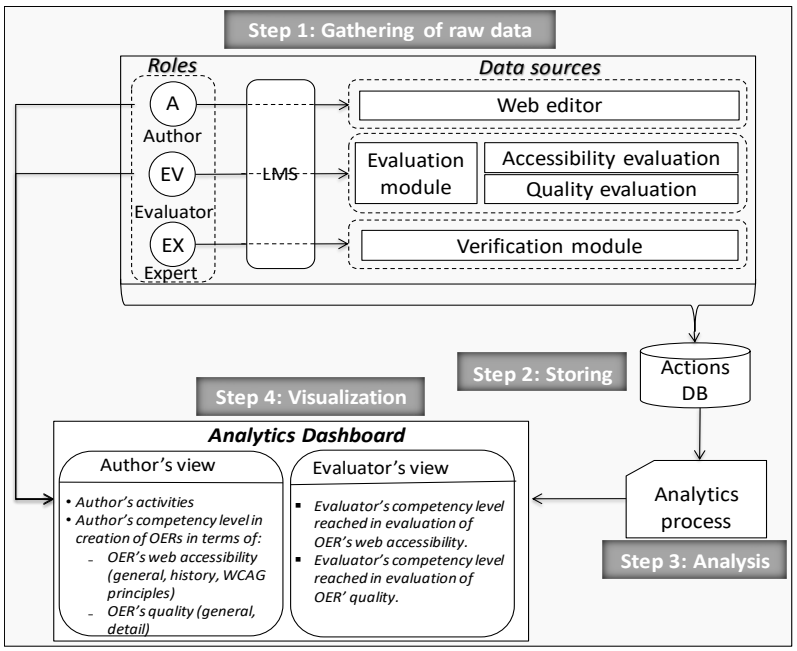


Figure 4-3. Learning analytics process in the LAMTCE model

4.4 LAMTCE – Step 1: Gathering of raw data

The raw data to be gathered come from the interaction of each role when using the data sources as explained as follows. Once an OER is created, the author can add one or more webpages in the OER. When authors use the web editor to edit the webpages of an OER, the collected data are the HTML elements that an author adds, modifies or deletes on the webpages. While the changes made in the content of a webpage are saved, the system carries out a process where changes in HTML elements are identified in terms of the position of the HTML element and the content or the attributes of the HTML element. This process is based on the analysis of the webpages' DOM structure which has been previously used in other studies such as the one conducted by Watanabe et al. (Watanabe, Dias, & Fortes, 2015) who use this strategy to identify changes in the attributes of the HTML elements.

Apart from analyzing changes in the HTML elements, an automatic web accessibility evaluation is conducted to identify whether the HTML elements present accessibility failures. This *automatic evaluation* of the web accessibility is carried out while changes are saved using the API of AChecker (AChecker, 2012) which is a tool for *automatic evaluation* of web accessibility. Data about such failures is also gathered.

Evaluators use the evaluation module to manually evaluate the web accessibility and quality of an OER. As for the accessibility evaluation, evaluators answer each one of the accessibility questions and also provide comments to each answer. Moreover, for each HTML element of a webpage in an OER, the evaluation module provides evaluators with options to see the accessibility questions, the properties of the HTML element evaluated and some more detailed description about each accessibility question. The evaluators are expected to answer the accessibility questions for each HTML element on a webpage and they can add comments to each answer. Possible answers are "yes", "no" or "not applicable".

Regarding the quality evaluation, authors rate each quality item assigning from one to five stars and provide comments for each item. Moreover, in the evaluation module evaluators have an option to consult a more detailed description about each item.

Comments from the evaluators are provided to authors as recommendations on how to improve the web accessibility and quality of their OER as a way to improve in their competence in the creation of OER.

The data to be gathered from the manual evaluation are the answers and comments from the accessibility evaluation for each HTML element evaluated and the ratings and comments from the quality evaluation for each OER evaluated.

When experts use the verification module to verify how well an evaluator evaluated an OER, they determine if each answer and the comment (in the web accessibility evaluation) and each rating and comment (in the quality evaluation) given by an evaluator were correct and appropriate respectively. Experts can also provide comments which are given to evaluators as recommendations on how to improve in their competence in the evaluation of OER. The data to be gathered from the verification module are the answers and comments provided by the expert.

4.5 LAMTCE – Step 2: Storing

The kind of raw data to be gathered was presented in the previous step by describing what happens when actors in each role use the data sources defined for the LAMTCE model.

As described in step 1, the web editor is used by authors to edit the webpages of an OER. The changes identified in the DOM structure of each webpage are stored with the state "created" (the first time an element is added), "modified" (changes in the attributes of the element), "moved" (the element changes its position in the hierarchy) or "deleted" (the element is removed). When the author deletes a webpage or a complete OER, the state of each HTML element is updated to "deleted". Fig. 4-4 depicts an example of the HTML content of a webpage, its source code and structure of the HTML elements, and the records to be stored considering those HTML elements. For each HTML element the system stores: an identifier, the html tag (p, img, table, etc.), an identifier of the webpage, the state, the modification date, the parent identifier, and the position of the element.

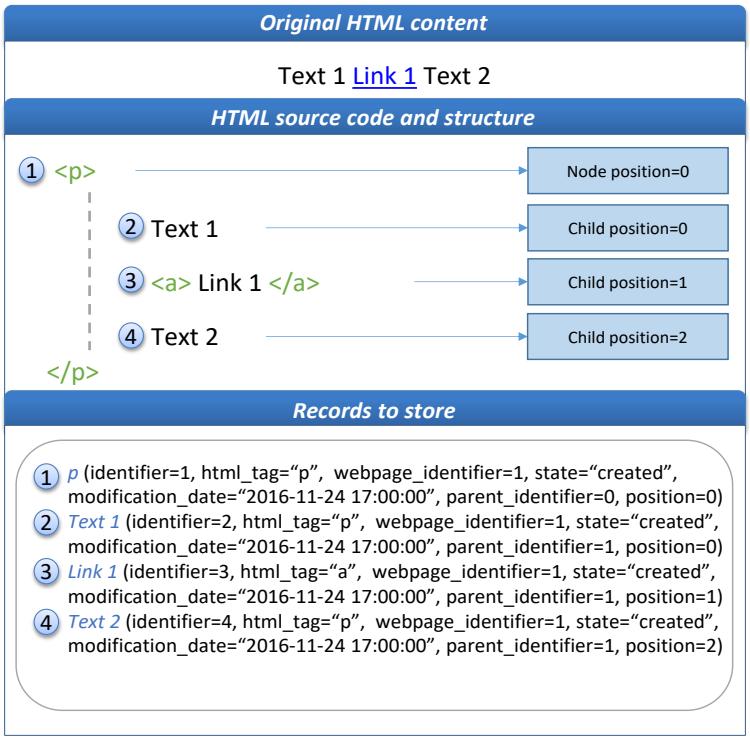


Figure 4-4. Example of the HTML structure and stored records for a webpage.

In the *automatic evaluation* of the web accessibility, data stored include information related to the questions checked by the AChecker tool (question identifier, accessibility check identifier), the identifier of the HTML element evaluated, the answers provided by the automatic validator, and the evaluation date.

In the manual accessibility evaluation, once the evaluator sends the request to store the accessibility answers for each HTML element, data stored include the evaluator identifier, the identifier of the questions answered, the identifier of the HTML elements evaluated, the answers, the comments provided by the evaluator, and the evaluation date.

In the quality evaluation, once the evaluator sends the request to store the quality ratings, data stored include the evaluator identifier, the identifier of the quality item rated, the identifier of the OER evaluated, the rating assigned, the comments provided by the evaluator, and the evaluation date.

When experts verify web accessibility and quality evaluations, the data to be stored includes the expert identifier, the identifier of the web accessibility answer or the quality rating provided by the evaluator, the answers, comments provided by the expert, and the verification date.

Based on the above description of the data to be stored we defined the data model for the LAMTCE model which is presented in Table 4-5. Its items include components such as the roles (author, evaluator, expert), elements related with the creation process (OER, webpages, HTML elements), elements related with the evaluation process (web accessibility questions, accessibility answers, quality items and quality ratings), and elements related with the verification of the evaluations.

Table 4-5. Items of the data model

Item	Data
Actor	identifier, name
Evaluator	identifier, name
Expert	identifier, name
OER	identifier, title, user_identifier_author, creation_date
Webpage	identifier, OER_identifier, user_identifier_author, html_source, modification_date
HTML element	identifier, html_tag, webpage_identifier, state, modification_date, parent_id, position
Accessibility questions	identifier, question_text, type (automatic, manual), html_tag, principle, help_text, accessibility_check_id
Accessibility answer	identifier, accessibility_question_identifier, html_element_identifier, user_identifier_evaluator, answer, comments, answer_date
Quality items	identifier, item_text, help_text
Quality rating	identifier, item_identifier, OER_identifier, rating, user_identifier_evaluator, comments, answer_date
Verification	identifier, user_identifierexpert, answer_identifier, context (accessibility, quality), verification_result, comments, verification_date

4.6 LAMTCE – Step 3: Analysis

Previous steps of LAMTCE describe the data to be gathered (step 1: Gathering of raw data) and stored (step 2: Storing). In the step 3, the gathered and stored data is retrieved to carry out the analysis. To analyze these data, two types of metrics were used, one related to general information about the quantity of HTML elements added to an OER and the other related to the teachers' competences. The latter, provides an overview of the teachers' competences in the creation and evaluation of OER. Table 6 presents the metrics classified

by type and indicating the competences. The table presents a total of 11 metrics, two metrics for the general information and nine metrics for the teachers' competences. The metrics identified with (*) in the table are used to identify the teachers' expertise level (beginner, intermediate, and advanced, as shown in Table 3 and Table 4) for each competence. The other metrics associated to the competences are additional supporting information for teachers.

Table 4-6. LAMTCE – Metrics

Type	Competence	Metric
General information	N/A	Quantity of HTML elements added by an author over time
	N/A	Quantity of HTML elements added by an author arranged by type of HTML element
Teacher's competences	Ability to create accessible OER	**Overall percentage of accessibility (*)**
		Percentage of accessibility by type of HTML element
		Overall percentage of accessibility over time
		Overall percentage of accessibility by WCAG principle
	Ability to create quality OER	**Overall percentage of quality (*)**
		Overall quality rating
		Quality rating by quality item
	Ability to evaluate the web accessibility of OER	**Percentage of correct answers in the accessibility evaluation (*)**
	Ability to evaluate the quality of OER	**Percentage of appropriate ratings in the quality evaluation (*)**

Each one of these metrics is described as follows:

- *Quantity of HTML elements added by an author over time*: this metric is calculated based on the total quantity of elements that an author adds to an OER in different modification dates (days in which the author modifies the contents of the OER). To calculate this quantity we get all modification dates and then we sum all elements added by an author on each modification date. This information can be taken from the activity logs registered in the Actions database.
- *Quantity of HTML elements added by an author arranged by type of HTML element*: this metric is calculated based on the total quantity of elements that an author adds to an OER by type of HTML element (paragraphs, images, links, etc.). To calculate this quantity we sum all HTML elements that an author adds to the OER by type of element. This information can be taken from the activity logs registered in the Actions database.
- *Overall percentage of accessibility*: this metric is calculated based on the accessibility questions that have been answered for the whole OER and the number of evaluators who answered each question. Formula 1 is used to calculate the percentage of all accessibility answers given to an OER, where *NAccQ* is the total number of questions answered for the OER, *NAccA* is the total number of answers for accessibility questions, *NEQi* is the total number of evaluators per question *i*, *AccjQi* is the answer *j* to the question *i, n* is the total number of answers per question. Taking into account that the answers of each accessibility question are given as passed or fail, a passed answer is represented as 1 and a fail answer is represented as 0. Formula 2 is used to calculate this metric. To use this formula, we need to obtain all the answers given to the accessibility questions for the whole OER.

$$\frac{\sum_{i=1}^{NAccQ} \frac{\sum_{j=1}^{n} Acc_j Q_i}{NEQ_i}}{NAccQ} * 100 \quad (1)$$

- *Percentage of accessibility by type of HTML element*: this metric is calculated for each type of HTML element, using only data from accessibility questions that have been answered for that type of HTML element (*NAccQte*) and the number of evaluators who answered each question *NEQi*. Formula 2 is used to calculate this metric.

$$\frac{\sum_{i=1}^{NAccQ_{te}} \frac{\sum_{j=1}^{n} A_{CCj} Q_i}{NEQ_i}}{NAccQ_{te}} * 100 \quad (2)$$

- *Overall percentage of accessibility over time*: this metric is calculated for each day of an evaluation, using only data from accessibility questions that have been answered on that day for every type of HTML element included in the OER (*NAccQde*) and the total number of evaluators who answered each question *NEQi*. Formula 3 is used to calculate this metric.

$$\frac{\sum_{i=1}^{NAccQ_{de}} \frac{\sum_{j=1}^{n} Acc_j Q_i}{NEQ_i}}{NAccQ_{de}} * 100 \quad (3)$$

- *Overall percentage of accessibility by WCAG principle*: this metric is calculated for each WCAG principle, using only data from accessibility questions that have been answered for each WCAG principle (*NAccQwp*) and the total number of evaluators who answered each question *NEQi*. Formula 4 is used to calculate this metric.

$$\frac{\sum_{i=1}^{NAccQ_{wp}} \frac{\sum_{j=1}^{n} A_{ccj} Q_i}{NEQ_i}}{NAccQ_{wp}} * 100 \quad (4)$$

- *Overall percentage of quality*: this metric is calculated for each OER, using only data from quality ratings (*QualR*) assigned to each quality item *j* and the total number of evaluators (*NEO*) who rated each quality item *j*. Each quality rating (*QualR*) is a number of stars from 1 to 5. There are 8 quality items leading to a maximum of 40 stars. Formula 5 is used to calculate this metric.

$$\frac{\sum_{i=1}^{NEO} \frac{\sum_{j=1}^{8} QualR_j}{40}}{NEO} * 100 \quad (5)$$

- *Overall quality rating*: this metric is calculated for each OER, using only data from quality ratings (*QualR*) assigned to each quality item *j* and the total number of evaluators (*NEO*) of that OER. Formula 6 is used to calculate this metric.

$$\frac{\sum_{i=1}^{NEO} \frac{\sum_{j=1}^{8} QualR_j}{40}}{NEO} \quad (6)$$

- *Quality rating by quality item*: this metric is calculated for each quality item, using only data from quality ratings (*QualR*) and the total number of evaluators (*NEO*) of that quality item. Formula 7 is used to calculate this metric.

$$\frac{\sum_{i=1}^{NEO} QualR_i}{NEO} \quad (7)$$

- *Percentage of correct answers in the accessibility evaluation*: this metric is calculated per day of evaluation for each evaluator. Data come from the total of correct answers to the web accessibility questions (*TCAccA*) and the total of answers given by the evaluator (*TAccA*) in a specific day. The system calculates the *TCAccA* using the decision tree depicted in Figure 4-5, by analyzing each web accessibility answer given by the evaluator (possible accessibility answers are passed or not passed) and the answer given by the expert to determine whether the evaluator's accessibility answer was correct (1 in the decision tree) or incorrect (0 in the decision tree). Formula 8 is used to calculate this metric.

$$\frac{TCAccA}{TAccA} * 100 \quad (8)$$

- *Percentage of appropriate ratings in the quality evaluation*: this metric is calculated per day of evaluation for each evaluator. Data come from the total of appropriate quality ratings (*TAQualR*) and the total of quality ratings (*TQualR*) given by the evaluator in a specific day. The system calculates the *TAQualR* using the decision tree depicted in Figure 4-6 determining if whether the each quality rating (possible ratings can be from 1 to 5 stars) was appropriate (1 in the decision tree) or not appropriate (0 in the decision tree). Formula 9 is used to calculate this metric.

$$\frac{TAQualR}{TQualR} * 100 \quad (9)$$

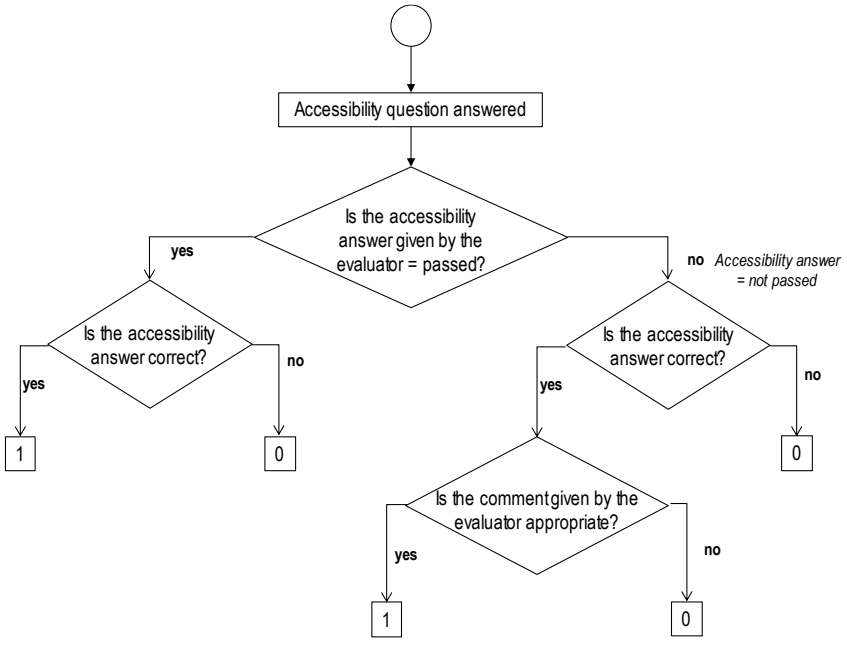


Figure 4-5.Decision tree for determining correct web accessibility answers

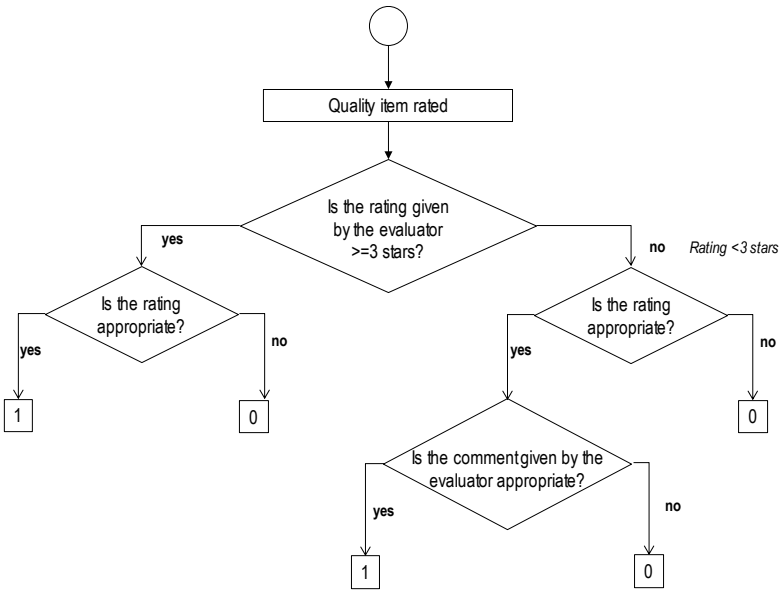


Figure 4-6. Decision tree for determining appropriate quality ratings

4.7 LAMTCE – Step 4: Visualization

The outputs of step 3 are the results of calculating the metrics presented in Table 6. These outputs are the inputs to generate the visualizations in this step. The visualizations are intended to provide teachers with information about the web accessibility and quality of their OER as an indicator of the competence in the creation of OER, as well as for informing them about how well they evaluated OER in terms of web accessibility and quality as an indicator of their competence in the evaluation of OER. The visualizations were divided into the following two groups:

1. Visualizations for the author (author's view):
    - Visualizations related to general information of the OER. These visualizations represent the quantity of HTML elements added by an author during the creation of the OER and the quantity of those elements classified by type of HTML element.
    - Visualizations related to the web accessibility of the OER created by an author. These visualizations represent the level of accessibility reached by an OER and thereby the level of competence reached by an author in the ability to create accessible OER.
    - Visualizations related to the quality of the OER created by an author. These visualizations represent the level of quality reached by an OER and thereby the level of competence reached by an author in the ability to create quality OER.
2. Visualizations for the evaluator (evaluator's view):
    - Visualizations related to the level reached by the evaluator regarding the web accessibility evaluation. These visualizations represent the level reached by an evaluator in the ability to evaluate the web accessibility of OER.
    - Visualizations related to the level reached by the evaluator regarding the quality evaluation. These visualizations represent the level reached by an evaluator in the ability to evaluate the quality of OER.

Table 4-7 presents the specific visualizations for each group with their corresponding metric, visualization title and type of chart. These visualizations are accompanied with text-

based reports giving teachers the recommendations provided by evaluators or experts in the evaluation or verification of those evaluations respectively.

Table 4-7. LAMTCE – Metrics and visualizations

Group		Metric	Visualization title	Type of chart
1. Author's view	General	Quantity of HTML elements added by an author over time	Your activity	Date axes chart
		Quantity of HTML elements added by an author arranged by type of HTML element	Elements in the OER	Bar chart
	Web accessibility	Overall percentage of accessibility	Overall accessibility	Gauge meter
		Percentage of accessibility by type of HTML element	Accessibility by type of element	Bar chart
		Overall percentage of accessibility over time	Accessibility history	Date axes chart
		Overall percentage of accessibility by WCAG principle	WCAG principles	Donut chart
	Quality	Overall percentage of quality	Overall quality	Gauge meter
		Overall quality rating	General quality	Rating stars
		Quality rating by quality item	Categories detail	Rating stars
2. Evaluator's view		Percentage of correct answers in the accessibility evaluation	Accessibility evaluation	Gauge meter
		Percentage of apppropriate ratings in the quality evaluation	Quality evaluation	Gauge meter

4.8 Conclusions of the chapter

The LAMTCE model presented in this chapter is aimed to trace the teacher's actions derived from the creation and evaluation of OER. This model was built through four steps for the learning analytics process in the creation and evaluation of OER. The step 1 (*Gathering of raw data*) describes the kind of data to be gathered according to the roles and data sources considered to collect all data related to the actions in the creation and evaluation of OER. The step 2 (*Storing*) describes how data collected in step 1 is stored by presenting the items considered for the data model. The step 3 (*Analysis*) describes the metrics considered to analyze the data gathered and stored in previous steps. These metrics are related to general information about the quantity of HTML elements added to an OER and also metrics related to the teachers' competences. The step 4 (*Visualization*) describes the visualizations proposed to deliver the information to teachers. Outputs from step 3 were inputs to generate the visualizations which were divided into two views, the author's view and the evaluator's view.

Main highlights of our LAMTCE are:

- Each step was described taking into account the previous experience we had with teachers creating and evaluating OER in the exploratory study.
- It uses traces generated through the actions carried out by teachers in the creation and evaluation of OER.
- It involves the development of teacher's competences in the creation and evaluation of OER considering web accessibility and quality characteristics.
- The model is contextualized by defining roles, data sources, the flowchart of actions in the creation and evaluation of OER, and the user model that represents the teacher's competences. Each role carries out certain actions using the data sources and outputs from such actions feed the information used for representing teacher's competences.
- Metrics were defined as the output data of LAMTCE and they are based on the user model of the teacher's competences. These outputs were used for defining the visualizations in LAMTCE and they were grouped into two views, the author's and evaluator's views.
- Visualizations are focused on supporting teachers in the improvement of the web accessibility and quality of their OER as well as in their competences as authors and evlauators of OER.

The definition of LAMTCE led us to the next phase defined in the research methodology of this thesis, the *Phase IV: Implementation tasks*. In that phase the LAMTCE model was implemented into a learning analytics tool. Thus, the next chapter (CHAPTER 5) describes the learning analytics tool.

CHAPTER 5
LEARNING ANALYTICS TOOL TO TRACE THE CREATION AND EVALUATION OF OER

The Learning Analytics Model to Trace de Creation and Evaluation of OER (LAMTCE) (described in CHAPTER 4) was implemented in ATCE – an Analytics Tool to Trace the Creation and Evaluation of OER. This chapter introduces ATCE and its functionalities. One of its functionalities is an analytics dashboard designed to inform teachers about the elements related to their ICT competences in the creation and evaluation of OER as well as to allow them to make decisions to improve the accessibility and quality of their OER.

Following the **Phase IV** in the research methodology defined for this thesis, this chapter presents the description of the ATCE tool developed as a result of the implementation of the LAMTCE model. Moreover, the development of this learning analytics tool also contributes to achieve the fifth specific objective of this thesis (***SO5*** – *To develop a learning analytics tool based on the proposed learning analytics model*).

The following sections present the main outputs of the LAMTCE model (section 5.1), the design decisions considered to develop the analytics tool (section 5.2), a general description of the analytics tool (section 5.3), the roles involved in the use of the tool (section 5.4), the main functionalities of ATCE (section 5.5), the dashboard and a use case with visualizations generated after using ATCE (section 5.6), and the last section presents the conclusions of this chapter (section 5.7).

5.1 Main outputs of the LAMTCE model

The definition of LAMTCE provides us the elements to be considered in an analytics solution to trace the creation and evaluation of OER considering the web accessibility and quality characteristics. In order to evaluate this model in a real scenario we decided to implement it in a learning analytics tool. Before specifying the design decisions taken to develop the learning analytics tool it is needed to highlight the main outputs of the LAMTCE model which are:

- **Roles**: main roles in LAMTCE are author, evaluator and expert.
- **Data sources**: these data sources are a web editor as an authoring tool, the modules to evaluate the web accessibility and quality of OER, and a verification module so that experts can verify answers given by evaluators in the evaluation process.
- **Flowchart of actions**: the flowchart of the actions carried out during the creation and evaluation of OER is depicted in Figure 4-2. Actions carried by users were differentiated from those carried out by the system. This flowchart gave us an overview of the process and particular actions carried out when teachers create and evaluate OER that are created as virtual courses in a LMS.
- **Data model**: the data model (presented in Table 4-5) defined for LAMTCE was built taking into account the analysis done about the actions that teachers carry out while they create and evaluate OER.

- **Web accessibility questions**: taking advantage of the automated tools for checking the web accessibility, we analyzed the guidelines proposed in each of the principles of the WCAG 2.0, and then we obtained the list of web accessibility questions to be considered in the manual and the automatic accessibility evaluation. These questions are presented in Table 4-1. Each question corresponds with a type of HTML element (texts, images, tables, etc.) and a type of evaluation (automatic, manual).
- **Quality questions**: here we used an adapted version of LORI in which the accessibility category was removed because it is evaluated in more specific way with the web accessibility questions.
- **Metrics**: metrics represent the output data of the LAMTCE model. These metrics were defined taking into account user model of the teacher's competences in the creation and evaluation of OER.
- **Visualizations**: metrics can be presented by means of visualizations or charts. Visualizations defined for LAMTCE were divided into three groups: accessibility, quality, and evaluator.

5.2 Design decisions

According to the outputs of the LAMTCE model described in the previous section, the design decisions (DD) to be considered in the development of the learning analytics tool are:

- **DD1 – Storing of HTML elements:** the learning analytics tool should automate the process of storing the HTML elements in each webpage of the OER. As pointed out earlier, currently the web editor of ATutor LMS does not store detailed information about each of the HTML elements added by an author in a webpage. This information will be used for two purposes. First, to have a record of the elements added by an author. Second, to relate each HTML with its corresponding accessibility questions.
- **DD2 – Automatic and manual evaluation:** the evaluation of OER should be divided into two parts, a manual evaluation and automatic evaluation. In this regard, the learning analytics tool should support both evaluations automatic and manual.
    - **DD2.1 – Automatic evaluation:** the automatic evaluation refers to the evaluation of web accessibility. To do the automatic evaluation we can take advantage of an automatic tool such as AChecker. It provides an API so that external web applications can connect to check some of the accessibility guidelines in an automatic way. Moreover, AChecker works with different web accessibility standards among which are the WCAG 2.0.
    - **DD2.2 – Manual evaluation:** in the exploratory study the manual accessibility evaluation consisted in answering some web accessibility questions for the whole OER, now the analytics tool should allow evaluators to answer the accessibility questions for each one of the HTML elements added in the different webpages of the OER. With regard to the quality evaluation, we considered to integrate in the learning analytics tool the same instrument used in the exploratory study which is an adaptation of the LORI because we work with its accessibility category in a separate instrument.
- **DD3 – Verification instrument:** the role of expert implies the verification of the evaluations done by evaluators. Thus, the learning analytics tool should integrate a mechanism so that experts can verify the answers given by evaluators to both accessibility and quality instruments.
- **DD4 – Option to change the state of an OER:** it should be taken into account that an OER cannot be created (edited), evaluated or verified at the same time, and then the learning analytics tool should have a mechanism to manage the state of an OER.

- **DD5 – Dashboard:** since the main actors involved in the analytic process of LAMTCE are the authors and evaluators of OER, they need a mechanism to access the results derived from tracing the creation and evaluation of OER. Thereby, the learning analytics tool should integrate an analytics dashboard which informs teachers about the accessibility and quality of the OER as indicators of the creation competence and the level reached in the evaluation of the accessibility and quality of the OER as indicators of the evaluation competence.
    - **DD5.1 – Dashboard views:** the information to show in the analytics dashboard refers basically to the three groups of visualizations defined in section 4.7: accessibility, quality and evaluator.
    - **DD5.2 – Detail of the web accessibility failures:** Apart from the visualizations defined to appear in the dashboard, the tool should integrate a mechanism to facilitate authors the labor of improving their learning contents. This can be achieved by allowing authors to have access to detailed information about the accessibility failures during the evaluation process from one of the accessibility visualizations. For instance, a button to access to the failures description in each of the WCAG 2.0 principles can be added. This description should indicate at least the failure found, the webpage in which is the failure and the element that presents the failure.
- **DD6 – The learning analytics tool as an ATutor module:** Due to the fact that the OER are created as virtual courses in the ATutor LMS, the above mentioned functionalities would facilitate the labor of authors and evaluators if the learning analytics tool is integrated as a module in the ATutor platform.
- **DD7 – Name:** we denominated our analytics tool as ATCE – Analytics Tool to Trace the Creation and Evaluation of OER.

5.3 General description

This section presents an overview of the learning analytics tool in which the LAMTCE model was implemented. Based on the design decisions described in section 5.2 we developed ATCE – an analytics tool to support teachers in the creation and evaluation of OER (*DD7*) taking into account the accessibility and quality characteristics. Moreover, due to the fact that teachers create the OER in the ATutor LMS in the form of virtual courses, ATCE was developed as a module under the ATutor LMS (*DD9*) for teachers to have the tool at hand. Then, the tool can be deactivated without affecting the other functionalities of the ATutor LMS. Interfaces of this tool were translated into two languages English and Spanish. Main purposes of ATCE are:

1) To store actions performed by teachers during the creation and the evaluation of OER (*DD1*, *DD2*).

2) To inform teachers about the accessibility and quality of the OER created (as indicators of the creation competence) as well as the competence level reached in the evaluation competence (*DD5*).

With regard to the manual and automatic evaluation of OER, we integrated the web instruments used in the exploratory study to evaluate the accessibility and quality of OER but using the questions defined in the LAMTCE model. Besides, we integrated the use of the AChecker tool (*DD2.1*) which has an API to enable web application use the web accessibility checker system. Those questions that needed a proof of concept from a human evaluator were integrated in the new web accessibility evaluation instrument. This new instrument enables evaluators to check the accessibility in each HTML element added in each webpage of the OER. The accessibility instrument together with the same quality instrument used in the exploratory study, were integrated in ATCE under an option called *evaluation of OER*

(*DD2.2*).

After the evaluation of OER an expert should verify the answers given by the evaluator, thereby we integrated a verification instrument in ATCE (*DD3*). This instrument is a web form which was developed taking into account the indicators of the competence domain 2 (*evaluation of accessibility and quality of OER*) defined in the user model of the teacher's competences (presented in Table 4-3 and Table 4-4) and the decision tree to define if the answer given is right or not (depicted in Figure 4-5 and Figure 4-6).

Due to the fact that an OER cannot be created (edited), evaluated or verified at the same time, we integrated in ATCE an option to change the state of an OER (*DD4*).

On the other hand, the interpretation of visualizations depends on an understanding of the context in which the data are collected (Lockyer et al., 2013). In ATCE, visualizations and text-based reports are connected with the creation and evaluation of OER and have a simple design to facilitate the interpretation of the data collected and analyzed. Visualizations are presented by means of a dashboard with different views (*DD5.1*). A valuable characteristic of the dashboard is the integration of a mechanism so that authors can easily identify the detail of web accessibility failures presented in their OER as well as a link to access the webpages that have such failures (*DD5.2*).

5.4 Roles

ATCE was designed thinking of teachers as the main users. However, the tool can be used by anyone interested in the creation and evaluation of OER. Roles defined for LAMTCE can be considered also as the roles in the analytics tool, but because of the dynamic in the use of the tool there are some of the functionalities that should be carried out by an administrator of the tool. Thereby, the following role descriptions correspond with the actions performed by the users interacting with ATCE:

- **Author**: person who creates OER, adds webpages in an OER, and adds HTML elements in a webpage.
- **Evaluator**: person who carries out the manual evaluation of an 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.
- **Administrator**: person in charge of the management options in the analytics tool.

5.5 Functionalities of ATCE

As mentioned before, OER are created in the ATutor LMS in the form of virtual courses. Each OER is formed by a set of webpages that can be edited with the ATCE web editor. Figure 5-1 shows the process followed in ATCE according to the steps of LAMTCE. All actions correspond with the activities carried out by each one of the actors and the system during the creation and evaluation of OER. These actions also drove the definition of the specific functionalities of the ATCE tool. The following subsections describe all the options provided in each of the functionalities involved in the use of ATCE.

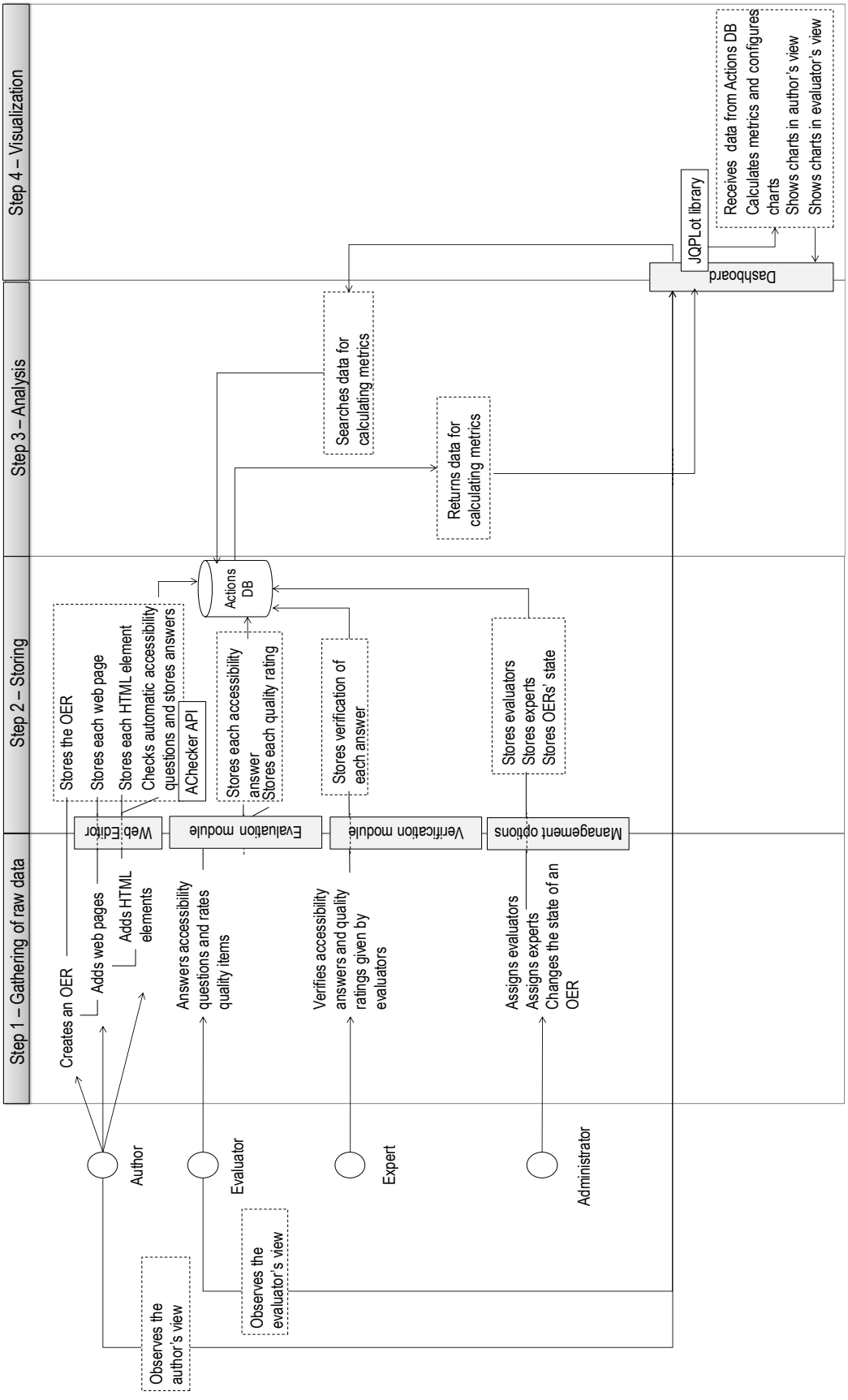


Figure 5-1. The LAMTCE model and functionalities of the ATCE tool.

5.5.1 Management options

The administrator of the tool has access to the management options which include the assignment of evaluators, the assignment of experts and an option to change the states in the creation of an OER. Possible states are: edit (by author), evaluate (by an evaluator), and verify (by an expert).

Welcome message: this section presents a welcome message for the administrator of the tool. The message also mentions the option allowed for that user (Figure 5-2).

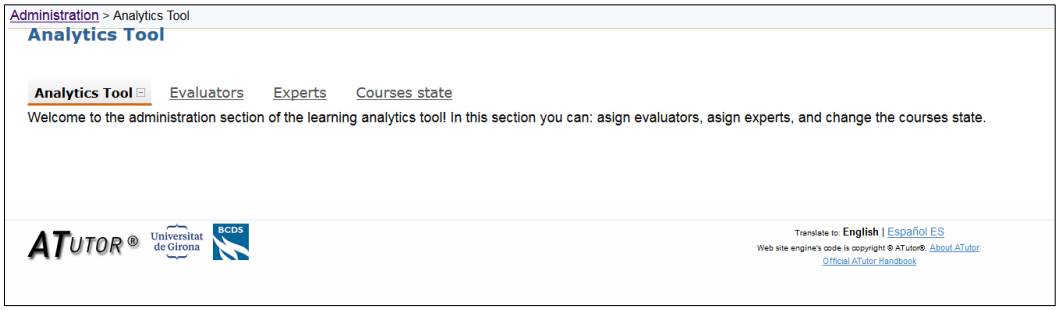


Figure 5-2. ATCE –Administrator – Welcome message

Evaluators option: to assign an evaluator to evaluate an OER, the administrator of the tool should select an OER, an evaluator, and then click on the Save button. The new assignment will appear in the table below. An evaluation assigned can be activated or deactivated (Figure 5-3).

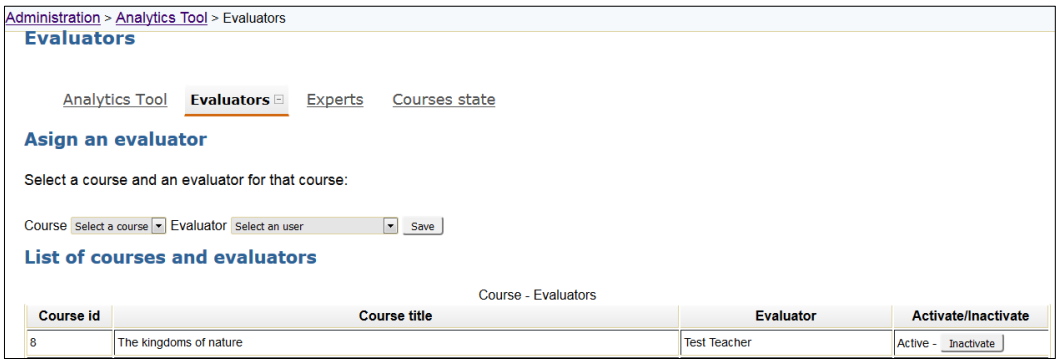


Figure 5-3. ATCE –Administrator - Evaluators

Experts option: to assign new experts, the administrator of the tool should select one user from the select list and then click on the Save button. The new expert will appear in the table below. An expert can be activated or deactivated Figure 5-4.

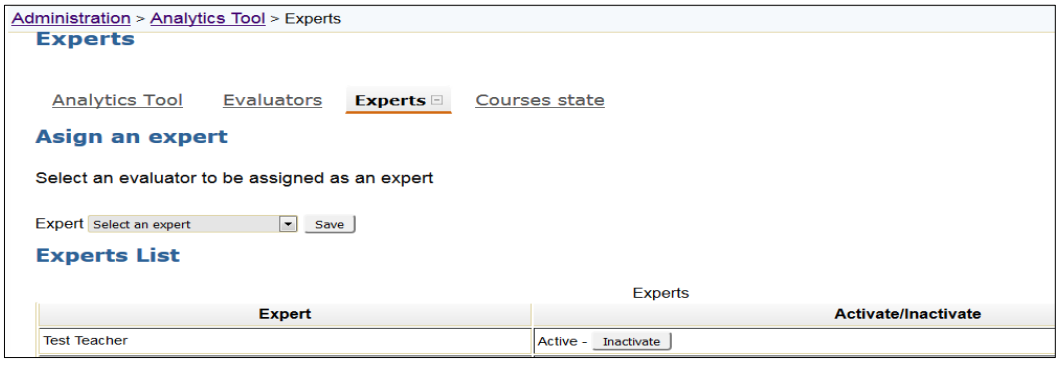


Figure 5-4. ATCE – Administrator - Experts

Courses' states option: one OER cannot be created (edited) by an author, evaluated by an evaluator and verified by an expert at the same time. It means that an OER has only one state. To do so the tool administrator should select one state for each OER: "create", "evaluate", or "verify". The state "create" is the state by default.

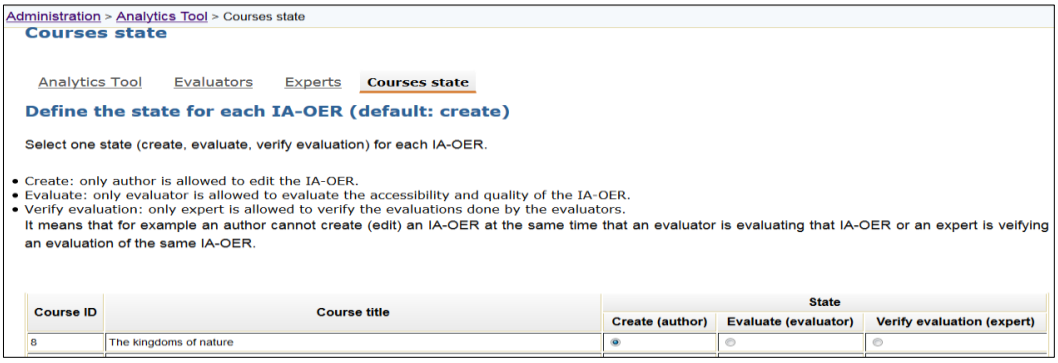


Figure 5-5. ATCE – Administrator – Courses' state

5.5.2 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 webpage of the OER (text, links, images, videos, etc.) are stored in the actions database. This process is executed once the author saves the changes in the webpage. 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 as is shown in the example depicted in Figure 4-4 . This position is controlled by using the information of the parents of each node (the main parent is called *root*). Besides that, each record is stored together with the username of the author and the modification date. Changes in each HTML element are controlled by means of four states: *created* for the first time the element is added to the webpage, *modified* each time the element changes its plaintext or HTML properties, *moved* each time the element changes of position in the HTML structure, or *deleted* each time an element is removed from the content.

5.5.3 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 AChecker[8] 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 automatic accessibility question and it is therefore stored in the database as an automatic answer to the corresponding accessibility evaluation question.

[8] http://achecker.ca/

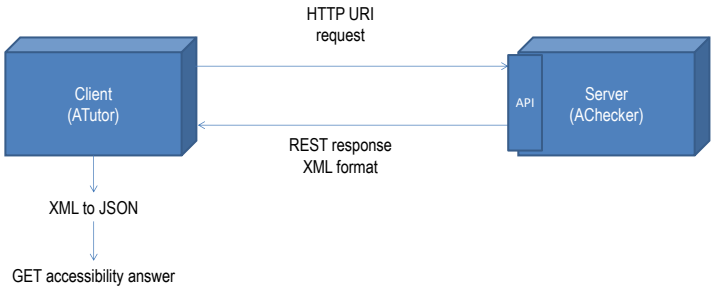


Figure 5-6. AChecker API – REST service

Table 5-1 presents the parameters of the request format that were used to validate the accessibility of an HTML element using the AChecker API. These parameters should be sent via HTTP as is shown in Figure 5-6. The REST response has an XML format and the root element of this XML is called *resultset* which has two main elements: the *summary* of the validation and the *results* element. Inside the *results* element the results for each accessibility criterion are listed with the element *result*. To read through this structure, we recover the XML in the client side and then we parse this XML to a JSON format. From each result we retrieve the check id (one check id per accessibility criterion) and the decision made. We compare the check ids recovered from the automatic evaluation with those we have in the automatic accessibility questions data table.

Table 5-1. AChecker API – request parameters

Parameter	Description	Default value
Uri	The encoded URL of the document to validate.	URL to the file where is the HTML source code
Id	This ID is a 40 characters long string. It can always be retrieved from user's "Profile" page.	This ID is given by the AChecker
Guide	As we are working with the WCAG 2.0 guidelines, the parameter we send as “guide” is WCAG2-AA.	WCAG2-AA
Output	By default the response is given in an HTML format but as we need to obtain the accessibility answer for certain criteria then we use the REST format.	rest
offset	The line offset to begin validation on the html output from URI.	0

5.5.4 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 OER. The manual evaluation is carried out once an 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 each page of an OER (images, videos, links, etc.). Possible answers are: Yes, No or Not applicable. Moreover, there is a space to add comments on each question. As mentioned before, accessibility questions are based on the WCAG 2.0 principles. Questions appear in a tooltip with a button to see the information of the element revised and a button to access help information of each question. This tooltip is appended to each HTML element thereby questions that appear in the tooltip are related to the type of HTML element.

In the quality evaluation the evaluator uses the quality instrument. As mentioned in previous sections, 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 tool has an instrument so that experts can verify if the answers given by the evaluator are right or not. The instrument consists in a web form that shows to the expert the answers given by a specific evaluator to a specific OER. The expert should indicate if each answer is correct and if comments are appropriate. Results from this verification are used to analyze and obtain the level reached by an evaluator in the evaluation competence.

A user takes the evaluator role when:

a) The user has been subscribed with an instructor account in the ATutor LMS.

b) The tool administrator has assigned an instructor as an evaluator.

When an evaluator logs in the ATutor LMS and has OER to evaluate the system will show a green tool tip indicating that the evaluator has OER to evaluate. When the evaluator goes to the "OER evaluation" section in the ATutor LMS, the available options are:

Welcome section: in this section the system shows the welcome message depicted in Figure 5-7.

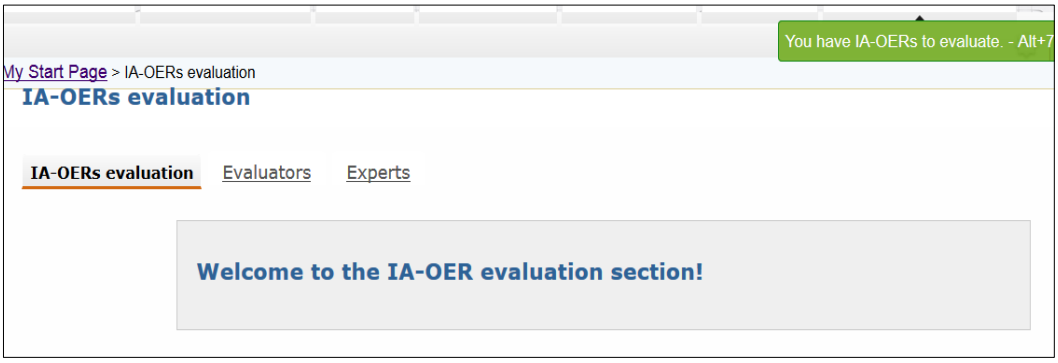


Figure 5-7. ATCE – Manual evaluation – welcome message

Evaluators section: in this section a list with the OER that have been assigned to the evaluator appears (Figure 5-8).

Experts section: when an evaluator has been assigned as an expert, in the "Experts" section, the evaluator will appear in a select list with the name of the evaluators and another select list with the name of the OER evaluated.

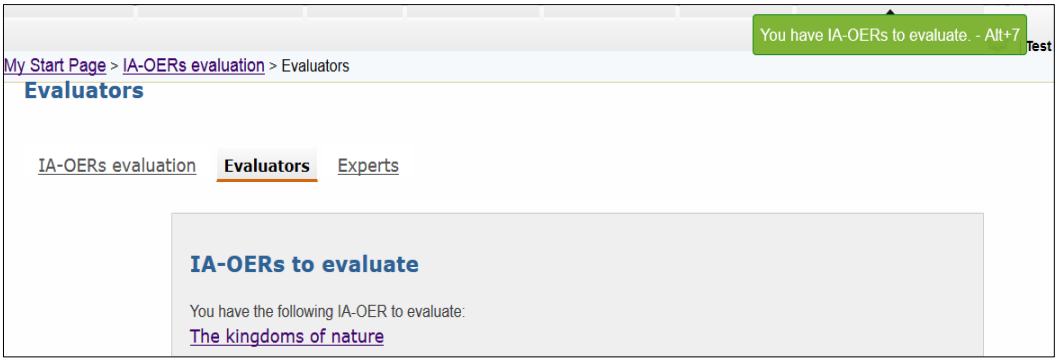


Figure 5-8. ATCE – Manual evaluation – Evaluators

In the "Evaluators" section, when an evaluator tries to evaluate and OER with the state "create" (it is edited by an author) or "verify" (an evaluation done on this OER is being verified by an expert) the system will show to the evaluator the message depicted in Figure 5-9:

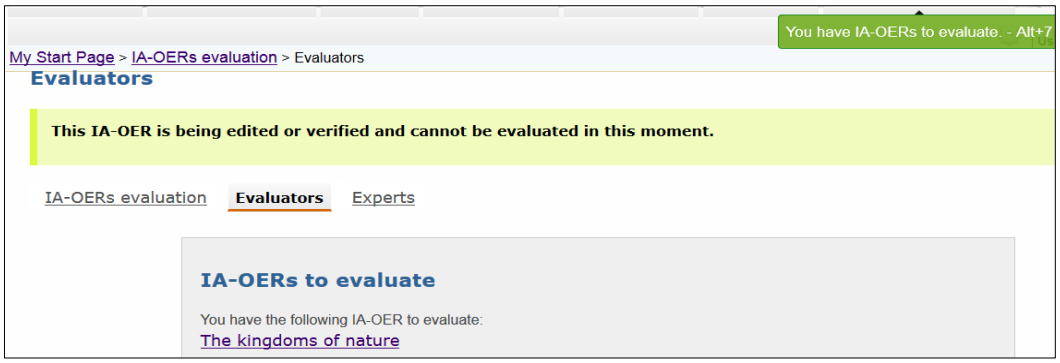


Figure 5-9. ATCE – Manual evaluation – message when the OER cannot be evaluated

When the evaluator goes to evaluate an OER the system shows an interface in which the evaluator can navigate through different sections or webpages of the OER to evaluate the accessibility as well as to Access the quality evaluation option. Figure 5-10 shows the welcome message of the evaluation mode.

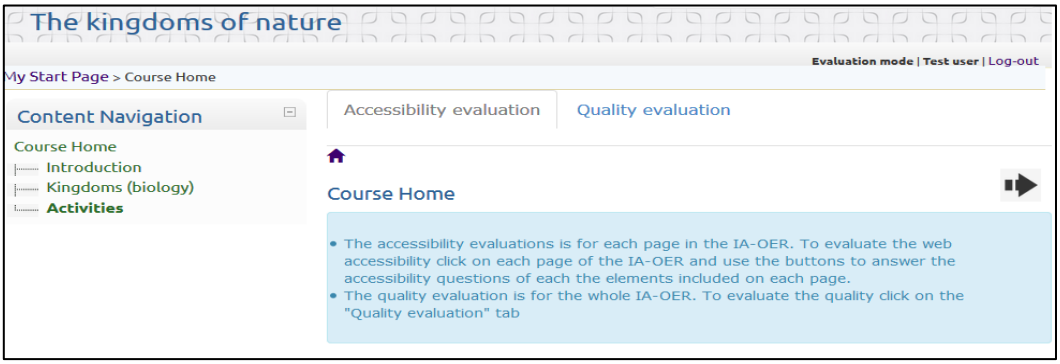


Figure 5-10. ATCE – Manual evaluation – Evaluation's home page

When the evaluator opens one of the pages of the OER (Figure 5-11) it appears the content of the page together with the accessibility checking buttons in each one of the elements (titles, paragraphs, links, etc.).

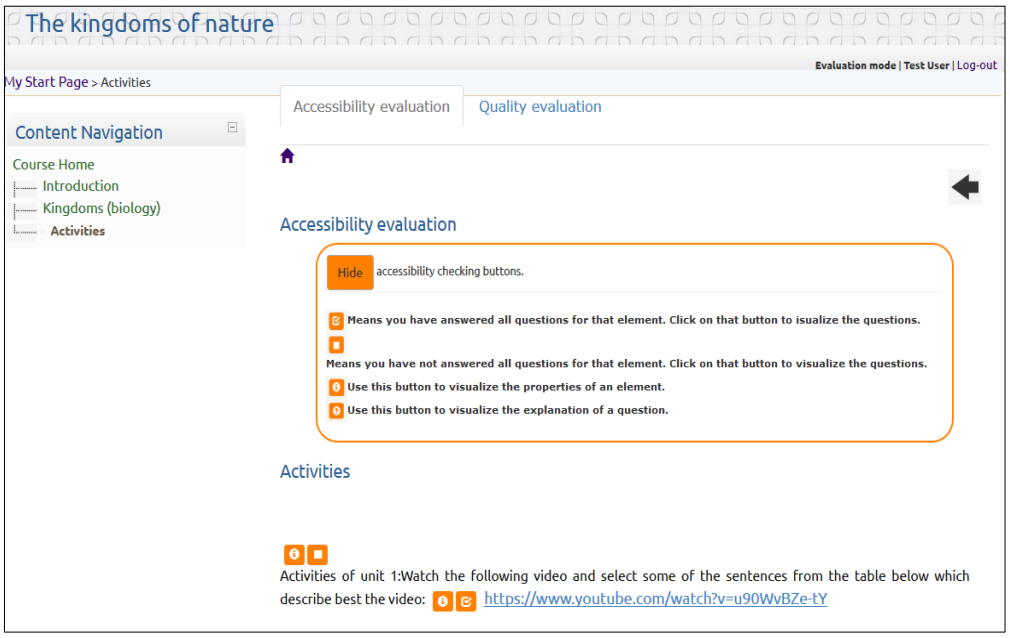


Figure 5-11. ATCE – Manual evaluation – Accessibility

Accessibility checking buttons are described in Table 5-2:

Table 5-2. Options of the manual accessibility evaluation.

Button	Description
Hide	(hide/show button) To hide/show the accessibility checking buttons
	(all questions answered button) Means all questions of an element have been answered. This button is also used to see the questions.
	(questions button) Means not all questions of an element have been answered. This button is also used to see the questions.
	(help button) To visualize the properties of an element.
	(properties button) Button used to see explanation of a question.

When the evaluator clicks on the properties button a popup window appears with some of the characteristics of the HTML element (Figure 5-12).

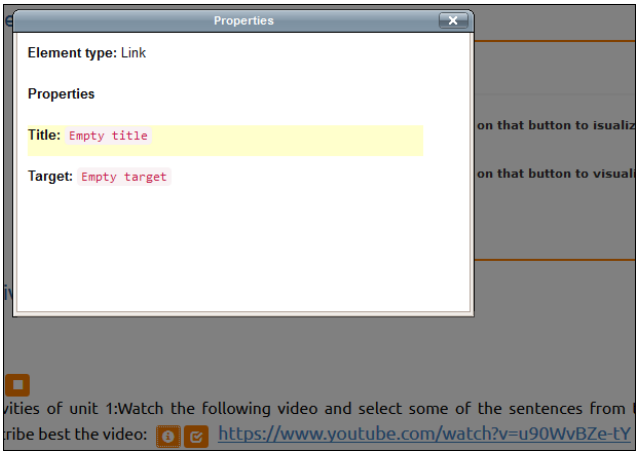


Figure 5-12. ATCE – Manual evaluation – Accessibility – Properties popup

When the evaluator clicks on the questions button, a tooltip with the accessibility question corresponding with that particular HTML element appear. Moreover, when the evaluator moves the point over the question or properties buttons the HTML element to be evaluated is highlighted as can be seen in Figure 5-13.

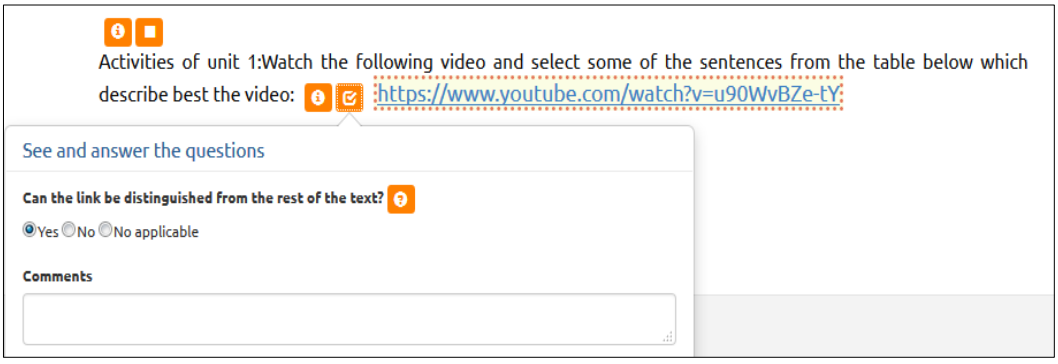


Figure 5-13. ATCE – Manual evaluation – Accessibility – Questions tooltip

When the evaluator clicks on the help button of one question , a popup message appears with an explanation and depending on the question with an example to guide the evaluator on how to answer the question (Figure 5-14).

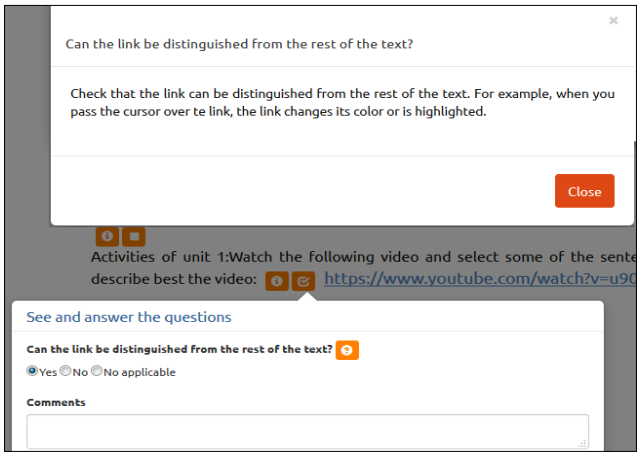


Figure 5-14. ATCE – Manual evaluation – Accessibility – Help popup

When the evaluator goes to the quality evaluation option it will appear in the same window the form with the questions of the quality instrument (Figure 5-15). In this form the evaluator has a help button in each question or category, five stars to rank the category and a field to add comments.

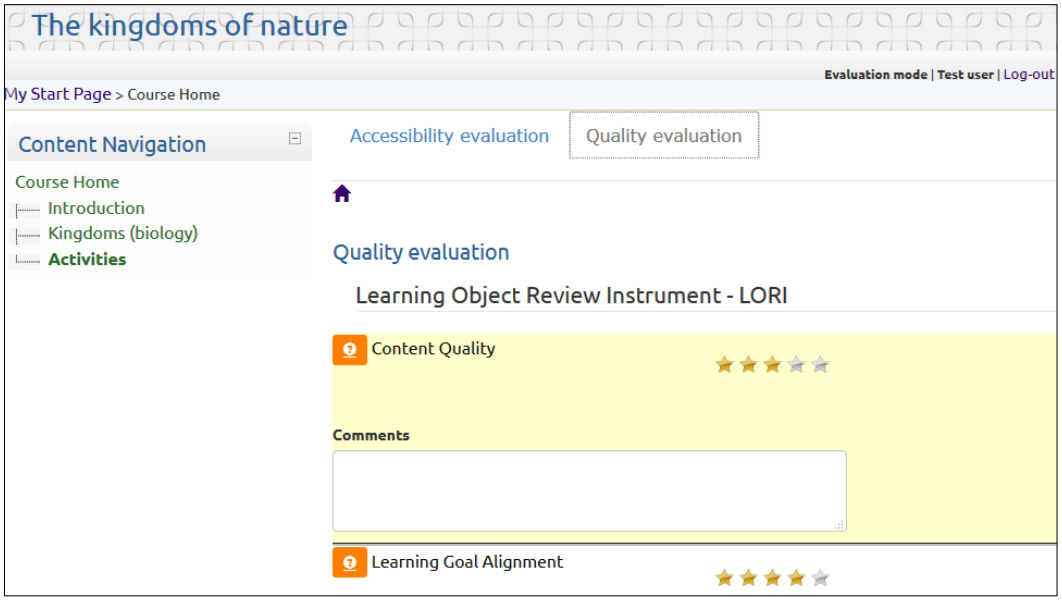


Figure 5-15. ATCE – Manual evaluation – Quality instrument form

When the evaluator clicks the help button a tooltip with the criteria to be evaluated in each category appears (Figure 5-16).

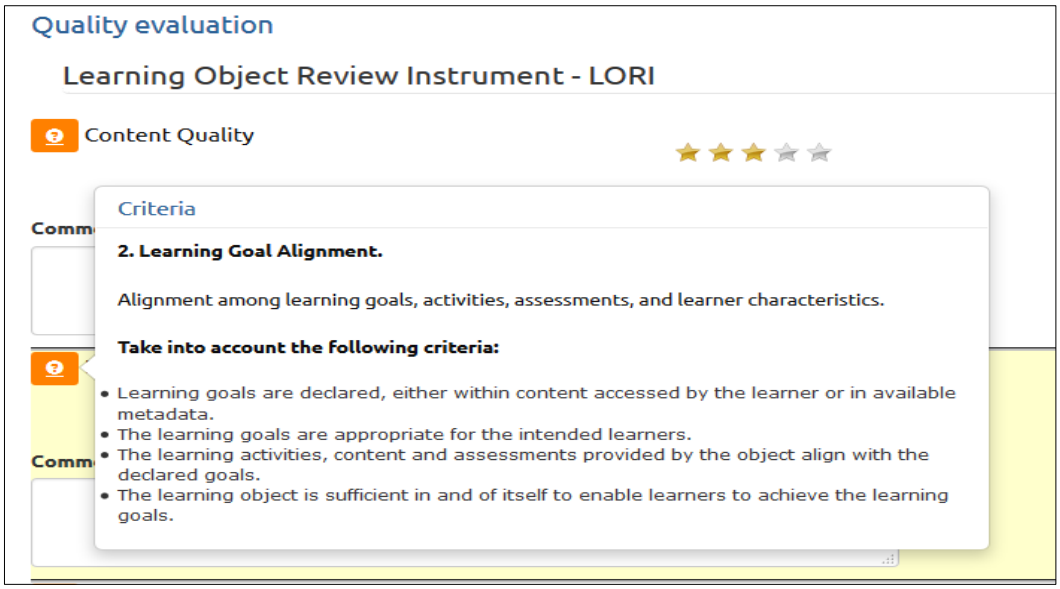


Figure 5-16. ATCE – Quality instrument – Help tool tip

5.5.5 Dashboard

As part of the functionalities of ATCE we developed a dashboard including the visualizations defined for the LAM. Interfaces with the visualizations showed in this dashboard are explained in detail in section 5.6 by means of a use case of one OER created using the ATCE.

5.6 Dashboard and the use case *The kingdoms of nature*

The dashboard of ATCE informs teachers about the accessibility and quality of the OER created (as indicators of the creation competence) as well as the competence level reached in the evaluation competence. The dashboard has three main views:

- The *Accessibility view* presents information about teachers' activities and the accessibility of the OER taking into account the evaluations conducted on them.
- The *Quality view* presents information about the quality of the OER taking into account the evaluations conducted on them.
- The *Evaluator view* presents information about the competence in the evaluation of OER taking into account the evaluations conducted on OER.

Results in the *Accessibility view* and *Quality view* are indicators of the teachers' competence level in the creation of OER. Results presented in the *Evaluator view* are indicators of the competence in the evaluation of OER. Moreover, in the *Accessibility* and the *Quality* views the author has the opportunity to visualize the information from all OER or from one specific OER. The types of visualizations included in the dashboard are described in section 5.6 by means of a use case.

The use case about the OER *The kingdoms of nature* is intended to describe the visualizations obtained in the dashboard after using the aforementioned functionalities of the ATCE tool. The use case shows the process of using the ATCE tool and then it gives a description of the visualizations that appear when the ATCE's dashboard is opened. The visualizations described correspond to those that appear in each of the views of the ATCE's dashboard: *Accessibility view*, *Quality view*, and *Evaluator view*.

First of all, *The kingdoms of the nature* is an OER created as a virtual course in the ATutor LMS by using the functionalities of ATCE. This OER has three webpages named: 1)

Introduction, 2) Kingdoms (biology), and 3) Activities. Those pages include different HTML elements (texts, headings, images, etc.). This OER was created in four stages:

1) A teacher (author), who took the training course in the creation of OER, created this OER. Meanwhile, the tool stored all HTML elements added by the author and carried out the automatic evaluation.
2) Another teacher (evaluator) evaluated the accessibility and quality of the OER (manual evaluation).
3) An expert verifies the evaluation.
4) The author used the information provided in the *Accessibility* and *Quality* views of the ATCE's dashboard to improve the learning contents of the OER. Likewise the evaluator received feedback through the *Evaluator view*.

The following subsections explain the contents in each of the screenshots of the dashboard according to each of its views.

5.6.1 Welcome interface

Each time an author or evaluator opens the dashboard it appears a general description about the dashboard and its views. Figure 5-17 shows a screenshot of this welcome interface.

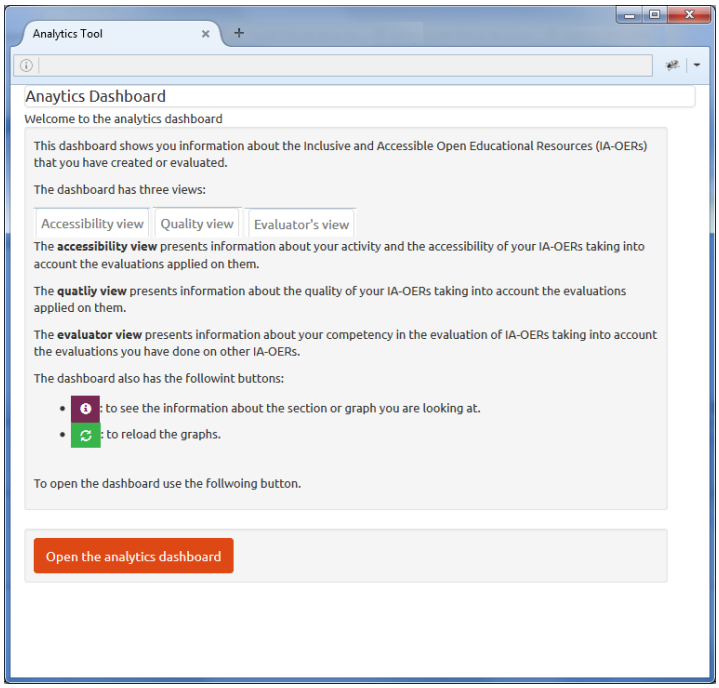


Figure 5-17. ATCE – Dashboard's welcome interface

5.6.2 Author's view - Accessibility

The author's view is divided into two parts namely accessibility and quality. The accessibility part is depicted in Figure 5-18. This interface has an option to choose one OER from the list of OER created by the author (*Choose one OER*). Once the OER is selected,the OER's title in the right side of that option will appear and also in some of the messages shown in the different interfaces of the dashboard. Main sections in this interface are:

- The first section is related to the elements added in the OER (*Your activity* tab – Figure 5-18).

- The second one is related to the general accessibility and the accessibility by type of element (*General* tab –Figure 5-19).
- The third one is related to the accessibility history of the OER (*Accessibility history* tab – Figure 5-20).
- The fourth one is related to the accessibility classified by the WCAG principles (*WCAG principles* tab – Figure 5-21). As we will explain later, 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 HTML elements of the OER.

The *General* section (Figure 5-18) includes two visualizations. The first with a time line chart that shows the quantity of HTML elements added by the author in different dates, in this case 33 elements were added in October 10th and 9 elements were added in October 11th. It does not take into account if the elements were deleted just the elements added in each date. The second one with a bar chart which indicates that the OER has different types of HTML elements, a total of 29 elements (3 paragraphs, 20 links, 3 images, 2 tables, and 1 elements list).

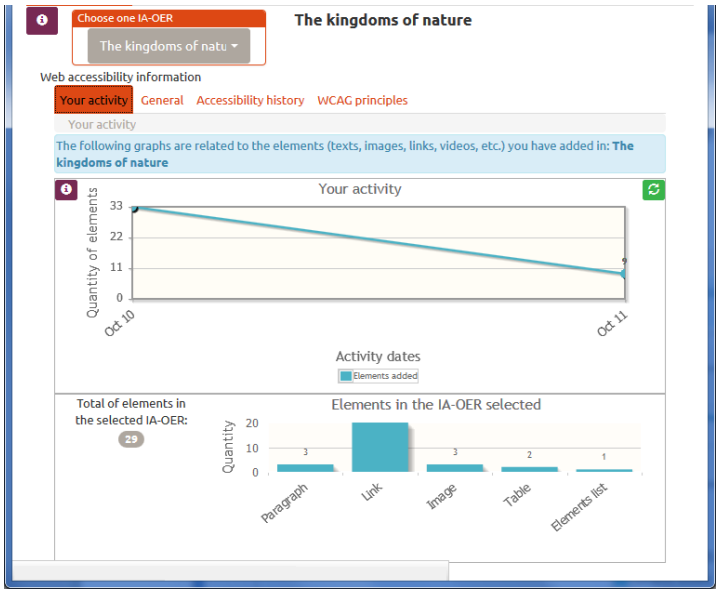


Figure 5-18. ATCE – Dashboard's Accessibility view - Your activity

The *General* section (Figure 5-19) includes a progress bar which indicates the percentage of the advance in the manual evaluations started for that OER. Moreover, this section includes two visualizations:

- The first visualization is related to the level of accessibility of the OER which in this case has an *Overall accessibility* of about 80%.
- The second visualization shows the level of *Accessibility by type of element*. This last visualization is a bar chart and each bar corresponds with a type of HTML element from those included in the OER. The green color indicates the percentage of accessibility criteria that the OER meets (*Accessible*) according to the answers given by the evaluator in the manual accessibility evaluation. Similarly, the red color indicates the percentage of the accessibility failures identified (*No accessible*). From these two visualizations the author can have a first impression on how is the accessibility of the OER and with regard to the second visualization the author can easily identify which is the HTML that presents some accessibility failures. For instance, this OER seems to have a good level of accessibility but according to the results from the evaluation of the OER it has some failures in paragraphs, links, images, and tables.

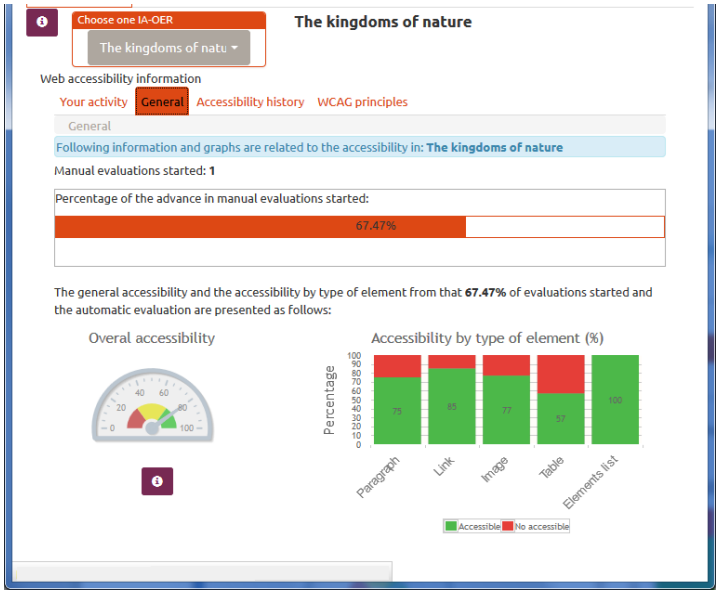


Figure 5-19. ATCE – Dashboard's Accessibility view- General

The *Accessibility history* section (Figure 5-20) includes a visualization that shows how the accessibility has evolved over time. Red area means the percentage in which the OER is *Accessible* and the green area means the percentage in which the OER is *No accessible*. Accordingly, this is an area chart and in each date there are two points which indicate the *Accessible* and the *No accessible* result. The main idea with this chart is that each time the OER is evaluated the green area reaches or be near to the top of the chart which represents a 100% in accessibility. In this case the accessibility of the OER has been improved.

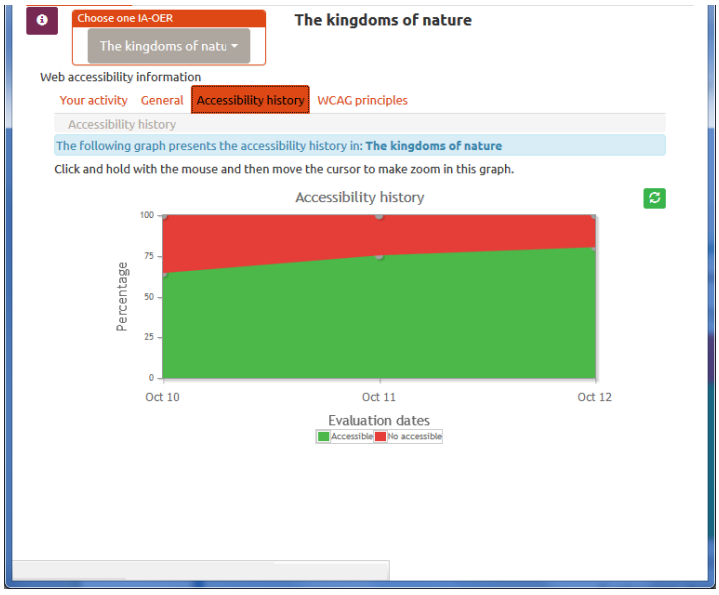


Figure 5-20. ATCE – Dashboard's Accessibility view - Accessibility history

The *WCAG principles* section (Figure 5-21) shows visualizations related to the level of accessibility in each of the WCAG 2.0 principles. Although the robust principle was not considered in the accessibility questions, it appears in this section of the dashboard as a way to help the teachers to remember that the WCAG 2.0 standard is based on the four principles known also as POUR (Perceivable, Operable, Understandable, and Robust). The visualization of each principle is presented by means of a donut chart. The gray color means that there were no questions answered related to that principle, the darker color in each donut means

the percentage in which the OER is accessible for that principle, and the lighter color means the percentage in which the OER is no accessible for that principle. In this case, the OER is 80.8% accessible in the *Perceivable* principle, 85.1% accessible in the *Operable* principle, and 61.5% accessible in the *Understandable* principle. The *Robust principle* appears as *No applicable* because this principle is not considered in the accessibility questions as mentioned before but it may be useful for teachers to remember all the 4 principles of the WCAG 2.0.

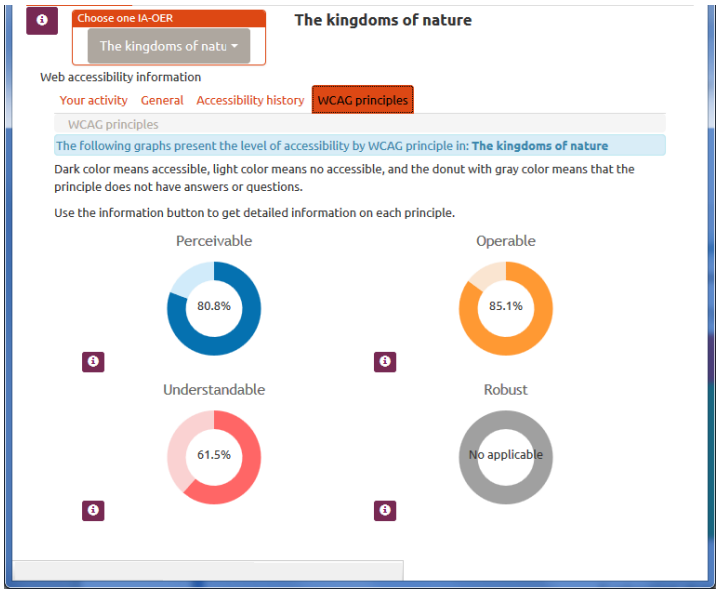


Figure 5-21. ATCE – Dashboard's Accessibility view- WCAG principles

The ideal situation here is that the OER reaches a 100% of accessibility in each principle. But in those principles in which the accessibility does not reach the top, we have integrated an option so that the author can easily identify the accessibility failures identified for the OER in the evaluation process. For instance, if the author goes to check the failures identified in the Perceivable principle (Figure 5-22), a box with the types of HTML elements that have failures is shown. When the author clicks on one of the elements, for instance *Table* then it shows a table with the following data:

- The first column corresponds with the name of the OER.
- The second column corresponds with the title of the webpage.
- The third column is the element (e.g. table) which presents accessibility failures. Together with the type of element it includes a link to show or hide a previsualization of the element.
- The fourth column presents the failures identified and the comments that evaluators had added.
- The last column provides a link to open the web page in which the element that presents accessibility failures is located. When the author clicks on this option, the webpage is opened in another window. This action allows the author to go directly to the webpage that should be edited in order to improve the HTML elements according to the accessibility failures identified.

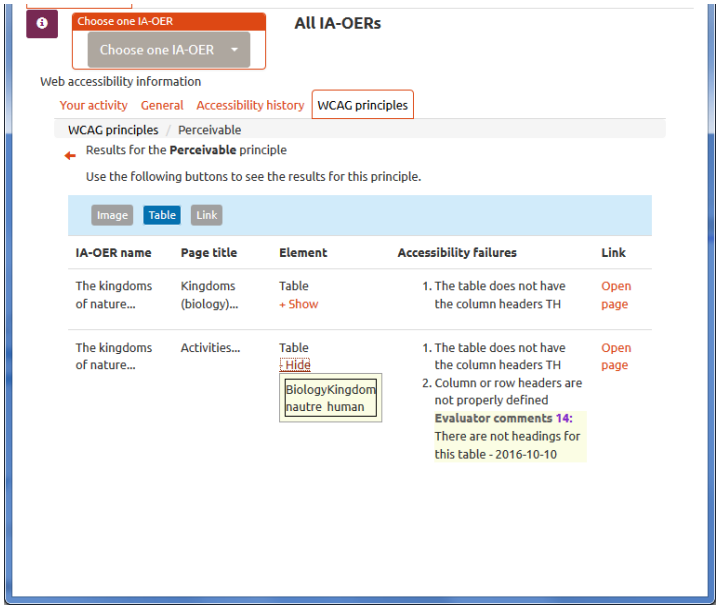


Figure 5-22. ATCE – Dashboard – detailed view of the accessibility failures

5.6.3 Author's view – Quality

The *Quality* part shows the same option to *Choose one OER* as in the *Accessibility view*. The *Quality view* is divided into two main sections:

- The first section presents information related to the overall quality of the OER (*General* tab – Figure 5-23).
- The second section presents information related to the quality in each one of the categories of the quality instrument (*Categories detail* tab – Figure 5-24).

The *General* section includes a visualization with five starts which is the maximum punctuation that an OER can obtain as a result of the quality evaluation. In this case the OER obtained 3 out of 5 starts as is shown in Figure 5-23. This result comes from the average of the punctuations obtained in each of the quality categories. Since this a general result, it gives an overview of the quality in the whole OER, we integrated another section so that the author could see the results per each category, this is the *Categories detail* section.

Figure 5-23. ATCE – Dashboard's Quality view - General

The *Categories detail* section includes the eight categories of the quality instrument (Figure 5-24), namely: content quality, learning goal alignment, feedback and adaptability, motivation, design and presentation, usability, reusability, standards compliance. In each category the author can see the punctuation obtained and the comments given by the evaluator. These comments serve as recommendations so that the author can make decisions of improvements in the learning contents of their OER.

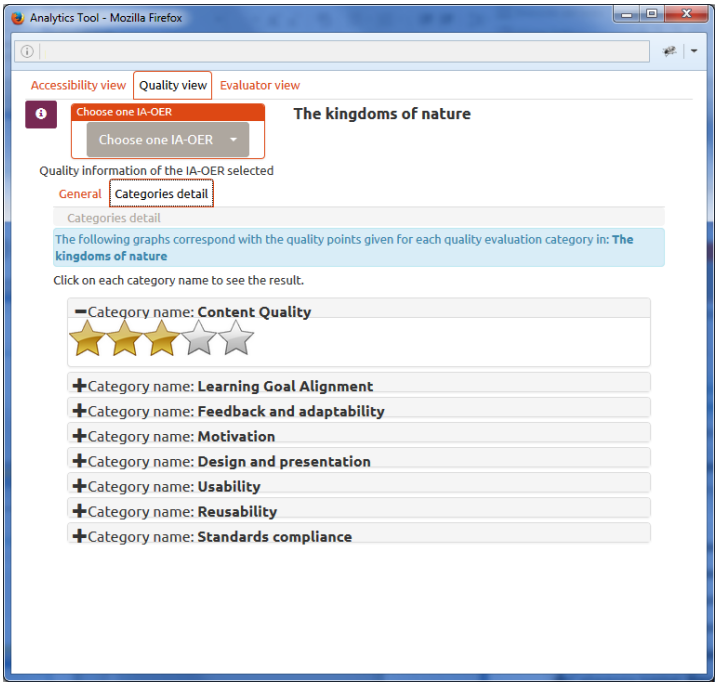


Figure 5-24. ATCE – Dashboard's Quality view – Categories detail

5.6.4 Evaluator's view

When the evaluator opens the *Evaluator view* (Figure 5-25), two sections are shown. The top section corresponds with the evaluation competence related to the Accessibility Evaluation (A in the figure) and the section at the bottom corresponds with the evaluation competence related to the Quality Evaluation (B in the figure). Each one of these parts includes a gauge meter chart which is colored with three stripes as an indicator of the level reached: a red strip to indicate a beginner level, a yellow strip to indicate an intermediate level, and a green stripe to indicate and advance level. Besides that, below the charta text with the level obtained and on the right side of the chart is shown as well as the recommendations given by the experts after verifying the answers given by the evaluator.

If the evaluator wants to know the level reached in each part of the evaluation competence, then the first step is to select a date from the list (*Choose one date*). Once the date is selected, the gauge meter indicates the level reached and on the right side the recommendations are shown. The evaluator can use these recommendations in order to improve the tasks in its role as evaluator.

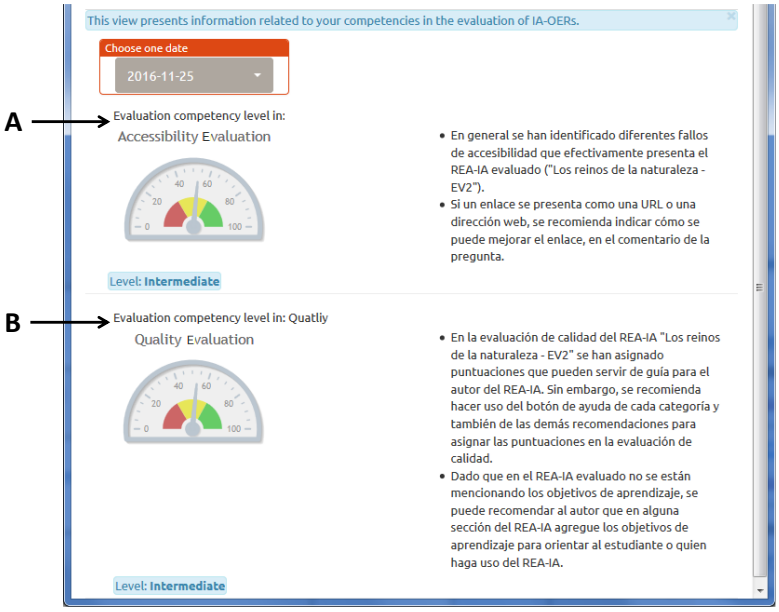


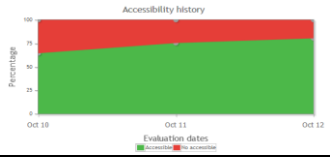
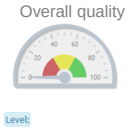
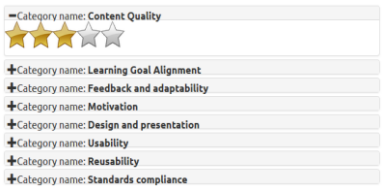
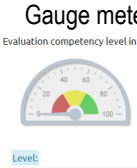
Figure 5-25. ATCE – Dashboard's Evaluator view

5.6.5 Summary of the visualizations

All the visualizations described above correspond with the metrics and therefore the visualizations defined in the LAM. Table 5-3 presents a summary of these visualizations.

Table 5-3. ATCE – Visualizations in ATCE dashboard

Group		Metric	Visualization title	Chart
1. Author's view	General	Quantity of HTML elements added by an author over time	Your activity	Date axes chart
		Quantity of HTML elements added by an author arranged by type of HTML element	Elements in the OER	Bar chart
	Web accessibility	Overall percentage of accessibility	Overall accessibility	Gauge meter
		Percentage of accessibility by type of HTML element	Accessibility by type of element	Bar chart

Group		Metric	Visualization title	Chart
		Overall percentage of accessibility over time	Accessibility history	Date axes chart 
		Overall percentage of accessibility by WCAG principle	WCAG principles	Donut chart 
	Quality	Overall percentage of quality	Overall quality	Gauge meter 
		Overall quality rating	General quality	Rating stars 
		Quality rating by quality item	Categories detail	Rating stars 
2. Evaluator's view		Percentage of correct answers in the accessibility evaluation	Accessibility evaluation	Gauge meter 
		Percentage of appropriate ratings in the quality evaluation	Quality evaluation	Gauge meter 

5.7 Conclusions of the chapter

This chapter introduced the main outputs of the LAMTCE model and based on these outputs we described the design decisions considered to develop the analytics solution we proposed to implement the learning analytics tool. We called this tool ATCE – an Analytics Tool to Trace the Creation and Evaluation of OER. Main functionalities of the tool include:

- *Management options*: the administrator of the tool uses the ATCE management options to assign evaluators, assign experts, and change the states of an OER. Possible states of an OER are: edit (by author), evaluate (by an evaluator), and verify (by an expert). The OER's states are used to ensure that an OER is not created/edited, evaluated or verified at the same time.
- *Storing of HTML elements*: when authors use the ATCE web editor, ATCE stores each change of an HTML element included in the webpages of an OER as a separate record in the actions database. This functionality was not included in the original web editor of

ATutor because the web editor stored the whole source code of each webpage but not each HTML element as a separate record.

- *Automatic accessibility evaluation*: after storing of the HTML elements, ATCE carries out an automatic accessibility evaluation. For this automatic evaluation we integrated AChecker (AChecker, 2012) which is an automatic tool to check accessibility criteria in web contents. AChecker works according to different accessibility standards among which are the Web Content Accessibility Guidelines 2.0 (WCAG 2.0). We used the API provided by AChecker which facilitates its integration in web environments.
- *Manual evaluation*: teachers in their role of evaluators are provided with 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 webpage by using the questions presented in Table 1 and the quality is evaluated with the items presented in Table 2.
- *Dashboard*: teachers are informed through the ATCE dashboard about the accessibility and quality of the OER created (as indicators of the creation competence) as well as the competence level reached in the evaluation competence. The ATCE dashboard has two views: the *Author's view* presents information about the teacher's activity, the OER's web accessibility, and the OER's quality; the *Evaluator's view* presents information about the competence in the evaluation of OER in terms of web accessibility and quality.

The usefulness of this tool was illustrated through a use case of an OER called "The kingdoms of the nature" which was created and evaluated using the functionalities of ATCE. This use case demonstrates how the ATCE tool can be used to provide information about the accessibility and quality of an OER. This information is presented to users by means of a dashboard. The visualizations included in the dashboard correspond with those defined in the LAMTCE model. The 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 OER.

The use of ATCE can help teachers to enhance the accessibility and quality of learning contents of their OER as well as to improve in the evaluation of OER. However, further research needs to be conducted with regard to the support that this tool can provide to teachers and the acceptance of the tool. Thus, the next chapter describes the activities carried out and the results obtained in the evaluation of the LAMTCE model and the ATCE tool.

CHAPTER 6
EVALUATION OF THE LEARNING ANALYTICS MODEL AND THE ATCE TOOL

As a result of the exploratory study described in CHAPTER 3, we confirmed that when teachers receive a technological support and an appropriate training, they are able to create accessible and quality OER. Taking the lessons learnt from the first exploratory study and the findings in the literature, we identified that learning analytics could serve as a mean to trace teachers' activities derived from the creation and evaluation of OER. With this idea in mind, we defined a Learning Analytics Model to Trace the Creation and Evaluation of OER (LAMTCE). The main aim of LAMTCE is to trace activities done by teachers in the creation and evaluation of OER (CHAPTER 4). Moreover, the LAMTCE model was implemented in the Analytics Tool to Trace the Creation and Evaluation of OER (ATCE) (CHAPTER 5). Thus, this chapter presents the deployment and results from the evaluation of the LAMTCE model.

Following the **Phase V** in the research methodology defined for this thesis, this chapter presents the deployment of the scenario to evaluate the LATMCE model and thereby the ATCE tool as well as the results and discussion obtained from this evaluation. Moreover, the development of this evaluation scenario contributes to achieve the sixth specific objective of this thesis (***SO6*** – *To conduct an evaluation for the proposed learning analytics model and the learning analytics tool*).

The following sections present the design of the evaluation (sections 6.1 to 6.6) including research questions, design methods selected and participants, materials, procedure, analysis of data and limitations of the study. Results and discussion are presented in section 6.7. Conclusions derived from this evaluation process are presented in section6.8.

6.1 Introduction

The purpose of this study is twofold. Firstly, the study aims at investigating whether the ATCE tool (developed based on the LAMTCE model) benefits teachers in the acquisition of competences in the creation and evaluation of OER. Secondly, it aims at identifying the perceptions of teachers 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 dashboard benefit teachers in the acquisition of competences in the creation and evaluation of OER?
- RQ2: What are the perceptions of teachers with regard to 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 the use of a training course in which teachers learnt how to create OER in terms of web accessibility and quality. To answer RQ2 we analyzed the perceptions of teachers when using the ATCE tool. Both parts of the study took place from October 2016 to June 2017. During these months a group of 19 teachers participated in the study.

6.2 Materials

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

- *Initial questionnaire:* questionnaire to gather data related to demographic information and the background of teachers in the use of ICT tools. The questionnaire consisted of four parts: 1) demographic information, 2) experiences and skills in the domain of ICT, 3) specific use of ICT, and 4) ICT in the creation of educational resources as part of the teaching practices. This questionnaire was created using Google forms.
- *Training course about the creation of OER***:** this virtual training course aimed at teaching teachers how to create OER considering the web accessibility and quality characteristics. The course included four units. Three units with theoretical foundations related to OER (Unit 1: Inclusive Learning, Unit 2: Universal Design for Learning, and Unit 3: Open Educational Resources). As part of Unit 3, teachers learnt how to add an open license for their OER in the ATutor LMS by 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 contents of the training course about the creation of OER and also to integrate 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 opinions of the teachers about the ATCE tool. LAAM was proposed and validated by Ali et al (2013). This model is based on the Technology Acceptance Model (F. Davis, 1989) and the main idea of LAAM is to analyze the factors influencing beliefs for adoption of a learning analytics tool. Authors of LAAM suggest that the questionnaire they created can be adapted according to the learning analytics tool being assessed. We adapted the original questions of this instrument to the ATCE tool. The open questions included in the questionnaire aimed at gathering additional feedback about functionalities of the ATCE tool such as the ATCE dashboard (comments about the dashboard), the ATCE web editor used for creating the webpages (comments about the web editor), and the ATCE evaluation module (comments about the evaluation module). Moreover, an additional question was included asking teachers about keywords they would use to describe the activities carried out in the evaluation process (general keywords). This questionnaire was created using Google forms.

6.3 Participants

Initially, 35 university and school teachers volunteered to participate in this study. At the end only 19 teachers completed the study.

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

Teachers participated as authors and evaluators of OER. Researchers of this study participated as experts by doing additional evaluations of the OER created by authors and verifications of the evaluations carried out by evaluators. The researchers have knowledge in the topics addressed in the units of the training course and experience in teaching and in the creation and evaluation of OER in terms of web accessibility and quality.

6.4 Procedure

Figure 6-1 depicts the research design to answer RQ1 and RQ2. The evaluation process encompassed four phases in which teachers participated as authors and evaluators of OER. Teachers took part in the training course about the creation of OER carried out during phase 2. In all phases, authors used the ATCE web editor and evaluators used the ATCE evaluation module. In phase 5, both authors and evaluators used the ATCE dashboard. In phase 4 and phase 5, an expert used the ATCE verification module to verify how well teachers created and evaluated OER in order to obtain measurement 1 and measurement 2. Activities carried out in the evaluation process are described as follows:

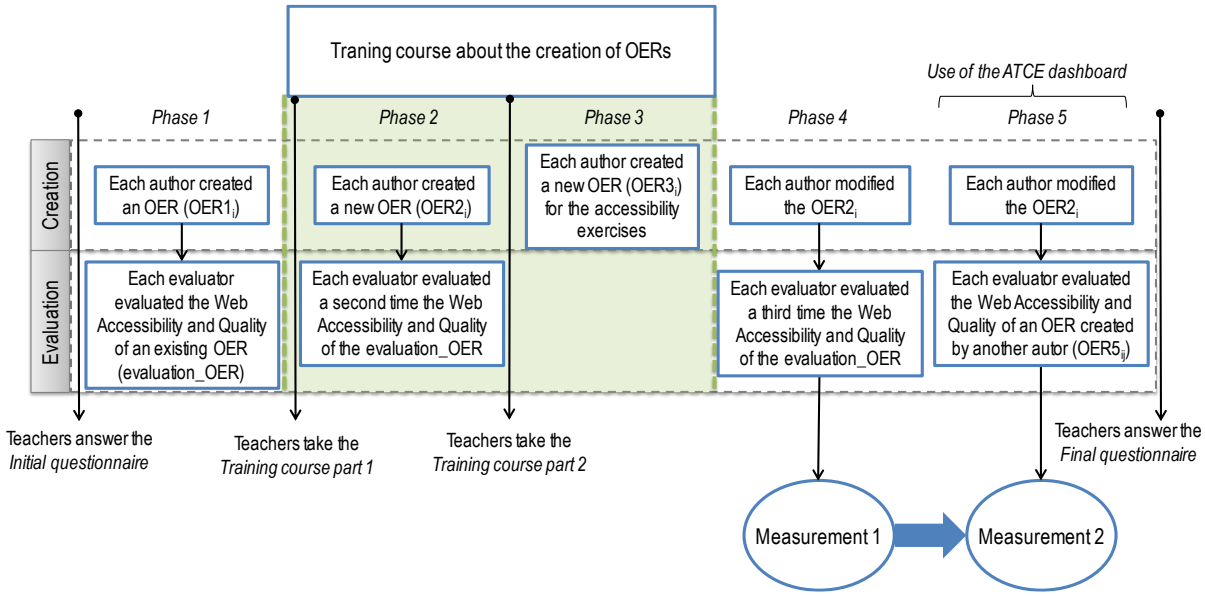


Figure 6-1. Research design.

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 the role of author was asked to create an OER ($OER1_i$, where $_i$ identifies the author) as a virtual course in the ATutor LMS using the ATCE web editor.
- *Evaluation phase 1:* each teacher in the role of evaluator was asked to evaluate the web accessibility and the quality of an existing OER (evaluation_OER) entitled *The kingdoms of nature* using the ATCE evaluation module.
- *Training course part 1:* 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 the role of author was asked to create a new OER ($OER2_i$, where $_i$ identifies the author) using the ATCE web editor.
- *Evaluation phase 2:* each teacher in the role of evaluator was asked to evaluate once more the web accessibility and quality of the evaluation_OER. In this stage, teachers had

more knowledge on what criteria to consider in the evaluation of the web accessibility and quality of the OER.

- *Training course part 2:* 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 the creation of accessible contents using the ATCE web editor. To do these practical exercises each teacher created another OER (OER3).
- *Creation phase 4:* each teacher in the role of author was asked to continue editing the $OER2_i$ created in the creation phase 2.
- *Evaluation phase 4:* each teacher in the role of evaluator was asked to evaluate once more the web accessibility and quality of the evaluation_OER.
- *Measurement 1:* an expert used the ATCE evaluation module to evaluate the OER edited by teachers in the creation phase 3 and the ATCE verification module to verify the evaluations done by teachers in the evaluation phase 4.
- *Creation phase 5:* teachers were introduced to the ATCE dashboard. After that, each teacher in the role of author was asked to continue editing $OER2_i$ but this time using the ATCE web editor and the information provided through the author's view of the ATCE dashboard.
- *Evaluation phase 5:* teachers were asked to participate in a peer-review process in which each teacher in the role of evaluator evaluated an OER created by another teacher ($OER5_{ij}$, 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 OER edited by teachers in the creation phase 4 and also verified the evaluations done by teachers in the evaluation phase 4.
- *Final questionnaire:* teachers were asked to answer the final questionnaire with questions based on the LAAM instrument and some open questions.

6.5 Data analysis

The methods used for the analysis of data to answer each research question 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 OER?

The dependent variables for RQ1 are:

- *Accessibility (creation)*: this variable shows how well authors can create accessible OER in terms of their competence level (from 0 to 100).
- *Quality (creation):* this variable shows how well authors can create quality OER in terms of their competence level (from 0 to 100).
- *Accessibility (evaluation):* this variable shows how well evaluators can evaluate the web accessibility of OER in terms of their competence level (from 0 to 100).
- *Quality (evaluation):* this variable shows how well evaluators can evaluate the quality of OER in terms of their competence level (from 0 to 100).

For answering RQ1, the results obtained in measurement 1 and measurement 2 were compared, considering the above mentioned dependent variables. A t-test was applied for comparing the variables with a normal distribution and the Mann Whitney U test for those with a non-normal distribution. We used Excel 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 of teachers with regard to the use of the ATCE tool?

For answering RQ2, the answers given by 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. We use Excel to organize the data collected and to calculate the descriptive statistics.

6.6 Limitations of the study

The fact that teachers evaluated the same OER (evaluation_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 influence the results obtained in measurement 1 for the competency of evaluating accessibility and quality of OER.

6.7 Results and discussion

This section presents general results about the web accessibility and quality of OER created by teachers (subsection 7.1) and results from both parts of the study. For answering RQ1, the results from the analysis applied on data collected from the actions carried out by participants in the creation and evaluation of the OER in the evaluation process are presented (subsection 7.2) and for answering RQ2, the answers given by the teachers to the final questionnaire are presented (subsection 7.3).

6.7.1 General results: overview of the web accessibility and quality

The results discussed in this section come from the evaluation of the web accessibility and quality of the OER created by teachers in their role of authors in the creation phase 5.

Fig. 8 shows results of web accessibility by type of HTML element. The level of web accessibility by type of HTML element varies between 79% and 98%.

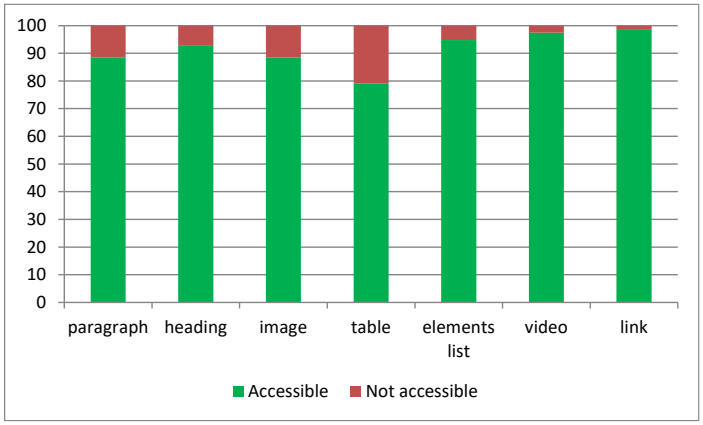


Figure 6-2. Level of web accessibility by type of HTML element.

Since web accessibility was addressed by using the WCAG 2.0 guidelines, the level of accessibility for each one of the three WCAG 2.0 principles considered in LAMTCE (Perceivable, Operable and Understandable) was also analyzed. As mentioned earlier in the definition of LAMTCE, the robust principle was not included here because criteria in this principle are related to the HTML source code of the webpages and teachers do not work directly with the source code of the webpages. Fig. 9 shows the level of web accessibility reached on each principle. These results revealed that the web accessibility of the OER still need to be improved but the level obtained in each principle is good (higher than 75% in all principles).

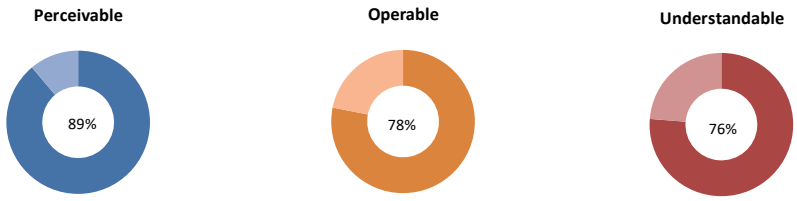


Figure 6-3. Level of web accessibility by WCAG principle.

Fig. 10 shows the results of the OER' 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 OER created in the creation phase 4 reached between 4 and 5 stars. These results suggest that the level quality in most of the OER was good (3 to 5 stars) and none of them obtained 1 or 2 stars.

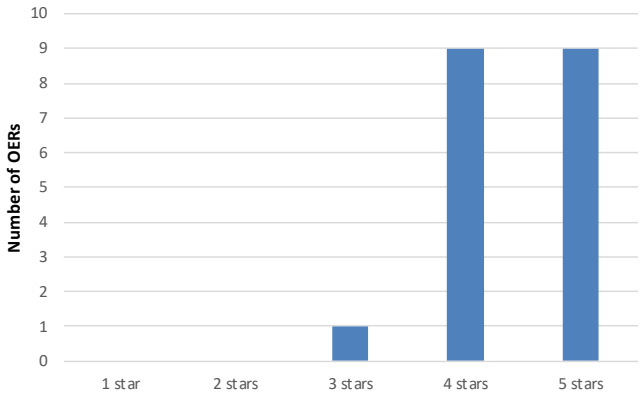


Figure 6-4. Level of quality.

At the end of the evaluation process, the ideal situation would be that, in the last measurement, all the OER reached a 100% in the level of accessibility and 5 stars in the quality rating for all OER. However, results in the accessibility by type of HTML element and by WCAG principle revealed a good level of web accessibility (higher than75%) and in terms of quality, OER obtained a good level with 4 and 5 stars in almost all OER.

6.7.2 Results RQ1: the teachers' competences in the creation and evaluation of OER

Results obtained from the measurements carried out before and after teachers created and evaluated OER using the ATCE dashboard, revealed that the teachers' competences in creation and evaluation of OER 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).

Table 6-1. RQ1 –data from Measurement 1 and Measurement 2

Participant	Measurement 1				Measurement 2			
	Creation		Evaluation		Creation		Evaluation	
	Accessibility	Quality	Accessibility	Quality	Accessibility	Quality	Accessibility	Quality
1	72.31	57.50	58.33	50.00	76.19	60.00	75.00	62.50
2	81.16	67.50	58.93	75.00	89.80	92.50	76.09	75.00
3	76.92	70.00	69.64	75.00	91.38	95.00	90.91	75.00
4	81.73	65.00	73.47	62.50	87.65	97.50	92.86	87.50
5	72.15	57.50	46.27	62.50	84.91	82.50	62.50	75.00
6	83.08	67.50	78.26	75.00	90.00	95.00	95.00	87.50
7	72.50	67.50	70.00	62.50	86.51	90.00	81.82	87.50
8	75.00	40.00	52.00	50.00	78.79	72.50	54.55	62.50
9	52.00	57.50	69.77	50.00	89.19	80.00	72.97	75.00
10	53.00	60.00	63.33	62.50	85.29	77.50	75.68	75.00
11	52.70	72.50	74.47	62.50	91.80	87.50	85.00	87.50
12	64.70	65.00	81.25	62.50	85.71	90.00	79.49	75.00
13	36.30	57.50	80.00	75.00	86.66	87.50	81.00	87.50
14	78.94	67.50	78.72	62.50	80.95	92.50	84.62	87.50
15	56.98	67.50	92.59	75.00	80.48	87.50	85.26	87.50
16	52.50	60.00	74.29	62.50	85.29	85.00	81.08	87.50
17	69.38	62.50	61.90	75.00	84.00	95.00	93.33	87.50
18	52.89	67.50	71.43	62.50	83.72	90.00	77.78	75.00
19	69.38	62.50	55.81	75.00	85.45	82.50	75.00	87.50

Results for RQ1 were calculated based on statistical tests conducted for each of the four dependent variables presented in subsection 6.4 and are described as follows.

Accessibility (creation): data collected for how well authors can create accessible OER 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 used it (ACM2). Results of 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 $t(18)=-6.0638$, $p<0.05$. Effect size was large Cohen's $d=1.43$ and Power was 1.

Quality (creation): data collected for how well authors can create quality OER 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 used it (QCM2). Results of 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 was 0 and the sum of ranks with negative sign was 210, which means that quality in OER was better in QCM2. 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 OER 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 used it (AEM2). Results of 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. Effect size was large, Cohen's d=1.11 and Power was 1.

Quality (evaluation): data collected for how well evaluators evaluated the quality of the OER 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 of 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 was 0 and the sum of ranks with negative sign was 153, which means that the level of quality was better in QEM2. The effect size was large, r=1.74 and Power was 1.

Differences observed between measurement 1 and measurement 2 in the four dependent variables described above were positive and statistically significant. These results suggest that teachers 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 that feedback from dashboards guide users in the progress and performance in learning activities (N. R. Aljohani & Davis, 2013; Corrin & de Barba, 2014; Na & Tasir, 2017).

6.7.3 Results RQ2: teachers' perceptions with regard to the use of the ATCE tool

Results for answers given by teachers (*N=19*) for both parts of the final questionnaire (LAAM instrument and open questions) revealed positive perceptions of teachers towards the use of the ATCE tool.

Table 6-2 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 question and 5 indicates very high agreement with the question. 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. After checking the answers for any problems, we identified that one of the participants gave the same answer for almost all questions even for the reverse question. Consequently, for ensuring reliability the answers from this participant were not taken into account in this analysis. Thus, *N=18*.

For the reverse question (Q8), the result obtained in the mean score (2.06) is equivalent to 3.94 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 suggest 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 OER. The lowest scores were in Q8 (3.94) and Q13 (3.89). A potential explanation of this result might be that some of the teachers may have used other similar tools more intuitive in feedback provisioning and less overewhelming. 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 teachers seemed to be satisfied with the information presented in the dashboard.

Table 6-2. Results for the LAAM instrument

Category	Question in the questionnaire	Mean	Standard deviation
Perceived value of visualizations presented in the ATCE dashboard	Q1a: I use the information presented in the accessibility section of the *Authors view* of ATCE as feedback to support my process as author of OER.	4.89	0.32
	Q1b: I use the information presented in the quality section of the *Author's view* of ATCE as feedback to support my process as author of OER.	4.61	0.50
	Q1c: I use the information presented in the *Evaluator's view* of ATCE as feedback to support my process as evaluator of OER.	4.61	0.50
Perceived usefulness (usage belief) of the tool for improving the OER web accessibility and quality	Q2: ATCE enables me to get an insight into my process in the creation and evaluation of OER.	4.78	0.43
	Q3: The information ATCE provides helps me identify what needs to be improved in my OER.	4.72	0.46
	Q4: ATCE provides relevant information regarding the accessibility and quality of my OER.	4.50	0.51
	Q5: The information provided by ATCE helps me determine how to improve in my role of author and evaluator of OER.	4.67	0.49
	Q6: ATCE helps me identify the main accessibility and quality issues in my OER.	4.72	0.46
Perceived GUI (ease of use) of the tool	Q7: ATCE's GUI (Graphical User Interface) is intuitive enough.	4.39	0.61
	Q8: ATCE's GUI is overburdened with information. (*reverse question*)	2.06 (3.94)	0.64
	Q9: ATCE's GUI has a good design.	4.39	0.50
General perception of the tool	Q10: All in all, I found ATCE a handy tool for feedback provision.	4.67	0.49
	Q11: I would like to be able to use ATCE in my teaching practice.	4.83	0.38
	Q12: ATCE provides me with more useful feedback than other similar tool(s) I have used/tried.	4.28	0.67
	Q13: ATCE is more intuitive than the other tools capable of feedback provision I have used/tried.	3.89	0.83

Qualitative feedback with regard to the use of the ATCE tool was gathered through the comments provided on each of the four open questions included in that questionnaire which are discussed as follows:

- *Comments about the dashboard:* in general teachers found the dashboard provided in the ATCE tool very useful. Some strengths highlighted by the teachers were that the

dashboard allowed them to "… *observe the evolution of the creation process*", also that "*the analytics dashboard is an ideal and an excellent tool to obtain data that allow us to improve the quality of our resources*", another teacher stated that "s*ince this tool is integrated into the ATutor platform, it is of extreme importance because it allowed us to get all the information we need to improve our resources*". The feedback received through the ATCE dashboard was another aspect highlighted by the teachers (e.g. "*this is the first time I use an analytics dashboard and I found it excellent because of the feedback received*" or "*I liked a lot the feedback given to improve in both roles*"). With regard to the web accessibility, teachers understood one of the main contributions of the dashboard by giving opinions such as "*this tool allowed me to revise how accessible my OER was and to improve my contents making them more accessible*". Another aim of the dashboard was that teachers could follow their advances in the acquisition of the competences in the creation and evaluation of OER and some of the opinions of the teachers confirm this (e.g., "*I think the analytics dashboard allows me to see the result of the work done in both roles as an author and as an evaluator*", "*It is a good tool because it allowed me to know how to improve or things I need to change. It helps me to make my educational resources more meaningful*", "*This is a positive tool because it allows us to observe how we have advanced as authors and evaluators*", "*I think the analytics dashboard allows me to see the result of the work done in both roles as an author and as an evaluator. This tool is very explicit and concrete*"). Besides that, one of the teachers expressed an inconvenience related to the information provided in the dashboard by stating that "*one inconvenience I had was that the dashboard told me that one of my images was wrong but it wasn't because I had deleted it, but I found all other options very useful and easy to use*". This was a bug on the web editor identified when teachers started to use the dashboard because one teacher reported this. Apparently sometimes the tags of the images were not deleted properly. This bug was fixed as soon as the teacher made the report and the information on the dashboard was updated. Another recommendation to take into account for future scenarios involving the use of the dashboard was that "*at the beginning of the evaluation of the OER it would be useful to emphasize a little bit more that our evaluations and comments will be used by the authors of the OER*".

- Comments about the evaluation module: the use of the evaluation module served so that teachers could improve as evaluators of OER (e.g. "at the beginning for me it was difficult to understand some questions or categories presented in the evaluation module but little by little I could understand them", "The evaluation module got us an idea about the characteristics we needed to take into account when evaluating but also when creating OER"). Teachers also reflected about their role as evaluators and the impact on the end users (students) (e.g. "The evaluation module is very interesting because it is a way to think about the end users from the perspective of an evaluator"). Furthermore, a teacher pointed out that "it is very useful to perform evaluations on the OER because in each question presented in the evaluation module, I founded tips to improve my own contents". Another teacher found giving comments as a mechanism to improve the quality of the OER ("I found that all the options available to evaluate the accessibility and quality of the OER were useful. I think it is important that both web accessibility and quality can be evaluated by other people. The diversity of comments can increase the quality of the OER"). One of the teachers recommended to revise the number of accessibility questions provided for some elements ("for some elements, to identify if one element is accessible there are lot of questions).
- Comments about the ATCE web editor: one teacher stated "in my case that I am not from the computer science field, I would like to have an extra guidance to learn more about the use of the web editor". Teachers also expressed some difficulties when using the web editor such as that they sometimes got logged out from the ATutor platform while working on their webpages and therefore sometimes lost content or that they found it difficult to use the option to copy and paste contents. Moreover, teachers found

the web editor as a supporting tool to improve the OER's web accessibility (e.g., "an excellent tool that allows to improve the webpages of the OER and also to improve their accessibility", "it is an easy to use tool, the images it uses allowed me to remember the options I could use and sincerely when I created resources I did not realize the importance of taking into account certain requirements of the content that should be meet for those in an inclusion process", "the web editor is essential so that the webpages have the appropriate information and meet with standards").

- *General keywords:* the ATCE tool was intended to support teachers in the creation and evaluation of the OER. Moreover, the tool aims at contributing to the development of the teachers' competences when they participate as authors and evaluators of OER with focus on web accessibility and quality of OER. In this context, keywords mentioned by teachers for describing the activities carried out in the training course and the phases of creation and evaluation of OER were: *inclusion, web accessibility, quality, feedback, evaluator, useful tool, improve, error correction, analysis, charts, innovation, easy interaction, creativity, appropriateness, and inclusive teaching*, among others. These terms show that teachers were familiarized with the concepts addressed in the evaluation process.

Our observations are in agreement with prior research on the teachers' behavioral intentions to use a learning analytics tool (Papamitsiou & Economides, 2015) because the information provided through that tool was perceived by users as useful, easy to use and users claimed their intention to use the tool in the future.

Some studies identified in the literature involved the use of learning analytics for informing about improvements in learning contents by using data from students' interactions (Prasad, Totaram, & Usagawa, 2016a; María Jesús Rodríguez-Triana, Martínez-Monés, Asensio-Pérez, & Dimitriadis, 2015). These studies demonstrate that the monitoring through learning analytics is an effective way for helping teachers or content creators to make decisions of improvements in learning contents using the information gathered from the interaction of students with learning activities and contents. However, such studies do not consider characteristics that can be improved at the creation time such as web accessibility and quality.

Consequently, this study differs from other studies in the field of OER and learning analytics in the sense that the evaluation described in this chapter allowed us to confirm that when teachers are provided with a tool that support them in the acquisition of competences in the creation and evaluation of OER, teachers can receive feedback with recommendations on how to improve as authors and evaluators of OER as well as they can use such information in order to improve the learning contents included in the OER in terms of web accessibility and quality.

6.8 Conclusions of the chapter

This study sought to analyze whether the ATCE dashboard benefited teachers in the acquisition of competences in the creation and evaluation of OER, and to analyze the teachers' perceptions with regard to the use of the ATCE tool. General results from the evaluation of ATCE suggest that the OER created reached a good level of accessibility and quality. Moreover, the use of the ATCE dashboard benefited teachers in the acquisition of competences in the creation and evaluation of OER and teachers had positive perceptions of using the ATCE tool.

Based on the results and findings drawn from the tests applied to the two measurements taken in the evaluation of the tool (t-test and Wilcoxon signed-rank), we conclude that the use of the ATCE dashboard allowed teachers to improve in their competences in the creation and evaluation of OER. As authors, teachers were informed on how to improve the

web accessibility and quality of their learning contents, and as evaluators of OER, teachers were informed on how to improve in their task of evaluation in terms of web accessibility and quality. Moreover, the answers given by teachers to the final questionnaire suggest that teachers had positive perceptions with regard to the use of the ATCE tool. Particularly, they acknowledge the information provided through the dashboard because they received detailed information that allowed them as authors to improve the web accessibility and quality of their OER as well as to improve in their role as evaluators. Teachers also reported that the evaluation they did of other OER was an opportunity to reflect on what they should improve in their own OER.

Openness makes educational resources to be in a continuous improvement (Bodily et al., 2017). The support given by LAMTCE and ATCE presented in this paper is a contribution so that such continuous improvement takes place during the creation of OER. The definition of LAMTCE and the implementation of it into the ATCE tool allowed to collect data from the activities done by teachers when they create and evaluate OER.

As discussed by Navarrete and Luján-Mora (2017), people with disabilities face barriers to access OER. They also state that one way to attain this issue is to create tools and learning contents that cope with such barriers. In line with this need, supporting tools like the one presented in this paper can make teachers more aware of and can contribute to the creation of OER with learning contents that address the diversity of students' learning needs.

PART 4
FINAL REMARKS

CHAPTER 7
CONCLUSIONS, CONTRIBUTIONS AND FUTURE WORK

The research work done in this thesis led us to tackle the challenges derived from our main research question: *how can learning analytics support teachers in the creation and evaluation of accessible open educational resources?* This chapter presents the concluding remarks of this thesis, as well as the contributions, and some directions for future work.

Previous chapters presented the findings and the analysis of results derived from the activities carried out following the phases of the research methodology defined for this thesis (presented in section 1.4). Outcomes from the activities carried out contributed to answer the main research question and to achieve the main and the six specific objectives of this thesis.

7.1 General overview of this thesis

As discussed in the introductory part (CHAPTER 1), the concern about the attention to the diversity of students' learning needs, lessons learnt from our experience working with teachers in the creation of OER within the context of different research projects, and the benefits that learning analytics could bring to support teachers in the creation and evaluation of accessible OER motivated the research work done in this thesis. The activities carried out and the results obtained in the different phases of development of this thesis led us to answer the main research question which was: ***How can learning analytics support teachers in the creation and evaluation of accessible open educational resources?***

Based on the literature review about OER presented in CHAPTER 2, we have stated that accessibility and quality are two characteristics of OER that are in somehow connected and that should be considered in the creation of OER. As we identified that there is little evidence of empirical studies evaluating such characteristics, we pointed out that the creation process should be accompanied by an evaluation process to ensure that an OER meets with accessibility and quality requirements.

Consequently, there was a need to conduct an exploratory study (CHAPTER 3) in order to observe how teachers created accessible OER. In the exploratory study we adopted the CO-CREARIA model to guide teachers in the creation process and we defined a peer-review evaluation approach so that teachers could evaluate the OER considering accessibility and quality characteristics. Due to the fact that one of the pillars of CO-CREARIA is the Universal Design for Learning (UDL) that promotes inclusive learning practices, then we adopted the term Inclusive and Accessible OER (OER). Moreover, in that exploratory study we defined a peer review evaluation approach so that teachers could evaluate the OER in terms of accessibility and quality. Results from the exploratory study allowed us to identify the main aspects to consider when teachers create and evaluate such resources. These aspects were included as part of the user model we defined to represent the teacher's competences in the creation and evaluation of OER considering the accessibility and quality characteristics.

The actions carried out by teachers in the exploratory study, the tools used by teachers and the user model were the inputs to come up with the Learning Analytics Model to Trace de Creation and Evaluation of OER (LAMTCE) (CHAPTER 4). LAMTCE was built following the four common steps in a learning analytics process, namely: gathering of raw data, storing, analysis and visualization. Moreover, we implemented the LAMTCE model in a learning analytics tool we called ATCE – Analytics Tool to Trace the Creation and Evaluation of OER (CHAPTER 5). To develop this tool, we firstly analyzed the outcomes obtained from LAMTCE building process and then we defined some design decisions that guided the development of ATCE. Functionalities of the tool were described in detail and the visualization obtained after using it were described by means of a use case of an OER created using the tool.

The LAMTCE model and the ATCE tool were validated in a real scenario with teachers (CHAPTER 6). The purpose of that evaluation scenario was twofold. Firstly, it attempted to investigate whether ATCE (implemented based on the LAMTCE model) benefits teachers in the acquisition of competences in the creation and evaluation of OER. Secondly, it it aimed at identifying the perceptions of teachers with regard to the use of the ATCE tool.

All the above mentioned activities contributed to the achievement of the specific objectives and thereby to achieve the main objective of this thesis which was: ***to define a learning analytics model for supporting teachers in the creation and evaluation of accessible open educational resources***. Following section give details of the main contributions of this thesis according to each specific objective.

7.2 Contributions

The main contributions of this thesis are described according to each specific objective as follows:

SO1: To conduct a literature review on open educational resources and monitoring mechanisms to support teachers in the creation of open educational resources.

The main contribution aligned with SO1 was the literature review in the topic of OER which was conducted by analyzing 175 studies. This literature review gave us important insights into the topic of OER and particularly on how the creation of OER has been carried out in the last years. Another contribution in this line was that we broadened the literature review by including other topics that were addressed in this thesis, namely: web accessibility, quality in educational resources, ICT competences for teachers, user modelling and learning analytics.

SO2: To conduct an exploratory study to identify aspects that provide a better support in the creation and evaluation of accessible open educational resources.

To achieve the SO2 we conducted an exploratory study in which teachers could create their own OER and they also have the opportunity to participate as evaluators of OER. The exploratory study took place in the context of a training course about the creation of OER. Then main contributions derived from this exploratory study are described as follows:

- In the exploratory study we adopted the CO-CREARIA model so that teachers created their OER. Unlike other methodologies, CO-CREARIA is based on the UDL principles to promote inclusive learning. This model provided us with a set of templates that allowed teachers to be more aware of the qualities of their students and other characteristics of their learning contents. One of the phases of CO-CREARIA is the evaluation, then as part of this phase the contribution of this thesis was to define a peer evaluation approach to evaluate the accessibility and quality of the OER involving the participation of teachers as authors and evaluators of these resources.

- The evaluation approach included the use of some existing revision tools and the QWAE tool which has two web instruments that we developed to facilitate teachers the evaluation of the accessibility (WAI) and quality (QI) of the OER. Regarding the accessibility instrument we analyzed the guidelines proposed in the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) and for the quality instrument we adopted the Learning Object Review Instrument (LORI).
- The preparation of all materials and tools needed to carry out the course including: installation of the ATutor platform, installation of the Inclusive Learning Handbook for teachers, recording and edition of the video tutorials, and preparation of the class materials.
- According to the results from the exploratory study, we could identify some aspects to improve in the creation and evaluation of OER for providing teachers with a better support. For instance, the automatic tools used for checking the web accessibility of the OER do not provide an appropriate guidance for answering the questions. Another aspect was that the web accessibility evaluation was applied for the whole OER and for this reason when the authors received the report, they could not easily identify the detail of the failures to fix in the learning contents. Moreover, in the adquisition of the competences in the creation and evaluation of OER, teachers did not know how well they were advancing in the adquisition of those competences.

SO3: To define a user model to represent the teacher's competences in the creation and evaluation of accessible open educational resources.

The main contribution to achieve the SO3 was the definition of a user model of the teacher's competences in the creation and evaluation of OER. The two main competence domains which were included as part of the user model: Domain 1(Creation of accessible contents) and Domain 2 (Evaluation of the accessibility and quality of OER). These two competence domains were defined based on the analysis of the actions carried out by teachers in the exploratory study to create and evaluate the OER considering the accessibility and quality characteristics. For each competence domain we defined a set of competences including indicators in each one and considering three levels for those indicators: beginner, intermediate, and advance. This user model was included as part of the analytics model referred in the contributions of the SO4.

SO4: To define a learning analytics model to trace the creation and evaluation of accessible open educational resources.

The main contribution aligned with SO4 was the definition of a Learning Analytics Model to Trace the Creation and Evaluation of OER (LAMTCE) considering the web accessibility and quality as two featured characteristics of OER. This model was built based upon the main steps of a learning analytics process, namely: 1) gathering of raw data, 2) storing, 3) analysis, and 4) visualization. Contributions of LAMTCE are:

- Analysis of all actions derived from the creation and evaluation of OER.
- Definition of the roles participating in the creation and evaluation process.
- Description of the instruments to be used in the collection of data. These instruments were selected taking into account the experience in the exploratory study. Besides, we defined the improvements for these instruments that should be taken into account according to conclusions from the exploratory study.
- Description of the creation and evaluation of OER considering all the elements involved in the exploratory study. This description was represented by means of a flowchart.
- Definition of the data model to store the data collected.
- Analysis of the WCAG 2.0 guidelines

- Definition of the user model of the teacher's competences in the creation and evaluation of OER considering the web accessibility and quality characteristics.
- Definition of a set of metrics considered as the output data of the LAMTCE model. These metrics were defined with regard to the teacher's competences defined in the user model.
- Definition of the visualizations that should be considered in the implementation of LAMTCE. These visualizations are based on the metrics defined in the previous step.

SO5: To develop a learning analytics tool based on the proposed learning analytics model.

The main contribution aligned with the SO4, which is also another major contribution of this thesis, was the development and implementation of the LAMTCE model into a learning analytics tool that we called ATCE. ATCE was integrated as a module in the ATutor LMS to facilitate teachers when they create and evaluate OER. Main functionalities of ATCE are:

- It stores the details of each HTML element added by an author in an OER.
- It checks some of the accessibility criteria that can be evaluated in an automatic way (automatic evaluation) by using the API of AChecker which is an automatic validator.
- It provides the instruments for the manual evaluation so that evaluators answer questions related to the accessibility and quality of the OER.
- It includes a dashboard with visualizations related to the accessibility and quality of the OER created as well as information related to the level reached in the evaluation of the accessibility and quality. Such information can be used by teachers to improve the OER and therefore to improve their competences in the creation and evaluation of these resources.
- The dashboard includes an option so that teachers can easily identify the exact location (webpage) of the HTML elements that present accessibility failures. This option saves teachers' time in the sense they can access to the webpage that have accessibility failures directly from the dashboard.

SO6: To conduct an evaluation for the proposed learning analytics model and the learning analytics tool.

The main contribution aligned with the SO6 was the definition of an evaluation scenario with two main purposes. On the one hand, to investigate if the ATCE (implemented based on the LAMTCE model), benefited teachers in the acquisition of competences in the creation and evaluation of OER. On the other hand, it purports to identify the perceptions of teachers influencing the acceptance in the use of the ATCE tool. Contributions derived from this evaluation scenario were:

- The analysis of results derived from the first part of this evaluation led us to confirm that the use of the ATCE tool really benefited teachers in the adquisition of competences in the creation and evaluation of OER considering the web accessibility and quality characteristics.
- The analysis of results derived from the second part of this evaluation helped us to identify the perceptions of teachers with regard to the use of the ATCE tool. Thus, we identified that teachers perceived the tool as useful and easy to use. Moreover, teachers claimed their intention to use the tool in the future.

7.3 Conclusions

Nowadays teachers use digital tools and platforms to create, publish or share their learning contents. These learning contents are mostly presented in the form of Open Educational Resources (OER) because of its open availability, they are free of charge, and they give

teachers many possibilities to represent the learning contents. Despite the high adoption of OER, this change in the way learning contents are delivered has also brought another challenge for teachers in the sense OER should address the diversity of students' learning needs. One way to face this challenge is to provide students with accessible OER, but the creation process should be complemented with an evaluation of the OER in order to ensure that the resources meet with accessibility and quality requirements. Based on our experience working with teachers and the findings in the literature we realized that this is not a straightforward task and this motivated us to focus our research on supporting teachers in the creation and evaluation of accessible open educational resources considering the accessibility and quality characteristics. Moreover, taking advantage of the learning analytics approach we realized that it can be used as a way to give teachers information or feedback related to the process they followed in the creation and evaluation of accessible OER. Then, we defined our main research question as: ***how can learning analytics support teachers in the creation and evaluation of accessible open educational resources?***

In this thesis we have discussed the challenge that teachers face when they have to create OER considering accessibility and quality characteristics. Resources with such characteristics may contribute to address the diversity of students' learning needs. Moreover, from the literature review about OER (presented in CHAPTER 2) we concluded that the creation process must go hand in hand with an evaluation process to ensure that the OER meet with accessibility and quality requirements. Besides, we found that one of the challenges for teachers is to provide their students with access to better learning contents and with none or the minimum content access barriers. This is possible when teachers, as the authors or evaluators of OER, are trained or have access to the appropriate supporting tools to create and evaluate OER.

The analysis of the topics in the literature review also led us to conclude that there was a need for further research to examine the elements and actions involved in the creation of accessible OER when teachers are the main actors. Then we deployed an exploratory study (CHAPTER 3) in which we adopted a methodology for the creation of accessible OER and we proposed an evaluation approach focused on the evaluation of the accessibility and quality of OER. As for the creation methodology we adopted the CO-CREARIA model which promotes the inclusive learning by considering approaches such as the UDL and the web accessibility. The CO-CREARIA model also includes an evaluation phase in which we integrated our peer review evaluation approach which is aimed to evaluate the accessibility and quality of OER. Moreover, this approach was validated in an exploratory study which involved the participation of teachers in a training course where they learnt and practiced about the creation and evaluation of OER from two roles: author and evaluator. Teachers created their own OER in the form of virtual courses by using the ATutor LMS and were allowed to participate in the peer review evaluation process. From the exploratory study we could conclude that tools for evaluating the web accessibility of contents are not focused on teachers as the main users because of the technical language used for presenting the results. Moreover, the feedback provided to teachers were text-based reports and feedback from instructors. However, teachers would benefit from tools with a feedback provisioning system that allows them to identify the failures to fix in the OER' contents. It means that when teachers have the appropriate supporting tools then they are able to create and evaluate OER obtaining good results..

The procedure followed and instruments used in the exploratory study, led us to identify some aspects to be considered in the definition of the Learning Analytics Model to Trace the Creation and Evaluation of OER (LAMTCE) considering the web accessibility and quality characteristics (CHAPTER 4). These elements included: actions in the creation and evaluation of OER considering accessibility and quality characteristics, roles played by actors involved in the process and instruments used by teachers. The analysis of these elements allowed us to conclude that the instruments provided to teachers could be

improved in order to give a better support for teachers and also to alleviate them from the workload that is involved in the process.

The first step to build a learning analytics model is to think about *what* we want to trace, the actors *who* would be involved in the process, the reasons of *why* we build the model, and the way on *how* we want to collect and analyze the data. These elements were taken from the model proposed by Chatti et al. (2012). Thereby this was the first step we followed, we thought on those elements and then we defined the main steps for LAMTCE considering common steps for a learning analytics process identified in other existing learning analytics models. The steps are: gathering of raw data, storing, analysis and visualization. After working on the development of each step the main outputs of LAMTCE were:

- Roles of actors involved in the process, instruments needed including the improvements suggested by the conclusions of the exploratory study.
- The flowchart of actions followed by teachers in their role of authors and evaluators.
- The data model with all data we wanted to collect.
- The web accessibility questions considering the differentiation between questions related to the automatic evaluation and questions related to the manual evaluation.
- The metrics based on the user model of the teachers' competences in the creation and evaluation of OER considering accessibility and quality characteristics.
- Visualizations that can represent useful information to support teachers in the creation and evaluation of OER.

The LAMTCE model is a flexible model that can be extended in order to include other roles, other characteristics of the OER, other competences of teachers or other instruments to collect data. In order to validate the LAMTCE in a real scenario with teachers, we implemented it in a learning analytics tool we called ATCE – Analytics Tool to Trace the Creation and Evaluation of OER (CHAPTER 5).

Results from the evaluation of the LAMTCE model, and thereby the ATCE tool, led us to conclude that each time teachers used the tool they improved in their role as authors (competence in the creation of OER) and evaluators (competence in the evaluation of OER). Moreover, at the end of the evalauation OER reached a good level in both the web accessibility and quality. With regard to the factors influencing the ATCE tool, teachers had a positive acceptance because they found very useful the information provided through the dashboard. For instance, they highligthed that the detailed information allowed them to improve the web accessibility and quality of their OER. They also reported that using this tool they could improve in their role as evaluators and that to evaluate other OER was an opportunity to reflect on what they should improve in their own OER.

7.4 Future work

This section describes some ideas for future research directions that can be followed to extend the research conducted in this thesis.

Automating other phases in the creation process

- First phases (analysis and design) of the model adopted for the creation of OER (CO-CREARIA) involved the use of templates in which teachers defined elements such as the context in which the OER will be used, the students' profile, possible barriers and opportunities according to the student's profile, and description of materials to be included in the OER. These templates could be automated so that teachers have always available the source information that was used to create the resource. This information could be integrated with the analytics tool to enrich the aids provided in the manual evaluation process.

Promoting a collaborative approach for the creation of OER

- Further research can be conducted on tracing the creation and evaluation of OER from a collaborative perspective. This means that a group of teachers work together to create an OER and that they also have a guide on how to apply collaborative techniques to develop each one of the phases in the creation and evaluation processes.
- Other competences related to the creation and evaluation of OER can be included as part of the user model of the teacher's competences that we defined in this thesis. For instance, competences related to the work in collaborative teams. If a more collaborative approach were adopted, we would be able to analyze interactions among teachers working in the same creation team. Moreover, from the analysis of those interactions it would be possible to do learning analytics to give teachers a collaborative view of the tasks they carried out together with other teachers.

Giving institutions an active role

- Institutions would benefit from the analytics solution proposed in this thesis if they would have access to reports generated from the activity carried out by all teachers in the creation of OER. The learning analytics tool developed in this thesis can be enriched so that it generates reports oriented to show compiled results that institutions can use in order to make decisions on how to improve training processes or the support given to teachers when they create educational resources. This active role of institutions in the use of learning analytics is better known in the analytics field as academic analytics.

Expanding the learning analytics model

- The LAMTCE model is focused on how learning analytics support teachers in the creation and evaluation of OER considering the accessibility and quality characteristics. This model can be extended to consider other characteristics of the OER and characteristics more related to the learning context such as characteristics of the learning scenario, characteristics of students, technical requirements to use the contents, etc.
- The analytics model could consider the use of analytical techniques that lead to identify patterns of common mistakes made by teachers in the creation and evaluation of OER. This information may serve to provide teachers with automatic recommendations that help them to improve their competences as authors and evaluators of OER.

Motivating teachers in the creation and evaluation process

- Results coming from the creation and evaluation of OER helped us to generate recommendations for teachers on how to improve their competences in the role of authors and evaluators of OER. The acquisition of these competences involves activities that can be viewed as learning activities. If teachers receive a kind of recognition for the activities they carry out when they create or evaluate their OER, they would feel more engaged in this process. In this context, the digital badge systems are being used to acknowledge learners for their formal and informal activities (Law & Law, 2014).

Going beyond the evaluation phase

- In this thesis the evaluation process was focused on the achievement of OER that meet with accessibility and quality requirements. As reported in the exploratory study few of the teachers implemented their OER in a real scenario with students. The evaluation scenario can be extended to test the OER in real learning experiences with students to determine how this affects their learning process.

REFERENCES

Abeer, W., & Miri, B. (2014). Students' Preferences and Views about Learning in a MOOC. *Procedia - Social and Behavioral Sciences*, *152*, 318–323. https://doi.org/10.1016/j.sbspro.2014.09.203

Abeywardena, I. S., Chan, C. S., & Tham, C. Y. (2013, September 30). OERScout technology framework: A novel approach to open educational resources search. *The International Review of Research in Open and Distributed Learning*.

Abeywardena, I. S., Tham, C. Y., & Raviraja, S. (2012). Conceptual Framework for Parametrically Measuring the Desirability of Open Educational Resources using D-Index. *International Review of Research in Open and Distance Learning*, *13*(2), 59–76. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=U1z4h6Wfv8q8gS4weWE&page=13&doc=123

AChecker. (2012). IDI Web Accessibility Checker: Web Accessibility Checker. Retrieved from http://achecker.ca/checker/index.php

Achieve Inc. (2011). Commons core - OER rubrics. Retrieved from http://www.achieve.org/publications/achieve-oer-rubrics

Algers, A., Lindström, B., & Pajor, E. A. (2010). A New Format for Learning about Farm Animal Welfare. *Journal of Agricultural and Environmental Ethics*, *24*(4), 367–379. https://doi.org/10.1007/s10806-010-9271-5

Algers, A., Silva-Fletcher, A., Gregory, N., & Hunt, M. (2013). The development of a new methodology for knowledge sharing in the interface between university and society--an example from the meat sector. *Meat Science*, *95*(3), 672–8. https://doi.org/10.1016/j.meatsci.2013.04.060

Ali, L., Asadi, M., Gašević, D., Jovanović, J., & Hatala, M. (2013). Factors influencing beliefs for adoption of a learning analytics tool: An empirical study. *Computers & Education*, *62*, 130–148. https://doi.org/10.1016/j.compedu.2012.10.023

Ali, L., Hatala, M., Gašević, D., & Jovanović, J. (2012). A qualitative evaluation of evolution of a learning analytics tool. *Computers & Education*, *58*(1), 470–489. https://doi.org/10.1016/j.compedu.2011.08.030

Aljohani, N., & Davis, H. (2012). Learning analytics in mobile and ubiquitous learning environments. In *11th World Conference on Mobile and Contextual Learning: mLearn 2012*. Retrieved from http://eprints.soton.ac.uk/342971/

Aljohani, N. R., & Davis, H. C. (2013). Learning Analytics and Formative Assessment to Provide Immediate Detailed Feedback Using a Student Centered Mobile Dashboard. In *2013 Seventh International Conference on Next Generation Mobile Apps, Services and Technologies* (pp. 262–267). IEEE. https://doi.org/10.1109/NGMAST.2013.54

Alonso, N. (2010). Docentes 2.0. Retrieved December 23, 2015, from http://www.educacontic.es/blog/docentes-2-0

Alter-Nativa Project. (2013). Retrieved from http://titanic.udg.edu:8000/www_alternativa/

Amara. (n.d.). Retrieved June 26, 2015, from http://www.universalsubtitles.org/

Amiel, T. (2013). Identifying Barriers to the Remix of Translated Open Educational Resources. *International Review of Research in Open and Distance Learning*, *14*(1), 126–144.

Anderson, T. (2013). Open access scholarly publications as OER. *The International Review of Research in Open and Distributed Learning*.

Anderson, T., & McGreal, R. (2012). Disruptive Pedagogies and Technologies in Universities. *EDUCATIONAL TECHNOLOGY & SOCIETY*, *15*(4), 380–389. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=10&doc=94

Angell, C., Hemingway, A., & Hartwell, H. (2011). Surfing the net for public health resources. *Public Health*, *125*(8), 547–53. https://doi.org/10.1016/j.puhe.2011.02.007

Arendt, A. M., & Shelton, B. E. (2009). Incentives and Disincentives for the Use of OpenCourseWare. *International Review of Research in Open and Distance Learning*, *10*(5).

Arimoto, M. M., & Barbosa, E. F. (2012). A systematic review of methods for developing open educational resources. In *Proceedings of the 20th International Conference on Computers in Education, ICCE 2012* (pp. 262–269). National Institute of Education, Nanyang Technological University. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84896321532&partnerID=tZOtx3y1

Arimoto, M. M., & Barbosa, E. F. (2013). Towards the Establishment of an Agile Method for OERs Development and Delivery. *2013 IEEE FRONTIERS IN EDUCATION CONFERENCE*. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=Y1JdzW6fSv1UEknj6hV&page=6&doc=57

Atenas-Rivera, J., Rojas-Sateler, F., & Pérez-Montoro, M. (2012). Repositorios de recursos educativos abiertos. *El Profesional de La Informacion*, *21*(2), 190–193. https://doi.org/10.3145/epi.2012.mar.10

Atkins, D. E., Brown, J. S., & Hammond, A. L. (2007). *A Review of the Open Educational Resources (OER) Movement: Achievements, Challenges, and New Opportunities*. *Hewlett OER Report | Hewlett Foundation*. California. Retrieved from http://www.hewlett.org/library/hewlett-foundation-publication/hewlett-oer-report

ATutor. (2002). ATutor Learning Management System. Retrieved from http://atutor.ca

Avila, C., Baldiris, S., Fabregat, R., & Graf, S. (2014). Open Educational Resources Evaluation in a Learning Management System. In *ICERI2014 Proceedings* (pp. 1940–1950). IATED. Retrieved from https://library.iated.org/view/AVILAGARZON2014OPE

Avila, C., Baldiris, S., Fabregat, R., & Graf, S. (2016). Cocreation and Evaluation of Inclusive and Accessible Open Educational Resources: A Mapping Toward the IMS Caliper. *IEEE RITA*, *11*(3), 167–176. https://doi.org/10.1109/RITA.2016.2589578

Avramides, K., Hunter, J., Oliver, M., & Luckin, R. (2015). A method for teacher inquiry in cross-curricular projects: Lessons from a case study. *British Journal of Educational Technology*, *46*(2), 249–264. https://doi.org/10.1111/bjet.12233

Bae, J.-H., Cho, Y.-S., & Lee, J. (2015). Designing a Reference Model for Learning Analytics Interoperability. In *The 2nd ICCE workshop on Learning Analytics (LA2015)*. ICCE. Retrieved from https://drive.google.com/file/d/0B9GyZ3n5dNZ4bTlMNHREalVzbFE/view

Baker, R. S. J. d., & Yacef, K. (2009). The State of Educational Data Mining in 2009: A Review and Future Visions. *JEDM - Journal of Educational Data Mining*, *1*(1), 3–17.

Bakharia, A., Corrin, L., de Barba, P., Kennedy, G., Gašević, D., Mulder, R., … Lockyer, L. (2016). A conceptual framework linking learning design with learning analytics. In *Proceedings of the Sixth International Conference on Learning Analytics & Knowledge* (pp. 329–338). New York, New York, USA: ACM Press. https://doi.org/10.1145/2883851.2883944

Baldiris, S. (2012). Supporting competence development processes on open learning systems through personalization. *TDX (Tesis Doctorals En Xarxa)*. Universitat de Girona.

Baldiris, S., Avila, C., Fabregat, R., Jové, T., Vilà, R., Rodríguez, P., & Duque, N. (2014). Inclusive Learning Handbook: un REA para Promover una Cultura de Aprendizaje Inclusivo. *Conferencias LACLO*, *5*(1).

Baldiris, S., Avila, C., Fabregat, R., Potes, E., Cuesta, J., Muñoz, T., & Cardona, S. (2015). CO-CREARIA: Modelo de Co-Creación de REA Inclusivos y Accesibles. In *Anais do VII congresso internacional de ambientes virtuais de aprendizagem adaptativos adaptativos e acessivos*. Feevale, Brazil.

Baldiris, S., Fabregat, R., Graf, S., Tabares, V., Duque, N., & Avila, C. (2014). Learning Object Recommendations Based on Quality and Item Response Theory. https://doi.org/10.1109/ICALT.2014.238

Baldiris, S., Graf, S., Fabregat, R., & Duque, N. (2012). Searching for and positioning of contextualized learning objects. *The International Review of Research in Open and Distributed Learning*, *13*(5), 76–101.

Banzato, M. (2012). Barriers to teacher educators seeking, creating and sharing open educational resources: An empirical study of the use of OER in education in Italy. In *2012 15th International Conference on Interactive Collaborative Learning (ICL)* (pp. 1–6). IEEE. https://doi.org/10.1109/ICL.2012.6402105

Birks, M., & Mills, J. (2011). *Grounded theory : a practical guide*. London : SAGE. Retrieved from http://cbueg-mt.iii.com/iii/encore/record/C__Rb4713983__Sgrounded theory a practical guide__P0,1__Orightresult__U__X4?lang=cat&suite=def

Blyth, C. (2013). Special Issue Commentary LCTLs and Technology: The Promise of Open Education. *Language Learning & Technology*, *17*(1). Retrieved from http://scholarspace.manoa.hawaii.edu/handle/10125/24501

Bodily, R., Nyland, R., & Wiley, D. (2017). *International review of research in open and distance learning. The International Review of Research in Open and Distributed Learning* (Vol. 18). Athabasca University. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/2952/4085

Boulanger, D., Seanosky, J., Clemens, C., Kumar, V., & Kinshuk. (2016). SCALE: A Smart Competence Analytics

Solution for English Writing. In *2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT)* (pp. 468–472). IEEE. https://doi.org/10.1109/ICALT.2016.108

Boyle, T., & Ravenscroft, A. (2012). Context and deep learning design. *Computers & Education*, *59*(4), 1224–1233. https://doi.org/10.1016/j.compedu.2012.06.007

Branson, R., Rayner, G., Furman, J., Cox, L., King, F. J., & Hannum, W. (1975). Executive summary and model. In *Inerservice procedures for instructional systems development*. Springfield: National Technical Information Service.

Brooks, C., Erickson, G., Greer, J., & Gutwin, C. (2014). Modelling and quantifying the behaviours of students in lecture capture environments. *Computers & Education*, *75*, 282–292. https://doi.org/10.1016/j.compedu.2014.03.002

Brown, M. (2012). Learning Analytics: Moving from Concept to Practice, (July), 1–5.

Bruni, F. (2014). FROM MOODLE TO OPEN EDUCATIONAL RESOURCES: EDUCATE TO SEISMIC RISK IN ITALIAN PRYMARY SCHOOL BETWEEN EXPERIENCE AND PROSPECTS FOR DEVELOPMENT. In *Proceedings of the 10th International Scientific Conference "eLearning and Software for Education" Bucharest, April 24 - 25, 2014*. Editura Universitatii Nationale de Aparare "Carol I." Retrieved from http://proceedings.elseconference.com/index.php?r=site/index&year=2014&index=papers&vol=13&paper=568f4450331b3e6e5019339c4503a318

Brusilovsky, P., & Millán, E. (2007). User Models for Adaptive Hypermedia and Adaptive Educational Systems. In *The Adaptive Web* (pp. 3–53). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-72079-9_1

Bull, S., & Kay, J. (2010). Open Learner Models (pp. 301–322). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-14363-2_15

Bull, S., & Kay, J. (2016). SMILI: A Framework for Interfaces to Learning Data in Open Learner Models, Learning Analytics and Related Fields. *International Journal of Artificial Intelligence in Education*, *26*(1), 293–331. https://doi.org/10.1007/s40593-015-0090-8

Cabrera, L. G., Almagro, J. R. B., & Ruano, I. R. (2014). A higher education social network to share and promote teaching innovation experiences. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings* (pp. 1–8). IEEE. https://doi.org/10.1109/FIE.2014.7044307

Caeiro, M., Santos, J. M., Llamas, M., & Lama, M. (2014). Towards a folksonomy solution to support open educational activities and resources in Edu-AREA. In *2014 IEEE Global Engineering Education Conference (EDUCON)* (pp. 257–266). IEEE. https://doi.org/10.1109/EDUCON.2014.6826100

Çakmak, T., Özel, N., & Yılmaz, M. (2013). Evaluation of the Open Course Ware Initiatives within the Scope of Digital Literacy Skills: Turkish Open CourseWare Consortium Case. *Procedia - Social and Behavioral Sciences*, *83*, 65–70. https://doi.org/10.1016/j.sbspro.2013.06.014

Casquero, O., Ovelar, R., Romo, J., & Benito, M. (2014). Personal learning environments, higher education and learning analytics: A study of the effects of service multiplexity on undergraduate students' personal networks [Entornos de aprendizaje personales, educación superior y analítica del aprendizaje: un es. *Cultura Y Educacion*, *26*(4), 696–738. https://doi.org/10.1080/11356405.2014.985945

Cechinel, C., & Ochoa, X. (2014). A brief overview of quality inside learning object repositories. In *Proceedings of the XV International Conference on Human Computer Interaction - Interacción '14* (pp. 1–7). New York, New York, USA: ACM Press. https://doi.org/10.1145/2662253.2662336

Chanayotha, P., & Na-songkhla, J. (2015). Development of the Open Educational Rajabhat University Students Resources Using Service Learning to Enhance Public Consciousness and Creative Problem Solving. *Procedia - Social and Behavioral Sciences*, *174*, 1976–1982. https://doi.org/10.1016/j.sbspro.2015.01.863

Chatti, M. A., Dugoija, D., Thus, H., & Schroeder, U. (2014). Learner Modeling in Academic Networks. In *2014 IEEE 14th International Conference on Advanced Learning Technologies* (pp. 117–121). IEEE. https://doi.org/10.1109/ICALT.2014.42

Chatti, M. A., Dyckhoff, A. L., Schroeder, U., & Thüs, H. (2012). A reference model for learning analytics. *International Journal of Technology Enhanced Learning*, *4*(5/6), 318. https://doi.org/10.1504/IJTEL.2012.051815

Chen, Q. (2010). Use of Open Educational Resources: Challenges and Strategies. In P. Tsang, S. K. S. Cheung, V. S. K. Lee, & R. Huang (Eds.), *Hybrid Learning* (Vol. 6248, pp. 339–351). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-14657-2

Chiappe, A., & Arias, V. (2015). Understanding reusability as a key factor for open education: A review. *The International Review of Research in Open and Distributed Learning*. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/2042/3212

Chikh, A. (2014). A general model of learning design objects. *Journal of King Saud University - Computer and Information Sciences*, *26*(1), 29–40. https://doi.org/10.1016/j.jksuci.2013.03.001

Chou, C.-Y., Tseng, S.-F., Chih, W.-C., Chen, Z.-H., Chao, P.-Y., Lai, K. R., … Lin, Y.-L. (2015). Open Student Models of Core Competencies at the Curriculum Level: Using Learning Analytics for Student Reflection. *IEEE Transactions on Emerging Topics in Computing*, 1–1. https://doi.org/10.1109/TETC.2015.2501805

Clements, K., & Pawlowski, J. (2012). User-oriented quality for OER: understanding teachers' views on re-use, quality, and trust. *Journal of Computer Assisted Learning*, *28*(1), 4–14. https://doi.org/10.1111/j.1365-2729.2011.00450.x

Clements, K., Pawlowski, J., & Manouselis, N. (2014). Why Open Educational Resources Repositories fail - Review of Quality Assurance Approaches. In Besedilni in slikovni podatki. Nasl. z nasl. zaslona. (Ed.), *EDULEARN14 Proceedings* (pp. 929–939). Barcelona, Spain: International Association of Technology, Education and Development (IATED).

Clements, K., Pawlowski, J., & Manouselis, N. (2015). Open educational resources repositories literature review – Towards a comprehensive quality approaches framework. *Computers in Human Behavior*, *51*, 1098–1106. https://doi.org/10.1016/j.chb.2015.03.026

Clow, D. (2012). The learning analytics cycle. In *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge - LAK '12* (p. 134). New York, New York, USA: ACM Press. https://doi.org/10.1145/2330601.2330636

Cobo, C. (2013). Exploration of Open Educational Resources in Non-English Speaking Communities. *International Review of Research in Open and Distance Learning*, *14*(2), 106–128. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=9&doc=84

Cochrane, T. (2005). Interactive QuickTime: Developing and evaluating multimedia learning objects to enhance both face-to-face and distance e-learning environments. *Journal of E-Learning and Learning Objects*, *1*(1), 33–54. Retrieved from http://www.editlib.org/p/44865/

Commonwealth of Learning. (2011). *Guidelines for open educational resources (OER) in higher education.* Commonwealth of Learning, Vancouver and UNESCO. Retrieved from http://unesdoc.unesco.org/images/0021/002136/213605e.pdf

Compendium. (2013). Retrieved June 26, 2015, from http://compendiuminstitute.net/

Connolly, T. (2013). Visualization Mapping Approaches for Developing and Understanding OER. *International Review of Research in Open and Distance Learning*, *14*(2), 129–155. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=9&doc=86

Conole, G., & Culver, J. (2010). The design of Cloudworks: Applying social networking practice to foster the exchange of learning and teaching ideas and designs. *Computers & Education*, *54*(3), 679–692. https://doi.org/10.1016/j.compedu.2009.09.013

Constantinescu, Z., & Vladoiu, M. (2013). Evaluation and Comparison of eight Open Courseware based on a quality model. *QUALITY AND EFFICIENCY IN E-LEARNING, VOL 1*, 436–441. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=7&doc=70

Corbi, A., & Burgos, D. (2015). Implementation of the recommendation model LIME in cognitive and visual interactive tutors from PSLC. *IEEE Latin America Transactions*, *13*(2), 516–522. https://doi.org/10.1109/TLA.2015.7055573

Corrin, L., & de Barba, P. (2014). Exploring students' interpretation of feedback delivered through learning analytics dashboards. In *ASCILITE 2014 - The Australasian Society for Computers in Learning in Tertiary Education* (pp. 629–633). ASCILITE. Retrieved from http://ascilite.org/conferences/dunedin2014/files/concisepapers/223-Corrin.pdf

Cruz-Benito, J., Therón, R., García-Peñalvo, F. J., Maderuelo, C., Pérez-Blanco, J. S., Zazo, H., & Martín-Suárez, A. (2014). Monitoring and feedback of learning processes in virtual worlds through analytics architectures: A real case. In *Iberian Conference on Information Systems and Technologies, CISTI*. https://doi.org/10.1109/CISTI.2014.6877097

Cruz, G., Costa, A., Martins, P., Gonçalves, R., & Barroso, J. (2015). Toward educational virtual worlds: Should identity federation be a concern? *Educational Technology and Society*, *18*(1), 27–36. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-84936805671&partnerID=40&md5=bd0462076b2394b1cf9e165ce37ea510

Cueva Carrion, P. S., Morales Rodriguez, del R. G., & Pelaez Romero, A. E. (2010). OER's production cycle with social authorship and semantic tools. In *IEEE EDUCON 2010 Conference* (pp. 121–128). IEEE. https://doi.org/10.1109/EDUCON.2010.5492588

Daradoumis, T., Bassi, R., Xhafa, F., & Caballe, S. (2013). A Review on Massive E-Learning (MOOC) Design, Delivery and Assessment. In *2013 Eighth International Conference on P2P, Parallel, Grid, Cloud and Internet Computing* (pp. 208–213). IEEE. https://doi.org/10.1109/3PGCIC.2013.37

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319. https://doi.org/10.2307/249008

Davis, H. C., Carr, L., Hey, J. M. N., Howard, Y., Millard, D., Morris, D., & White, S. (2010). Bootstrapping a Culture of Sharing to Facilitate Open Educational Resources. *IEEE Transactions on Learning Technologies*, *3*(2), 96–109. https://doi.org/10.1109/TLT.2009.34

Dawson, S., & Siemens, G. (2014). Analytics to literacies: The development of a learning analytics framework for multiliteracies assessment. *The International Review of Research in Open and Distance Learning*, *15*(4). Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/1878/3039

De Freitas, S., Gibson, D., Du Plessis, C., Halloran, P., Williams, E., Ambrose, M., … Arnab, S. (2015). Foundations of dynamic learning analytics: Using university student data to increase retention. *British Journal of Educational Technology*, *46*(6), 1175–1188. https://doi.org/10.1111/bjet.12212

Deimann, M., & Farrow, R. (2013). Rethinking OER and their use: Open education as Bildung. *The International Review of Research in Open and Distributed Learning*.

DeVries, I. (2013). Evaluating Open Educational Resources: Lessons Learned. *Procedia - Social and Behavioral Sciences*, *83*, 56–60. https://doi.org/10.1016/j.sbspro.2013.06.012

Dichev, C., & Dicheva, D. (2012). Open educational resources in computer science teaching. In *Proceedings of the 43rd ACM technical symposium on Computer Science Education - SIGCSE '12* (p. 619). New York, New York, USA: ACM Press. https://doi.org/10.1145/2157136.2157314

Dicheva, D., & Dichev, C. (2014). Finding Open Educational Resources in Computing. In *2014 IEEE 14th International Conference on Advanced Learning Technologies* (pp. 22–24). IEEE. https://doi.org/10.1109/ICALT.2014.17

Dietze, S., Sanchez-Alonso, S., Ebner, H., Yu, H. Q., Giordano, D., Marenzi, I., & Nunes, B. P. (2013). Interlinking Educational Resources and the Web of Data: A Survey of Challenges and Approaches. *Program: Electronic Library and Information Systems*, *47*(1), 60–91. Retrieved from http://eric.ed.gov/?id=EJ1004426

Dimitriadis, Y., McAndrew, P., Conole, G., & Makriyannis, E. (2009). New design approaches to repurposing open educational resources for collaborative learning using mediating artefacts. In *ASCILITE 2009 - The Australasian Society for Computers in Learning in Tertiary Education*. Retrieved from http://oro.open.ac.uk/19378/1/dimitriadis.pdf

Dinevski, D. (2008). Open educational resources and lifelong learning. In *ITI 2008 - 30th International Conference on Information Technology Interfaces* (pp. 117–122). IEEE. https://doi.org/10.1109/ITI.2008.4588393

Dodero, J. M., del Val, Á. M., & Torres, J. (2010). An extensible approach to visually editing adaptive learning activities and designs based on services. *Journal of Visual Languages & Computing*, *21*(6), 332–346. https://doi.org/10.1016/j.jvlc.2010.08.007

Drachsler, H., Stoyanov, S., & Specht, M. (2014). The impact of learning analytics on the dutch education system. In *Proceedins of the Fourth International Conference on Learning Analytics And Knowledge - LAK '14* (pp. 158–162). New York, New York, USA: ACM Press. https://doi.org/10.1145/2567574.2567617

Dyckhoff, A. L., Zielke, D., Bültmann, M., & Chatti, M. A. (2012). Design and Implementation of a Learning Analytics Toolkit for Teachers, *15*, 58–76.

EdTech. (2015). The 20 Digital Skills Every 21st Century Teacher should Have. Retrieved December 22, 2015, from http://www.educatorstechnology.com/2012/06/33-digital-skills-every-21st-century.html

European Agency for Special Needs and Inclusive Education. (2012). *Profile of Inclusive Teachers*. (A. Watkins, Ed.). Retrieved from https://www.european-agency.org/sites/default/files/Profile-of-Inclusive-Teachers.pdf

European Commission. (2008). Explaining the European Qualifications Framework for Lifelong Learning.

European Commission. (2015). *Information and Communication Technologies - Work Programme 2016 - 2017*. Retrieved from https://ec.europa.eu/programmes/horizon2020/en/h2020-section/information-and-communication-technologies

Ezz, I., Loureiro-Koechlin, C., & Stergioulas, L. (2012). An investigation of the use of simulation tools in management education. In *Proceedings Title: Proceedings of the 2012 Winter Simulation Conference (WSC)* (pp. 1–14). IEEE. https://doi.org/10.1109/WSC.2012.6465054

Fenton, G. (2014). Involving a young person in the development of a digital resource in nurse education. *Nurse Education in Practice*, *14*(1), 49–54. https://doi.org/10.1016/j.nepr.2013.04.014

Ferguson, R. (2013). Learning analytics: drivers , developments and challenges. *International Journal of Technology Enhanced Learning*, *4*(5/6).

Fernandez-Delgado, M., Mucientes, M., Vazquez-Barreiros, B., & Lama, M. (2014). Learning Analytics for the Prediction of the Educational Objectives Achievement. *2014 IEEE Frontiers in Education Conference*, 2500–2503. https://doi.org/10.1109/FIE.2014.7044402

Fernández-Gallego, B., Lama, M., Vidal, J. C., & Mucientes, M. (2013). Learning analytics framework for educational virtual worlds. *Procedia Computer Science*, *25*, 443–447. https://doi.org/10.1016/j.procs.2013.11.056

Ferrari, A. (2012). *Digital Competence in practice: An analysis of frameworks*. Retrieved from http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=5099

Florian-Gaviria, B., Glahn, C., & Fabregat Gesa, R. (2013). A Software Suite for Efficient Use of the European Qualifications Framework in Online and Blended Courses. *IEEE Transactions on Learning Technologies*, *6*(3), 283–296. https://doi.org/10.1109/TLT.2013.18

Fragou, O., & Kameas, A. (2013). Developing a user oriented design methodology for learning activities using boundary objects. In *Proceedings of the International Conference e-Learning 2013* (pp. 231–238). Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84886929491&partnerID=tZOtx3y1

Frydenberg, M., & Andone, D. (2014). TOOLBOX 2.0: WEB-BASED OER FOR CONNECTIVISM LEARNING. In *Proceedings of the 10th International Scientific Conference "eLearning and Software for Education" Bucharest, April 24 - 25, 2014*. Retrieved from http://proceedings.elseconference.com/index.php?r=site/index&year=2014&index=papers&vol=13&paper=ec70c0ca88d8a695588421bb4043aade

Fulantelli, G., & Taibi, D. (2014). Learning Analytics in Open Education: an overview. In *Proceedings of the 10th International Scientific Conference "eLearning and Software for Education" Bucharest, April 24 - 25, 2014*.

Fulantelli, G., Taibi, D., & Arrigo, M. (2013). A Semantic approach to Mobile Learning Analytics. In *ACM International Conference Proceeding Series* (pp. 285–292). https://doi.org/10.1145/2536536.2536579

Gašević, D., Mirriahi, N., & Dawson, S. (2014). Analytics of the effects of video use and instruction to support reflective learning. In *ACM International Conference Proceeding Series* (pp. 123–132). https://doi.org/10.1145/2567574.2567590

Gillani, N., & Eynon, R. (2014). Communication patterns in massively open online courses. *The Internet and Higher Education*, *23*, 18–26. https://doi.org/10.1016/j.iheduc.2014.05.004

Ginon, B., Johnson, M. D., Turker, A., & Kickmeier-Rust, M. (2016). Helping teachers to help students by using an open learner model. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *9891 LNCS*, 587–590. https://doi.org/10.1007/978-3-319-45153-4_69

Glahn, C., Kalz, M., Gruber, M., & Specht, M. (2010). Supporting the Reuse of Open Educational Resources through Open Standards. *Workshop Proceedings of the 18th International Conference on Computers in Education, ICCE 2010*. Retrieved from http://dspace.ou.nl/handle/1820/2836

GLOMaker. (2009). Retrieved June 26, 2015, from https://weblearn.ox.ac.uk/portal/site/:info:software:glomaker

GLUE!-PS. (2012). Retrieved June 26, 2015, from http://www.gsic.uva.es/glueps/

Goldsmith, G. R., Fulton, A. D., Witherill, C. D., & Espeleta, J. F. (2014). Improving the efficacy of web-based educational outreach in ecology. *Ecosphere*, *5*(10). https://doi.org/10.1890/ES14-00206.1

Gordillo, A., Barra, E., & Quemada, J. (2014). Towards a Learning Object pedagogical quality metric based on the LORI evaluation model. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings* (pp. 1–8). IEEE. https://doi.org/10.1109/FIE.2014.7044499

Graf, S., Ives, C., Rahman, N., & Ferri, A. (2011). AAT – A Tool for Accessing and Analysing Students ' Behaviour Data in Learning Systems. In *1st International Conference on Learning Analytics and Knowledge* (pp. 174–179).

Greller, W., & Drachsler, H. (2012). Translating Learning into Numbers: A Generic Framework for Learning Analytics. *Educational Technology & Society*, *15*(3), 42–57. Retrieved from http://dblp.uni-trier.de/db/journals/ets/ets15.html#GrellerD12

Güler, Ç., & Altun, A. (2010). Teacher Trainees as Learning Object Designers: Problems and Issues in Learning Object Development Process. *TOJET: The Turkish Online Journal of Educational Technology*, *9*(4), 119–127. Retrieved from http://www.tojet.net/articles/v9i4/9412.pdf

Gurell, S., Kuo, Y.-C., & Walker, A. (2010). The pedagogical enhancement of open education: An examination of problem-based learning. *The International Review of Research in Open and Distributed Learning*, *11*(3), 95–105. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/886/1635

Hart, K. L. de, Chetty, Y. B., & Archer, E. (2015). Uptake of OER by staff in distance education in South Africa. *The International Review of Research in Open and Distributed Learning*.

Hatzipanagos, S. (2012). Open Educational Resources in Distance Education: Exploring Open Learning in Academic Practice. In *Proceedings of the 7th International Conference on eLearning* (pp. 132–135). ACAD CONFERENCES LTD, CURTIS FARM, KIDMORE END, NR READING, RG4 9AY, ENGLAND. Retrieved from http://apps.webofknowledge.com/full_record.do?product=UA&search_mode=GeneralSearch&qid=1&SID

=P18bb9oDgM5K7SnuO8d&page=1&doc=1

Hawkridge, D., Armellini, A., Nikoi, S., Rowlett, T., & Witthaus, G. (2010). Curriculum, intellectual property rights and open educational resources in British universities—and beyond. *Journal of Computing in Higher Education*, *22*(3), 162–176. https://doi.org/10.1007/s12528-010-9036-1

Haya, P. a., Daems, O., Malzahn, N., Castellanos, J., & Hoppe, H. U. (2015). Analysing content and patterns of interaction for improving the learning design of networked learning environments. *British Journal of Educational Technology*, *46*(2), 300–316. https://doi.org/10.1111/bjet.12264

Hemingway, A., Angell, C., Hartwell, H., & Heller, R. F. (2011). An emerging model for publishing and using open educational resources in public health. *Perspectives in Public Health*, *131*(1), 38–43. https://doi.org/10.1177/1757913910391034

Hernández-Carranza, E.-E., Romero-Corella, S.-I., & Ramírez-Montoya, M.-S. (2015). Evaluation of Digital Didactic Skills in Massive Open Online Courses: a Contribution to the Latin American Movement. *Comunicar*, *22*(44), 81–90. https://doi.org/10.3916/C44-2015-09

Hernández-García, Á., González-González, I., Jiménez-Zarco, A. I., & Chaparro-Peláez, J. (2015). Applying social learning analytics to message boards in online distance learning: A case study. *Computers in Human Behavior*, *47*, 68–80. https://doi.org/10.1016/j.chb.2014.10.038

Hernández-Leo, D., Moreno, P., Chacón, J., & Blat, J. (2014). LdShake support for team-based learning design. *Computers in Human Behavior*, *37*, 402–412. https://doi.org/10.1016/j.chb.2012.05.029

Hernández-Leo, D., & Pardo, A. (2016). Towards integrated learning design with across-spaces learning analytics: A flipped classroom example. In *CEUR Workshop Proceedings* (Vol. 1601, pp. 74–78). Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-84977619496&partnerID=40&md5=5e4f97be0e6fb07a95e2e707ed79dfa7

Hilton III, J. L., & Wiley, D. (2011). Open access textbooks and financial sustainability: A case study on Flat World Knowledge. *The International Review of Research in Open and Distributed Learning*.

Hilton III, J., Wiley, D. A., & Lutz, N. (2012). Examining the Reuse of Open Textbooks. *International Review of Research in Open and Distance Learning*, *13*(2), 45–58. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=Y2eebzVGr11yWdtSJSS&page=13&doc=122

Holtham, C., Martin, R., Brown, A., Jawaheer, G., & Dove, A. (2012). Evaluating engagement to address undergraduate first year transition: A case study. In *CSEDU 2012 - Proceedings of the 4th International Conference on Computer Supported Education* (Vol. 1, pp. 223–228). Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84864871346&partnerID=tZOtx3y1

Hoppe, H. U., Erkens, M., Clough, G., Daems, O., & Adams, A. (2013). Using network text analysis to characterise teachers' and students' conceptualisations in science domains. In *CEUR Workshop Proceedings* (Vol. 985). Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-84922572509&partnerID=40&md5=93b3b32b8f80d4dea623e961da52a9d9

Hoyer, R. W., & Hoyer, B. B. Y. (2001). What Is Quality? *Quality Progress*, *34*(7), 53–62.

IMS. (2015). IMS accessibility specifications. Retrieved from http://www.imsglobal.org/activity/accessibility

IMS Global. Caliper Analytics Framework (2013). Retrieved from http://imsglobal.org/caliper/index.html

Inclusive Learning Project. (2014). Retrieved May 25, 2016, from http://inclusive-learning.eu/

Iniesto, F., McAndrew, P., Minocha, S., & Coughlan, T. (2016). Accessibility of MOOCs: Understanding the Provider Perspective. *Journal of Interactive Media in Education*, *2016*(1). https://doi.org/10.5334/jime.430

INTEF. (2013). *Marco común de competencia digital docente V 2.0*. Retrieved from http://educalab.es/documents/10180/12809/MarcoComunCompeDigiDoceV2.pdf

ISTE. (2008). Standards for Teachers. Retrieved December 23, 2015, from http://www.iste.org/standards/iste-standards/standards-for-teachers

Ivanova, M., Grosseck, G., & Holotescu, C. (2014). Open Educational Resources - How Open They Are? In *LET'S BUILD THE FUTURE THROUGH LEARNING INNOVATION!, VOL. 1* (pp. 255–260). CAROL I NATL DEFENCE UNIV PUBLISHING HOUSE, PANDURI ST, 68-72, BUCHAREST, 00000, ROMANIA. Retrieved from http://apps.webofknowledge.com/full_record.do?product=UA&search_mode=GeneralSearch&qid=5&SID=U1weJv981ZTNAuz2VrM&page=5&doc=45

Ives, C., & Pringle, M. M. (2013). Moving to Open Educational Resources at Athabasca University: A Case Study. *International Review of Research in Open and Distance Learning*, *14*(2), 1–13.

Jameson (Eds.), S. (2013). Educational Resources Review: Open Educational Resources. *Journal of Hospitality, Leisure, Sport & Tourism Education*, *12*(1), 1–6. https://doi.org/10.1016/j.jhlste.2012.07.002

jqPlot. (n.d.). Retrieved June 26, 2015, from http://www.jqplot.com/

Kalayanapan, N., Wuwongse, V., & Dittawit, K. (2014). A Quality Assurance Support System for Learning-Object

Development (pp. 1–10). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-43454-3_1

Kaosaiyaporn, O., Na-Songkhla, J., & Boonthong, L. (2015). Open Educational Resources Development Model for an Inquiring Cultural Skill of Higher Education Students. *Procedia - Social and Behavioral Sciences*, *174*, 2031–2035. https://doi.org/10.1016/j.sbspro.2015.01.872

Karkalas, S., Mavrikis, M., & Labs, O. (2016). Towards analytics for educational interactive e-books. In *Proceedings of the Sixth International Conference on Learning Analytics & Knowledge* (pp. 143–147). New York, New York, USA: ACM Press. https://doi.org/10.1145/2883851.2883943

Kelly, B., Sloan, D., Brown, S., Seale, J., Petrie, H., Lauke, P., & Ball, S. (2007). Accessibility 2.0: people, policies and processes. In *Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A) - W4A '07* (p. 138). New York, New York, USA: ACM Press. https://doi.org/10.1145/1243441.1243471

Kelly, H. (2014). A Path Analysis of Educator Perceptions of Open Educational Resources Using the Technology Acceptance Model. *International Review of Research in Open and Distance Learning*, *15*(2), 26–42. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=Y1JdzW6fSv1UEknj6hV&page=3&doc=25

Kelty, C. M., Burrus, C. S., & Baraniuk, R. G. (2008). Peer Review Anew: Three Principles and a Case Study in Postpublication Quality Assurance. *Proceedings of the IEEE*, *96*(6), 1000–1011. https://doi.org/10.1109/JPROC.2008.921613

Kennedy, G., Corrin, L., Lockyer, L., Dawson, S., Williams, D., Mulder, R., … Copeland, S. (2014). Completing the loop: Returning learning analytics to teachers. In *Proceedings of ASCILITE 2014 - Annual Conference of the Australian Society for Computers in Tertiary Education* (pp. 436–440). Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-84955318873&partnerID=40&md5=09a54cdc405e763b5f9853aafc4ed80c

Kerres, M., & Heinen, R. (2015). Open informational ecosystems: The missing link for sharing resources for education. *The International Review of Research in Open and Distributed Learning*.

Khalil, M., & Ebner, M. (2015). A STEM MOOC for school children - What does learning analytics tell us? In *Proceedings of 2015 International Conference on Interactive Collaborative Learning, ICL 2015* (pp. 1217–1221). https://doi.org/10.1109/ICL.2015.7318212

Khanna, P., & Basak, P. C. (2013). An OER Architecture Framework : Needs and Design. *International Review of Research in Open and Distance Learning*, *14*(1), 65–83.

Kim, B. W., Lee, W. G., Lee, B. R., & Shon, J. G. (2015). Influencing factors in OER usage of adult learners in Korea. *The International Review of Research in Open and Distributed Learning*. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/2051/3290

Kinshuk, & Jesse, R. (2013). Mobile Authoring of Open Educational Resources as Reusable Learning Objects. *INTERNATIONAL REVIEW OF RESEARCH IN OPEN AND DISTANCE LEARNING*, *14*(2), 28–51. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=8&doc=78

Kothari, C. R. (2012). Research Methodology: An introduction. In *Research Methodology: Methods and Techniques* (2nd ed., p. 418). New Age International Publishers. Retrieved from http://www.newagepublishers.com/samplechapter/000896.pdf

Kourbetis, V., & Konstantinos, B. (2014). Accessible Open Educational Resources for Students with Disabilities in Greece: They are Open to the Deaf. In C. Stephanidis & M. Antona (Eds.), *Universal Access in Human-Computer Interaction. Universal Access to Information and Knowledge* (Vol. 8514). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-07440-5

Kreijns, K., Van Acker, F., Vermeulen, M., & van Buuren, H. (2013). What stimulates teachers to integrate ICT in their pedagogical practices? The use of digital learning materials in education. *Computers in Human Behavior*, *29*(1), 217–225. https://doi.org/10.1016/j.chb.2012.08.008

Kurilovas, E., Bireniene, V., & Serikoviene, S. (2011). Methodology for Evaluating Quality and Reusability of Learning Objects. *Electronic Journal of E-Learning*, *9*(1), 39–51.

Kursun, E., Cagiltay, K., & Can, G. (2014). An investigation of faculty perspectives on barriers, incentives, and benefits of the OER movement in Turkey. *The International Review of Research in Open and Distributed Learning*. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/1914/3158

LabSpace. (2012). Retrieved June 26, 2015, from http://www.olnet.org/content/openlearn-labspace

Lane, A. (2009). The Impact of Openness on Bridging Educational Digital Divides. *INTERNATIONAL REVIEW OF RESEARCH IN OPEN AND DISTANCE LEARNING*, *10*(5). Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N2N5qWgyUemMyCPJFOV&page=22&doc=213

Lane, A., & McAndrew, P. (2010). Are open educational resources systematic or systemic change agents for

teaching practice? *British Journal of Educational Technology*, *41*(6), 952–962. https://doi.org/10.1111/j.1467-8535.2010.01119.x

Law, P., & Law, A. (2014). Digital badging at The Open University: recognition for informal learning. In *The Open and Flexible Higher Education Conference 2014: 'New Technologies and the Future of Teaching and Learning '*. Krakow, Poland: The Open University. Retrieved from http://oro.open.ac.uk/41354/

LdShake. (2010). Retrieved June 26, 2015, from http://ldshake.upf.edu/

Leacock, T. L., & Nesbit, J. C. (2007). A Framework for Evaluating the Quality of Multimedia Learning Resources. *Journal of Educational Technology & Society*, *10*(2), 44–59.

Lebron, D., & Shahriar, H. (2015). Comparing MOOC-based platforms: Reflection on pedagogical support, framework and learning analytics. In *2015 International Conference on Collaboration Technologies and Systems, CTS 2015* (pp. 167–174). https://doi.org/10.1109/CTS.2015.7210417

Lei, C.-U., Man, K. L., & Ting, T. O. (2014). Using learning analytics to analyze writing skills of students: A case study in a technological common core curriculum course. *IAENG International Journal of Computer Science*, *41*(3), 193–197. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-84906957659&partnerID=40&md5=7d5d62d3ef5eb55574ae41cba5790ee1

Leinonen, T., Purma, J., Põldoja, H., & Toikkanen, T. (2010). Information Architecture and Design Solutions Scaffolding Authoring of Open Educational Resources. *IEEE Transactions on Learning Technologies*, *3*(2), 116–128. https://doi.org/10.1109/TLT.2010.2

Limongelli, C., Sciarrone, F., & Temperini, M. (2015). A social network-based teacher model to support course construction. *Computers in Human Behavior*, *51*, 1077–1085. https://doi.org/10.1016/j.chb.2015.03.038

Lin, Y.-L., Lin, H.-W., & Hung, T.-T. (2015). Value hierarchy for Massive Open Online Courses. *Computers in Human Behavior*, *53*, 408–418. https://doi.org/10.1016/j.chb.2015.07.006

Little, S., Ferguson, R., & Rüger, S. (2012, July 11). Finding and reusing learning materials with multimedia similarity search and social networks. *Technology, Pedagogy and Education*. Retrieved from http://oro.open.ac.uk/33991/

Llamas-Nistal, M., & Mikic-Fonte, F. A. (2014). Generating OER by Recording Lectures: A Case Study. *IEEE Transactions on Education*, *57*(4), 220–228. https://doi.org/10.1109/TE.2014.2336630

Lockyer, L., & Dawson, S. (2011). Learning designs and learning analytics. In *ACM International Conference Proceeding Series* (pp. 153–156). https://doi.org/10.1145/2090116.2090140

Lockyer, L., Heathcote, E., & Dawson, S. (2013). Informing pedagogical action: Aligning learning analytics with learning design. *American Behavioral Scientist*, *57*(10), 1439–1459. https://doi.org/10.1177/0002764213479367

Long, W., & Håklev, S. (2012). A practical model of development for China's National Quality Course Plan. *British Journal of Educational Technology*, *43*(6), 920–932. https://doi.org/10.1111/j.1467-8535.2011.01254.x

Maina, M. F., Pérez-Mateo, M., Guàrdia, L., & Sangrà, A. (2015). Diseño de un Curso de Formación Docente Como Práctica Educativa Abierta. *Procedia - Social and Behavioral Sciences*, *196*, 120–127. https://doi.org/10.1016/j.sbspro.2015.07.021

Manso-Vázquez, M., & Llamas-Nistal, M. (2015). Proposal of a Learning Organization Tool with Support for Metacognition. *Revista Iberoamericana de Tecnologias Del Aprendizaje*, *10*(2), 35–42. https://doi.org/10.1109/RITA.2015.2417932

Marcus-Quinn, A., & Diggins, Y. (2013). Open Educational Resources. *Procedia - Social and Behavioral Sciences*, *93*, 243–246. https://doi.org/10.1016/j.sbspro.2013.09.183

Marquès, P. (2011). Funciones de los docentes de hoy. Retrieved January 22, 2016, from http://www.peremarques.net/docentes2.htm

Martínez, D. R., Muñoz-Merino, P. J., Ruipérez-Valiente, J. A., Kloos, C. D., Díaz, H. J. P., & Ruiz, J. S. (2015). Combining Learning Analytics and the Flipped Classroom in a MOOC of maths. In *CEUR Workshop Proceedings* (Vol. 1599, pp. 71–79). Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-84977514095&partnerID=40&md5=9df608d980315a4f4a4b01fac474828d

McGreal, R., Kinuthia, W., & Marshall, S. (2013). Open Educational Resources: Innovation, Research and Practice. Retrieved September 9, 2014, from http://www.col.org/PublicationDocuments/pub_PS_OER-IRP_web.pdf

McKerlich, R., Ives, C., & McGreal, R. (2013). Measuring Use and Creation of Open Educational Resources in Higher Education. *The International Review of Research in Open and Distributed Learning*, *14*(4), 90–103.

Mejía, C. (2013). Framework for detection, assessment and assistance of university students with dyslexia and/or reading difficulties. *TDX (Tesis Doctorals En Xarxa)*. Universitat de Girona.

MEN. (2013). *Competencias TIC para el desarrollo profesional docente*. Colombia. Retrieved from http://www.colombiaaprende.edu.co/html/micrositios/1752/articles-318264_recurso_tic.pdf

Meyer, A., Rose, D. H., & Gordon, D. (2014). *Universal design for learning: Theory and Practice*. Wakefield, MA:

CAST Professional Publishing.

Millard, D. E., Borthwick, K., Howard, Y., McSweeney, P., & Hargood, C. (2013). The HumBox: Changing educational practice around a learning resource repository. *Computers & Education*, *69*, 287–302. https://doi.org/10.1016/j.compedu.2013.07.028

Miller, G. E. (1990). The assessment of clinical skills/competence/performance. *Academic Medicine : Journal of the Association of American Medical Colleges*, *65*(9 Suppl), S63-7. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2400509

Mishra, S., & Kanwar, A. (2015). Quality Assurance for Open Educational Resources: What's the difference? (Pre-print).

Mitros, P., & Sun, F. (2014). Creating Educational Resources at Scale. In *2014 IEEE 14th International Conference on Advanced Learning Technologies* (pp. 16–18). IEEE. https://doi.org/10.1109/ICALT.2014.15

Mohamed Nour, M., Williams, K., & Suleman, H. (2012). *The Outreach of Digital Libraries: A Globalized Resource Network*. (H.-H. Chen & G. Chowdhury, Eds.), *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 7634). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-34752-8

Mor, Y., Ferguson, R., & Wasson, B. (2015). Editorial: Learning design, teacher inquiry into student learning and learning analytics: A call for action. *British Journal of Educational Technology*, *46*(2), 221–229. https://doi.org/10.1111/bjet.12273

Morales, G. del R. R., & Carrión, S. P. C. (2010). OERs, Standards and Trends. *RUSC. Universities and Knowledge Society Journal // INTERNATIONAL JOURNAL OF EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION*, *7*(1).

Moreno, J., & Defude, B. (2010). Learning Styles and Teaching Strategies to Improve the SCORM Learning Objects Quality. In *2010 10th IEEE International Conference on Advanced Learning Technologies* (pp. 414–416). IEEE. https://doi.org/10.1109/ICALT.2010.121

Moreno, L., Iglesias, A., Martínez, P., & Ruiz-Mezcua, B. (2008). Accessible Interfaces for Educational Multimedia Contents.

Mtebe, J. S., & Raisamo, R. (2014). Challenges and Instructors' Intention to Adopt and Use Open Educational Resources in Higher Education in Tanzania. *International Review of Research in Open and Distance Learning*, *15*(1).

Mulder, F. (2013). The LOGIC of National Policies and Strategies for Open Educational Resources. *INTERNATIONAL REVIEW OF RESEARCH IN OPEN AND DISTANCE LEARNING*, *14*(2), 96–105. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=9&doc=83

Mullins, K. (2014). Good IDEA: Instructional Design Model for Integrating Information Literacy. *The Journal of Academic Librarianship*, *40*(3–4), 339–349. https://doi.org/10.1016/j.acalib.2014.04.012

Muñoz Arteaga, J., Reyes, H. C., Collazos Ordoñez, C. A., & González-Calleros, J. M. (2015). Modelo Productor-Consumidor de un Libro de Texto para la Comunidad de Interacción Humano-Computadora en Latinoamérica. *VAEP-RITA*, *3*(1), 27–35. Retrieved from http://rita.det.uvigo.es/VAEPRITA/index.php?content=Num_Pub&idiom=Pt&visualiza=3&volumen=3&numero=1&articulo=5

Murphy, P., & Wolfenden, F. (2013). Developing a pedagogy of mutuality in a capability approach: Teachers' experiences of using the Open Educational Resources (OER) of the teacher education in sub-Saharan Africa (TESSA) programme. *International Journal of Educational Development*, *33*(3), 263–271. https://doi.org/10.1016/j.ijedudev.2012.09.010

Na, K. S., & Tasir, Z. (2017). A Systematic Review of Learning Analytics Intervention Contributing to Student Success in Online Learning. In *2017 International Conference on Learning and Teaching in Computing and Engineering (LaTICE)* (pp. 62–68). IEEE. https://doi.org/10.1109/LaTiCE.2017.18

Navarrete, R., & Lujan-Mora, S. (2015). Evaluating findability of open educational resources from the perspective of users with disabilities: a preliminary approach. In *2015 Second International Conference on eDemocracy & eGovernment (ICEDEG)* (pp. 112–119). IEEE. https://doi.org/10.1109/ICEDEG.2015.7114457

Navarrete, R., & Luján-Mora, S. (2017). Bridging the accessibility gap in Open Educational Resources. *Universal Access in the Information Society*, 1–20. https://doi.org/10.1007/s10209-017-0529-9

Nevile, L., & Treviranus, J. (2006). Interoperability for Individual Learner Centred Accessibility for Web-based Educational Systems. *Journal of Educational Technology & Society*, *9*(4), 215–227.

Ngimwa, P., & Wilson, T. (2012). An empirical investigation of the emergent issues around OER adoption in Sub-Saharan Africa. *Learning, Media and Technology*, *37*(4), 398–413. https://doi.org/10.1080/17439884.2012.685076

Niemann, K., & Wolpers, M. (2015). Creating Usage Context-Based Object Similarities to Boost Recommender Systems in Technology Enhanced Learning. *IEEE Transactions on Learning Technologies*, *8*(3), 274–285. https://doi.org/10.1109/TLT.2014.2379261

Nistor, N., Baltes, B., Dascălu, M., Mihăilă, D., Smeaton, G., & Trăuşan-Matu, Ş. (2014). Participation in virtual academic communities of practice under the influence of technology acceptance and community factors. A learning analytics application. *Computers in Human Behavior*, *34*, 339–344. https://doi.org/10.1016/j.chb.2013.10.051

Ochoa, X., & Duval, E. (2006). Towards Automatic Evaluation of Learning Object Metadata Quality. In J. F. Roddick, V. R. Benjamins, S. Si-said Cherfi, R. Chiang, C. Claramunt, R. A. Elmasri, … C. Vangenot (Eds.), *Advances in Conceptual Modeling - Theory and Practice: ER 2006 Workshops BP-UML, CoMoGIS, COSS, ECDM, OIS, QoIS, SemWAT, Tucson, AZ, USA, November 6-9, 2006. Proceedings* (pp. 372–381). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/11908883_44

OECD. (2007). *Giving Knowledge for Free: The Emergence of Open Educational Resources*. Organization for Economic Co-operation and Development (OECD). Retrieved from http://www.oecd.org/edu/ceri/givingknowledgeforfreetheemergenceofopeneducationalresources.htm

OERPub. (2012). Retrieved June 26, 2015, from http://oerpub.org/

Okonkwo, C. A. (2012). A needs assessment of ODL educators to determine their effective use of open educational resources. *The International Review of Research in Open and Distributed Learning*, *13*(4), 293–312.

Olcott, Jr., D. (2013). New Pathways to Learning: Leveraging the Use of OERs to Support Non-formal Education. *RUSC. Revista de Universidad Y Sociedad Del Conocimiento*, *10*(1), 327–344. https://doi.org/10.7238/rusc.v10i1.1562

OpenTapestry. (2012). Retrieved June 26, 2015, from http://www.opentapestry.com/

Papamitsiou, Z., & A. Economides, A. (2014). Learning Analytics and Educational Data Mining in Practice: A Systematic Literature Review of Empirical Evidence. *Journal of Educational Technology & Society*, *17*(4), 49–64. Retrieved from http://www.ifets.info/advance_search.php

Papamitsiou, Z., & Economides, A. A. (2015). Temporal learning analytics visualizations for increasing awareness during assessment. *RUSC. Universities and Knowledge Society Journal*, *12*(3), 129. https://doi.org/10.7238/rusc.v12i3.2519

Pavel, V., Manolea, B., Bucur, A., Voicu, O., & Constantinescu, N. (2014). OER: Policy and best practices from Romania. In *Proceedings of the 10th International Scientific Conference "eLearning and Software for Education" Bucharest, April 24 - 25, 2014*.

Pawlowski, J. M. (2007). The Quality Adaptation Model: Adaptation and Adoption of the Quality Standard ISO/IEC 19796-1 for Learning, Education, and Training. *Educational Technology & Society*, *10*(2), 3–16.

Pawlowski, J. M., & Bick, M. (2012). Open Educational Resources. *Business & Information Systems Engineering*, *4*(4), 209–212. https://doi.org/10.1007/s12599-012-0219-3

Pedraza, N., Farías, G., Lavín, J., & Torres, A. (2013). Las competencias docentes en TIC en las áreas de negocios y contaduría Un estudio exploratorio en la educación superior. *Perfiles Educativos*, *35*(139), 8–24. https://doi.org/10.1016/S0185-2698(13)71806-3

Peña López, I. (2013). Heavy switchers in translearning: from formal teaching to ubiquitous learning. *On the Horizon*, *21*(2), 127–137. https://doi.org/10.1108/10748121311323021

Persico, D., & Pozzi, F. (2015). Informing learning design with learning analytics to improve teacher inquiry. *British Journal of Educational Technology*, *46*(2), 230–248. https://doi.org/10.1111/bjet.12207

Petrides, L., Nguyen, L., Kargliani, A., & Jimes, C. (2008). Open Educational Resources: Inquiring into Author Reuse Behaviors. *TIMES OF CONVERGENCE: TECHNOLOGIES ACROSS LEARNING CONTEXTS, PROCEEDINGS*, *5192*, 344–353. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N2N5qWgyUemMyCPJFOV&page=23&doc=230

Piedra, N., Chicaiza, J., Lopez, J., & Caro, E. T. (2016). Integrating OER in the design of educational material: Blended learning and linked-open-educational-resources-data approach. In *2016 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1179–1187). IEEE. https://doi.org/10.1109/EDUCON.2016.7474706

Piedra, N., Chicaiza, J., Lopez, J., & Tovar Caro, E. (2014). Supporting openness of MOOCs contents through of an OER and OCW framework based on Linked Data technologies. In *2014 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1112–1117). IEEE. https://doi.org/10.1109/EDUCON.2014.6826249

Pirkkalainen, H., Jokinen, J. P. P., & Pawlowski, J. M. (2014). Understanding Social OER Environments—A Quantitative Study on Factors Influencing the Motivation to Share and Collaborate. *IEEE Transactions on Learning Technologies*, *7*(4), 388–400. https://doi.org/10.1109/TLT.2014.2323970

Politis, Y., Deveril, D., Navarro, S. B., Avila, C., Lera, E. de, Monjo, T., & Goodman, L. (2014). *Introducting the*

Inclusive Learning Handbook: an OER for Teachers and Policy Makers. *EDULEARN14 Proceedings*. International Association of Technology, Education and Development (IATED).

Ponti, M. (2014). Self-directed learning and guidance in non-formal open courses. *Learning Media and Technology*, *39*(2), 154–168. https://doi.org/10.1080/17439884.2013.799073

Prasad, D., Totaram, R., & Usagawa, T. (2016a). A Framework for Open Textbooks Analytics System. *TechTrends*, *60*(4), 344–349. https://doi.org/10.1007/s11528-016-0070-3

Prasad, D., Totaram, R., & Usagawa, T. (2016b). Development of Open Textbooks Learning Analytics System. *The International Review of Research in Open and Distributed Learning*, *17*(5). https://doi.org/10.19173/irrodl.v17i5.2541

Prasad, D., & Usagawa, T. (2014). Towards development of OER derived custom-built open textbooks: A baseline survey of university teachers at the University of the South Pacific. *The International Review of Research in Open and Distance Learning*, *15*(4).

Prieto, L. P., Asensio-Pérez, J. I., Muñoz-Cristóbal, J. A., Jorrín-Abellán, I. M., Dimitriadis, Y., & Gómez-Sánchez, E. (2014). Supporting orchestration of CSCL scenarios in web-based Distributed Learning Environments. *Computers & Education*, *73*, 9–25. https://doi.org/10.1016/j.compedu.2013.12.008

Raman, R., Achuthan, K., Nedungadi, P., Diwakar, S., & Bose, R. (2014). The VLAB OER Experience: Modeling Potential-Adopter Student Acceptance. *IEEE Transactions on Education*, *57*(4), 235–241. https://doi.org/10.1109/TE.2013.2294152

Raposo-Rivas, M., Martínez-Figueira, E., & Sarmiento-Campos, J.-A. (2015). A Study on the Pedagogical Components of Massive Online Courses. *Comunicar*, *22*(44), 27–35. https://doi.org/10.3916/C44-2015-03

Rayon, A., Guenaga, M., & Nunez, A. (2014). Ensuring the integrity and interoperability of educational usage and social data through Caliper framework to support competency-assessment. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings* (pp. 1–9). IEEE. https://doi.org/10.1109/FIE.2014.7044448

Read, T., Ros, S., Pastor, R., Hernandez, R., & Rodrigo, C. (2011). The Generation and Exploitation of Open Educational Resources in Virtual Attendance in UNED. In F. V. Cipolla Ficarra, C. de Castro Lozano, M. Pérez Jiménez, E. Nicol, A. Kratky, & M. Cipolla-Ficarra (Eds.), *Advances in New Technologies, Interactive Interfaces, and Communicability* (Vol. 6616, pp. 132–141). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-20810-2

Rejas-Muslera, R. J., Cuadrado, J. J., Abran, A., & Sicilia, M. A. (2008). Information Economy Philosophy in Universal Education. The Open Educational Resources (OER): Technical, Socioeconomics and Legal Aspects. *2008 IEEE INTERNATIONAL PROFESSIONAL COMMUNICATION CONFERENCE*, 301–305. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N2N5qWgyUemMyCPJFOV&page=23&doc=221

Rennie, F., Johannesdottir, S., & Kristinsdottir, S. (2011). Re-Thinking Sustainable Education Systems in Iceland: The Net-University Project. *International Review of Research in Open and Distance Learning*, *12*(4), 88–104. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=U1z4h6Wfv8q8gS4weWE&page=16&doc=157

Richter, T., & McPherson, M. (2012). Open educational resources: education for the world? *Distance Education*, *33*(2), 201–219. https://doi.org/10.1080/01587919.2012.692068

Robinson, T. J., Fischer, L., Wiley, D., & Hilton, J. (2014). The Impact of Open Textbooks on Secondary Science Learning Outcomes. *Educational Researcher*, *43*(7), 341–351. https://doi.org/10.3102/0013189X14550275

Rodrigo, C., & García-Serrano, A. (2015). Social Accessibility Action to Improve Quality of OER User-generated Video-classes and Associated Resources. *Procedia Computer Science*, *67*, 19–27. https://doi.org/10.1016/j.procs.2015.09.245

Rodriguez-Triana, M. J., Govaerts, S., Halimi, W., Holzer, A., Salzmann, C., Vozniuk, A., … Gillet, D. (2014). Rich open educational resources for personal and inquiry learning: Agile creation, sharing and reuse in educational social media platforms. In *2014 International Conference on Web and Open Access to Learning (ICWOAL)* (pp. 1–6). IEEE. https://doi.org/10.1109/ICWOAL.2014.7009219

Rodríguez-Triana, M. J., Martínez-Monés, A., Asensio-Pérez, J. I., & Dimitriadis, Y. (2012). Script-aware monitoring model: Using teachers pedagogical intentions to guide learning analytics. *CEUR Workshop Proceedings*, *894*, 1–6.

Rodríguez-Triana, M. J., Martínez-Monés, A., Asensio-Pérez, J. I., & Dimitriadis, Y. (2015). Scripting and monitoring meet each other: Aligning learning analytics and learning design to support teachers in orchestrating CSCL situations. *British Journal of Educational Technology*, *46*(2), 330–343. https://doi.org/10.1111/bjet.12198

Rodríguez, G., Pérez, J., Cueva, S., & Torres, R. (2017). A framework for improving web accessibility and usability

of Open Course Ware sites. *Computers & Education*, *109*, 197–215. https://doi.org/10.1016/j.compedu.2017.02.013

Rodriguez, P., Méndez, N. D., Baldiris, S., Avila, C., Fabregat, R., Jové, T., & Bacca, J. (2015). Guías para que profesores implementen la diversidad en sus aulas - Casos de estudio. In *LACLO 2015* (Vol. 10, p. 90). Retrieved from http://www.br-ie.org/pub/index.php/teste/article/view/5789

Rodriguez M., G., Cueva Carrion, S. P., & Tovar Caro, E. (2011). Reusable and interoperative specifications for OERs based on Standards. In *2011 IEEE Global Engineering Education Conference (EDUCON)* (pp. 763–770). IEEE. https://doi.org/10.1109/EDUCON.2011.5773225

Romero, A., & Morocho, J. (2016). Características inherentes para OER's accesibles. *Opción*, *32*(2). Retrieved from http://produccioncientificaluz.org/index.php/opcion/article/view/21559

Ros, S., Hernandez, R., Read, T., Artacho, M. R., Pastor, R., & Diaz Orueta, G. (2014). UNED OER Experience: From OCW to Open UNED. *IEEE Transactions on Education*, *57*(4), 248–254. https://doi.org/10.1109/TE.2014.2331216

Rosell-Aguilar, F. (2013). Delivering unprecedented access to learning through podcasting as OER, but who's listening? A profile of the external iTunes U user. *Computers & Education*, *67*, 121–129. https://doi.org/10.1016/j.compedu.2013.03.008

Ruiperez-Valiente, J. A., Munoz-Merino, P. J., Gascon-Pinedo, J. A., & Kloos, C. D. (2016). Scaling to Massiveness With ANALYSE: A Learning Analytics Tool for Open edX. *IEEE Transactions on Human-Machine Systems*, 1–6. https://doi.org/10.1109/THMS.2016.2630420

Ruiz-Iniesta, A., Jimenez-Diaz, G., & Gomez-Albarran, M. (2014). A Semantically Enriched Context-Aware OER Recommendation Strategy and Its Application to a Computer Science OER Repository. *IEEE Transactions on Education*, *57*(4), 255–260. https://doi.org/10.1109/TE.2014.2309554

Sampson, D., & Zervas, P. (2008). eAccess2Learn: Supporting Technology-Enhanced Training for All. In *2008 Eighth IEEE International Conference on Advanced Learning Technologies* (pp. 1034–1035). IEEE. https://doi.org/10.1109/ICALT.2008.30

Sánchez-Alonso, S., Sicilia, M.-A., García-Barriocanal, E., Pagés-Arévalo, C., & Lezcano, L. (2011). Social models in open learning object repositories: A simulation approach for sustainable collections. *Simulation Modelling Practice and Theory*, *19*(1), 110–120. https://doi.org/10.1016/j.simpat.2010.06.022

Sancho Vinuesa, T., Villalonga Pons, J., Carboneil, M. R. E., & Sanchez-Bonvehi, C. (2014). Opening up an interuniversity collaboration among Catalan university academic staff: The case of CIRAX pilot experience. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings* (pp. 1–8). IEEE. https://doi.org/10.1109/FIE.2014.7044357

Santos-Hermosa, G. (2012). ORIOLE, in the Search for Evidence of OER in Teaching. Experiences in the Use, Re-use and the Sharing and Influence of Repositories. *QRE - Qualitative Research in Education*. Retrieved from http://www.hipatiapress.com/hpjournals/index.php/qre/article/view/1003

Santos-Hermosa, G., Ferran-Ferrer, N., & Abadal, E. (2012). Recursos educativos abiertos: repositorios y uso. *El Profesional de La Informacion*, *21*(2), 136–145. https://doi.org/10.3145/epi.2012.mar.03

Santos, G. S., & Jorge, J. (2013). Interoperable Intelligent Tutoring Systems as Open Educational Resources. *IEEE Transactions on Learning Technologies*, *6*(3), 271–282. https://doi.org/10.1109/TLT.2013.17

Sapire, I., & Reed, Y. (2011). Collaborative design and use of open educational resources: a case study of a mathematics teacher education project in South Africa. *Distance Education*, *32*(2), 195–211. https://doi.org/10.1080/01587919.2011.584847

Schwendimann, B. A., Rodriguez-Triana, M. J., Vozniuk, A., Prieto, L. P., Boroujeni, M. S., Holzer, A., … Dillenbourg, P. (2017). Perceiving Learning at a Glance: A Systematic Literature Review of Learning Dashboard Research. *IEEE Transactions on Learning Technologies*, *10*(1), 30–41. https://doi.org/10.1109/TLT.2016.2599522

Sellami, H. M. (2013). Can the Agent Based Modeling Represent the OER. In *2013 IEEE/WIC/ACM International Joint Conferences on Web Intelligence (WI) and Intelligent Agent Technologies (IAT)* (pp. 16–22). IEEE. https://doi.org/10.1109/WI-IAT.2013.209

Shelton, B. E., Duffin, J., Wang, Y., & Ball, J. (2010). Linking open course wares and open education resources: creating an effective search and recommendation system. *Procedia Computer Science*, *1*(2), 2865–2870. https://doi.org/10.1016/j.procs.2010.08.012

Shum, S. B., & Crick, R. D. (2012). Learning dispositions and transferable competencies. In *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge - LAK '12* (p. 92). New York, New York, USA: ACM Press. https://doi.org/10.1145/2330601.2330629

Sicilia, M.-Á. (2007). Beyond content: sharing the design of open educational resources. *RUSC. Universities and Knowledge Society Journal*, *4*(1). https://doi.org/10.7238/rusc.v4i1.297

Sicilia, M.-Á., Lytras, M. D., Sánchez-Alonso, S., García-Barriocanal, E., & Zapata-Ros, M. (2011). Modeling

instructional-design theories with ontologies: Using methods to check, generate and search learning designs. *Computers in Human Behavior*, *27*(4), 1389–1398. https://doi.org/10.1016/j.chb.2010.07.040

Siemens, G. (2011). 1st International Conference on Learning Analytics and Knowledge 2011 | Connecting the technical, pedagogical, and social dimensions of learning analytics. Retrieved March 24, 2017, from https://tekri.athabascau.ca/analytics/

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 to integrate heterogeneous learning analytics techniques. SOLAR.

Sinclair, J., Joy, M., Yau, J. Y.-K., & Hagan, S. (2013). A Practice-Oriented Review of Learning Objects. *IEEE Transactions on Learning Technologies*, *6*(2), 177–192. https://doi.org/10.1109/TLT.2013.6

Slade, S., & Prinsloo, P. (2013). Learning Analytics: Ethical Issues and Dilemmas. *American Behavioral Scientist*, *57*(10), 1510–1529. https://doi.org/10.1177/0002764213479366

Stacey, P. (2013). Government Support for Open Educational Resources: Policy, Funding, and Strategies. *International Review of Research in Open and Distance Learning*, *14*(2), 67–80. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=9&doc=81

Steffens, K. (2015). Competences, Learning Theories and MOOCs: Recent Developments in Lifelong Learning. *European Journal of Education*, *50*(1), 41–59. https://doi.org/10.1111/ejed.12102

Stylianidis, P. (2015). Mobile learning: Open topics, concept and design of a learning framework. In *Proceedings of 2015 International Conference on Interactive Mobile Communication Technologies and Learning, IMCL 2015* (pp. 421–424). https://doi.org/10.1109/IMCTL.2015.7359634

Tabares, V., Duque, N., Ovalle, D., Rodríguez, P., & Moreno, J. (2013). Learning Objects Repository Management Using an Adaptive Quality Evaluation Multi-Agent System (pp. 351–362). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-38061-7_33

Tabuenca, B., Kalz, M., Drachsler, H., & Specht, M. (2015). Time will tell: The role of mobile learning analytics in self-regulated learning. *Computers and Education*, *89*, 53–74. https://doi.org/10.1016/j.compedu.2015.08.004

Thoms, J. J., & Thoms, B. L. (2014). Open educational resources in the United States: Insights from university foreign language directors. *System*, *45*, 138–146. https://doi.org/10.1016/j.system.2014.05.006

Toetenel, L. (2014). Social networking: a collaborative open educational resource. *Computer Assisted Language Learning*, *27*(2), 149–162. https://doi.org/10.1080/09588221.2013.818561

Tonks, D., Weston, S., Wiley, D., & Barbour, M. K. (2013). "Opening" a New Kind of High School : The Story of the Open High School of Utah. *International Review of Research in Open and Distance Learning*, *14*(1), 255–271. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=9&doc=87

Tovar, E., Dimovska, A., Piedra, N., & Chicaiza, J. (2013). OCW-S: enablers for building sustainable Open Education Evolving OCW and MOOC. *2013 IEEE GLOBAL ENGINEERING EDUCATION CONFERENCE (EDUCON)*, 1262–1271. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=N12HRgn6tEID91hSaFK&page=7&doc=62

Tovar, E., & Piedra, N. (2014). Guest Editorial: Open Educational Resources in Engineering Education: Various Perspectives Opening the Education of Engineers. *IEEE Transactions on Education*, *57*(4), 213–219. https://doi.org/10.1109/TE.2014.2359257

Tovar, E., Piedra, N., Chicaiza, J., Lopez, J., & Martinez-Bonastre, O. (2012). OER Development and Promotion. Outcomes of an International Research Project on the OpenCourseWare Model. *JOURNAL OF UNIVERSAL COMPUTER SCIENCE*, *18*(1), 123–141. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=U1z4h6Wfv8q8gS4weWE&page=14&doc=139

Toven-Lindsey, B., Rhoads, R. A., & Lozano, J. B. (2015). Virtually Unlimited Classrooms: Pedagogical Practices in Massive Open Online Courses. *The Internet and Higher Education*, *24*, 1–12. https://doi.org/10.1016/j.iheduc.2014.07.001

Tuomi, I. (2013). Open Educational Resources and the Transformation of Education. *European Journal of Education*, *48*(1), 58–78. https://doi.org/10.1111/ejed.12019

Tzelepi, M. (2014). Personalizing Learning Analytics to Support Collaborative Learning Design and Community Building. In *2014 IEEE 14th International Conference on Advanced Learning Technologies* (pp. 771–773). https://doi.org/10.1109/ICALT.2014.226

UNESCO and Microsoft. (2011). *UNESCO ICT Competency Framework for Teachers*. Retrieved from

http://www.unesco.org/new/en/unesco/themes/icts/teacher-education/unesco-ict-competency-framework-for-teachers/

Van Acker, F., Vermeulen, M., Kreijns, K., Lutgerink, J., & van Buuren, H. (2014). The role of knowledge sharing self-efficacy in sharing Open Educational Resources. *Computers in Human Behavior*, *39*, 136–144. https://doi.org/10.1016/j.chb.2014.07.006

Van Harmelen, M., & Workman, D. (2012). Analytics Series Analytics for Learning and Teaching. *CETIS Analytics Series*, *1*(3), 1–41.

Van Rosmalen, P., Boon, J., Bitter-Rijpkema, M., Sie, R., & Sloep, P. (2014). Supporting co-creation with software, the idSpace platform. *Computers in Human Behavior*, *37*, 413–422. https://doi.org/10.1016/j.chb.2014.04.036

Vatrapu, R., Teplovs, C., Fujita, N., & Bull, S. (2011). Towards visual analytics for teachers' dynamic diagnostic pedagogical decision-making. In *ACM International Conference Proceeding Series* (pp. 93–98). https://doi.org/10.1145/2090116.2090129

Ventura, P., Bárcena, E., & Martín-Monje, E. (2014). Analysis of the Impact of Social Feedback on Written Production and Student Engagement in Language Moocs. *Procedia - Social and Behavioral Sciences*, *141*, 512–517. https://doi.org/10.1016/j.sbspro.2014.05.089

Vetter, M. (2012). Shifting actor and shifting audiences: from academic analytics to learning analytics. Nerdcomp.

Vladoiu, M., & Constantinescu, Z. (2013). Towards Assessment of Open Educational Resources and Open Courseware Based on a Socio-constructivist Quality Model (pp. 684–693). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-41033-8_86

Vladoiu, M., Constantinescu, Z., & Moise, G. (2013). QORECT - A Case-Based Framework for Quality-Based Recommending Open Courseware and Open Educational Resources. *COMPUTATIONAL COLLECTIVE INTELLIGENCE: TECHNOLOGIES AND APPLICATIONS*, *8083*, 681–690. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=Y1JdzW6fSv1UEknj6hV&page=6&doc=55

W3C. (2005). Introduction to Web Accessibility. Retrieved June 3, 2013, from http://www.w3.org/WAI/intro/accessibility.php

W3C. (2008). Accessibility Evaluation Resources. Retrieved August 30, 2016, from https://www.w3.org/WAI/eval/Overview.html

W3C. (2014). WCAG-EM Overview: Website Accessibility Conformance Evaluation Methodology | Web Accessibility Initiative (WAI) | W3C. Retrieved March 26, 2017, from https://www.w3.org/WAI/eval/conformance.html

W3C-WAI. (2008). Web Content Accessibility Guidelines (WCAG) 2.0. Retrieved August 30, 2016, from https://www.w3.org/TR/WCAG20/

Wagner, G. (2012). Simurena — A web portal for open educational simulation. In *Proceedings Title: Proceedings of the 2012 Winter Simulation Conference (WSC)* (pp. 1–12). IEEE. https://doi.org/10.1109/WSC.2012.6465217

WAI. (2011). WCAG 2 at a Glance. Retrieved from http://www.w3.org/WAI/WCAG20/glance/

Watanabe, W., Dias, A., & Fortes, R. (2015). Fona: Quantitative Metric to Measure Focus Navigation on Rich Internet Applications. *ACM Transactions on the Web*, *9*(4), 1–28. https://doi.org/10.1145/2812812

Wiley, D. A. (2000). *Learning object design and secuencing theory*.

Wolfenden, F., & Buckler, A. (2013). Capturing changes in Sudanese teachers' teaching using reflective photography. *Teaching and Teacher Education*, *34*, 189–197. https://doi.org/10.1016/j.tate.2012.12.007

Wright, C. R., & Reju, S. A. (2012). Developing and Deploying OERs in sub-Saharan Africa: Building on the Present. *INTERNATIONAL REVIEW OF RESEARCH IN OPEN AND DISTANCE LEARNING*, *13*(2), 181–220. Retrieved from http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=AdvancedSearch&qid=1&SID=U1z4h6Wfv8q8gS4weWE&page=13&doc=124

Wu, Y., Zhong, W., Zhou, C., & Ma, X. (2016). Construction on Learning Analytics Object for Sharing and Interoperation of Educational Big Data (pp. 186–195). Springer, Cham. https://doi.org/10.1007/978-3-319-32865-2_20

Xia, J. (2012). Let us take a Yale open course: a Chinese view of open educational resources provided by institutions in the West. *Journal of Computer Assisted Learning*, *29*(2), 122–137. https://doi.org/10.1111/j.1365-2729.2012.00477.x

Ye, L., Recker, M., Walker, A., Leary, H., & Yuan, M. (2015). Expanding approaches for understanding impact: integrating technology, curriculum, and open educational resources in science education. *Educational Technology Research and Development*, *63*(3), 355–380. https://doi.org/10.1007/s11423-015-9377-6

Young, S. S.-C., & Hung, H.-C. (2014). Coping with the challenges of open online education in Chinese societies in the mobile era: NTHU OCW as a case study. *The International Review of Research in Open and Distributed Learning*. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/1742/2939

Yuan, M., & Recker, M. (2015). Not All Rubrics Are Equal: A Review of Rubrics for Evaluating the Quality of Open Educational Resources. *The International Review of Research in Open and Distributed Learning*, *16*(5). https://doi.org/10.19173/irrodl.v16i5.2389

Zervas, P., & Sampson, D. G. (2013). A Quantitative Analysis of the Reuse of Mobile Assisted Language Learning Resources: The Case of Mobile2Learn Repository. In *2013 IEEE 13th International Conference on Advanced Learning Technologies* (pp. 36–40). IEEE. https://doi.org/10.1109/ICALT.2013.16

Zervas, P., & Sampson, D. G. (2014). The effect of users' tagging motivation on the enlargement of digital educational resources metadata. *Computers in Human Behavior*, *32*, 292–300. https://doi.org/10.1016/j.chb.2013.06.026

In this doctoral thesis a Learning Analytics Model to Trace the Creation and Evaluation of Open Educational Resources (LAMTCE) is introduced. The model considers web accessibility and quality as two featured characteristics of Open Educational Resources (OER). The research process started with the development of a web-based tool to support teachers in the evaluation of the web accessibility and quality of OER and an exploratory study conducted with teachers as authors and evaluators of OER. As a result of this study we confirmed the importance of giving teachers supporting tools to create and evaluate accessible and quality OER.

With the lessons learned during the exploratory study and the open issues identified in the literature, we defined the LAMTCE model. As part of this model we defined a teacher's user model with the teachers' competences in the creation and evaluation of the web accessibility and quality of OER. The LAMTCE model was implemented in a learning analytics tool that we called ATCE (Analytics Tool to Trace the Creation and Evaluation of OER) which was integrated as a module within the ATutor LMS. This tool was validated in the context of a virtual training course in which teachers had the opportunity to use the ATCE tool. Results obtained highlight a positive attitude towards the use of ATCE as a supporting tool in the creation and evaluation of accessible and quality OER.

Tracing the Creation and Evaluation of Accessible Open Educational Resources Through Learning Analytics

Universitat de Girona