convOERter: A Technical Assistance Tool to Support Semi-Automatic Conversion of Images in Educational Materials as OER

Von der Fakultät für Mathematik, Informatik und Naturwissenschaften der RWTH Aachen University zur Erlangung des akademischen Grades eines Doktors der Naturwissenschaften genehmigte Dissertation

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Abstract

Open Educational Resources (OER) are seen as an important element in the process of digitizing higher education teaching and as essential building blocks for openness in education. They can be defined as teaching, learning, and research materials that have been made openly available, shareable, and modifiable. OER include different types of resources such as full courses, textbooks, videos, presentations, tests, and images, which are usually published under the open Creative Commons licences.

OER can play an important role in improving education by facilitating access to high quality digital educational materials. Accordingly, there is a steady increase among higher education institutions to participate in the so-called "open movement" in general and in utilizing OER in particular. Nevertheless, there are many challenges that still face the deployment of OER in the educational context. One of the main challenges is the production of new OER materials and converting already existing materials into OER, which could be viable by qualifying educators through training courses and/or supporting them with specific tools.

There are many platforms and tools that support the creation of new OER content. However, to our knowledge, there are no tools that perform fully- or semi-automatic conversion of already existing educational materials. This identified gap was the basis for the design and implementation of the OER conversion tool (convOERter). The tool supports the user by semi-automatically converting educational materials containing images into OER-compliant materials. The main functionality of the tool is based on reading a file, extracting all images as well as all possible metadata, and substituting the extracted images with OER elements in a semi-automated way. The retrieved OER images are referenced and licenced properly according to the known TASLL rule. Finally, the entire file is automatically licenced under Creative Commons excluding specific elements from the entire licence such as logos.

In order to evaluate the effectiveness of the tool in promoting the use of OER, a comprehensive user study was conducted with educators and OER enthusiastic at different universities. The study was accomplished by offering a series of OER evaluation workshops to compare the conversion efficiency of the tool with manual conversion. The results show that using the conversion tool improves the conversion process in terms of speed, license quality, and total efficiency. These results highlight that the tool can be a valuable addition to the community, especially for users less experienced with OER. As a future work, it is intended to further develop the tool and improve its functionality. Additionally, a long-term study can be conducted to assess the impact of the tool in facilitating and enhancing the production of OER on a larger scale.

Zusammenfassung

Offene Bildungsressourcen (Open Educational Resources, OER) gelten als ein wichtiges Element im Prozess der Digitalisierung der Hochschullehre und werden als wesentliche Bausteine für die Offenheit der Bildungssysteme angesehen. Sie können definiert werden als Lehr-, Lern- und Forschungsmaterialien, die offen zugänglich, gemeinsam nutzbar und veränderbar gemacht wurden. OER umfassen verschiedene Arten von Ressourcen wie vollständige Kurse, Lehrbücher, Videos, Präsentationen, Tests und Bilder, die in der Regel unter offenen Creative-Commons-Lizenzen veröffentlicht werden. OER können eine wichtige Rolle bei der Verbesserung der Bildung spielen, indem sie den Zugang zu hochwertigen digitalen Bildungsmaterialien erleichtern. Dementsprechend beteiligen sich allgemein immer mehr Hochschuleinrichtungen an dem sogenannten „open movement“ und besonders an der Nutzung von OER. Nichtsdestotrotz gibt es immer noch viele Herausforderungen bezüglich des Einsatzes von OER im Bildungssektor. Eine der größten Herausforderungen bildet die Erstellung neuer OER-Materialien und die Umwandlung bereits vorhandener Materialien in OER, die durch die Qualifizierung von Lehrenden in Form von Schulungen und/oder durch die Unterstützung mit spezifischen Tools möglich ist.

Es existieren zahlreiche Tools, die die Erstellung neuer OER-Inhalte unterstützen. Unseres Wissens gibt es jedoch keine Tools, die eine voll- oder halbautomatische Konvertierung von bereits bestehenden Bildungsmaterialien durchführen. Dieses ermittelte Defizit war die Grundlage für die Konzeption und Implementierung des OER-Konvertierungstools (convOERter). Das Tool unterstützt die Nutzer bei der halbautomatischen Umwandlung von Bildungsmaterialien, die Bilder enthalten, in OER-konforme Materialien. Die Hauptfunktionalität des Tools basiert auf dem Lesen einer Datei, dem Extrahieren aller Bilder sowie sämtlicher Metadaten und dem halbautomatischen Ersetzen der extrahierten Bilder durch OER-Elemente. Die gefundenen OER-Bilder werden referenziert und entsprechend der bekannten TULLU-Regel lizenziert. Schließlich wird die gesamte Datei automatisch unter Creative Commons lizenziert, wobei bestimmte Elemente wie Logos von der gesamten Lizenz ausgeschlossen werden.

Um die Wirksamkeit des Tools bei der Konvertierung von OER zu evaluieren, wurde eine umfassende Nutzerstudie mit Lehrenden und OER-Interessierten an verschiedenen Universitäten durchgeführt. Hierzu wurde eine Reihe von OER-Evaluierungsworkshops angeboten, um die Konvertierungseffizienz des Tools mit der manuellen Konvertierung zu vergleichen. Die Ergebnisse zeigen, dass die Verwendung von convOERter den Konvertierungsprozess in Bezug auf Geschwindigkeit, Lizenzqualität und Gesamteffizienz verbessert. Diese Ergebnisse unterstreichen, dass das Tool eine wertvolle Ergänzung für die Gemeinschaft darstellt, insbesondere für Nutzer, die weniger Erfahrung mit OER haben. Für die Zukunft ist geplant, das Tool weiterzuentwickeln und seine Funktionalität zu verbessern. Außerdem bietet es sich an, eine Langzeitstudie durchzuführen, um die Auswirkungen des Tools auf die Erleichterung und Verbesserung der Produktion von OER in größerem Umfang zu bewerten.

Acknowledgement

With pleasure and gratitude, I would like to express my thanks to all who accompanied and supported me during my studies and my PhD journey, without whom this achievement would not have been possible.

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Great thanks go to my lovely family: to my parents, sisters and my brother for their love and encouragement, to my kids: Lien, Arien, and Rayan, who understood my circumstances as a working mom and as a PhD student, especially during the stressful days and when I was abroad at conferences. Last but not least, I deeply thank my dear husband Jakob. His unwavering support has been the driving force behind my success. Thank you for standing by me and cheering me on every step of the way. Without you, this journey would really have been impossible!

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Eidesstattliche Erklärung

Declaration of Authorship

I, Lubna Kamel Nazih Ali,

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I do solemnly swear that:

1. This work was done wholly or mainly while in candidature for the doctoral degree at this faculty and university;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this university or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others or myself, this is always clearly attributed;
4. Where I have quoted from the work of others or myself, the source is always given. This thesis is entirely my own work, with the exception of such quotations;
5. I have acknowledged all major sources of assistance;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Parts of this work have been published before as listed in Appendix G.

Aachen, 10.10.2023

- Lubna Kamel Nazih Ali –

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Chapter 1. Introduction

This chapter presents the outline and background of the dissertation by first explaining the motivation for this work and the objective of the thesis. Then, the methodology used throughout this research is discussed, followed by a presentation of the major contributions of the thesis. The final section of this chapter summarizes the structure of the dissertation and provides an overview of each chapter.

1.1. Motivation

Education is a top priority for UNESCO because it is a fundamental human right and the basis for building peace and promoting sustainable, social and economic development (Miao et al., 2019). To achieve these goals and to make education accessible to all, it is necessary to implement appropriate strategies, plans, and policies worldwide. OER are seen as a strategic opportunity to improve knowledge, sharing, and universal access to high quality learning and teaching resources ("Ljubljana OER UNESCO," n.d.). This would be applicable as OER hold the promise of reducing the cost of higher education and support learners in completing their degrees by providing free access to top course materials with permission to revise, use, remix, and distribute the content of these educational resources (Richter and McPherson, 2012). Furthermore, learning from anywhere would be possible, and access to higher education would be expedited for millions of learners worldwide. This will strengthen borderless access to knowledge and reduce educational inequity in the world (Richter and McPherson, 2012).

Despite the motivations and benefits of OER, there are many challenges that still hinder the deployment of OER (Wang and Towey, 2017), such as lack of know-how on creating, combining, licensing or finding OER, uncertainty regarding the use of open licences, and issues concerning quality assurance and evaluating the quality of OER. Further challenges were identified by investigating literature (see subsection 2.2.6) while others were recognized during working on OER projects (see section 4.2) and preparing educational materials. One of the major challenges was the lack of technical tools to facilitate the production of OER by converting already existing educational materials.

In the context of this work, the issue of converting existing materials into OER has been addressed and elaborated. Accordingly, the functionality of some tools which support producing OER such as H5P[1], CC-Mixer[2], Tutory[3], WordPress[4] was examined. It has been found that these tool are preliminary suitable for producing new OER content.

[1] https://h5p.org/, accessed 26.07.2023
[2] https://ccmixer.edu-sharing.org/, accessed 26.07.2023
[3] https://www.tutory.de/, accessed 26.07.2023
[4] https://wordpress.com/de/, accessed 26.07.2023

Considering the large amount of available and well-tested educational materials that could be converted into OER instead of producing new content, the concept of a web-based tool (convOERter) was developed

The framework of the tool was developed at the Learning Technologies Research Group of RWTH Aachen University to facilitate converting already-produced educational materials semi-automatically into OER. The main functionality of the tool is to read a file, extract the images in that file and replace them with OER compliant images from OER portals. After the development and deployment of the tool, the prototype was presented and tested in various workshops offered locally at RWTH Aachen University and internationally (at various conferences and universities). The feedback from the participants of these workshops helped us to improve the functionality of the tool and to develop it further.

To evaluate the efficiency of the tool in comparison with manual conversion, a series of OER workshops were conducted with educators and OER enthusiasts at different universities. The results show that converting the materials semi-automatically using the tool helped finding appropriate images, accelerated the conversion process, and enhanced the quality of image- as well as file-licences.

To summarize, OER play a central role in improving the borderless access to knowledge and making education available to all. Nevertheless, there are many challenges in the domain of OER that need to be addressed and resolved to enhance the utilization of OER. In this work, the challenge of lack of technical tools for converting existing materials into OER is highlighted and a solution as a web-based tool is presented. Finally, the proposed tool is evaluated in comparison to the manual conversion process and future improvements and research directions are presented.

1.2. Methodology

The thesis follows the principles of Design-Based Research (DBR) (see Chapter 5) to investigate the problem, to design and implement a suitable solution, and afterwards to evaluate the impact of the proposed solution on solving the problem or improving the addressed issue. To illustrate, the following steps were considered throughout this work:

Problem analysis and investigation: In the initial phase of the research process, previous research, theoretical investigations as well as practical implementations related to OER tools were systematically examined. The results show a lack of technical support and shortcomings in utilizing existing educational materials and converting them into OER. Accordingly, the idea of a tool to overcome the addressed shortcomings and facilitate converting the existing resources into OER was developed.

Design and implementation of a potential solution: In this step, a prototype of the OER conversion tool was designed and implemented. The main functionality of the tool is based on semi-automatic replacement of non-OER images with OER equivalents, as images are the most frequently used resources (according to a pre-survey conducted

with educators). The tool was developed and tested incrementally in various OER workshops held at RWTH Aachen University and other international universities and events.

Evaluation of the respective solution: To evaluate the tool functionality and to investigate to what extent the semi-automatic conversion of educational materials can be beneficial compared to the traditional manual conversion process, a series of evaluation workshops was conducted. The workshops were conducted as a comprehensive user study with participants from different universities. The workshops took place in the period from May to November 2022 (the user study is presented in detail in Chapter 8). The collected data from the workshops were analysed quantitatively and qualitatively. The overall concept and the evaluation results are discussed and the design limitations are addressed for future replications of the study and further enhancements (see section 8.5).

1.3. Contributions

The main contributions of this thesis in the domain of OER can be summarized in the following points:

- Theoretical analysis and investigation of previous research conducted in the field of OER, focusing mainly on tools and applications for producing or facilitating the creation of OER.
- Addressing the challenges still facing the use of OER in the educational context and highlighting some issues related to the conversion of existing educational materials into OER.
- Designing a technical solution to promote and facilitate producing more OER by converting existing educational resources semi-automatically into OER and implementing this solution as a web-based tool (convOERter).
- The results of evaluating the effectiveness of the developed tool in converting educational materials into OER, compared to manual conversion.
- Introducing some suggestions for future work and recommendations for enhancing the production of OER.

These contributions guided us to answer the following main research question:

Can a technical assistance tool support the production of OER by converting images in existing educational materials into OER?

To answer the main research question systematically, the following sub-questions were derived:

S-RQ1: What would be the framework of a technical assistant tool to support educators in converting their materials into OER?

The first sub-question focuses mainly on identifying the framework of a technical assistance tool that can facilitate the conversion of existing educational materials into

OER. Answering this question defines the concept of the developed tool and outlines its design and implementation.

S-RQ2: How can the semi-automatic conversion of educational materials facilitate the production of OER in comparison to manual conversion in terms of licence quality, conversion speed, and total efficiency?

This sub-question addresses the efficiency of semi-automatic conversion of educational materials into OER compared to manual conversion. To answer this question, several criteria have been taken into consideration (e.g. conversion speed and licence quality). Based on these criteria, the total efficiency of the conversion process has been calculated.

S-RQ3: Do proficiency & previous knowledge influence the speed and quality of converting educational materials into OER?

The aim of this research sub-question is to find out if there is a relationship between the proficiency in OER and the efficiency of converting the materials semi-automatically or manually into OER. Answering this question provides some insights into the target group that could benefit the most from the tool.

1.4. Dissertation Outline

This dissertation is divided into the following Chapters:

Chapter 1 (Introduction): Summarizes the main topic of the dissertation and highlights the primary motivation for conducting this study and developing convOERter. It also outlines the theoretical and practical contribution of this thesis. Additionally, it addresses the main research question and the sub-questions.

Chapter 2 (Fundamentals): Presents the theoretical concepts and terminologies needed to understand the background of this work. It establishes the foundations and defines the terms used throughout the thesis. This includes a general overview on the concept of openness in education. Further, it introduces particular terms related to OER such as: OER cycle, Creative Commons licences, motivation to utilize OER within educational practices, and challenges still facing the deployment of OER.

Chapter 3 (Related Work): Summarizes relevant work and research in the domain of OER such as: OER certification, OER recommender systems and OER quality. Afterwards, it presents a systematic literature review on existing OER tools. Finally, it briefly introduces various tools and applications that can support producing OER. The chapter concludes by addressing the research gap in converting existing educational materials into OER.

Chapter 4 (OER Projects): Outlines a brief overview on various OER projects at different levels (i.e. internationally, nationally and locally at RWTH Aachen University). Then, two OER projects of the Learning Technologies Research Group will

be introduced, as the concept of a tool to facilitate the conversion of educational materials has developed during the work on these two projects.

Chapter 5 (Research Design): Describes the research methodology adopted throughout this thesis. It maps the DBR approach to the research conducted within this work.

Chapter 6 (Converting Existing Material into OER): Introduces the concept of converting existing educational materials semi-automatically into OER using convOERter. It illustrates the concept, design and the technical implementation of the tool.

Chapter 7 (convOERter in Practice): Focuses on the practical utilization of the tool in two different contexts. The first context presents the conversion of real educational resources into OER and comparing the time efficiency of the semi-automatic process with the manual conversion. The second context presents an evaluation system that was developed and integrated within the tool to trace its usage and provide feedback for further development.

Chapter 8 (Evaluation): Introduces the design of a user study conducted to evaluate the efficiency of convOERter in converting educational materials compared to manual conversion. It introduces the results of a comparative user study conducted by offering a series of OER workshops at different universities**.** The chapter concludes by summarizing the findings derived from the study and discusses its limitations as well potential enhancements for future replications.

Chapter 9 (Conclusion and Future Work): Concludes the research and summarizes the main findings of the dissertation. Furthermore, it summarizes the practical and theoretical contributions achieved within this work. Finally, it presents suggestions for future research directions and further improvements of the tool.

Chapter 2. Fundamentals

This chapter presents the fundamentals related to the principle of OER. In the first section, the term openness and openness-related definitions are introduced. Then, in the second section, OER history, OER definition, Creative Commons, OER Cycle are presented. Finally, the benefits of applying OER and the challenges facing the deployment of OER are investigated.

2.1. Openness in Education

The concept of "openness" is based on the idea that knowledge should be freely disseminated and shared for the benefit of society as a whole (Yuan et al., 2008). The two most important aspects of openness are free availability and minimum restrictions regarding the use of resources, whether technical, legal, or financial (Yuan et al., 2008). These aspects are emphasized by the definition of "openness" appeared in Oxford Advanced Learner's Dictionary, where the term "openness" is defined as "the quality of being honest and not hiding information or feelings" and "the quality of not being limited or covered." ("Openness Oxford," n.d.).

Although terms like Open Education have become increasingly a matter of course, many different meanings of "openness" and "education" are being used nowadays, especially in pedagogical, political, economic, and scientific discourses (Hug, 2017). According to (Hug, 2017): "openness in education can refer to pedagogical attitudes towards fostering and maintaining processes of dialogue, reflection, and a climate of mutual learning, listening, and recognition." Further classification related to openness in education were summarized by (Deimann et al., 2015) as follows:

- **Open Science**: is a generic term that aims to make science more easily accessible to a larger number of people. These include product-oriented approaches that make results as openly accessible as possible. On the other hand, it can also be understood as opening up the scientific processes. Other scientists or the interested public are given insights into the emergence of scientific results or even opportunities to participate in them themselves.
- **Open Data**: This term refers to the free availability and usability of, mostly public, data. For this purpose, the creators use licence models that largely dispense with copyright, patents or other proprietary rights.
- **Open Source**: Open Source is a software whose source code is open and whose licensing fulfils some further conditions. In the narrower sense, it is licenced under a licence recognized by the Open-Source Initiative (OSI).
- **Open Education**: Open Education refers to the educational policy concern to make education freely available. It is often reduced to the transfer of knowledge via the internet and can be summarized by making the learning materials accessible to the user free of charge and making the learning platforms freely accessible to everyone.

However, Open Education must not be equated with E-Learning, but should be seen as a social demand to open up education and make it available for all.

- **OpenCourseWare (OCW)**: The concept of OCW is defined by the OCW Consortium as a freely accessible and openly licenced digital publication of high-quality educational materials at university level. They are designed as courses and include usually course planning materials and evaluation tools.
- **Open Content**: Open content is defined as free content. It indicates the content whose free use and distribution is permitted under copyright law. This may be the case after the expiry of legal protection periods, so that originally protected works are considered to be in the public domain. Alternatively, content is deemed to be free if the author or owner of the full rights of use has placed a work under a free licence.
- **Open Access**: When talking about open access, we consider accessing scientific literature and other materials on the Internet. Publishing a scientific document under Open Access terms gives everyone permission to read, download, save, link to, print and use it free of charge.
- **Open Textbooks**: This is usually understood to mean digitized textbooks, which are freely accessible and provided with non-restrictive licences.
- **Massive Open Online Courses (MOOCs):** MOOCs are online courses that are open to a large number of participants. They combine traditional forms of knowledge transfer such as videos, reading materials and problem-solving with forums where teachers and learners can communicate with each other and form communities.

After a brief introduction to the different concepts of openness, OER will be introduced as they represent one of the most important areas of openness in education.

2.2. Open Educational Resources

As stated previously, this section presents several aspects concerning OER; like history, definition, Creative Commons etc.

2.2.1. OER History

The history of OER is marked by key milestones which have shaped the global movement towards accessible and freely available educational materials. In January 1999, the University of Tubingen in Germany released a series of its lectures online, this was considered by many to be the official starting instance of OER (Infographics, 2014). However, it is argued by others that the Massachusetts Institute of Technology (MIT) provided the template for OER by launching its OpenCourseWare program in 2001 (Havemann, 2016). The program consisted of a comprehensive collection of 32 courses published in Fall 2002 (Infographics, 2014). In the same year, UNESCO organized a "Forum on the Impact of OpenCourseWare for Higher Education in

Developing Countries" to discuss how MIT's approach could be internationally expanded to support sharing open content. Participants at this event coined the term OER and consequently the OER movement was officially born (Havemann, 2016).

Followed by that, many initiatives conducted various activities in the field of "openness" and "open resources". China Open Resources for Education (CORE) emerged in November 2003 through a partnership with MIT OpenCourseWare, aiming to share resources with numerous Chinese universities (Infographics, 2014). The Organization for Economic Cooperation and Development (OECD) contributed by launching a study on OER in January 2005, leading to the report: "Giving Knowledge for Free: The Emergence of Open Educational Resources" (OECD, 2007).

September 2006 witnessed the inception of the Khan Academy by Salman Khan, providing free educational materials for K-12 subjects. Apple introduced iTunes U in May 2007, expanding to include K-12 materials alongside higher education content (Infographics, 2014). Notably, in January 2008, the Cape Town Open Education Declaration urged global governments and publishers to make educational resources freely available online. Key developments in OER continued with YouTube EDU in March 2009 (Infographics, 2014), California's Free Digital Textbook Initiative in August 2009, and Stanford University's offering of free online courses in September 2010. In April 2011, Bangladesh was the first to digitize textbooks for grades 1-12. Codecademy, the first free resource for learning computer programming, launched in August 2011 (Infographics, 2014).

In Germany, the year 2012 is considered to be the turning point of OER (Orr et al., 2018). In this year, the first white paper on OER for schools in Germany was published, the first OER camp took place and an expert discussion on OER was held by the Federal Ministry of Education and Research (BMBF) in Berlin (Knight et al., 2021). In 2015, a working group of the BMBF and the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder (KMK) published a report with short- and medium-term recommendations regarding OER. This report demonstrates awareness of the importance of OER at the national level (Knight et al., 2021). In 2017-2018, a number of projects have been funded and further policies have been adapted to improve OER in the country. Since then, many projects have been conducted and great results have been achieved. The materials generated in these projects have been published on the OERinfo-Portal (Knight et al., 2021).

2.2.2. OER Definition

The Open Educational Resources (OER) as a term was first introduced at the UNESCO's 2002 forum on Open Course Ware in Higher Education (Yuan et al., 2008). The definition recommended by UNESCO 2002 for OER was: "The 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" ("UNESCO Document," n.d.).

Ten years later, UNESCO adopted a detailed definition for OER, which highlights how OER can be utilized in different contexts. This definition was called Paris OER

Declaration ("Paris OER Declaration," 2012). Accordingly, OER has been 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 licence that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions. Open licensing is built within the existing framework of intellectual property rights as defined by relevant international conventions and respects the authorship of the work" ("OER UNESCO," n.d.). The nature of these materials, according to this definition, allows them to be adopted, used, and redistributed because they are published under an open licence.

For OER, the most widely used open licences are the Creative Commons licences, which make it possible for educators to freely and legally share their work ("Open Licences," n.d.). These licences are presented in the next subsection.

2.2.3. Creative Commons

Creative Commons (CC), according to CC's official website, is defined as: "A non-profit organization that helps overcome legal obstacles to the sharing of knowledge and creativity to address the world's pressing challenges" ("Creative Commons," n.d.). These licences provide standardization that indicates how a creative work can be used, distributed and how it can be attributed to its owner. The aim of the CC licence is to protect ownership right of art or work creators such as designers, video creators, artists, and scientists. It can be applied to any work or art created by a person to own the rights to his work. There are six different licence types offered by CC ("Creative Commons Licences," n.d.):

- CC BY: Re-users are allowed to use, adapt and redistribute the material under this licence, as long as attribution is given to the owner.
- CC BY-SA: Re-users are allowed to use, adapt and redistribute the material under this licence, as long as attribution is given to the creator. However, the modified material must also be licenced under the same licence.
- CC BY-NC: Re-users are allowed to use, adapt and redistribute the material under this licence for non-commercial purposes only, as long as attribution is given to the creator.
- CC BY-NC-SA: Re-users are allowed to use, adapt and redistribute the material under this licence for non-commercial purposes only, as long as attribution is given to the creator. However, the modified material must also be licenced under the same licence.
- CC BY-ND: Re-users are only allowed to use and redistribute the material under this licence, as long as attribution is given to the creator and no derivatives or adaptations of the work are permitted.
- CC BY-NC-ND: Re-users are only allowed to use and redistribute the material under this licence for non-commercial purposes only, as long as attribution is given to the creator and no derivatives or adaptations of the work are permitted.

In addition to the six licence models mentioned above, there is a special type of CC licence, namely CC0. Here, there are no restrictions or conditions regarding the use, distribution, adoption or remixing of the material. Figure 1 illustrates the CC licence models together with the licence symbols and acronyms.

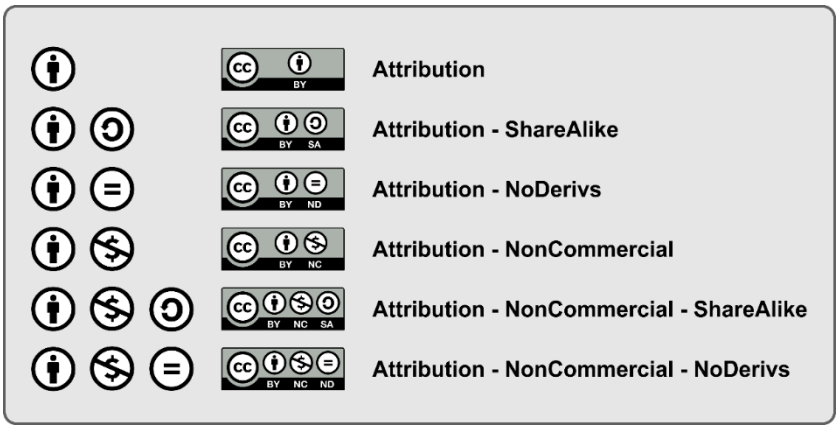

Figure 1: Creative Commons licence models

2.2.4. OER Cycle

When addressing the practical use of OER, two communities can be considered. The first community is the OER community, which normally creates, uses, edits and distributes materials. The second community is the education community, which usually searches for the educational materials, uses and edits them; however, they rarely produce their own materials as OER and they do not disseminate them. The approach

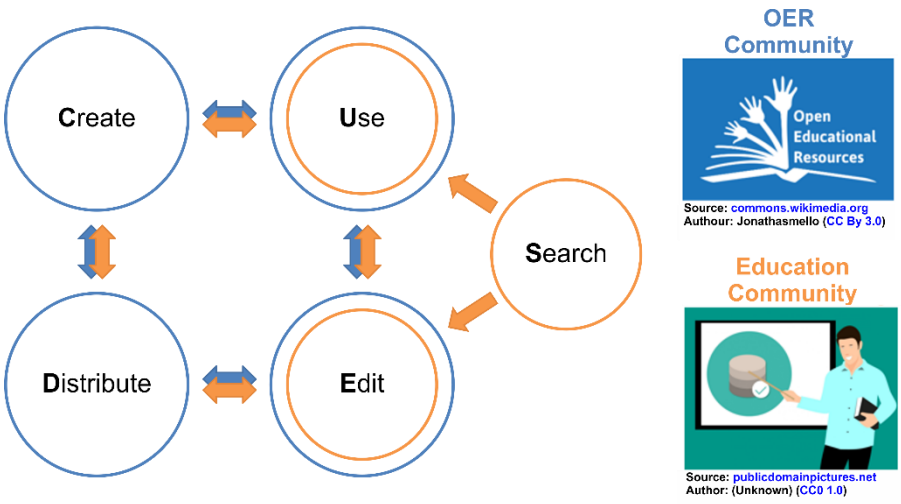

Figure 2: OER Cycle, where the OER community is represented in blue and the education community in orange.

of utilizing OER by the two communities can be represented by the OER cycle (Ali et al., 2020). The cycle consists of five activities related to utilizing OER, which are

search, use, create, edit, and distribute. Figure 2 illustrates the OER cycle. As can be seen in Figure 2, the process of creating, using, editing, and distributing OER is repetitive. This approach corresponds with the definition of "open" in OER presented by (Wiley and Hilton, 2018). According to this definition, a content can be considered "open" if it provides free permission to everyone to engage in the following 5R activities introduced in (Wiley, 2021):

1. Retain: the right to make, own and control copies of the content (e.g. download, store and manage).
2. Revise: the right to edit, adapt, and modify the content (e.g. translate to another language).
3. Remix: the right to combine the original or revised content with other material to create a new content (e.g. incorporate several contents together).
4. Reuse: the right to utilize the content in a wide range of ways (e.g. in a class, in a study group etc.).
5. Redistribute: the right to share the original, a revised, or a remixed copy of the resource with others (e.g. distribute a copy of the content).

Applying the complete cycle leads to producing a pool of free materials, which can be accessed and utilized by anyone. This is one of the main benefits of OER. Other benefits will be presented and discussed in the following subsection.

2.2.5. OER Benefits

The cost of educational materials can impose an immense economic burden on learners, which can affect their academic success. In this regard, OER can play an important role as they can promote equal access to high-quality education by making a variety of learning materials, lectures, books, curricula, and online courses available on the Internet at little or no cost (Admin, 2013), The role of OER in reducing costs on students was reported in (Hilton et al., 2014), where the cost savings at eight colleges, when these colleges began utilizing OER instead of traditional commercial textbooks, were addressed. The results stated that the cost savings were greater than one million dollars for one academic school year (Hilton et al., 2014). This significant cost savings confirms the claim that OER can reduce costs for learners.

However, the benefits of OER exceeds reducing the financial burden on students and institutions to enabling free and equal accessibility of high-quality educational materials. This is considered part of a global movement of making education available to all (D'Antoni, 2009).

Further insights on the benefit of OER have been introduced in (Yuan et al., 2008). The authors investigated various funding models, motivations, and outcomes of OER initiatives in higher education. According to (Yuan et al., 2008), motivations for OER adoption include altruism, cost reduction, and improving quality. They emphasized through their investigations that the OER movement aims to enhance lifelong and

personalized learning, and can revolutionize education if institutions and governments adopt supportive policies and encourage a culture of sharing (Yuan et al., 2008).

The OECD Centre for Educational Research and Innovation[5], identified specific advantages of utilizing OER for various stakeholders (OECD, 2007). The first stakeholder are Governments, which can serve citizens through widening participation in higher education and reaching non-traditional learners. This can promote lifelong learning, bridging the gap between formal and non-formal learning (OECD, 2007). The second stakeholder are institutions, which may benefit in a number of ways such as reducing the cost of content development and improving the quality. Additionally, the public image of the institution can be enhanced and new students can join (OECD, 2007). Further stakeholder, who can benefit are educators, as they acquire increased reputation, gain publicity or reach the market more quickly, which may result in an economic advantage (OECD, 2007).

A Further benefit of OER is to achieve inclusive education for learners with disabilities as presented in (Ben Brahim et al., 2017). The paper highlights the importance of personalized and accessible OER delivery systems to provide inclusive learning experiences.

To conclude, deploying OER within the educational context can be beneficial to leaners as well as educators and can be summarized as follows (Ali et al., 2022):

- Reduction of expenses for books and materials: OER can reduce the costs on learners for purchasing books or educational materials, since they are freely available digitally.
- Augmentation of teaching materials: OER can provide supplementary instructional resources that can be accessed remotely.
- Achieving inclusive education: OER can participate in providing inclusive learning for leaners with disabilities.
- Development of flexible course infrastructure: Educators can utilize available OER to create their own infrastructure for teaching that better addresses the needs and interests of their students. This increases the relevance and efficiency of teaching and learning.
- Collaboration and scalability: Educators can enhance their visibility by sharing their own educational materials and content to be used by students and other educators all over the world.

2.2.6. OER Challenges

Despite the aforementioned benefits and opportunities of OER, there are still certain obstacles to its use and widespread adoption. These challenges have been addressed and discussed in various publications, with some attempts to find appropriate solutions.

[5] https://www.oecd.org/education/ceri/, accessed 03.08.2023

(Towey et al., 2019) discussed the challenges still face the adoption of OER from multiple points of view, as the authors represent six different regions in the world and considered familiar or even experts in OER issues. The limitations include a negative perception about OER, as many people are not aware of the concept of OER. A further addressed challenge is the skills needed to access OER, since the majority of available OER appear to be in English and accessing these for people and communities who do not possess the necessary language skills is a challenge. Further obstacles include understanding the licensing requirements as well as the actual pedagogical skills to identify appropriate existing OER, to adopt them to the local needs, and to eventually (re-)produce OER and share them with the community (Towey et al., 2019).

(Yuan et al., 2008) highlighted also OER challenges in higher education which include sustainability, copyright issues, quality assessment, and interoperability. Additionally, they mentioned policy concerns, social and pedagogical aspects, and technical considerations as well as copyright barriers and quality assurance, which need to be addressed. The authors stated that further research is needed to validate and support OER communities. (Yuan et al., 2008).

Further investigations on OER challenges and potential strategies for the adoption of OER in higher education introduced in (Wang and Towey, 2017). The authors highlighted the emergence of OER and their transformative potential, emphasizing their equity, quality, and efficiency aspects. They discussed major challenges, such as awareness and perception of OER, production and repurposing skills, language and localization barriers, institutional policy and support, and cultural acceptance. To address these challenges, the paper suggests OER curation, increasing diversity, institutional vision, policy support, recognition, interdisciplinary collaboration, and student as well as teacher inclusion in OER development, staff development, and learner support. The authors concluded by noting their ongoing work in advocating for increased OER adoption and express the need to evaluate the effectiveness of these strategies in the future (Wang and Towey, 2017).

Another study that analyses challenges in OER and proposes solutions using emerging technologies like AI and blockchain, was introduced in (Tlili et al., 2021). The study relies mainly on literature review without empirical validation, where specific challenges have been highlighted such as data standardization, privacy, and financial support for OER projects. Future work suggested developing smart OER repositories and studying cultural impacts on OER adoption (Tlili et al., 2021).

Barriers to the adoption of social OER environments and their influence on teachers' lack of motivation to share and collaborate were examined by (Pirkkalainen et al., 2014). The authors conducted an exploratory quantitative study based on responses from 754 teachers in 19 European countries. The key findings showed that language and cultural barriers were the strongest predictors of lack of motivation, followed by lack of organizational support and quality concerns (Pirkkalainen et al., 2014). The study provides insights for OER providers and educational institutions to address these barriers and enhance teachers' motivation to engage in social OER environments.

Technical challenges related to OER were explored by Steven Ovadia in (Ovadia, 2019) with the focus on issues of file formats, licences, and version control. The study highlights the importance of plain text and Git repositories to ensure content is truly open, editable, and redistributable. The findings emphasize the need for easier-to-use interfaces for Git, user education about file formats and their limitations, and the establishment of document formatting standards. The scope of the paper covers OER content creation, sharing, revising, and remixing. Challenges include the complexity of Git for non-technical users and the need to educate content creators about open file formats. Limitations include the current lack of widespread adoption of Git for OER content management (Ovadia, 2019).

To summarize, the deployment of OER still faces a number of challenges. These challenges along with short descriptions are listed in the following table and were addressed in (Ali et al., 2022).

Table 1: OER Challenges

NO	Challenges	Description
1	Low Awareness	Many regions and communities who are unaware of OER.
2	Online Literacy	Many learners in many places are still digitally illiterate so they are unable to take advantage of OER.
3	Linguistic and cultural challenge	Majority of OERs are written in English, thus potential learners, who do not know the language might lose interest in. Also, some communities adhere to the existing academic schemes and are less open to modernizing their teaching and learning formats.
4	OER Policy of Institution	Many institutions do not have a clear OER policy. Furthermore, there is a lack of knowledge of the impact of the use of open licences for educators and administrators who produce teaching materials.
5	Perceptions of OER Quality	Issues concerning quality assurance and evaluating the quality of OER.
6	Lack of know-how	Lack of know-how (create, combine, licence or find OER) among the educators.
7	Lack of Technical tools for producing OER	Lack of tools that can support finding, producing OER or converting already-existing educational materials into OER.

Chapter 3. Related Work

This chapter provides an overview of related work and research that has been conducted so far in the field of OER, with a focus on OER tools. Investigating the research conducted to date on OER revealed the following five research topics: Benefits and Challenges of OER, OER Recommender System, OER Certification, OER Quality, and OER Tools. Benefits and Challenges of OER have been already introduced in Chapter 2. OER Certification, Quality, and Recommender Systems are considered, in the scope of this work, as adjacent research areas and are presented in section 3.1. OER tools are the closest related work to this dissertation and will be considered from two perspectives. The first perspective provides a systematic analysis of previous research related to OER tools (see section 3.2), whereas the second perspective presents an overview on the existing tools that can facilitate producing OER (see section 3.3). Based on the study of the related work, the research gap will be identified and discussed in section 3.4.

3.1. Review of Existing Adjacent Research in OER

This section provides an overview of the existing work in the field of OER. The overview aims to highlight the current research and summarize some findings in the following adjacent domains: OER Recommender Systems, OER Certification and OER Quality.

3.1.1. OER Recommender Systems

OER recommender systems or recommendation systems are intended to help users to find the most appropriate OER that fit their profiles and needs. (Hajri et al., 2017) addressed the role of recommender systems in supporting personalization in Online Learning Environments (OLE). Accordingly, a MOOC-based OER recommender system was proposed that can suggest recommendations of OER in an OLE by using metadata. The presented system has been integrated in the widely used edX MOOCs Platform. By integrating the proposed system in the MOOC platform, leaner profiles are calculated by extracting relevant information from the platform. During the course, the user profiles are updated depending on their progress. If the system detects a lack of knowledge, the recommendation will be triggered and the appropriate OER will be suggested for the users. The proposed system utilizes the metadata saved in the repositories. This means, having a greater amount of stored metadata will enhance the quality of the recommended resources (Hajri et al., 2017).

Another OER recommender system was presented in (Elias et al., 2020b). The personalized system considers learners skills, occupations as well as accessibility skills to recommend high quality OER. This is done by firstly identifying the learner profile during the registration process. The users are asked to enter their personal information, the accessibility preferences, and the target skills. After that, the quality of OER is predicted based on a scoring and prediction model of OER. Then, the recommender engine uses the learner's data profile as well as quality prediction to retrieve the best

matching of OER. The proposed system has been evaluated through two use cases covered both visually impaired users and cognitive impaired users. For each case, the OER have been filtered according to the quality prediction model and users' accessibility preferences (Elias et al., 2020b).

A special OER recommendation system to support career development was introduced by (Tavakoli et al., 2020b). The authors proposed a personalized OER recommendation system that can match learners' skills with an appropriate OER from the OER repositories. The model can apply quality control and predict the quality of the resources based on the associated metadata. The learners can interact with the system via a dashboard, where they can set specific parameters related to their experience and skills. Accordingly, the system recommends appropriate OER, which match the user profile. The users can evaluate their satisfactions regarding the retrieved OER during the whole process. Consequently, the system can adjust the precisions of the retrieved OER. The proposed system has been tested and the results showed that the learners were satisfied with more than 70% of the system recommendations (Tavakoli et al., 2020b).

Further investigations on open educational videos were presented in (Tavakoli et al., 2020c), where a recommender system oriented for open educational videos was proposed. Accordingly, a personalized learning prototype that combines text mining and text classification methods was built to create an OER recommender system for videos. The proposed system recommends new video contents to the users based on popularity, length of video, fit probability to specific skills, and similarity between skills and video description (Tavakoli et al., 2020c). The system was evaluated by 15 experts from the data science field, regarding the general objectives, logic and the potential contribution of the proposed system. The result showed that approximately 82.8% of the recommendations were classified as useful and matched participants' expectations (Tavakoli et al., 2020c).

Another recommender system for Informatics Institute for Postgraduate Studies (IIPS) has been suggested in (Hameed and El-Ameer, 2019). The system utilized the advantage of Content Based recommendation systems to retrieve the best recommendations for the user. The profile attributes of the users were analysed to define their preferences and compare them with resource attributes. Accordingly, a user profile can be created and an appropriate OER can be recommended. Additionally, the proposed system can recommend resources based on ratings from other users. The evaluation results showed that reasonable recommendations for the users can be obtained, which overcome the issues of trust, sparsity and performance (Hameed and El-Ameer, 2019).

3.1.2. OER Certification

One of the research topics in the field of OER is how to certify individuals and institutions for OER. The following research question was addressed by (Ebner, 2018): "How a concept for a nation-wide OER-certification in higher education can look like?". Accordingly, the concept of certification of OER for lecturers and for higher education institutions has been introduced and discussed. The certification of lecturers can be

acquired in two steps; the first one can be accomplished if the lecturer created and published three OERs and the second step can be achieved if the lecturer completed an OER training. The certification of higher education institutions can be demonstrated by the proficiencies and experiences in the domain of OER. This can be reached by applying the following three steps: (1) the institution has specific training measures and intends to use OER strategically, (2) the institution has a number of OER certified-lecturers, and (3) the institution has its own repository to save OER. Open Badges have been suggested and recommended to be used for the certification, since they are standardized, verifiable and portable. Additionally, the efforts of a special interest group (SIG)[6] in integrating OER in higher education has been highlighted. The certification concept would be one of the motivational steps to promote the utilization of OER in higher education (Ebner, 2018).

In (Schön et al., 2021), the authors examined several publications from the field of certification of individuals and higher education institutes to utilize them on developing OER certification for educators and institutions. Within this research, two aspects were investigated. The first one was to outline the idea behind planning OER certification in higher education in Austria and the second one was to examine the existing procedures to recognize the proficiencies and the competencies in the domain of OER for individuals and institutions. According to the investigations accomplished by the authors, exact descriptions related to the status of OER certification for higher education institutions could not be found. Consequently, they presented and described the OER certification procedure within the "Open Education Austria Advanced" Project. The proposed procedure for certification includes four components: Open Development, Open Content, Open Assessment and Open Certificates. Under each component, there are different criteria to be further considered. Within the timeframe of the project, all Austrian Universities should be able to apply the certification procedure to their educators as well as the institutions (Schön et al., 2021).

The authors in (Ebner et al., 2022) discussed the impact of OER and the effect of specific OER initiatives on enhancing the education at Graz University of Technology (TU Graz). Several aspects have been presented such as: the status of OER in Austrian higher education institutions, the OER Policy, OER activities at TU Graz, and some experiences on the positive impacts of OER on teaching innovation. One of the topics that has been highlighted, is granting the staff of TU Graz an OER Certification since 2019. The certification can be acquired by completing a training course of 25 hours. In case of joining an extra OER online course along with creating own OER and submitting the certificate of participation, the educators will be awarded the university OER certificate. This will allow them to use the Plug-in of the TU Graz LMS for uploading their OER content (Ebner et al., 2022). The certification system of TU Graz can be a role model for other universities and institutions to broaden the utilization of OER.

[6] SIG was founded by the nation-wide association called fnma (Forum Neue Medien in der Lehre Austria).

3.1.3. OER Quality

Quality of OER has been addressed in different papers and many researchers have elaborated on this issue; since it is one of the challenges that still face the utilization of OER (see subsection 2.2.6).

A literature research on quality assurance (QA) in OER, which focus on the reliability and quality aspects were introduced in (Almazyad, 2019). The author presented a review on quality assurance measures that could be implemented in OER to increase its reliability and quality. The idea is to apply the quantitative research approach and conduct an online survey to collect data about different approaches related to quality assurance such as: infrastructure, learning content, OER development, and initial support (Almazyad, 2019).

In the study introduced by (Elias et al., 2020a), a set of evaluation metrics to asses OER quality were suggested. The idea behind these metrics is to provide guidance to OER content creators to create high quality OER. They used the collaborative OpenCourseWare Platform SlideWiki to implement and evaluate the introduced concept. Two research questions have been addressed within this research. The first one focused on "How to evaluate the quality of OER?" and the second one elaborated on "How to use the evaluation metrics to guide authors and learners of OERs?" To answer the first question, three quality evaluation metrics regarding three aspects of quality assessment were established, which are: content structure, learning content and self-assessment. To resolve the second question, selected metrics in SlideWiki were implemented. The concept was evaluated by collecting feedback from OER users and creators using a questionnaire. The overall results indicated that the metrics have addressed different quality aspects and can be used to determine the quality of OER (Elias et al., 2020a).

Another proposal for assessing the quality of OER was presented by (Romero-Pelaez et al., 2019). The authors introduced a general framework for evaluating OER in order to facilitate discovering of resources by users. The proposed framework has been developed based on the functionalities and properties of a number of well-known OER repositories. The quality framework consists of three layers. The first one is analysing the existing quality models in the domain of E-Learning and OER. The second layer is responsible for applying the concept of semantic web technologies, natural language processing, and knowledge representation. The third one is responsible for ensuring that the retrieved OER is complying with the proposed guidelines (Romero-Pelaez et al., 2019).

Further studies introduced in (Tavakoli et al., 2021) and (Tavakoli et al., 2020a) have been conducted on metadata level. In these research towards developing a model to predict the quality of OER, the authors collected the metadata of a huge set of OERs to perform data analysis to examine the metadata quality. Accordingly, they suggested a metadata scoring model (Tavakoli et al., 2020a) and built a prediction model to evaluate the quality of OER. The proposed model showed that it can predict high-quality OER with an accuracy of 94.6%. In the future, it is planned to improve and validate the model

by considering further metadata features and collecting more data from other OER repositories (Tavakoli et al., 2021).

In a study conducted by (Segarra-Faggioni and Romero-Pelaez, 2022), the quality of a huge amount of OER metadata from SkillsCommons repository was evaluated. Based on the machine learning methods Support Vector Machine (SVM) and Random Forest Classifier (RFC), two metadata, which are description and material type, were automatically evaluated. First classification results reported that the proposed procedure reached 70% accuracy rates (Segarra-Faggioni and Romero-Pelaez, 2022).

A further study on introducing quality models to investigate which quality attributes can be applied to OER, was presented in (De Oliveira et al., 2021). The authors introduced a systematic mapping of OER quality attributes and models. Accordingly, the following research questions were discussed: What are the quality models and attributes proposed for OER? How have these quality models and attributes been established for OER? And how have quality models and attributes for OER been evaluated? For each research question, a couple of metrics was described. The metrics based mainly on examining the existing literature studies on OER models and attributes, and analysing them in order to characterize them. Based on this analysis, the authors identified quality models and attributes for various OER formats such as OpenCourseWare (OCW) and MOOCs. Additionally, they identified specific OER attributes that have been used in OER models such as accessibility and reusability (De Oliveira et al., 2021).

Since retrieving OER from reliable and peer reviewed portals is a major concern of the OER community, introducing these portals and illustrating the evaluation criteria would be crucial for the leaners as well as the educators. In (Shmueli, 2017), MERLOT (Multimedia Educational Resources for Learning and Online Teaching), which is considered a reliable metadata repository for OER platform, was introduced. The repository, which is supported by the international community, adopts a peer-review strategy to assure the quality of the data. Accordingly, learners worldwide are provided with high-quality OER. The platform can be used to discuss educational issues with other educators, sharing educational materials with community members, and contribute peer reviewed or commented materials. The materials are rated by an editorial board composed of an editor, an associate editor and peer reviewers. The evaluation is based on the following criteria: quality of learning materials, the effectiveness of the materials in improving the education, and whether the materials can be easily used by students and educators. The rating adapts the 5-star system, where one star means that the materials are not worth at all, and five stars means that the overall content is excellent. Due to its reliable content and evaluation procedure, MERLOT is considered one of the largest metadata repositories serving the educational community all over the world (Shmueli, 2017).

The quality issue was also addressed at the Learning Technologies Research Group while working on OER projects (see Chapter 4). Accordingly, a preliminary quality model was proposed (Ali et al., 2021) to answer three key questions: (1) Who can evaluate the quality of OER? (2) What can be evaluated? and (3) Which methods or

measures could be applied to evaluate OER? To answer these questions, an OER quality model was created and all potential answers to the three questions (WHO, WHAT, HOW) were listed. Then, all possible links that could connect the different items in the lists were drawn and preliminary analysed. It is intended to extend and evaluate the proposed model in further research (Ali et al., 2021).

To conclude the search presented in this section, it is worth to highlight a paper that summarizes a systematic review of OER research. The work conducted by (Meng et al., 2020) presents a systematic review of research on OER from 2002 to 2019. It employs bibliometric analysis to explore the development progress, research focus, and trends in OER literature. The study identifies three stages of OER development: Incubation (2002-2007), Exploration (2008-2011), and Application (2012-2019). Key findings include the emphasis on quality assurance, sustainability mechanisms, teacher education, copyright issues, and the international context. The authors propose five recommendations for OER practice and research: enhance international cooperation, pay attention to OER's impact on developing countries, explore sustainable mechanisms, improve OER quality, and promote teacher education. The paper suggests that further research should explore sustainable mechanisms for OER projects, ensure quality assurance, and promote teacher education. Detailed investigation into these areas can enhance the effectiveness and impact of OER initiatives (Meng et al., 2020).

3.2. Systematic Literature Review on OER Tools

As stated earlier, OER tools are the closest area to the work done in this thesis. Accordingly, a systematic review of the related literature is conducted to examine the results of recent research and, more importantly, to identify potential research gaps. The systematic search was performed in the following digital libraries: IEEE Xplore[7], Web of Science[8], ACM Digital Library[9], and ERIC[10]. To ensure that all possible publications related to converting or producing OER in the educational context in the aforementioned period were retrieved, the following search query was executed: *((OER OR "Open Educational Resources") AND (Converting OR Producing OR Editing OR Licence OR support OR automatic OR manual OR semi OR Tools OR Kits OR images) AND (learn* OR edu*))*, where the publication years were chosen to cover the period from 2011-2021.

The preliminary search retrieved 3.254 publications, which were filtered and classified according to the following inclusion criteria (IC):

- IC1: Duplicates were removed.

[7] https://ieeexplore.ieee.org/, accessed 20.02.2022
[8] https://www.webofscience.com/, accessed 20.02.2022
[9] https://dl.acm.org/, accessed 20.02.2022
[10] https://eric.ed.gov/, accessed 20.02.2022

- IC2: Accessibility was checked (i.e. whether the publication is accessible or downloadable via the university library or as an open access).
- IC3: Publication is written in English or German.
- IC4: Relevance to (support) producing OER or converting materials into OER or other tools related to OER.

To perform the fourth inclusion criterion, a two-step filtering process was applied. In the first step, the title of the publication and the associated keywords were examined. Accordingly, non-relevant topics were discarded. The second step was to read the publication's abstract and determine whether the publication is relevant to OER tools or the production of OER, or the conversion of materials into OER in the educational context. This reduced the number of potential relevant publications to 10. Table 2 illustrates an overview about the retrieved publications from each digital library and the number of relevant publications after applying the inclusion criteria and performing the filtering process.

Table 2: Number of retrieved and relevant publications on OER Tools

	IEEE Xplore	Web of Science	ACM Digital Library	ERIC
No. of retrieved publications	686	545	1033	990
No. of relevant publications	3	1	3	3

These publications were read and analysed to determine the current research status and to answer the following questions:

- Are there any tools or technical assistance that could support converting existing educational materials into OER?
- Are there any studies addressing the efficiency of producing new OER content in comparison to converting existing materials into OER?
- Are there any studies comparing the efficiency of converting existing materials into OER using a tool with converting them manually?

In the following, the results of analysing the related publications are presented.

In 2011, (Sampson et al., 2011) introduced ASK-LOM-AT 2.0, a web-based tool aimed to simplify the process of educational metadata authoring for OER using the IEEE Learning Objects Metadata (LOM) standard. The tool offers step-by-step form-based educational metadata authoring, based on different IEEE LOM Application Profiles. Additionally, the tool supports browsing, editing, and exporting metadata records,

enhancing interoperability among various learning object repositories. Further, it presents metadata elements based on importance and automatically completes elements using user profiles. As a future work, the authors (Sampson et al., 2011) mentioned the use of ASK-LOM-AT 2.0 in further project and suggest further research and application in science education contexts (Sampson et al., 2011). While the paper focuses on educational metadata authoring, it highlights the importance of interoperability, accessibility, and standardization in the context of OER.

A following publication presented a web-based service for collaborative authoring learning, aimed at creating, sharing, and exploring dynamic content in an educational setting (Awang Hj Hamid et al., 2011). The new web-based service enhances collaborative tools and authoring environments through grid portal technology. The study demonstrates how this environment fosters web-assisted education beyond digital learning materials, encouraging skills sharing, knowledge exchange, and teamwork among students. The collaborative authoring learning approach is shown to be effective in terms of performance evaluation analysis (Awang Hj Hamid et al., 2011). Further research could focus on refining the grid portal technology and exploring its integration with diverse educational tools and platforms.

In 2014, (Motz and Tansini, 2014) presented a study focused on the evaluation of OER repositories. The authors propose a set of tools to enhance the evaluation process and improve the quality of OER repositories. They introduce the concept of Specialized Profiles of OER Metadata, which defines user needs and desired repository quality. These profiles are used to adapt OER Metadata dynamically based on user feedback, enhancing thereby the usability. As a future work, the authors suggested evaluating the proposed toolkit in real-world scenarios and refining the integration of user evaluations and recommendations within educational platforms (Motz and Tansini, 2014).

A following study (Liang et al., 2015) presented BBookX; a computer-facilitated system for automatically and collaboratively building open online books using publicly available educational resources such as Wikipedia. The authors propose two components of BBookX: one that creates an open version of existing books by linking book Chapters to relevant Wikipedia articles, and another that supports interactive real-time book creation based on user queries and explicit feedback. The system aims to address the challenge of creating and maintaining high-quality, up-to-date learning resources in fast-changing domains. The authors describe the system overview, the construction of the open book repository, and the interactive book creation process. They discuss the performance of the candidate ranking method and present a case study to demonstrate the effectiveness of their query subsystem. The paper concludes by highlighting the advantages of BBookX in reducing costs, contributing to OER, and providing up-to-date information. The future goals and scope of BBookX include further exploration of relevance feedback mechanisms and applications in reducing the cost of creating instructional content (Liang et al., 2015).

Further publication that addressed OER tools is the work-in progress paper introduced by (Towey and Zhao, 2017). In this paper, the authors present an automated Java

programming tutorial tool that would be released as OER to support learning programming languages. The proposed system has been designed to include a course interface, where the users can update the settings of a specific course and add or remove courses. Additionally, the tool has a study page which contains the activity services as well as the question types. One further component is the statistics interface or the dashboard, where statistical information about the user learning behaviour or progress can be displayed. The system has been developed partially and it is intended to be further implemented, tested and finally released as an OER (Towey and Zhao, 2017).

Another work (Andone et al., 2017) highlights the effect of integrating Open Education Tools (OEP), within the Virtual Campus platform (CVUPT) Moodle of Politehnica University of Timisoara, on the student teacher interaction. The work discusses the utilization of a Moodle-based virtual campus in a traditional university, focusing on the implementation and impact of OEP to enhance student-teacher interaction. The authors (Andone et al., 2017) explore the evolution of the virtual campus over multiple academic years, highlighting the introduction and adoption of various Web 2.0 technologies as OEP. These tools include communication platforms, resource sharing, assignments, and more. The study analyses user interactions, communication patterns, and the growing adoption of OEP. It also emphasizes the positive influence of OEP on student engagement and collaboration. The analysis reveals that introducing OEP and training teachers on using them in a specific pedagogical settings can be useful for the student interaction, raising their interest in certain activities and not ultimately reaching the goals of better retention and higher grades (Andone et al., 2017).

Further work (Cox and Trotter, 2017) introduced three tools to determine and analyse the adoption of OER in higher educational settings. The tools have been introduced as an analytical framework called the OER Adoption Pyramid. It explores six critical factors for OER adoption: access, permission, awareness, capacity, availability, and volition. The paper investigates the relationship between institutional culture and the factors affecting OER adoption. The authors suggest that further research is needed to expand the application of the OER Adoption Pyramid to other institutional contexts and geographic regions. Additional studies could refine the framework and explore the dynamics of OER adoption in different cultural settings (Cox and Trotter, 2017).

Further investigation on tools was introduced in (Jeria and Villalon, 2017). This research paper focuses on the importance of formative feedback in higher education and proposes the use of OER to enhance the quality of feedback provided by teachers. The study implemented a computer-supported marking tool that integrated an OER search feature, allowing markers to access relevant educational materials while grading exams. The experiment compared a control group, using a text box for feedback, with an experimental group using the OER tool. The results indicated that the use of OER in the feedback interface led to markers generating more and longer feedback compared to the control group. The paper suggests that technology, coupled with OER, can reduce costs, promote collaboration among markers, and enhance the depth of learning. Future work includes further experimental designs, measuring student perceptions, and developing

collaborative versions of the OER tool to improve feedback production efficiency (Jeria and Villalon, 2017).

Another work (Avila et al., 2017) introduced an innovative OER Analytics tool to Trace the Creation and Evaluation (ATCE) of Inclusive and Accessible Open Educational Resources (IA-OERs) (Avila et al., 2017). The authors highlighted the challenges faced by teachers in creating IA-OERs that align with Universal Design Learning principles, ensure quality, and address web accessibility. They present a use case of IA-OER creation and evaluation using ATCE, which includes an analytics dashboard with visualizations to assess teachers' competences. The tool supports the identification of accessibility and quality issues in IA-OERs, provides feedback to teachers, and enables decision-making for content improvement. The work emphasizes the need for learning analytics solutions that assist teachers in creating educational resources and identifies a gap in this area of research. The proposed tool aims to fill this gap and offers potential benefits for enhancing teacher competences in IA-OER creation and evaluation. The authors express the intention to further investigate the tool's effectiveness and acceptance in supporting teachers, along with future goals for refinement and expansion of its capabilities (Avila et al., 2017).

The limitations of OER adoption and potential technological solutions were highlighted in (Tlili et al., 2021). The paper discusses the role of Artificial Intelligence (AI) in providing personalized learning experiences, improving search and retrieval of OER, and enabling assessment and feedback. It also addresses the use of blockchain technology to protect intellectual property rights, prevent fraud, and enhance trust in OER. The work emphasizes the importance of considering technological limitations and sociological factors in implementing these solutions. The authors argue that overcoming challenges requires addressing technological limitations and considering sociological factors. The future research can involve empirical studies to validate the proposed solutions and their effectiveness. Developing an OER smart repository that utilizes machine learning to enhance OER use could be a potential direction. The study also suggests further investigation into the impact of culture on OER adoption and the development of sustainable revenue models for OER projects (Tlili et al., 2021).

According to the review introduced in this section, there are several publications that addressed OER tools used for creating OER content. Nevertheless, the idea of converting educational materials into OER and the role of technical support on enhancing the utilization of OER have not been mentioned or discussed explicitly. In the following section, various applications that can support producing OER are introduced and their functionality or usage are briefly illustrated.

3.3. Overview on Existing OER Supportive Tools

In addition to presenting and analysing the current research in the field of OER tools, some common applications that could support producing OER are introduced.

H5P[11]: One of the most famous tools available for creating and editing HTML5 content in multilingual way. As HTML5 is a widely used open standard, all the content can be viewed, edited and used on almost all devices. H5P helps to produce and reproduce interactive content like videos, presentations, games, quizzes, etc. Additionally, H5P offers tools and documentation for creating new OER content. It can also be integrated into Content Management Systems like WordPress. There are many H5P libraries, which widens its content-type support. Content creation is not the only focus of H5P; users with existing content can also use its libraries to create a user-friendly environment in a few easy steps and facilitates content editing and import/export. With H5P, a wide variety of interactive tasks can be created. The tasks range from searching images, answering questions and creating interactive videos. Within these videos, time-stamps can be set to show at which points questions have to be answered before the user can continue watching.

Tutory[12]: This tool supports the entire process of creating OER. Worksheets with a wide variety of content can be created in the internet browser. The tool offers numerous aids for this purpose. Cloze texts and multiple-choice tasks can be created and notes can be added with a few clicks. Images can also be easily integrated. Within the tool, several OER image sources can be searched automatically, and the selected images can be provided with source information. Through various modules, interactive worksheets can accordingly be created e.g. by embedding QR codes and YouTube videos. Even in the free basic version, one can have an access to materials from other authors. Unfortunately, Tutory is not completely free; registration is required and some offers are only available in a premium version for which a fee is charged.

Wisemapping[13]: With this internet application, interactive mind maps can be easily created. This can be practical in school lessons. For example, together with the pupils, the teacher can collect and visualize the learning content in a mind map in the class. Finally, this can be given to each pupil without having to pay attention to any copyrights; which is a great advantage of OER.

Short links[14]: When creating OER, relatively long links often have to be provided. For example, the references to the location of an image source or the obligatory link to the licence text when using the Creative Commons licences can become quite long and thus further reduce the often-limited space on worksheets. These long links can be shortened with the help of the short links webpage.

Creative Commons Mixer[15]: When combining different resources to produce a collage, it is necessary that the licences are compatible with each other. Using Creative Commons Mixer, different licences can be selected, and their combinability checked. If

[11] https://h5p.org/, accessed 08.08.2023
[12] https://www.tutory.de/, accessed 08.08.2023
[13] https://www.wisemapping.com/de/, accessed 08.08.2023
[14] https://bitly.com/, accessed 08.08.2023
[15] https://ccmixer.edu-sharing.org/, accessed 08.08.2023

the licences can be combined, licences under which the collage can be published are suggested.

Creative Commons Chooser[16]: More fundamental, of course, is the question of which licence to choose for one's own resource, for example for a document or image one has created oneself. Creative Commons itself offers support here. With the Licence Chooser, the right licence for one's own resource can be determined in just a few steps, with brief queries.

LibreOffice[17]: This software has established itself as a high-quality, free and open-source alternative to Microsoft's Office package. Like many open source projects, the project is financed to a considerable extent by voluntary donations from the users (Koschorreck, n.d.).

Wordpress[18]: is a widely used content management system for websites and blogs. The creators also offer a free online solution for those who do not have their own domain or want to quickly set up a blog for a course. Setting up a blog requires registration with a valid email address (Koschorreck, n.d.).

yopad.eu[19]: offers the possibility to set up free Etherpads, a collaborative writing tool. The offer is a joint project for the promotion of digital participation of the German Children and Youth Foundation (DKJS), the German Federal Youth Council (DBJR) and the International Youth Exchange (IJAB) (Koschorreck, n.d.).

Camtasia[20]: records videos that can then be edited in an easy-to-use editor. The 30-day trial version is free, the download requires registration with a valid email address. A free, open-source alternative for Windows, Linux and Mac is OBS Studio (Koschorreck, n.d.).

Comic Life[21]: allows the users to easily create comics using their own images. The 30-day trial version is free of charge, and discounts are offered to educational providers and institutions. The desktop version is available for Windows and Mac, the app for iOS (Koschorreck, n.d.).

OpenCourseWorld[22]: is a platform that offers free open online courses (MOOCs). Educational institutions or coaches, trainers, course instructors and lecturers can also offer courses themselves free of charge via the platform. In terms of content, the portal focuses on the area of professional development (Koschorreck, n.d.).

[16] https://creativecommons.org/choose/, accessed 08.08.2023
[17] https://www.libreoffice.org/, accessed 08.08.2023
[18] https://wordpress.com/de/, accessed 08.08.2023
[19] https://yopad.eu/, accessed 08.08.2023
[20] https://www.techsmith.com/video-editor.html, accessed 08.08.2023
[21] https://plasq.com/apps/comiclife/macwin/, accessed 08.08.2023
[22] https://www.opencourseworld.de/pages/landingpage.jsf?locale=de, accessed 08.08.2023

DriveOnWeb[23]: is an online storage service from Germany, which is committed to the comparatively strict German data protection standards. The basic package with 5GB storage volume and a maximum of two users is free of charge. Here, the user can store working materials and files and make them available to the course participants permanently or temporarily (Koschorreck, n.d.).

Lumi Education[24]: is a platform designed to facilitate the creation of interactive and engaging learning content. It offers educators tools to design dynamic presentations, quizzes, and assignments. This functionality allows OER creators to integrate multimedia elements like videos, images, and interactive components. By utilizing Lumi Education, OER developers can craft more immersive and effective educational materials that resonate with learners, fostering a deeper understanding and engagement with the content.

DeepAI[25]: This platform is capable of generating text, images, and media content using AI models. When integrated with OER projects, DeepAI can assist in producing supplementary visuals, diagrams, or even automatically generated text, enriching the comprehensiveness and diversity of OER content. By using DeepAI, OER creators can add visually appealing and informative components to their resources, enhancing the overall quality and variety of the educational materials provided to learners.

Inkscape[26]: is a free and open source vector graphics editor with various features. The tool can be used for creating creative and technical illustrations such as cartoons, clip art, logos, diagrams and flowcharts. The users own all file formats saved or exported from Inkscape.

In addition to the above-mentioned tools, popular search engines such as Google advanced search[27], DuckDuckGo[28], and Bing[29] allow users to retrieve images under Creative Commons licence. All of these mentioned tools and engines are valuable assets that support the production of OER. Nevertheless, they are designed to support the production of new content, rather than to convert existing materials into OER.

3.4. Review Results and Research Gap

Based on the review of adjacent research in OER introduced earlier and the systematic investigation on OER tools, as well as the presentation of a variety of tools that can support the production of OER, the following results can be summarized:

[23] https://storage.driveonweb.de/oauth/login.jsp, accessed 08.08.2023
[24] https://app.lumi.education/, accessed 08.08.2023
[25] https://deepai.org/, accessed 08.08.2023
[26] https://inkscape.org/, accessed 08.08.2023
[27] https://www.google.com/advanced_search, accessed 20.04.2022
[28] https://duckduckgo.com/, accessed 20.04.2022
[29] https://www.bing.com/images/feed, accessed 20.04.2022

- Various Research has been conducted so far in different fields of OER (Recommender Systems, Certification, Quality, and Tools) (see sections 3.1 and 3.2). Nevertheless, the idea of (semi-)automatic conversion of existing educational materials into OER using technical tools has not been yet investigated.
- There is a number of valuable tools or applications that can support producing new OER content (see section 3.3), but there are no existing applications that can support converting already-produced materials into OER.
- As there are no tools for automatic or semi-automatic conversion of materials into OER, there are no studies addressing the efficiency of producing new OER content in comparison to converting existing materials into OER.
- Additionally, there are no studies addressing the efficiency of converting existing materials into OER in comparison to converting them manually.

This reveals a research gap, as there is an extensive volume of existing and well-tested educational materials which are not OER. Accordingly, this raises the following question: Why shouldn't existing resources be utilized and converted into OER instead of producing new content from scratch? To address this question, a concept of a tool to support the semi-automatic conversion of educational materials into OER was proposed. The tool has been developed incrementally and the beta-version has been tested while working on OER projects at the Learning Technologies Research Group of RWTH Aachen University. Then, the functionality of the tool and the effectiveness of semi-automatic conversion has been evaluated by conducting a comprehensive user study.

Chapter 4. OER Projects

In this chapter, an overview of various OER projects at different universities is presented. In particular, two OER projects, MINT-L-OER-amt[30] and dOER[31], of the Learning Technologies Research Group at RWTH Aachen University, are introduced, since the idea of a tool for converting existing educational materials has developed during the work on these projects.

4.1. Overview on OER Projects at Universities

As a sign of the growing popularity of OER, several OER-related projects have been implemented at national and international universities. The topics covered by these projects range from OER plans, courses, policies, and certification to portals. These projects collectively underlines the potential of OER to enhance learning and revolutionize education. On a national level, a number of projects have been funded and policies have been adapted to improve OER in the country. The OER information portal (OERinfo[32]) which was launched in 2016 with the support of the BMBF, provides comprehensive information about the current state of knowledge, best practice examples, OER camps, and other initiatives related to OER activities in Germany. These projects highlight Germany's dedication to promoting open education, digital transformation, and information exchange. Locally at RWTH Aachen University, various OER projects have been funded. Some of them have already been accomplished, others are still ongoing. Two of these projects, in which the idea of convOERter has been developed, are presented in the following section. An overview on some projects at different levels (internationally, nationally and at RWTH Aachen University) and a summary of the achieved results are presented in Appendix M.

4.2. OER at the Learning Technologies Research Group

The main goal of the projects MINT-L-OER-amt and dOER conducted at the Learning Technologies Research Group is to qualify certain target groups about OER and to provide them with the needed skills to find, use, edit, and distribute OER. To achieve this goal, a series of qualification workshops were organized and a collection of materials were produced and have been used within these projects. An overview on the concept of the projects and the execution procedure is presented in the following subsections.

4.2.1. OER Competences in MINT Teacher Training

The aim of OER competences in MINT teacher-training project (abbreviated MINT-L-OER-amt) was to sustainably integrate the concept of OER into the STEM (Science,

[30] https://www.rwth-aachen.de/mint-l-oer-amt, accessed 29.07.2023
[31] https://www.rwth-aachen.de/lebiac-doer, accessed 29.07.2023
[32] https://open-educational-resources.de/, accessed 29.07.2023

Technology, Engineering, Mathematics) education and teacher-training programs at RWTH Aachen University (Ali et al., 2018) This was accomplished by qualifying and supporting certain target groups to create, edit and utilize OER Materials for teaching purposes. The target groups were: Lecturers and students of the STEM didactics at RWTH, current school teachers in the region, and other lecturers and STEM students of RWTH. The above-mentioned groups have been qualified gradually with the support of the centre of excellence at RWTH (MINT-L^4@RWTH[33]). All materials used within the qualification program have been published under the Creative Commons licence[34] and made available as OER.

Within the frame of the project, different materials in different formats have been produced to be used for the qualification workshops. The materials include: training manual for OER trainers, different handouts and worksheets, combination cards as well as videos and presentations. All materials are available on the website of the project. The project finished successfully at the end of September 2018.

4.2.2. OER Competences in Teacher Training

As part of the Teacher Training Quality Initiative, the Federal Government and the Länder supported the further development of teacher training. The Learning Technologies Research Group has also been active there since 1st, January 2019 in the subproject OER Competences in Teacher-Training programs (abbreviated dOER). The subproject dOER aims at raising awareness and qualification for open digital learning materials and learning applications in all subjects of teacher-training programs at RWTH Aachen University. It was built upon preliminary work from the successful BMBF project MINT-L-OER-amt presented in the previous subsection and addresses all educators as well as students in teacher-training programs.

By embedding suitable OER building blocks in curricular anchored didactic and educational science courses, it can be ensured that all students and educators of teacher-training programs at RWTH are qualified for dOER. The project concept follows the principle of "train the trainer", where the educators in teacher-training programs are qualified in order to qualify their students. The project coordinator has set up several means for the qualification process, such as qualification workshops, Moodle learning rooms, and various materials. Figure 3 shows an overview of the qualifying procedure of the dOER project. In the following, the concept of the workshops offered within the project, the produced materials and the OER Moodle learning rooms will be presented.

[33] https://www.fb1.rwth-aachen.de/cms/mathematik-informatik-naturwissenschaft/Die-Fakultaet/Zentren/~czls/MINT-L4/?lidx=1, accessed 10.01.2023
[34] https://creativecommons.org/licenses/?lang=en, accessed 11.11.2022

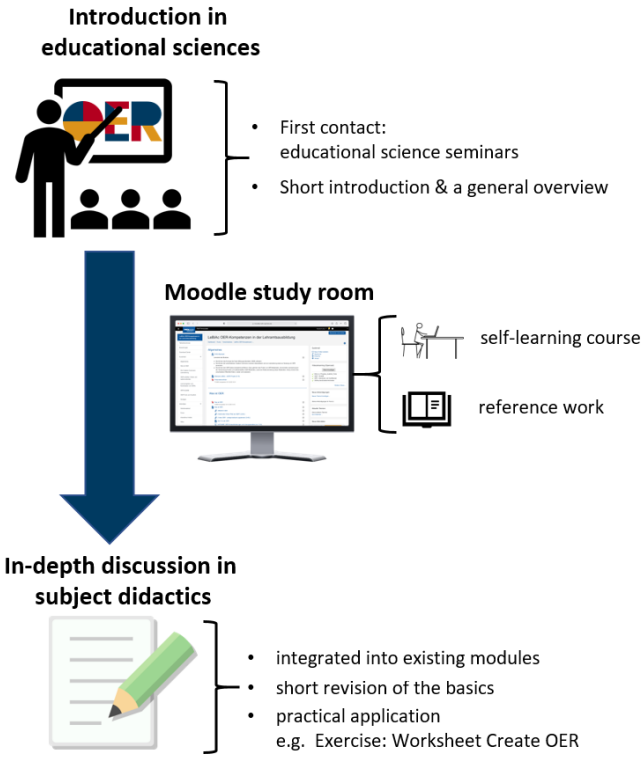

Figure 3: dOER Project qualifying procedure

OER Workshops

In order to qualify the aforementioned target groups for the concept of OER, several workshops were offered at RWTH Aachen University. The workshops were designed to encourage active participation. After the participants have acquired the necessary theoretical knowledge about finding, creating, editing, disseminating, and properly licensing OER, they were given the opportunity to actively participate in several practical sessions. In the first practical session, they discovered the world of OER by searching OER portals and platforms for freely available resources. For many potential OER users, finding appropriate material can be a difficult task. To assist participants in this process, they have received special handouts showing a variety of OER portals, as well as a collection of links for finding OER (see Appendix J).

The second practical session enables the participants to improve their OER-editing skills by combining different resources and licence cards. Working in teams, the participants identified ways to combine the cards, which represent different OER, to generate OER collages or OER compositions. The participants then discussed and decided under which licence to publish the new mixed OERs and why. For this purpose, other cards covering the different types of Creative Commons licences have been prepared and shared with the participants. During the workshops, the instructor was available to support the participants to accomplish the tasks. Figure 4 shows some of the resources

and licence cards (combination cards) that have been used within the workshops. Due to the Covid-19 pandemic, the workshops were restructured to be held digitally.

Figure 4: Resources and licences cards used during workshops to practice editing OER

OER Materials

In order to be able to qualify the educators and students through workshops, several materials have been produced. The idea behind the materials is to provide the target groups with sufficient tools needed to achieve the goals of the projects. All materials have been licenced under Creative Commons CC BY Attribution-Share Alike International (CC BY-SA 4.0). The materials are available on the project's website of dOER subproject in German as well as in English. Additionally, they have been uploaded to two Moodle rooms created during the COVID-19 pandemic to host the materials and facilitate OER self-qualification.

The produced materials encompass a variety of handouts on OER portals, OER link lists illustrating where to find OER, and a handout on how to edit OER. Additional links related to OER specific subjects have been also prepared (i.e. for mathematics, chemistry, biology, political science etc.). In addition to that, a training manual for OER trainers has been produced to support educators in teacher-training programs by qualifying their students about OER. These materials, which have been created in three different formats (pdf, Microsoft-Office, and Open-Office), supported the participants to expand their knowledge about OER. Examples of these handouts can be found in Appendix J.

OER Moodle rooms

As stated above, two Moodle learning rooms have been set up during the pandemic to allow the self-qualification about OER. The first room addresses the students directly, who are given admission to the room during their teacher-in-training studies. With the help of tutorial videos and uploaded materials, students without any previous knowledge about OER can be sensitized and qualified. Students with limited experience can use the available resources to extend their knowledge about OER. Similar to the workshops,

the self-study units are structured following the OER cycle (see subsection 2.2.4). The cycle works as a common thread that connects the different units together (Ali et al., 2022).

All of the produced and introduced materials within the previous section have been uploaded to the student room to make them available for the students digitally. Moreover, the room contains an interactive educational game, which was developed within the bachelor thesis of Quang Phung (Phung, 2021) at the Learning Technologies Research Group based on the OER editing game (Tran, 2021). The web-based game[35] that can run in most modern browsers, enables students to practice OER cycle presented in subsection 2.2.4. Figure 5 shows a screenshot of the OER cycle game.

Figure 5: Screenshot of OER cycle game

The second Moodle room is intended for educators. In addition to the materials available in the student room, this room contains a training manual for OER trainers to support the educators when qualifying their students. For instance, hints are provided regarding how to adapt and integrate materials into domain-specific teaching. These materials are also freely available as pdf, Microsoft- Office or Open-Office documents on the dOER-Project website[36]. The educator's Moodle room contains also a Forum that allows lecturers to share their experiences on OER.

[35] https://oer-cycle.elearn.rwth-aachen.de, accessed 27.07.2023
[36] https://learntech.rwth-aachen.de/cms/LearnTech/Forschung/Projekte/~zqae/dOER/?lidx=1, accessed 11.11.2022

Chapter 5. Research Design

This chapter introduces the research method that has been adopted thorough this thesis, which is the Design-Based Research (DBR). DBR emerged at the beginning of the 21st century and was recognized as a new research methodology that can make a fundamental evolution in the quality of education research (Anderson and Shattuck, 2012). In the following subsections, the characteristics of the DBR and how it matches the concept of this research are presented. Then, the research methodology followed to conduct this study is introduced.

5.1. Research Guidelines

This research is guided by the DBR method. DBR is defined as "a methodology designed by and for educators that seeks to increase the impact, transfer, and translation of education research into improved practice" (Anderson and Shattuck, 2012). It is considered as an effective method that can bridge theoretical research with practical implementations in formal education (Anderson and Shattuck, 2012). Moreover, it is proposed that DBR holds a great potential for enhancing teaching and learning through technology (Reeves, 2006). One of the primary advantages of DBR is that it requires collaboration between experts and researchers to identify the real problems, the creation of prototype solutions, and the testing and refinement of both the prototype solutions and the design principles (Reeves, 2006). Figure 6 illustrates the structure of DBR in educational technology research.

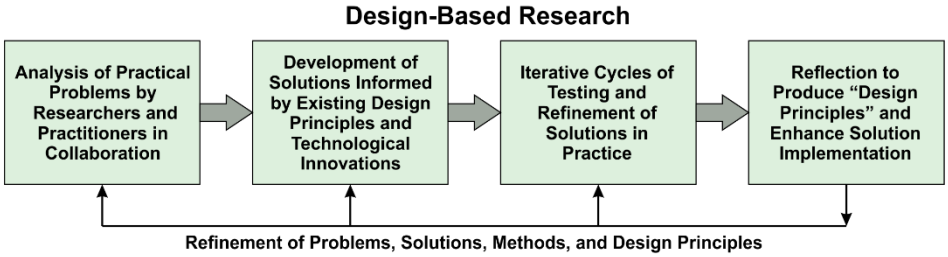

Figure 6: Design-Based research approaches in educational technology research (Reeves, 2006)

According to the research problem presented in Chapter 1 and the structure of DBR shown in Figure 6, the DBR approach was applied within this research work. As mentioned earlier, the following research question "Can a technical assistance tool support the production of OER by converting images in existing educational materials into OER?" is to be answered. Consequently, a systematic analysis of the existing problem, the design of a novel solution, the testing of the prototype, and the improvement of the proposed solution are required. Accordingly, the DBR approach is well suited to answer the research and sub-research questions presented earlier in section 1.3.

5.2. Research Methodology

The DBR study must meet a number of characteristics to be considered of high quality (Anderson and Shattuck, 2012). In the following, the DBR requirements and how they align with the research problem are presented.

- **DBR must be situated in real educational context**
  When the research emerges from a real educational context, the study can be validated and the results can be evaluated and effectively utilized to improve actual situations or real problems (Anderson and Shattuck, 2012). As illustrated previously in section 1.3, this thesis addresses the problem of converting existing educational materials semi-automatically into OER using the OER conversion tool (convOERter).

  The problem was identified during converting real educational materials at the Learning Technologies Research Group of RWTH Aachen University into OER, as it took a great amount of time and effort to perform the conversion of the materials manually. Consequently, the concept of a technical support tool (convOERter) was developed. Having a technical support to convert existing educational materials into OER will be an added-value not only for our research group, but also for the entire OER community. This has already been underlined by presenting the tool and testing its functionality with different OER stakeholders at various conferences and events.

- **DBR focuses on designing and testing of a significant intervention**
  Selecting and creating the intervention starts with accurate assessments of the local issue and is confirmed by investigating relevant literature as well as further theoretical and practical context. The intervention, which can be a learning activity, a type of assessment, or technological tool, is designed mainly to overcome a problem or enhance an existing practice (Anderson and Shattuck, 2012).

  Designing and implementing the intervention in this thesis has been done after examining the problem in the literature as well as examining the current projects in the domain of OER and discussing the issue with OER experts. Moreover, the developed solution is intended to solve an existing problem of converting the educational materials and enhancing accordingly the utilization of OER in (higher) education.

- **DBR applies mixed methods**
  DBR interventions are assessed using a variety of indices and applies usually various research tools and techniques (Anderson and Shattuck, 2012). Investigating and evaluating the intervention developed within this thesis has been done through conducting a systematic study using three workshop designs (see Chapter 8) and analysing the results qualitatively and quantitatively by collecting and analysing the results using surveys and practical sessions.

- **DBR involves multiple iterations**

  Design practice evolves normally through creating, testing, iteratively enhancing and updating the design. Normally, multiple iterations are needed to validate the intervention, since a single implementation or iteration is usually not adequate for the test and evaluation processes. Furthermore, there is a room for improvements in the subsequent evaluation (Anderson and Shattuck, 2012).

  The work accomplished within this thesis (developing and evaluating of convOERter) was achieved through successive processes of designing, implementing and testing of the tool with different stakeholders. Followed by further iterations for enhancing and optimizing its functionality.

- **DBR involves a collaborative partnership between researchers**

  Identifying the problem and negotiating the study in the DBR process are normally accomplished through a close partnership between groups of stakeholders such as: researchers, practitioners and interested community members. This covers the whole process starting from identifying the initial problem, through literature review, to intervention design, implementation, and evaluation of the design principles (Anderson and Shattuck, 2012).

  Defining the problem, designing the solution, and implementing and developing the tool, were achieved through close collaboration and intensive discussions and workshop sessions with colleagues and researchers at RWTH Aachen University, in addition to other community members, OER experts and researchers and at other universities.

- **DBR leads to developing of practical design principles**

  The requirement of developing practical design principles is the key strength of DBR compared to those types of research that disappears once the experiment has been concluded (Anderson and Shattuck, 2012). The practical outputs of DBR could appear in different formats such as tools or hardware units. The final results of the research must be presented in a way that enables the readers to clearly understand the motivation behind a particular claim and the designer must provide sufficient information, so that generalized claims can be verified (Obrenović, 2011).

  The practical output of this research was the development of a tool that supports the semi-automatic conversion of educational materials into OER in addition to the results obtained by evaluating its functionality in comparison to manual conversion. The practical result of this study has been made available to OER-interested and the OER community as open-source software. The theoretical results will also be made available to the researchers once this work is published.

Chapter 6. Converting Existing Materials into OER

This chapter introduces the concept of converting the existing educational materials semi-automatically into OER using the novel tool convOERter. The first section outlines the tool concept, whereas the second presents its design. The third section highlights the technical implementation of the tool. Finally, the results of a pilot study conducted to test the tool and collect feedback on its functionality are presented.

6.1. Tool Concept

While working on the OER projects presented in section 4.2 (MINT-L-OER-amt and dOER) and investigating previous research and tools on OER, it became apparent that, to our knowledge, there are no tools that could be used to (semi-)automatically convert existing educational materials into OER. This led to the following questions: What about the already existing and well-tested educational materials? Couldn't these be used and converted into OER rather than producing new materials from scratch? If so, how could this be accomplished and would this encourage educators to produce more OER? To answer these questions, a technical tool that facilitates the (semi-)automatic conversion of educational materials and support educators willing to produce OER, has been contemplated (Ali and Schroeder, 2020).

In order to determine the tool specifications, a pre-survey conducted in various OER workshops offered while working on dOER project (see subsection 4.2.2). The pre-survey has been conducted in different OER workshops held at RWTH Aachen University and at the OER international conference held from 28th-29th, January 2019 in Lucern[37]. Forty participants filled out the questionnaire, which contained questions regarding the concept of converting materials (semi-)automatically using a tool. The pre-survey has been adopted from an OER survey issued by the OER Hub-Research in the United Kingdom ("OER Hub," n.d.) and can be found in Appendix B. The questionnaire also addressed the challenges of producing OER from a practical perspective, as most of the participants in the workshop were educators at universities. The participants were asked to cross all challenges they face when producing OER. The participants' responses of the challenges can be seen in Figure 7.

Table 3 displays a clarification for each challenge appeared in Figure 7. As can be noticed from the diagram, the most noticeable challenges are finding the suitable OER that would fit the subject, finding high quality resources, and knowing where to find these resources respectively.

[37] https://openlearningdays.ch/en/archive-conference-2019/, accessed on 12.01.2023

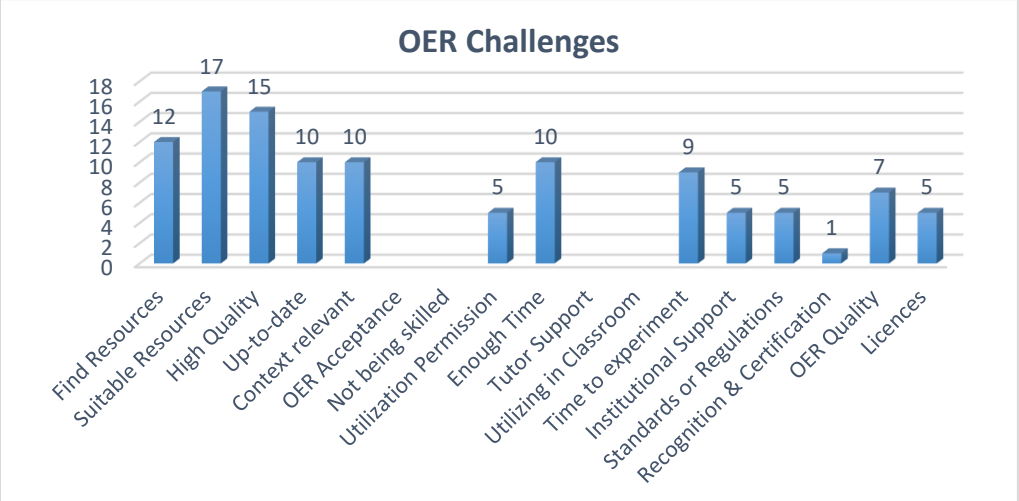

Figure 7: OER Challenges according to the pre-survey conducted in 2019

Further challenges, as can be depicted from the Figure, are finding up-to-date resources, not having enough time to look for suitable resources and difficulties to find resources relevant to the local context.

Table 3: Illustration of the challenges appeared in the above diagram

Description	Challenge
Knowing where to find resources	Find Resources
Finding suitable resources in my subject area	Suitable Resources
Finding resources of sufficiently high quality	High Quality
Finding resources that are up-to-date	Up-to-date
Finding resources that are relevant to my local context	Context relevant
Getting work colleagues/managers to accept the use of open educational resources	OER Acceptance
Not being skilled enough to edit resources to suit my own context	Not being skilled
Not knowing whether I have permission to use, change or modify resources	Utilization Permission
Not having enough time to look for suitable resources	Enough Time
Missing/needing the support of a tutor or teacher to help me work through open course materials	Tutor Support
Not knowing how to use the resources in the classroom	Utilizing in Classroom
Not having enough time/opportunities to experiment with using open educational resources in the classroom	Time to experiment
Lacking institutional support for the use of open educational resources	Institutional Support
Resources that are not based on professional standards or regulations	Standards or Regulations
Orientation towards recognition and/or certification	Recognition & Certification
Doubts about the quality of open educational resources	OER Quality
Lack of knowledge about the licensing of own materials	Licences

About 80% of the participants were interested in the idea of having a tool that could convert their materials into OER as can be shown in Figure 8. Further, the participants were asked about the most common used resource to produce the educational materials. The results showed that the most frequent used resource are images as can be seen in Figure 9. Based on these two inputs, the OER conversion tool was designed.

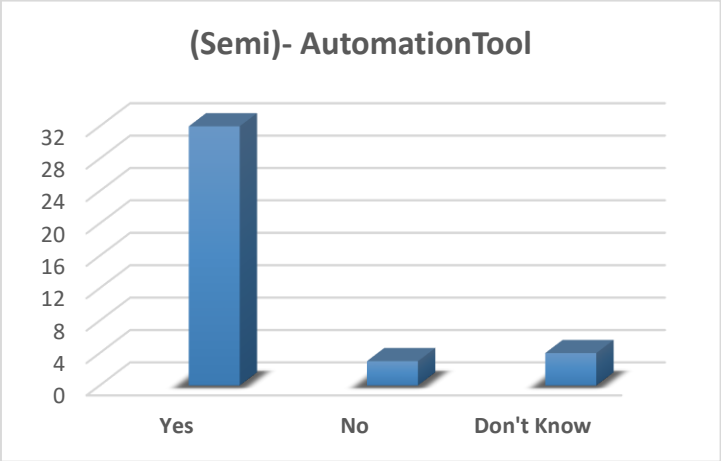

Figure 8: Participants' responses to the idea of OER conversion tool

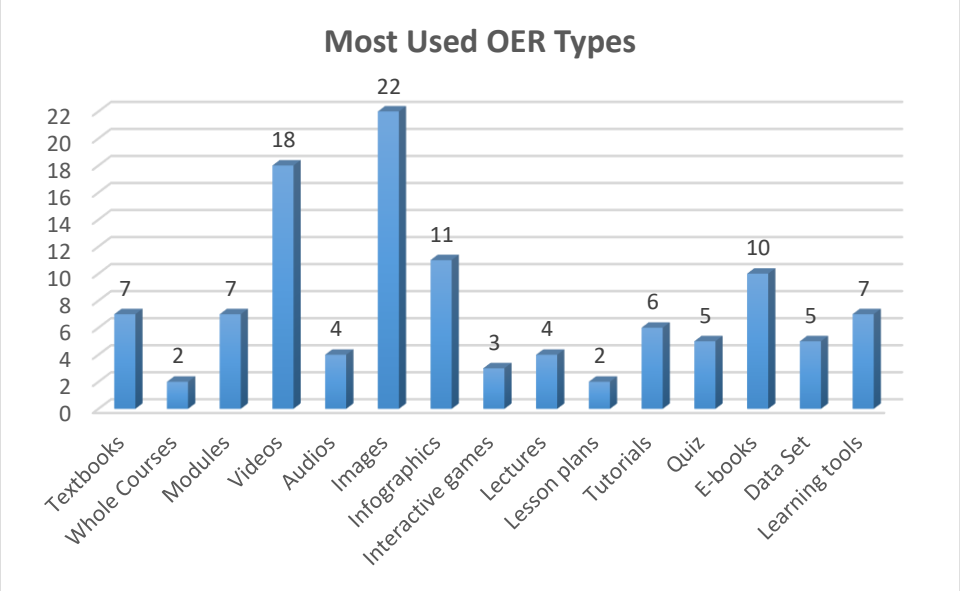

Figure 9: The most used resources in the educational context

6.2. Tool Design

The tool identifies the images in learning materials and replaces them semi-automatically with OER-compliant alternatives from the OER portals. Currently, the tool can search in two image portals: Flickr[38] and Openverse[39]. It retrieves the corresponding OER images with their Meta data and licences. Each retrieved image gets a reference number that is placed directly under the image. These reference numbers are listed in an extra slide, which is automatically added at the end of the document to license each image according to TASLL rule (see Appendix K). Depending on these references, the whole document is licenced and the non-CC licenced images such as loges are excluded from the licence. As a result, convOERter reduces the effort needed to search for freely licenced images and facilitates converting the supported formats into OER. The current version of the tool supports converting four file formats, which are: PowerPoint Presentations (.ppt), Open-Document Presentations (.odp), Microsoft Word Documents (.doc), and OpenOffice Documents (.odt). Figure 10 shows the main interface of the tool containing all information regarding convOERter usage and functionality.

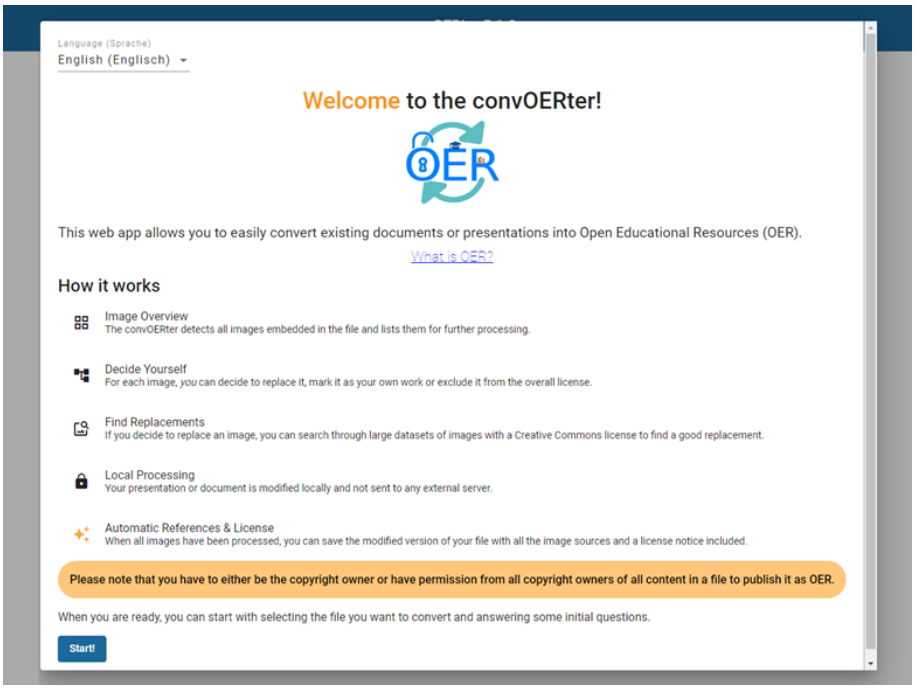

Figure 10: Main interface of convOERter

The process to convert a file into OER starts by clicking the start button. Here, the users will be directed to another interface, where they can open the file, choose the appropriate Creative Commons to license the file, and type their names as editors for the file. Then

[38] https://www.flickr.com/, accessed 25.05.2023
[39] https://search.openverse.engineering/, accessed 25.05.2023

they can check or edit the disclaimer text which is optional. Figure 11 displays screenshots of these steps.

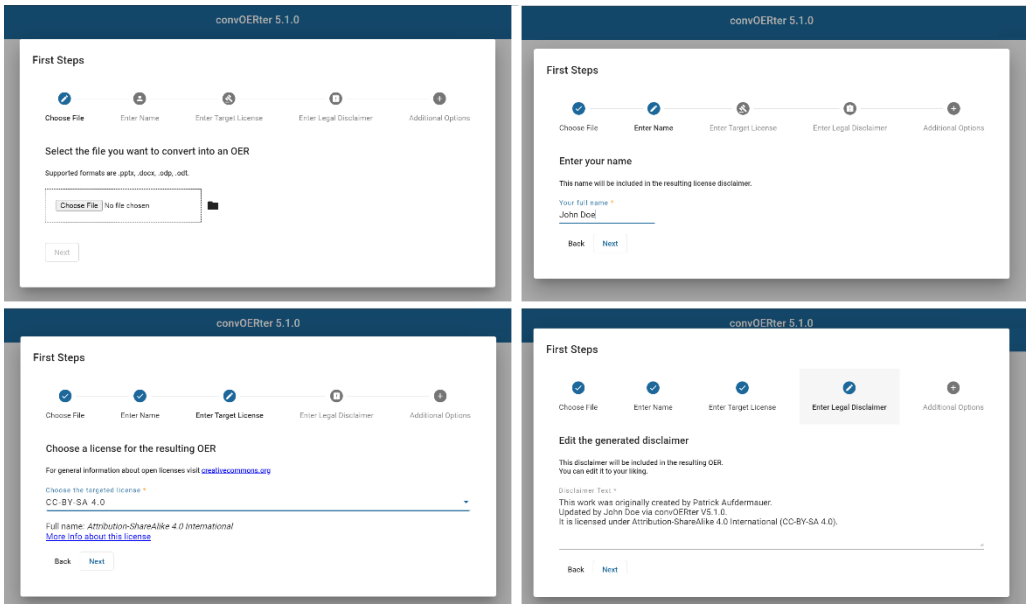

Figure 11: First steps of licensing a file

Next, the process of licensing a document starts, which can be divided into four main steps as follows:

1. **Extracting the images from the document**
   After opening the file and entering user's information, the tool extracts all supported image formats such as: JPEG, JPG, PNG, GIF and TIFF and lists them as can be shown in Figures 12.

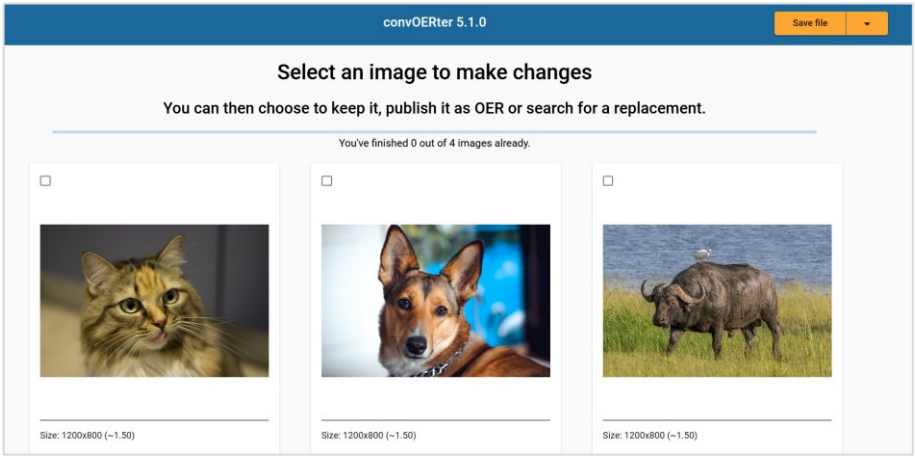

Figure 12: Displaying the images within a file

2. **Choosing an image to be replaced**
   After extracting the images, users can choose the image they want to replace with a corresponding OER image. Here, a pop-up menu with different options appears and the users can choose among these options. The four options to substitute an image are displayed in Figure 13.

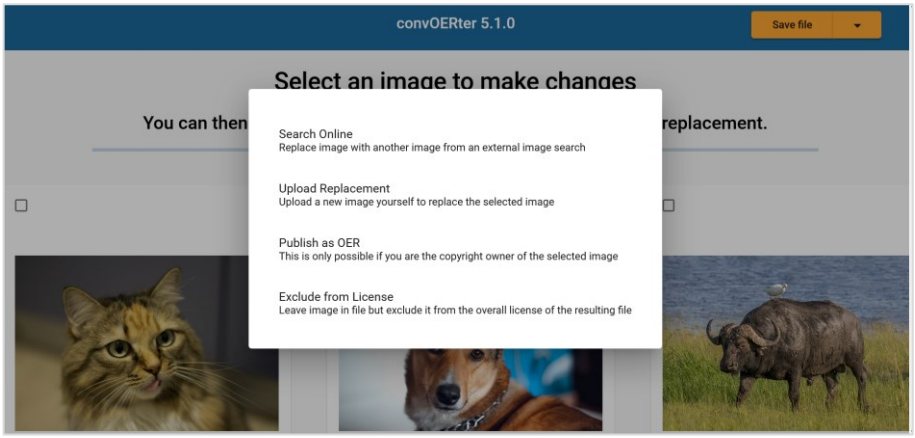

Figure 13: Screenshot of different options to replace an image

As can be seen, the four options offer different possibilities to replace the selected images as follows:

- Search Online
  This option allows users to search for a replacement image online. The text field can be used to enter the search query. Based on it, the tool automatically searches for alternative images whose licences are compatible. Optionally, clicking on the magic wizard on the right side of the text field generates automated a search term suggestion based on the image. Figure 14 shows the “Search Online” option.

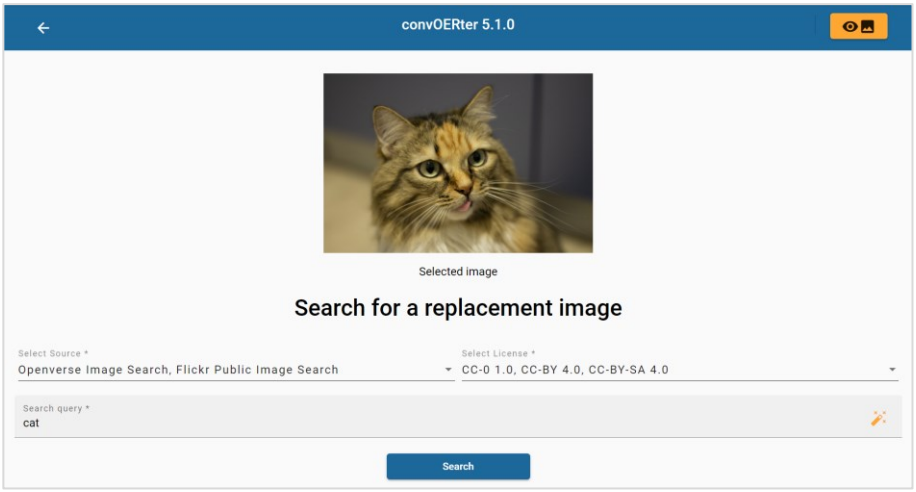

Figure 14: A Screenshot of the "Search Online" option

- Upload Replacement
  This option allows the users to easily utilize their own images or manually search for an alternative image, download it, and then choose it as a replacement. In both cases, the users have to enter information about the image (e.g. the author's name). After that, the image can be replaced. The image can be cropped to fit the original image dimensions. Figure 15 shows a screenshot for the "Upload Replacement" option.

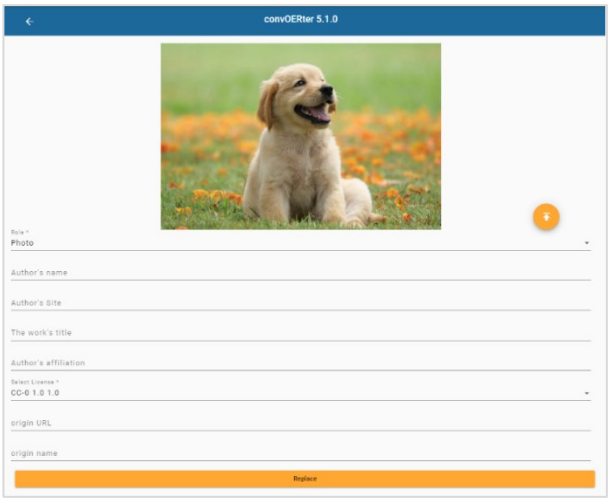

Figure 15: Screenshot of the "Upload Replacement" option

- Publish as OER
  Users can use this option if they want to retain the original image in the document. However, the image, in this case, must already have a compatible licence (CC), or the user must be the copyright holder of this image. Accordingly, the user has to provide the missing information, which will be included in the final file. Figure 16 displays a screenshot of the "Publish as OER" option.

Figure 16: Screenshot of the „Publish as OER „option

- Exclude from Licence
  In this case, the image remains in the document, however it is excluded from the licence. The user can enter a description or give a name for the image, which will be used at the end of the document when excluding the image from the overall licence. This option can be chosen if the selected image cannot be published under a compatible licence and must be excluded from the CC licence of the file (e.g. company logos). Figure 17 shows a screenshot of the “Exclude from Licence” option.

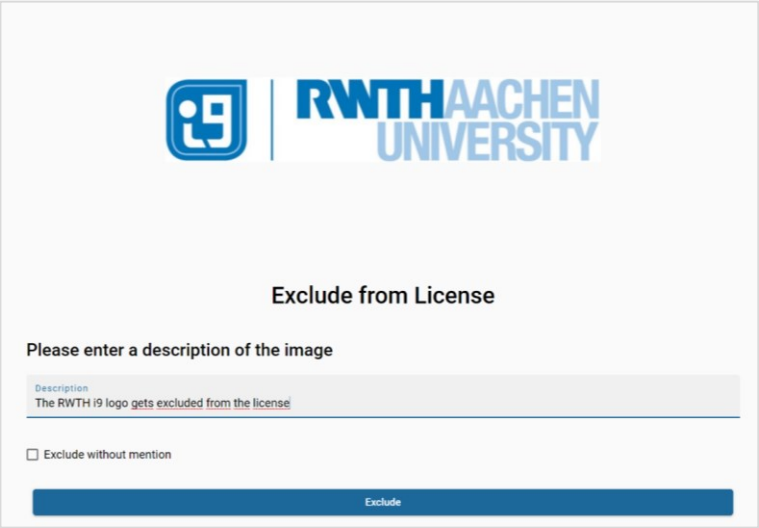

Figure 17: Screenshot of the „Exclude from Licence "option

3. **Adding references to license images**
   Each newly added image receives automatically a reference number in a small bracket, which will be used to license the image according to TASLL rule (see Appendix K). The reference numbers for all images will be added at the end in a separate slide in case of presentation files or in an extra page in case of word processing documents. Figure 18 shows an example of an automatically added slide or page.

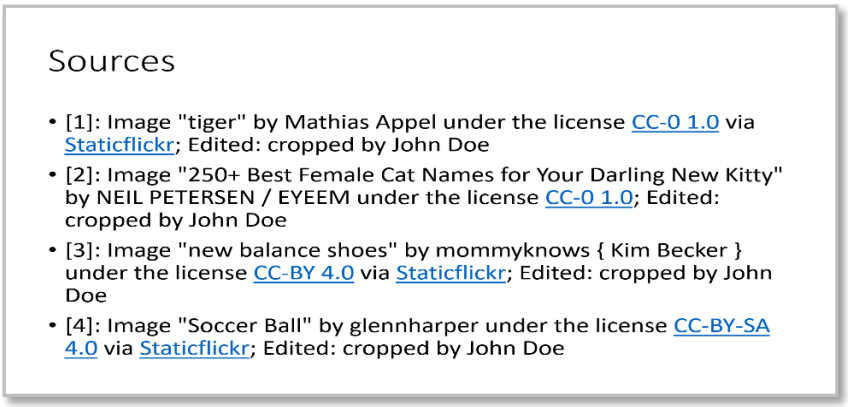

Figure 18: An example of an added slide for a PowerPoint file to license the images

4. **Licence the whole document**
   Based on the auto-added references of the images and the target licence chosen by the user at the beginning, the whole document will be licenced automatically under CC excluding special-case images such as logos, if they exist. Figure 19 shows an example of licensing a PowerPoint under CC. The modified document can be then saved and downloaded by the user.

Figure 19: An Example of licensing the whole document under CC licence

In addition to the aforementioned functionalities, the tool offers further functions such as editing the image by cropping or rotating it, activating image recognition feature to facilitate searching for images, in addition to the possibility of sharing feedback via the integrated feedback form. The tool can be inspected und utilized directly via this link: https://convoerter-eval.elearn.rwth-aachen.de/en/.

6.3. Tool Implementation

The convOERter tool was developed using a comprehensive technology stack comprising three main components - the frontend, the backend, and the MongoDB database[40]. The entire tool stack has been efficiently containerized and deployed using Docker[41]. The project development process was managed using the GitLab instance[42] of RWTH Aachen University, which leverages Git's[43] version management features, including an issue tracker, hosting web space, and a container registry[44]. GitLab's continuous integration tools were critical in automating responses to repository changes, resulting in auto-regeneration of frontend and backend documentation whenever changes were pushed to the master branch. Figure 20 shows the architecture overview of the tool, which will be illustrated briefly in the following. The detailed structure of the technical implementation can be found in the Git Repository[45].

[40] https://www.mongodb.com, accessed 25.05.2023
[41] https://www.docker.com/, accessed 25.05.2023
[42] https://git.rwth-aachen.de/users/sign_in, accessed 25.05.2023
[43] https://git-scm.com/, accessed 25.05.2023
[44] https://docs.gitlab.com/ee/user/packages/container_registry/index.html, accessed 25.05.2023
[45] https://git.rwth-aachen.de/oer-converter, accessed 25.05.2023

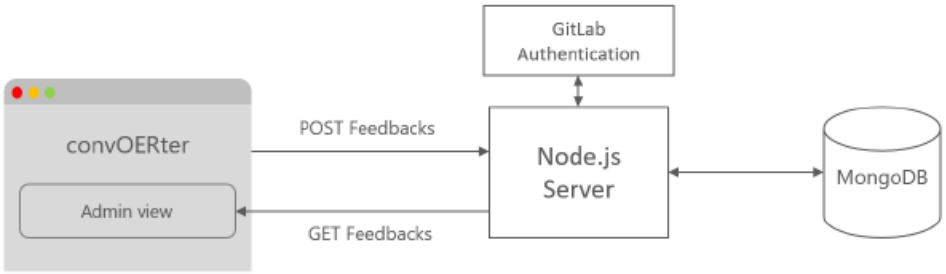

Figure 20: The architecture overview of convOERter

FRONTEND

The frontend utilizes Angular Framework[46] and Angular CLI[47] version 13.0.1, employing Angular material for design. The server environment for both frontend and backend is Node.js[48] version 16.13.1. The codebase is developed in TypeScript, providing additional constructs like classes and typing. To make it compatible with browsers, TypeScript is transpiled back to JavaScript by Angular CLI.

BACKEND

The backend is a Node.js application, which employs the Express Framework[49] to expose a REST API. It combines routes and HTTP methods, receiving request bodies, and sending responses. Mongoose[50] aids in database communication. Cross-Origin Resource Sharing (CORS) is managed via middleware cors, securing client-server communication. Furthermore, logs are stored in a Learning Record Store (LRS) using Learning Locker.

MONGODB

The database utilizes MongoDB[51], a source-available cross-platform, document-oriented database program, compatible with the MEAN Stack[52]. Mongoose, an ODM library for MongoDB, is used for data schema creation and user feedback storage.

DOCKER

Docker[53] manages the tool's deployment, developing lightweight virtualized environments called containers[54]. The frontend, backend, and the database are individually containerized via Dockerfile and composed together using docker-compose.yml. This approach encapsulates the parts, enabling inter-communication through authorized ports. convOERter leverages advanced technologies and

[46] https://angular.io/, accessed 25.05.2023
[47] https://angular.io/cli, accessed 25.05.2023
[48] https://nodejs.org/en, accessed 25.05.2023
[49] https://expressjs.com/, accessed 25.05.2023
[50] https://mongoosejs.com/, accessed 25.05.2023
[51] https://www.mongodb.com/pt-br, accessed 25.05.2023
[52] https://en.wikipedia.org/wiki/MEAN_(solution_stack), accessed 25.05.2023
[53] https://www.docker.com/, accessed 25.05.2023
[54] https://www.docker.com/resources/what-container/, accessed 25.05.2023

frameworks and employs the best development and deployment practices for maximum efficiency and user satisfaction.

6.4. Beta Test

The tool has been implemented and developed incrementally. The first version of the tool was developed within the bachelor thesis of Patrick Aufdermauer (Aufdermauer et al., 2020). After developing and deploying the beta version of the tool in 2020, the tool has been tested in different OER workshops and sessions. Some of the workshops have been held internally at RWTH Aachen University and others have been offered at national and international universities. In total, nine workshops have been conducted with 43 OER-interested participants in the period from October 2020 - March 2022 to test the beta version of the tool.

In order to examine the tool functionality and to collect feedback from the participants within this beta test study, a questionnaire has been prepared to collect participants' feedback about the preliminary functionality of the tool. Depending on participants' feedback and different test iterations accomplished at the Learning Technologies Research Group of RWTH Aachen University, the tool has been further developed and its functionalities have been enhanced. The feedback and the results gathered until the International OER conference "OPENINGLEARNINGDAYS.CH" held online on 6th, March 2021 in Lucerne in Switzerland ("zArchiv," n.d.) have been published in (Ali and Schroeder, 2021).

In the following two sections, an overview will be presented about the pilot study conducted in different OER workshops and the feedback gathered from the participants regarding its functionality.

6.4.1. Beta Test Setup

As mentioned above, the pilot study was conducted in the context of various OER workshops and sessions held at RWTH Aachen University and internationally. The idea was to test the prototype and collect feedback regarding the concept of semi-automatic conversion and the preliminary functionalities of the tool. Due to COVID-19 pandemic[55], all sessions and workshops were held online via the videoconferencing platform (Zoom)[56]. Table 4 shows an overview about the conducted workshops.

[55] https://www.who.int/europe/emergencies/situations/covid-19, accessed 16.06.2023
[56] https://zoom.us/, accessed 16.06.2023

Table 4: An overview about OER workshops held in the frame of the pilot study

Date	Workshop
20.10.2020	HOOU Workshop
16.02.2021	HOOU Workshop 2
04.03.2021	ExAcT Workshop
06.03.2021	OER Conference 2021
01.06.2021	ExAcT Workshop 2
29.09.2021	OER-Camp 2021
26.11.2021	Aachen Didactics Day
06.12.2021	OER Seminar RWTH
14.03.2022	Open Education Week

Within these workshops, the concept of OER was introduced with a focus on the OER cycle, motivation, challenges, and the design concept of the OER conversion tool. The participants received the link to the beta version of the tool through the Zoom chat function and were asked to test this version and fill out a survey. The survey consisted of demographical questions about the participants and their background in OER in addition to questions regarding the tool and its functionality.

The participants were optionally requested to provide their feedback on the beta version of the tool and suggestions for potential enhancements and further developments. The survey questions are listed in Appendix C. For testing purposes, the participants have been provided with a dummy file created previously and shared with the participants using the share file function of the Zoom platform. Figure 21 shows a screenshot of the slide presented during the workshops, which contained information about the practical session.

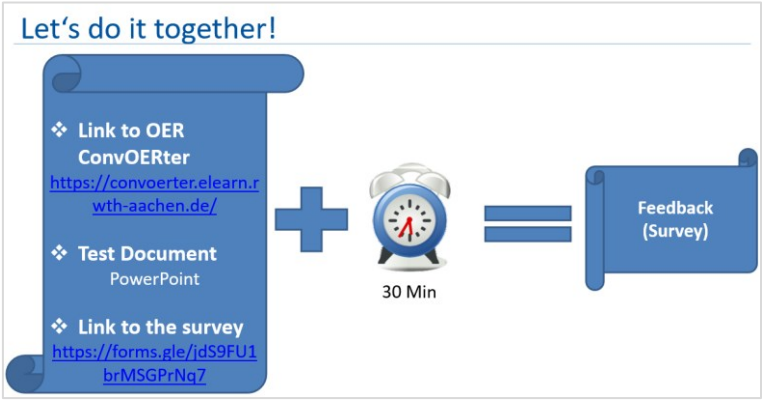

Figure 21: Screenshot of the practical session slide

6.4.2. Results and Feedback

The collected results and feedback from the participants have been analysed using Excel 2016. As can be shown in Figure 22, the participants came from different areas of specialization, where the major percent of the participants was from the field of science and computer science.

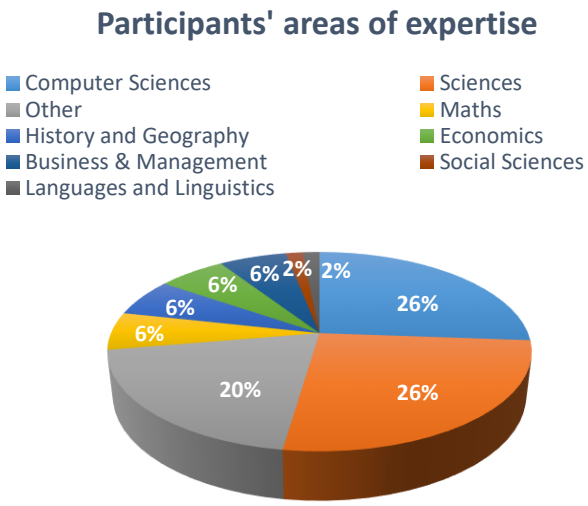

Figure 22: Areas of specializations of participants participated in testing the Beta version of convOERter

Most of the participants were interested in OER, but they don't create their own OER documents. This can be indicated from Figures 23 and 24 respectively, where more than 50% use OER for teaching purposes and approximately the same percentage have never created OER.

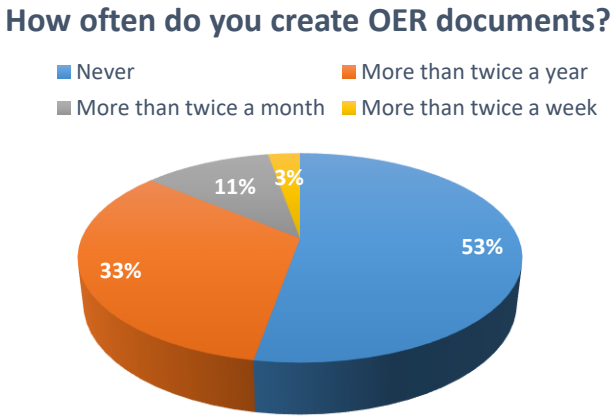

Figure 23: How often do Beta test participants create OER

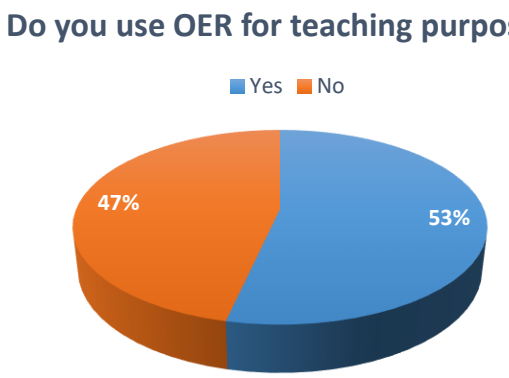

Figure 24: Participants' percentage using OER for teaching purposes

The participants have been asked to cross out some of the problems facing them when converting documents into OER. When considering finding appropriate images and licensing the documents together, half of the participants reported that they have faced difficulties. 40% of the participants stated that they haven't converted their materials into OER before and 10% specified they have encountered other problems. Participants' responses to this question can be seen in Figure 25.

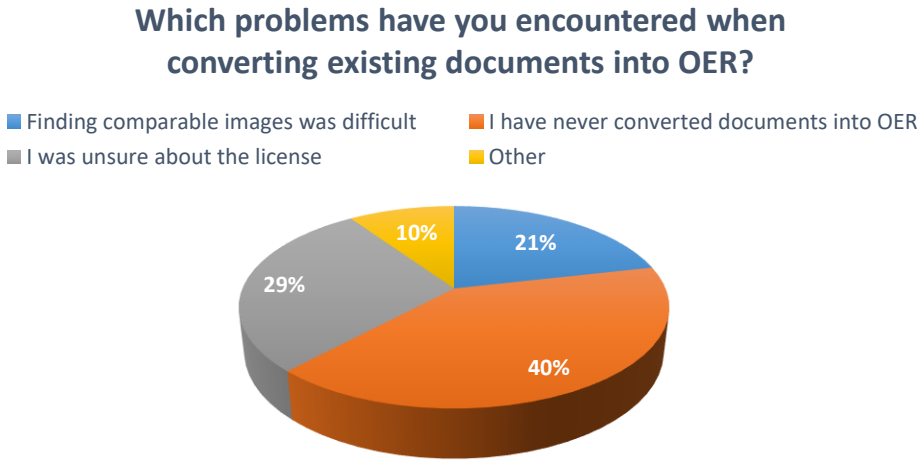

Figure 25: Problems faced participants by converting existing materials into OER

In order to collect participants' feedback about the tool's concept and preliminary functionalities, they were asked to answer a number of questions regarding the design of the tool and the Graphical User Interface (GUI) and to provide their suggestions and comments for further enhancements and future developments. Figure 26 and Figure 27 display participants' responses regarding using the tool and the interface of the tool respectively. 53% of the participants reported that they easily used the tool (very easy and easy in Figure 26) and more than 90% stated that the tool's interface is user friendly.

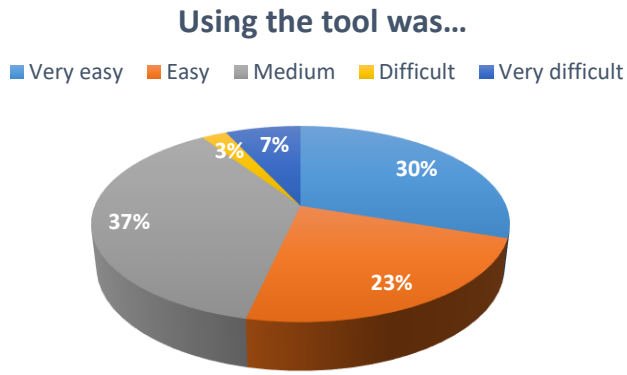

Figure 26: Participants' feedback regarding using the tool

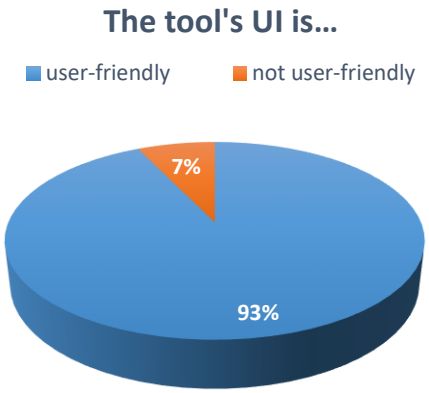

Figure 27: Participants' feedback regarding the tool's interface

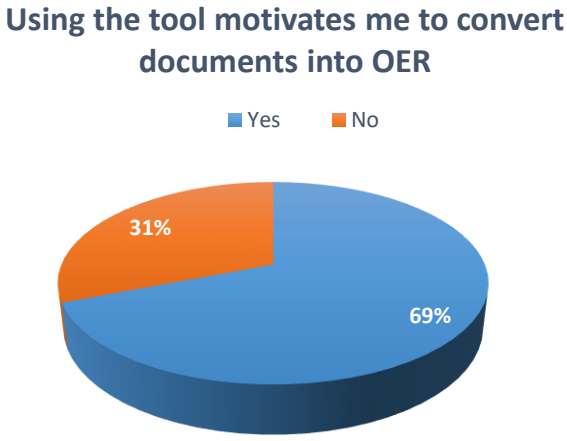

Figure 28: Participants' responses if the tool would motivate converting documents into OER

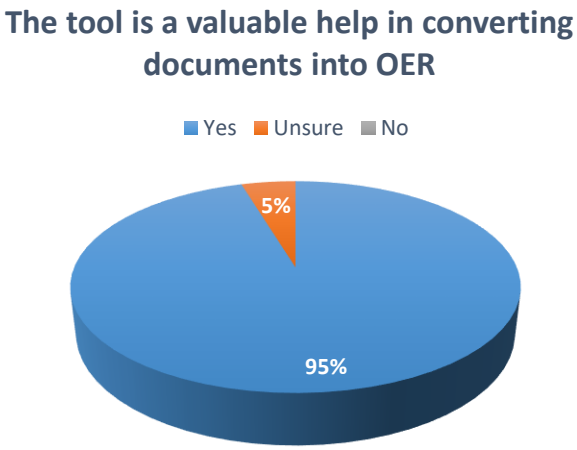

Figure 29: Participants' responses if convOERter would be a valuable tool in converting documents into OER

The tool's idea and the concept of converting existing educational materials into OER were welcomed from most of OER interested people attended the workshops. This can be seen in Figures 28 and 29 respectively, as about 70% of the participants reported that using the tool motivated them to produce more OER and 95% stated that the tool would be an asset in converting existing materials into OER.

However, since the tested version was the first prototype, participants were asked to share their suggestions and feedback or report problems they encountered while using the beta version of the tool. The feedback collected was mainly related to the problem of not being able to find suitable image replacements due to the limited number of portals integrated into the tool, and the difficulty of finding topic-related CC images, such as images of specific cells or images of tiny microcontrollers. Another frequently cited issue is lack of supporting other file types such as Open Formats and PDF documents, as the prototype could only handle PowerPoint and Microsoft Word files. Other problems concerned crashes when searching OER portals or not being able to find a suitable image. Further feedback addressed minor issues, such as restructuring some sentences on the user interface to make them more readable.

In addition, good suggestions and ideas were highlighted by users, such as: replacing an image that occurs multiple times in the file once instead of repeating the search for the same image. Another useful suggestion was to distinguish between CC images and non-OER images when opening the file, so that there is no need to search OER portals for replacements when the image is already CC-licensed. Other comments included adding help tips or links for non-expert users to assist them in using the tool, such as links to CC licences. Some screenshots of the beta version of the tool can be found in Appendix I.

At the end of the workshops, participants were asked to provide further suggestions or report any problems they encountered in using the tool to convert real educational

materials. The results and feedback from the workshops, as well as the discussion with interested participants about the concept of the technical support at various events such as conferences and OER camps, helped us to further develop the tool, improve its functionality, and structure the evaluation workshops (see Chapter 8). Further insights into the practical use of the tool for converting educational materials are presented in the following chapter.

Chapter 7. convOERter in Practice

This chapter presents the practical application of convOERter. In section 7.1, the process of converting real educational materials manually and semi-automatically using convOERter is introduced. Then, the time efficiency of both conversion processes are presented. In section 7.2, an evaluation system for tracking the real usage of convOERter will be demonstrated.

7.1. Manual vs. Automatic

The first practical usage of the tool was to convert the slides of a programming lecture into OER. The lecture “Programming for All - Java (Progra)” consisted of fourteen PowerPoint presentations and was offered as an introductory programming course for non-computer science students until the winter semester 2020/2021. The slides contained a variety of images that were not OER. In order to convert them into OER and analyse the time efficiency of the semi-automatic conversion, the slides were converted once manually and then with the most recently deployed version of convOERter (version 5.1.0). More details about the conversion process are presented in the following subsections.

7.1.1. Case Study Setting and Design

The first test performed to measure the efficiency of the tool is the conversion of "Progra" lecture slides into OER after the same slides were converted manually. The slides were assigned to two student assistants who work on OER projects and have good experience in OER. The first student manually converted the slides by searching various OER image portals for suitable image alternatives, manually licensing each image, and then licensing the entire presentation under a Creative Commons licence according to the TASLL rule. The second student used the latest version of the tool[57] to semi-automatically convert the same slides. The manual conversion took place during the winter semester 2019/2020 and summer semester 2020, while the semi-automatic conversion using the tool took place during the winter semester 2022/2023. The device settings used by the two students during the conversion process are shown in the following table.

Table 5: Device settings used for manual and automatic conversion

	Manual Conversion	**convOERter**
Device	MacBook Pro	Lenovo Thinkpad 720
Processor	2,5 GHz Quad-Core Intel Core i7	1.8 GHz Quad-Core Intel Core i5-8250U
RAM	16 GB	8 GB
System Type	64-bit Operating System	64-bit Operating System

[57] https://convoerter-eval.elearn.rwth-aachen.de/en/, accessed 20.07.2023

7.1.2. Results and Discussions

The time required to convert each set of the slides in minutes was registered as shown in Table 6 and the average time for converting all the slides was calculated. The following diagram illustrates the approximate time graphically.

Table 6: A comparison between the time invested in converting Progra slides manually vs. using convOERter (in minutes)

Slide Set	Manual Time [min]	convOERter Time [min]
1	406.4	53
2	301.4	41
3	264.4	33
4	154.4	22
5	118.4	31
6	215.4	26
7	204.4	19
8	255.4	14
9	211.4	27
10	133.4	7
11	153.4	18
12	110.4	17
13	220.4	14
14	98.4	30
Average	**203.40**	**25.14**

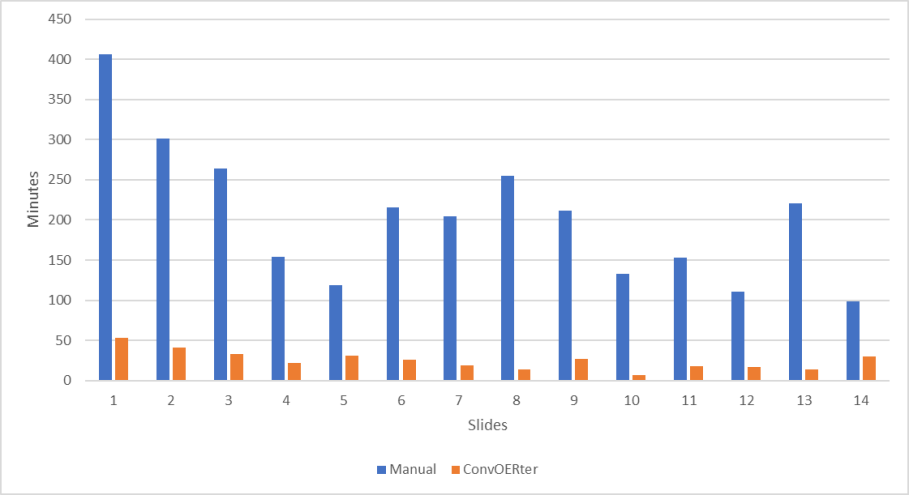

Figure 30: A graphical comparison of converting Progra slides manually and using convOERter

As can be seen from the Table and the corresponding graph, there is a great improvement when using the tool to convert the slide sets. The calculation of the relative

improvement shows that convOERter accelerated the conversion process by about eight times compared to manual conversion. Figures 31 shows an example of a manually converted slide of one of Progra's slide sets, while Figures 32 and Figure 33 show the same slide converted using convOERter and the corresponding slide, which has been automatically added to license the images.

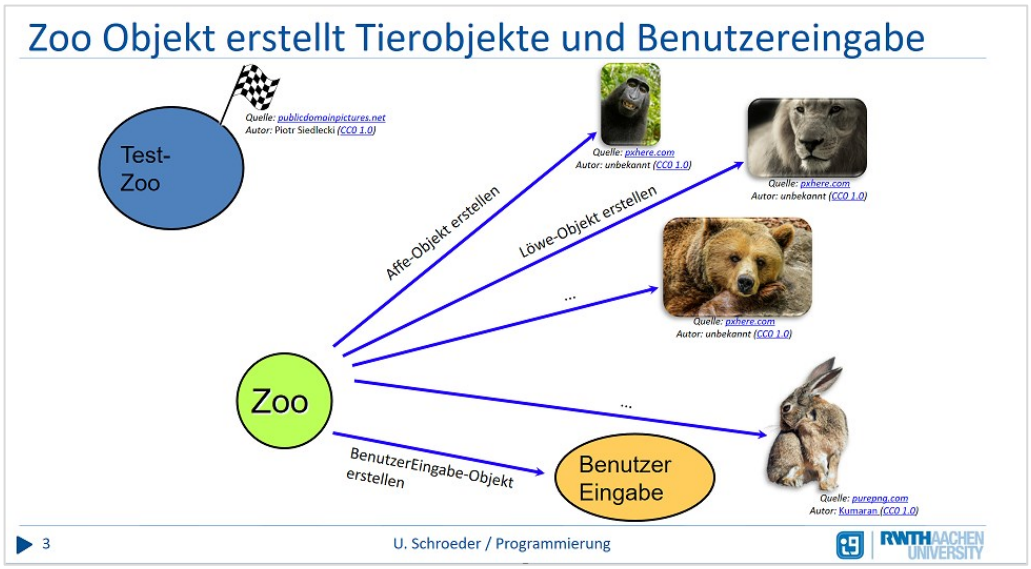

Figure 31: Screenshot of a slide converted manually into OER

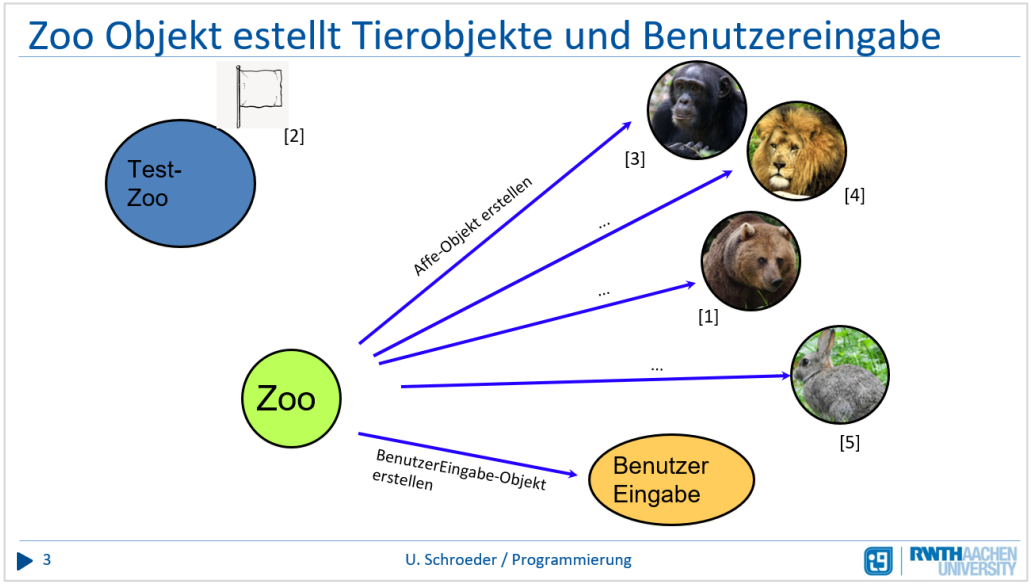

Figure 32: Screenshot of a slide converted into OER using convOERter

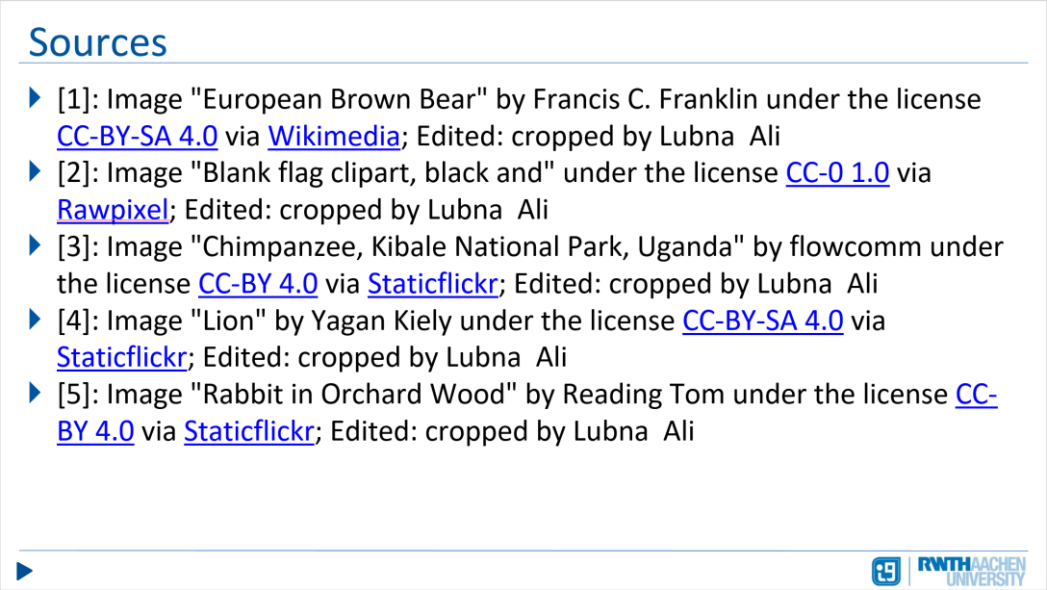

Figure 33: Screenshot of an automatically added slide by convOERter to display the licences of converted images

7.2. Technical Evaluation System

In order to determine the effectiveness of convOERter and to track the user interaction logs, an evaluation system was developed and integrated into the tool. The system was developed as part of the master thesis of Deekshith Shetty (Shetty, 2022). The system consists of several modules. These modules are presented in the following subsections along with the results of a usability study conducted with a small group of participants in 2022. The evaluation system has been integrated into the latest version of the tool (5.1.0) and made available at this link: https://convoerter-eval.elearn.rwth-aachen.de/en/.

7.2.1. System Design and Setup

The goal of developing and implementing an evaluation system for convOERter is to determine the effectiveness of convOERter and understand how the tool is being used. This information will help administrators to improve the functionality of the tool and develop it in the future. The system was designed and built based on an independent infrastructure for a modular, scalable, and secure cross-learning analytics platform (EXCALIBUR LA) (Judel and Schroeder, 2022). Understanding user interactions requires identifying logs, performing various types of analysis on those logs, and displaying analysis results on a dashboard. Accordingly, the system was designed to include three modules: A logging module, analysis engines, and a dashboard. These modules are shown in Figure 34 (Ali et al., 2023), which illustrates the architecture of the evaluation system.

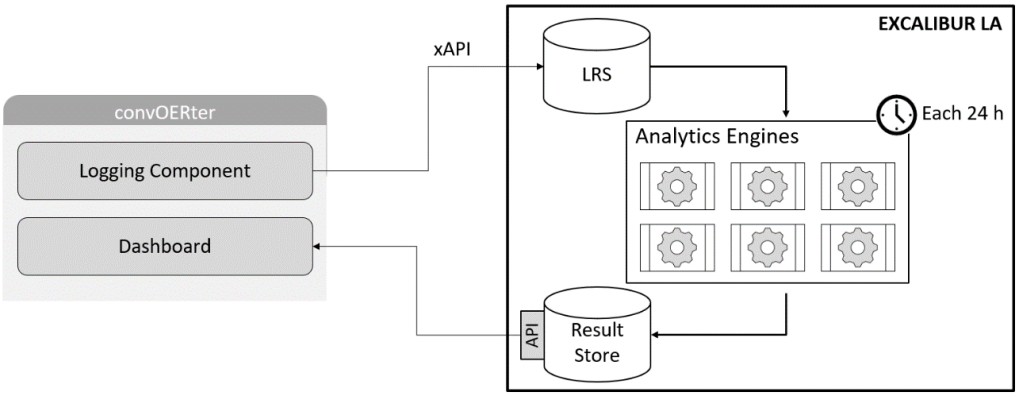

Figure 34: Evaluation System Architecture

7.2.2. System Components

In the following, the three components of the system shown in Figure 34 are introduced.

LOGGING MODULE

The Logging Module was implemented within convOERter as a separate component using Angular. It provides an interface for monitoring user actions and can be invoked at various points where user interactions occur, such as clicking on a button. The function creates logs using xAPI statements ("Experience API," n.d.). These xAPI statements are then stored asynchronously in a Learning Record Store (LRS). Other actions that are stored are shown in the following table along with their vocabularies (Shetty, 2022).

Table 7: Vocabulary of user interaction events that are identified to be logged

User Interaction	Event Vocabulary
User loads the convOERter web application	OER_CONVERSION_PROCESS_STARTED
User clicks on the save button to export the OER converted file	OER_CONVERSION_PROCESS_FINISHED
User clicks the start button to start the OER conversion process	FIRST_STEPS_DIALOG_STARTED
User finishes answering the initial questions	FIRST_STEPS_DIALOG_FINISHED
User uploads a file	FILE_IMPORTED
User enters their name	USERNAME_ENTERED
User selects a licence for the resulting OER	TARGET_LICENCE_SELECTED
User enters their legal disclaimer text	LEGAL_DISCLAIMER_ENTERED
User selects an image to make changes	IMAGE_SELECTED

User Interaction	Event Vocabulary
User edits the image before replacing (crop/rotate)	IMAGE_EDITED
User replaces the image	IMAGE_REPLACED
User clicks on auto-query option while searching for external image to replace	EXTERNAL_IMAGE_AUTO_QUERIED
User performs an external search for replacement	EXTERNAL_IMAGE_SEARCHED
User get the images retrieved from OER portals	EXTERNAL_IMAGE_FETCHED
User reverts the replacement action	REPLACED_IMAGE_UNDID
User submits their feedback on the tool	FEEDBACK_SUBMITTED

ANALYTICS ENGINES

The Analysis Engines are responsible for transforming the collected logs into useful outputs for gaining insights. This includes a pipeline for data cleaning, pre-processing, conversion and analysis. These results can be used to perform various analyses and determine different metrics, e.g.:

- Audience Growth: Number of new requests or geographic locations.
- Time Analysis: The average session length or average time spent on performing a specific task.
- User Activity: Frequent user interactions or types of user experience flows.

This includes both positive and negative experiences about how users continued to flow through the content. The following examples illustrate both cases (Shetty, 2022):

- Positive Flows:
  - The user replaced the non-OER images with the suggestions retrieved from the external API search and then clicked the "Save" button. This may imply that the user was satisfied with the process and functionality of the tool.
  - The user adopted the suggested search item from the external search auto query. This may indicate that the user was satisfied with the auto query functionality of the tool.

- Negative Flows:
  - The user cleared the suggested auto search query field and entered own search item. This may indicate that the user wasn't satisfied with the tool suggestion.
  - The user used the external API search to find OER images, but clicked back and selected other replacement options. This could indicate that the user was not satisfied with the images retrieved from the OER portals.

The transformed data is stored in a LRS along with the derived analytics. The engine container, which consists of a set of defined analytics engines, is responsible for filtering the statements from the LRS, performing analysis, and finally returning the results to the Result Store (Shetty, 2022).

DASHBOARD

Once the raw logs are converted and loaded into the Results Store, they can be used for further analysis operations, such as generating reports or creating visualizations on a dashboard. The dashboard allows system administrators to directly view the transformed data as well as the derived analytics. The analysis results can then be represented in tables or charts.

As part of the evaluation process, the system administrators were interested in gaining insights into the usage of convOERter, such as: origin of geographic access, frequent use of external search, and the types of files and images processed. Accordingly, the data was visualized using different chart types, such as: choropleth charts, bar charts, line charts, and directed charts. Figure 35 shows some of the visualization charts used within the evaluation system (Shetty, 2022).

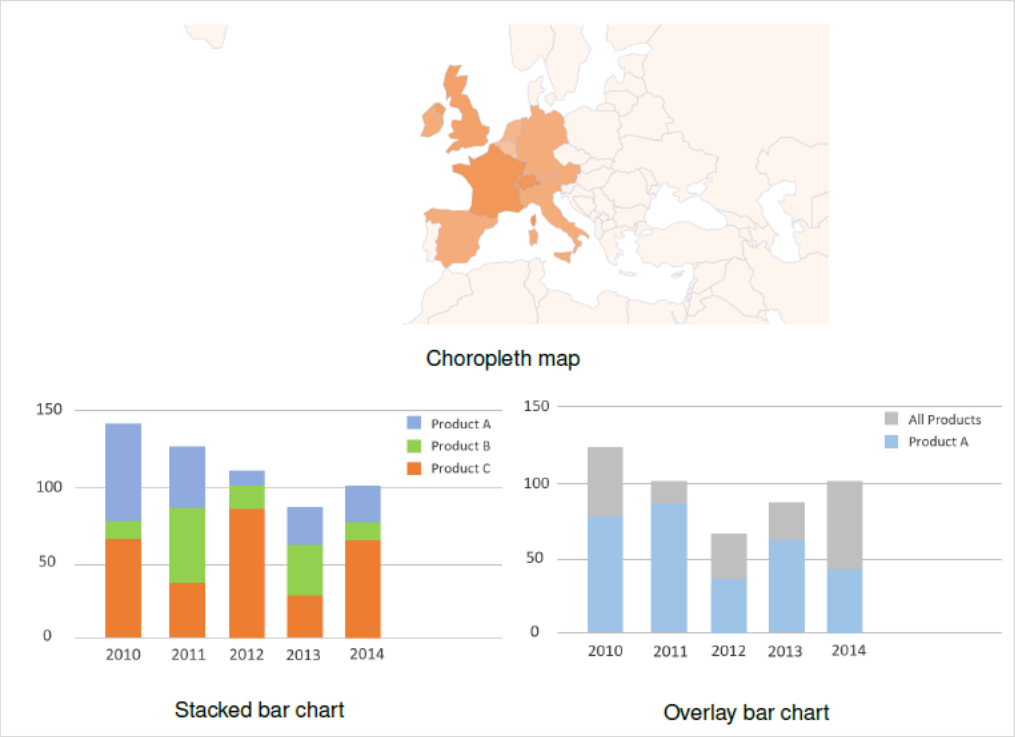

Figure 35: An example of visualization charts used within the evaluation system

7.2.3. Evaluation System in Practice

After integrating the Evaluation System within convOERter and deploying it, the OER community was informed via an article published on the central OERinfo-Portal[58] blog in Germany[59] and distributed on different social media platforms. The dashboard panel, which consists of users, tasks and feedbacks tabs, was observed over different time periods. This helped system administrators to trace the usage of convOERter and to examine various parameters such as: geographic traffic (where the tool is used), sessions frequency (how often the tool is used), and number of save clicks (how many files are saved). System administrators can choose to display results on a weekly or monthly basis. Figure 36 shows a screenshot of the dashboard panel illustrating the three tabs and the outputs of the Users tab in the period from Aug, 2022-Aug, 2023.

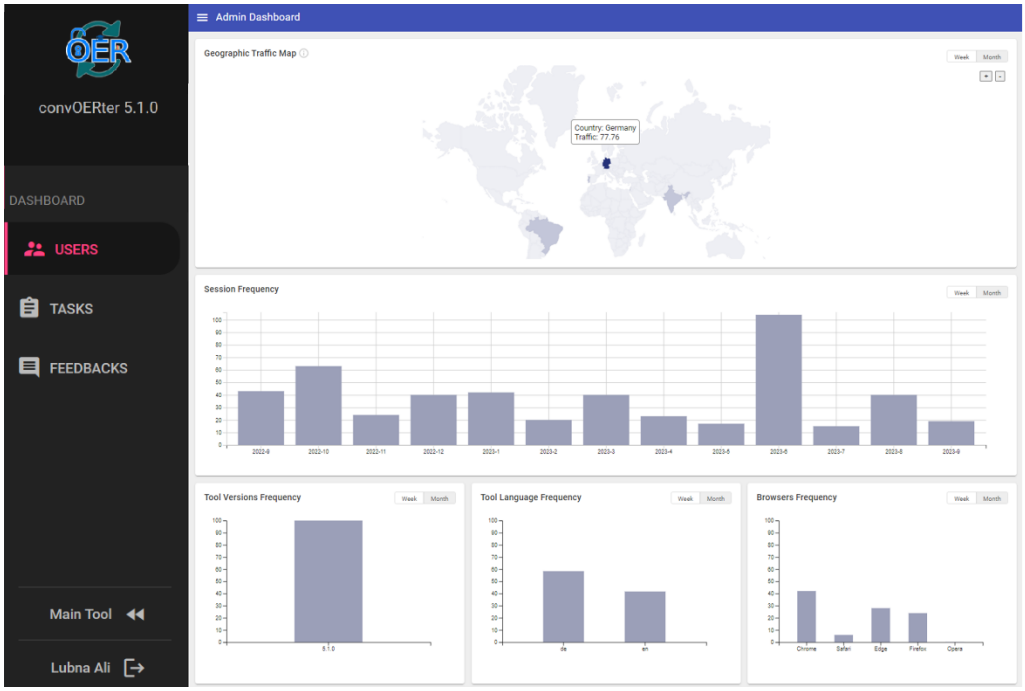

Figure 36: Screenshot of the Users tab of convOERter evaluation system

As can be seen from the Figure above, convOERter has been used in the period from Aug, 2022 to Aug, 2023 in different countries such as Germany, India, Brazil and Portugal. The Figure also shows further outputs such as the frequent usage of the tool (Session Frequency), the last version used (Tool Version Frequency), the interface chosen language (Tool Language Frequency), and the frequent usage of specific browser (Browsers Frequency). Figure 37 shows a screenshot of the Tasks tab of the dashboard.

[58] https://open-educational-resources.de/, accessed 27.07.2023
[59] https://open-educational-resources.de/der-convoerter-lehr-und-lernmaterialien-in-oer-umwandeln/, accessed 27.07.2023

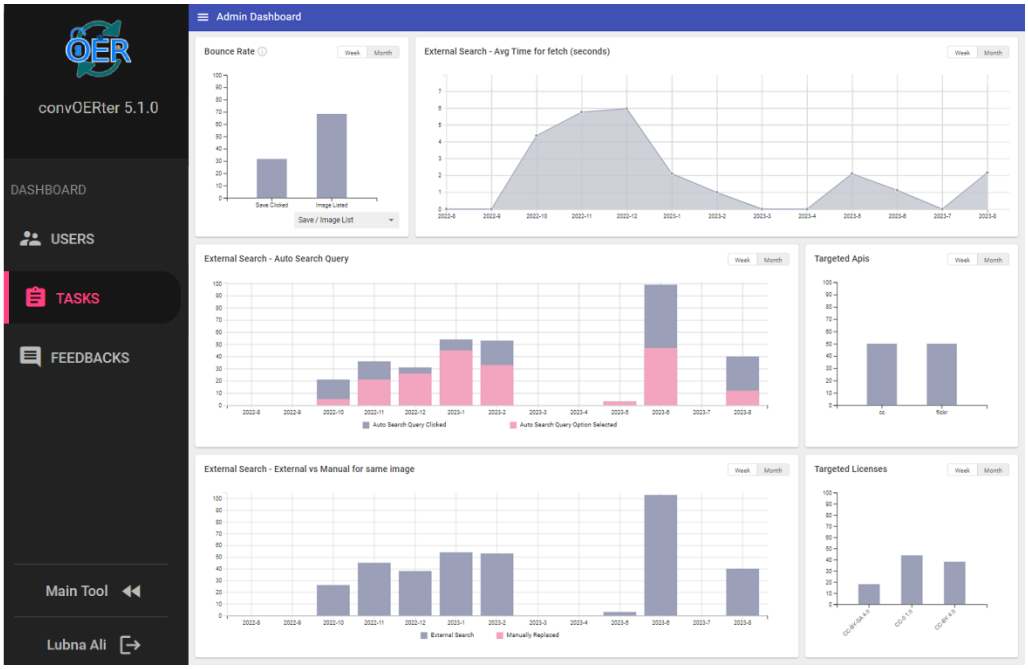

Figure 37: Screenshot of the Tasks tab of convOERter evaluation system

As can be noticed from the Figure above, other parameters are displayed within this tab such as:

- Bounce rate: Indicates the distribution of visitors who leave the tool after performing the chosen action.
- External Search-Avg. Time for Fetch: Indicates the average time in second for fetching images for a specific period
- External Search-Auto Search Query: Indicates the number of clicking the auto search query option compared to selecting the auto search query option suggested by the tool.
- External Search-External vs Manual for same image: Indicates the number of chosen images from the external portal compared to manually uploaded images (i.e. from one's device).
- Targeted APIs: Indicates the type of chosen image portal.
- Targeted Licences: Indicates the type of chosen licences.

Further outputs that can be displayed in the Tasks tab is the task model graph. The graph visualizes the flows introduced previously in section 7.2.2 and enables the administrators to trace a specific session visually. Accordingly, users actions can be determined and potential problems can be identified. Figure 38 shows an example of a task model graph along with the legends.

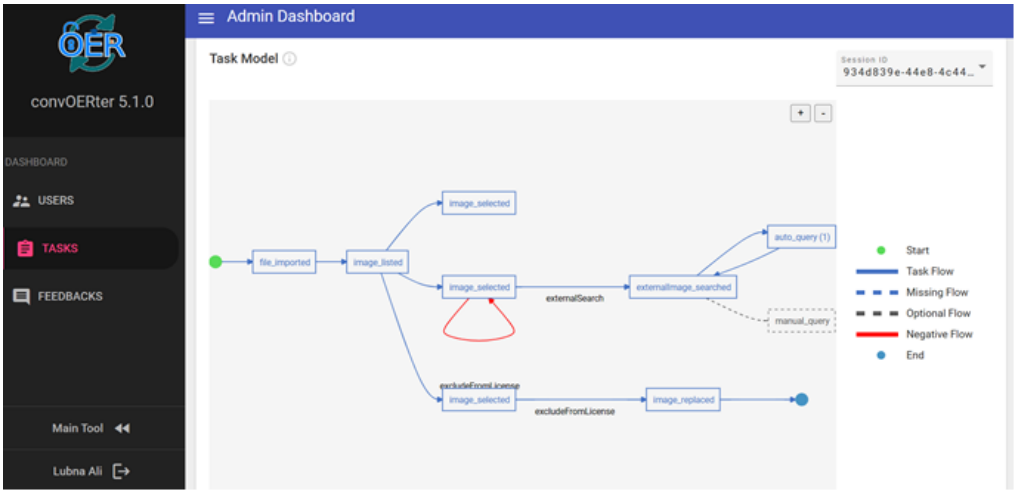

Figure 38: Screenshot of a task model graph for a specific session id

The third tab within the dashboard is the Feedbacks tab. In this tab, optional users' feedback and comments to the feedback form integrated within convOERter are displayed. Figure 39 shows a screenshot of the feedback form within convOERter and Figure 40 shows a screenshot of users' comments and answers to some of the questions in the feedback form.

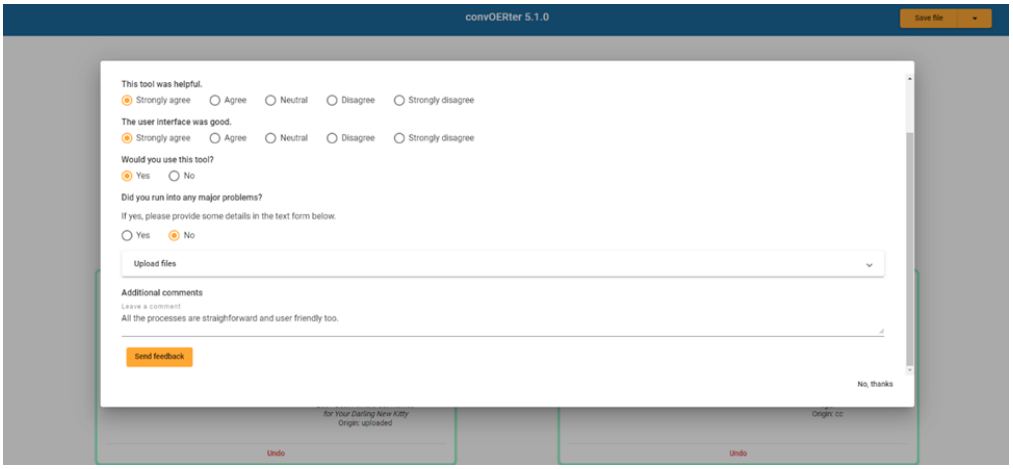

Figure 39: Screenshot of the feedback form integrated within convOERter

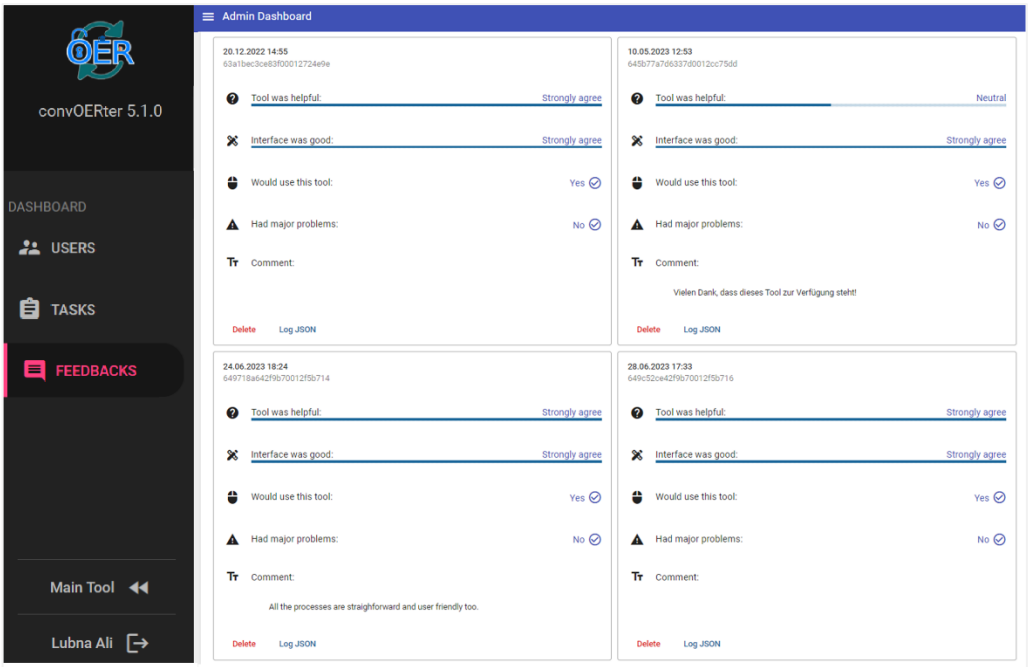

Figure 40: Screenshot of the Feedbacks tab of convOERter evaluation system

As mentioned earlier, user responses to the feedback form, as well as visualizations on the "Users" and "Tasks" tabs, provide insight into how the tool is being used, which can help identify issues users face when using the tool and guide convOERter administrators in finding appropriate solutions.

To assess the convOERter evaluation system and to identify potential issues, a user study was conducted with a group of volunteer educators at different universities (Shetty, 2022). The educators were selected from the OER community and contacted based on their good background in OER. Five responded positively and were willing to participate in the study. Accordingly, a one-hour Zoom session was arranged with each of them to introduce them to the evaluation system and the idea behind its development, give them the opportunity to explore it, and provide their feedback regarding its functionality and usability. The collected feedback and answers of the participants were analysed. Apart from a few suggestions that could be considered for further development, the overall attitude of the participants towards the tool and the integrated evaluation system was positive. Further information regarding the evaluation system, its design and its implementation can be found in the master thesis of Deekshith Shetty (Shetty, 2022).

Chapter 8. Evaluation

This chapter introduces an evaluation study performed to assess the effectiveness of convOERter as well as the quantitative and qualitative results of the conducted study. In section 8.1, the study setup and design is presented, followed by the evaluation method adopted to accomplish the study. The quantitative and qualitative results of the study are introduced in sections 8.3 and 8.4 respectively. Finally, the results and the limitations of the study are discussed.

8.1. Study Setup

In order to evaluate the functionality of convOERter and to answer the research questions introduced in section 1.3, a comprehensive user study was conducted with participants from different universities (Ali et al., 2024). The study is based on designing and offering a series of OER workshops to test the tool and compare its functionality with the traditional manual conversion process in terms of speed, quality of the generated licences, and the total efficiency. Accordingly, the participants were asked to convert two files into OER once manually and once using convOERter and upload them to a shared-cloud storage. Additionally, the participants were asked to fill out an anonymous survey to collect their responses regarding the manual and semi-automatic conversion in addition to collect information about their pre-experience in OER. The uploaded files and the survey responses were analysed to answer the research questions.

The workshop-based user study was conducted with 91 educators and OER-interested people from different universities in the period between the end of May 2022 and the end of November 2022. Two quantitative measures were mainly taken into consideration for the comparison process: the processing time of an image and the licence quality of the converted materials (images and files). Based on these two measures in addition to the number of converted images, the total efficiency of the conversion process was calculated. Taking the potential bias and the possible learning effects into account, the workshops were designed and offered in two different formats. The detailed design and structure of the evaluation workshops will be presented in the following subsections.

The workshops have been structured to contain theoretical as well as practical sessions. Within the theoretical sessions, the basics of OER have been introduced such as: definition of OER, the motivation and challenges of applying OER, the OER Cycle, Creative Commons licences, and licensing the materials correctly according to the TASLL rule (see Appendix K). The theoretical sessions also included an introduction to convOERter tool and an illustration of its functionality. In the practical sessions, the participants have applied what they have learnt during the theoretical sessions to convert a file into OER once manually by applying the TASLL rule and once using convOERter. The details of this process will be explained in the following subsections.

The target audience were universities educators including professors, lecturers, and researchers as well as teaching assistants (usually PhD students). Due to keen interest in the workshops, some other universities' members interested in OER have attended the workshops as well. The workshops have been conducted in English and German to accommodate the participants at different institutions. Due to the COVID-19 pandemic, most of the workshops have been conducted remotely using video conferencing platforms (Zoom[60] and Webex[61]).

For recruiting, the announcement and the invitation to the workshops have been distributed via different communication channels such as: Higher Education Institutions (HEI) qualification programs, (e.g. Excellent Academic Teaching (ExAcT) of RWTH Aachen University), staff mailing lists, contacting colleagues and professors at other universities, (inter-) national projects and portals as well as academic conferences. In total, 14 workshops were planned, 11 of them were conducted and three had to be cancelled due to connectivity problems and low number of participants.

The participants have been requested to fill out an anonymous survey consisting of three parts. The first part was intended to understand the participants' educational background and their pre-experience in the domain of OER; therefore, it contained demographical questions as well as questions regarding participants' pre-knowledge about OER. The participants have been asked to fill out this part at the beginning of the workshops in approximately five minutes slot. Figure 41 illustrates the positions of the participants at universities according to their responses and Figure 42 shows participants' responses regarding their proficiency in OER.

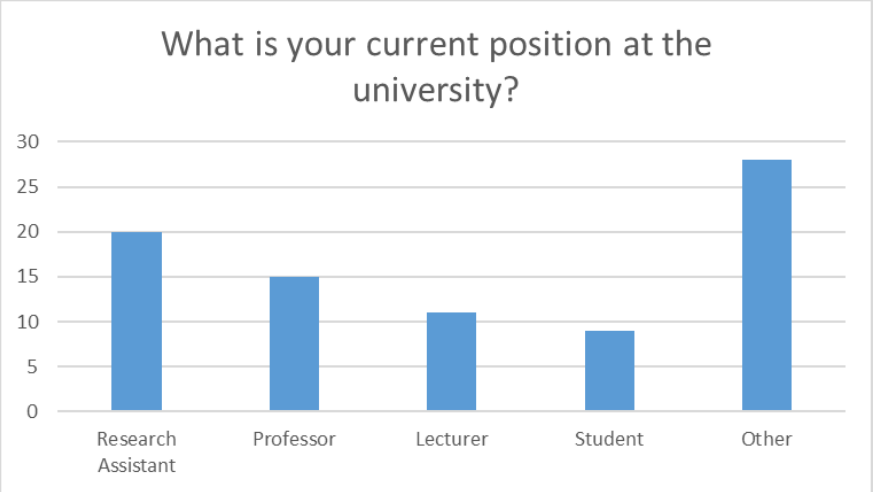

Figure 41: Positions of participants at universities

[60] https://zoom.us/, accessed 27.03.2023
[61] https://www.webex.com/, accessed 27.03.2023

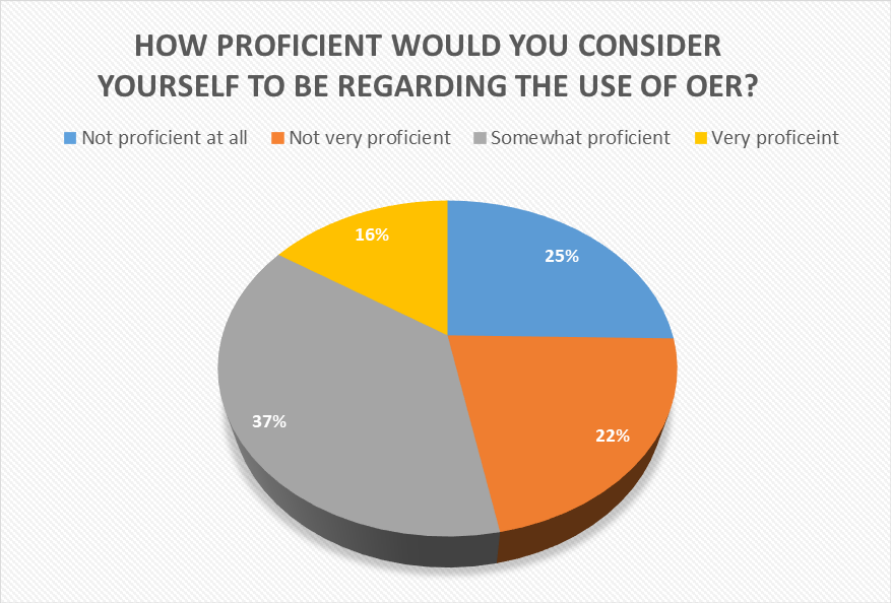

Figure 42: Participants' responses regarding their proficiency in OER

The second and third parts of the survey were to collect participants' responses about the manual conversion process and the semi-automatic conversion using convOERter respectively, therefore, the participants have been asked to fill out these parts of the survey directly after finishing the manual conversion session and convOERter session. The survey questions of part one, two and three are listed in the Appendices D, E, and F respectively. In all parts of the survey, the participants have been asked to generate a personal participant code to help us recognize the three anonymous parts of the survey for each participant. The participant's code was structured as follows:

- First letter of your father's first name (A-Z)
- First letter of your mother's maiden name (A-Z)
- Day of your own birthday as two digits (01-31)
- Day of your father's birthday as two digits (01-31)

Due to time constraints and to offer the participants more flexibility in attending the workshops, the workshops have been offered in two formats: the extended and the short or compact format. The extended workshops have been conducted in up to three hours and contained three theoretical sessions and two practical sessions: converting a file manually and converting a file semi-automatically using convOERter. The short workshops included a theoretical session and only one practical session, which is the semi-automatic conversion using convOERter and have been offered in 90 minutes.

To avoid any potential bias and to minimize the possible learning effects, the extended workshops have been conducted considering two different designs depending on the order of the practical sessions and their corresponding theoretical sessions. Figure 43 shows the abstract structure of the different types of workshops.

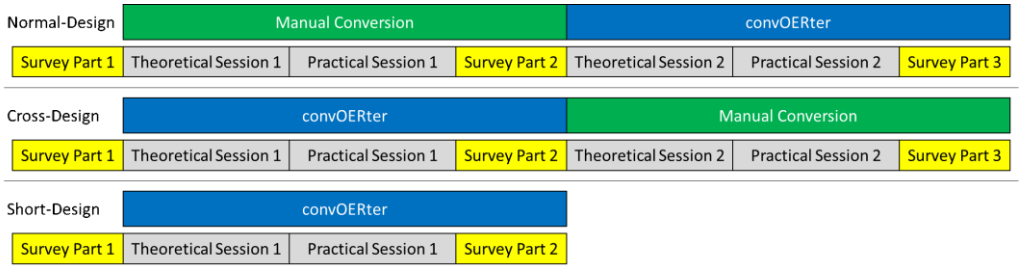

Figure 43: The abstract structure of workshops design

The first design workshops started with an introduction about OER and a theoretical session on manual conversion (Theoretical Session 1), followed by a practical session on manual conversion (Practical Session 1). After a break, the tool has been introduced and it's functionally has been illustrated theoretically (Theoretical Session 2) followed by a second practical session (Practical Session 2), in which the participants had to use convOERter to convert another file semi-automatically into OER. The participants have been requested to fill out three parts of a survey: at the beginning of the workshop, after the manual conversion session, and after convOERter practical session. This scenario or design will be referred to as scenario A or Normal-Design Workshops throughout this thesis.

In the second design, the order of the manual conversion sessions and the convOERter sessions are switched. The reason for that is to take consideration of possible bias or learning effects caused by the first conversion process. This scenario will be referred to as scenario B or Cross-Design Workshops throughout this thesis. The third type of workshops has been illustrated previously in this section. This scenario or design will be referred to as scenario C or Short-Design Workshops. In the following subsections, the three scenarios will be illustrated in details and their structure as well as some results will be highlighted.

8.1.1. Scenario A- Normal-Design Workshops

The Scenario-A or Normal-Design workshops have been offered in the period between the end of May and the beginning of September 2022. The workshops have been structured as follows: After welcoming the participants and presenting the workshop agenda, the participants have been asked to fill out an anonymous 5-minutes survey about their educational background and their pre-experience in the domain of OER. Figure 44 shows the slide presented in all Workshops to share the first part of the survey with the participants.

Subsequently, the OER concept and terminologies, including OER motivations, challenges and the OER-Cycle (see subsection 2.2.4), have been presented. Then the procedure to license the materials manually according to the TASLL rule has been illustrated. After that, the first practical session started, where the participants have been asked to choose one of two PowerPoint files (File A or File B), which were uploaded

previously to the shared-cloud storage (sciebo[62]) and could be downloaded directly via a link that was shared with the online participants via the chat or could be scanned using the provided QR-code by the in-presence participants. Both Files (A & B) have the same structure (i.e. the same topics and number of slides), however different images.

Figure 44: The slide presented during the workshops to share the first part of the survey with the participants

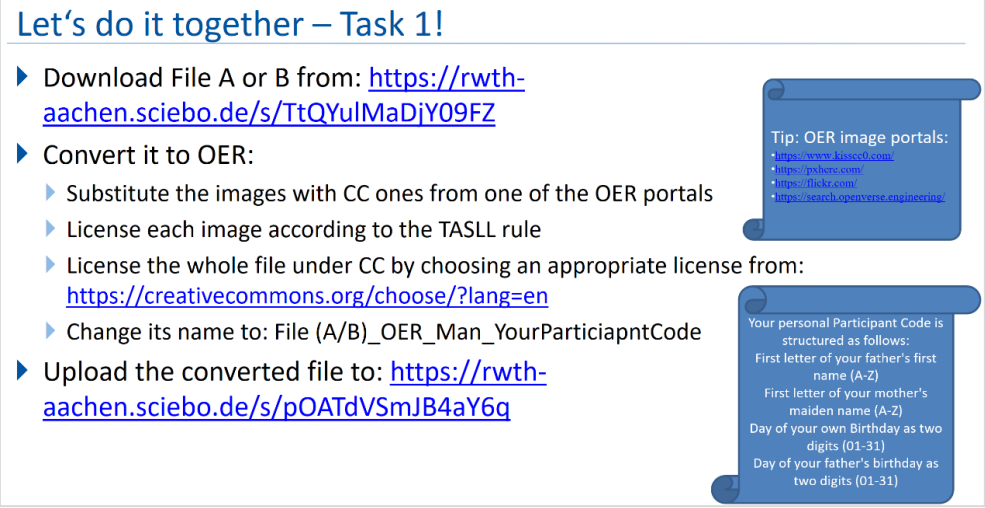

Figure 45: The slide that has been used during the Scenario A-Workshops to illustrate the manual conversion process

The participants have been informed about the procedure on how to download the files and how to upload them after processing in addition to some tips and hints on how to

[62] https://www.hochschulcloud.nrw

find and substitute the images. The participants have been assigned up to 30 minutes to convert their files manually into OER, to license the whole file under Creative Commons licence and to upload the processed files back to sciebo. Figure 45 shows the slide used during the workshop to illustrate this process.

After uploading the files, the link to the second part of the survey is shared with the participants, where they are requested to answer the questions related to the manual conversion and to provide their feedback regarding this process. For the workshops offered online, the link has been sent directly in the chat via Zoom and for the in-presence workshops, the participants scanned a QR-code of the survey link prepared previously and printed on paper (see Appendix L). Figure 46 shows the slide presented during scenario-A workshops to share the second part of the survey with the participants. After finishing the first practical session and filling out the corresponding survey, a coffee break has been offered to the participants.

Figure 46: The slide presented during scenario-A workshops to share the second part of the survey with the participants

The second part of the workshop started after the coffee break with a brief introduction about the available tools used for producing OER and clarifying the reasons for developing convOERter. The tool is then presented and its functionalities were explained using a demo video that illustrated the detailed steps to convert a file into OER. Then, the second practical session started, where the participants have been requested to use the tool to convert a file semi-automatically using convOERter. In this session, the participants were asked to download the second PowerPoint file i.e. File A in case they used B in the first practical session and vice versa. Figure 47 shows the slide presented during the workshops to clarify this process to the participants. After converting and uploading their files using convOERter, the participants have been asked to fill out the third part of the survey. Figure 48 shows the slide presented during Scenario-A workshops to share the third part of the survey with the participants. Finally, the participants have been asked if they have any open questions or matter to be discussed. Figure 49 shows the abstract structure of Normal-Design workshops.

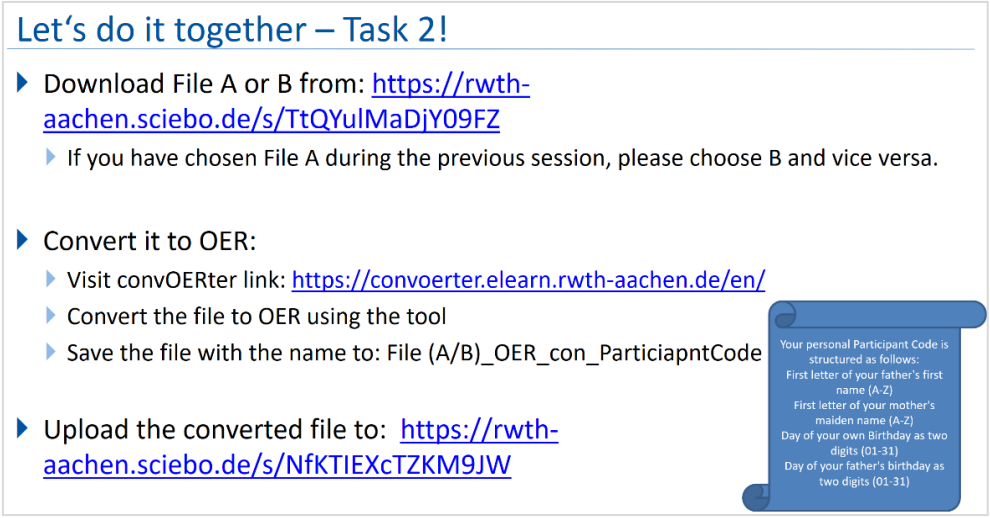

Figure 47: The slide that has been used during the Scenario A-Workshops to illustrate the semi-automatic conversion process using convOERter

Figure 48: The slide presented during scenario-A workshops to share the third part of the survey with the participants

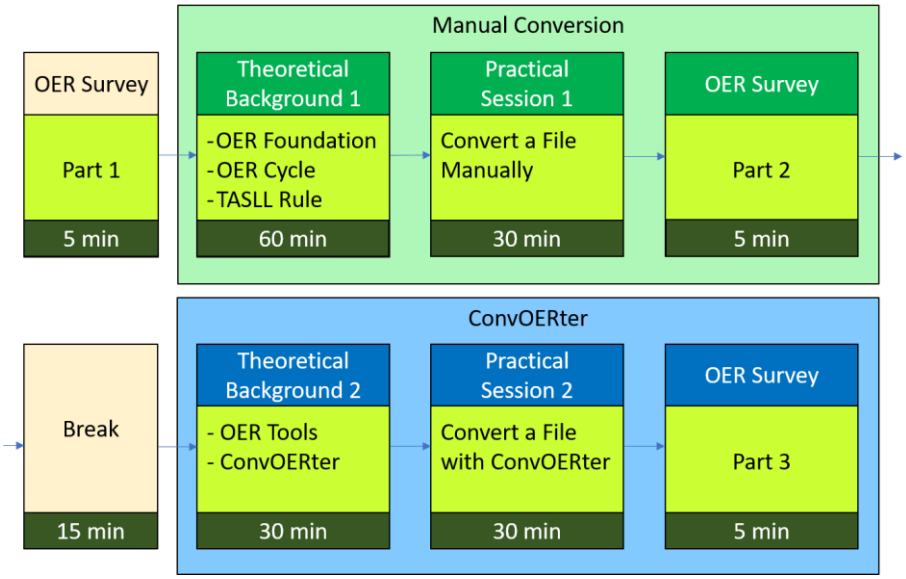

Figure 49: Structure of Scenario-A or Normal-Design Workshops

Scenario-A or Normal-Design workshops included five workshops; where four of them were held online and one was held in presence. Table 8 shows some statistics about these workshops such as: number of participants, number of participants filled out the survey completely, number of manual-uploaded files and number of uploaded files processed using convOERter.

Table 8: Some details about the participation in Normal-Design Workshops

Workshop Code	Date	Number of Participants	Survey completely filled out	Manual file uploaded	convOERter file uploaded
JTEL-ND-1	27.05.2022	5	5	4	3
EXACT-ND-2	03.06.2022	5	4	3	4
TUG-ND-3	23.06.2022	15	15	5	7
EXACT2-ND-4	01.09.2022	5	5	5	4
FNMA-ND-5	05.09.2022	6	6	5	6
	sum	**36**	**35**	**22**	**24**

As can be seen from the Table, some participants did not upload their files or answer the survey completely. This was due to internet connection troubles or unfamiliarity of some participants with the uploading mechanism used during the workshops. Some of these issues have been reported by the participants during or at the end of the workshops. These limitations among others will be introduced and discussed in detail in section 8.5. In the remaining part of this section, some initial results related to Normal-Design workshops will be introduced, further investigations and outputs will be introduced in section 8.3.

PROCESSING TIME

For every participant in each workshop, the *total processing time* needed to convert and upload the files in both practical sessions (manual and convOERter) was calculated by subtracting the *starting time* from the *upload timestamp*. The *upload timestamp* has been obtained directly from the time associated with each uploaded file in sciebo and the *starting time* has been noted down upon starting each practical session. Then the average processing time per image for both practical sessions in each workshop has been calculated. More information about calculating the time per image will be illustrated in subsection 8.3.1. Figure 50 shows the average time per image (in minutes) for Normal-Design workshops.

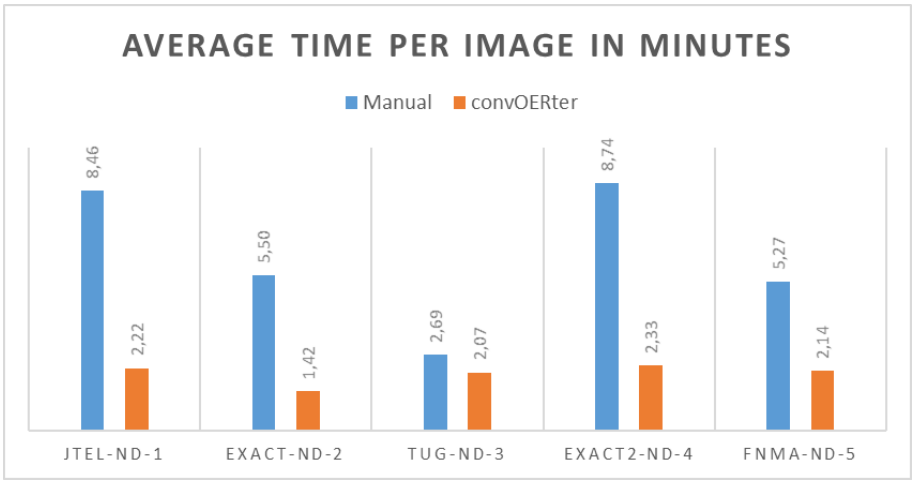

Figure 50: Average time per image for both practical sessions in Normal-Design workshops

As can be noticed from the diagram, the average processing time per image using convOERter was less compared to the manual conversion process in all workshops. However, the degree of improvement varied from one workshop to another. This was expected due to different participants' proficiency and pre-knowledge in the domain of OER. It was easier and faster for the experienced participants to convert their files manually compared to non-experienced participants. Further discussion about the relationship between participants' proficiency and processing the files manually and semi-automatically will be introduced in subsection 8.4.2.

PARTICIPANTS' PROFICIENCY AND RECOMMENDATIONS

Another aspect that has been considered during the evaluation process is, whether the participants would recommend and use the tool for converting the educational materials. The analysis was done taking participants' proficiency in OER into account. Determining the degree of the proficiency was obtained subjectively by the participants themselves by filling the first part of the survey. Further information about the survey structure will follow in section 8.4. Figure 51 displays the proficiency of the participants for all Normal-Design workshops and Figure 52 displays the relationship between the participants' proficiency and recommending the tool.

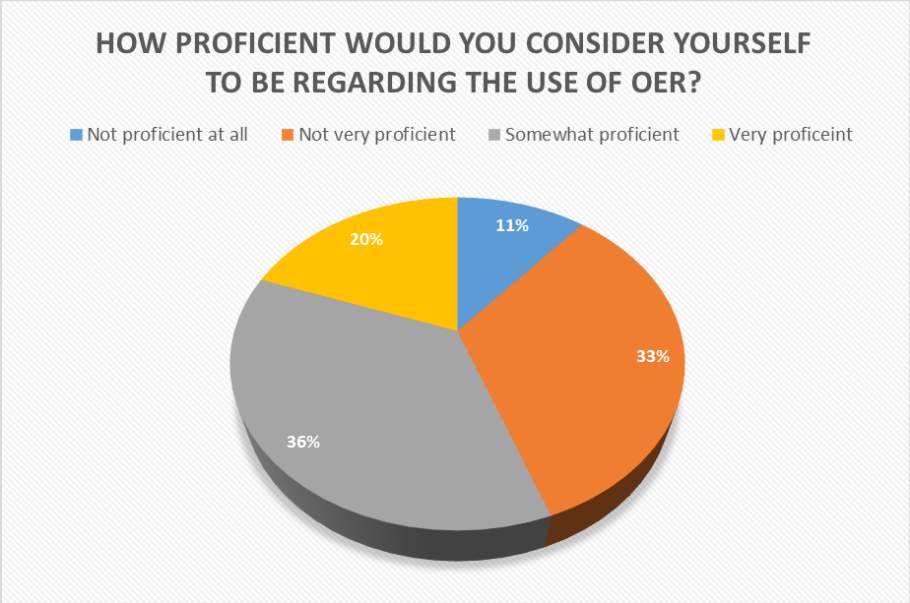

Figure 51: Participants proficiency in OER for all Normal-Design workshops

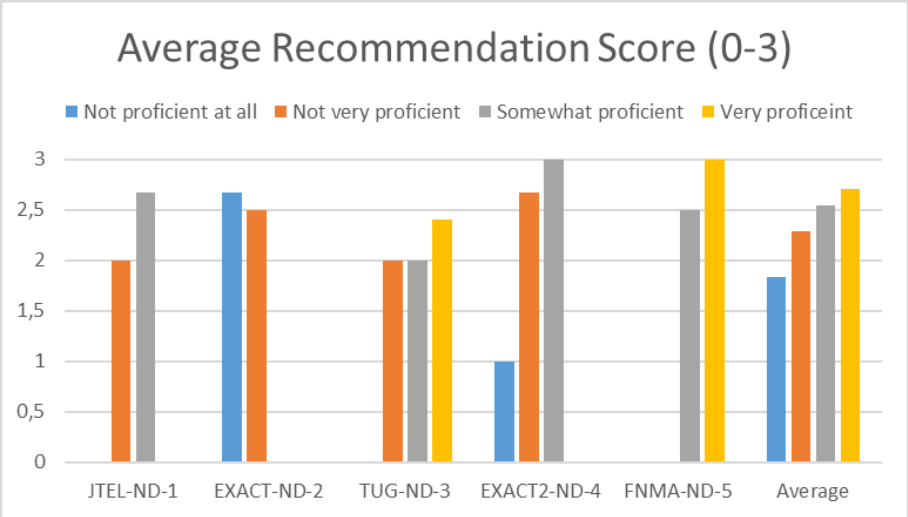

Figure 52: Average Recommendation Score of convOERter based on participants' proficiency in Normal-Design workshops

As can be seen from the two Figures, more than half of the participants in this series of workshops, can be considered as proficient in OER (very proficient and somehow proficient) and the tool has been recommended mostly from these participants. Further details and discussion about the relationships between participants' proficiency and recommending the tool will be presented in subsection 8.4.2.

8.1.2. Scenario B- Cross-Design Workshops

The Scenario-B or Cross-Design workshops have been offered in October and November 2022. In this series of workshops, the manual and convOERter sessions were

switched, so that that the participants had to convert their files semi-automatically using convOERter and then manually. The workshops have been structured as follows: after welcoming the participants and presenting the workshop agenda, the participants have been asked to fill out the first part of the survey, as it was the case in Normal-Design workshops. Subsequently, the OER concept and terminologies, including OER motivations, challenges and the OER-Cycle (section 2.2.3), have been presented. Afterwards, participants were introduced to some available tools for producing OER. Next, the motivation for developing a tool for converting already existing materials have been clarified. The tool was then presented and its functionalities were illustrated with a demo video. After that, the first practical session started, where the participants have been requested to download a file (A or B) from the shared-cloud storage (sciebo) and use convOERter to convert the file semi-automatically into OER. Figure 53 shows the slide that illustrated the semi-automatic conversion for the participants during the scenario-B workshops.

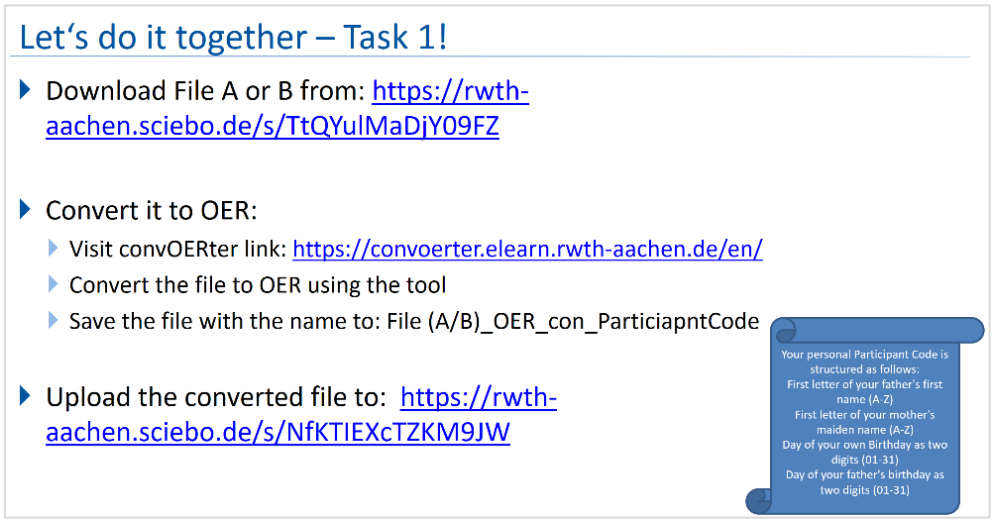

Figure 53: The slide that has been used during the Scenario B-Workshops to illustrate the semi-automatic conversion process using convOERter

After uploading the files, the link to the second part of the survey has been shared with the participants, where they are requested to answer the questions related to the semi-automatic conversion using convOERter and to provide their feedback regarding this process. For the workshops offered online, the link has been sent directly in chat via Zoom and for the in-presence workshops, the participants scanned a QR-code of the survey link prepared previously and printed on paper. A Screenshot of the slide used during the workshops to share the survey link with the participants has been already illustrated in the previous subsection. After finishing the first practical session and filling out the corresponding survey, a coffee break was offered to the participants.

The second part of the workshop started after the coffee break with a brief introduction on how to license materials manually using TASLL rule. Next, the second practical session started, where the participants were asked to download the second PowerPoint

files (File A or File B) from sciebo. The participants have been again informed about the exact procedure regarding downloading the files and uploading them. Then, they have been assigned up to 30 minutes to convert their files manually into OER, to license the whole file under Creative Commons licences and to upload the updated files back to sciebo. Figure 54 shows the slide presented during the workshops to clarify this process to the participants.

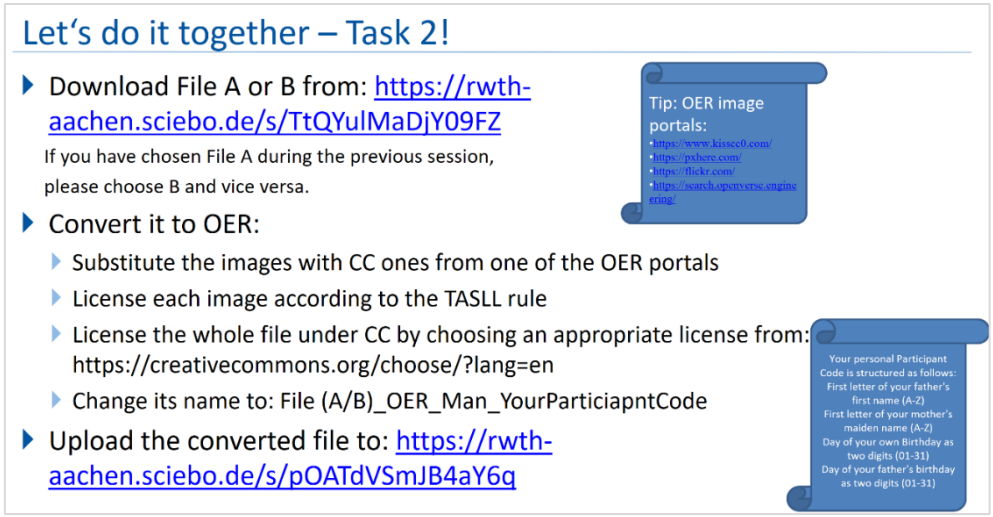

Figure 54: The slide that has been used during the Scenario B-Workshops to illustrate the manual conversion process

After uploading the files, the link to the third part of the survey was shared with the participants, where they answered the questions related to the manual conversion and provided their feedback regarding this process (as shown in the previous subsection).

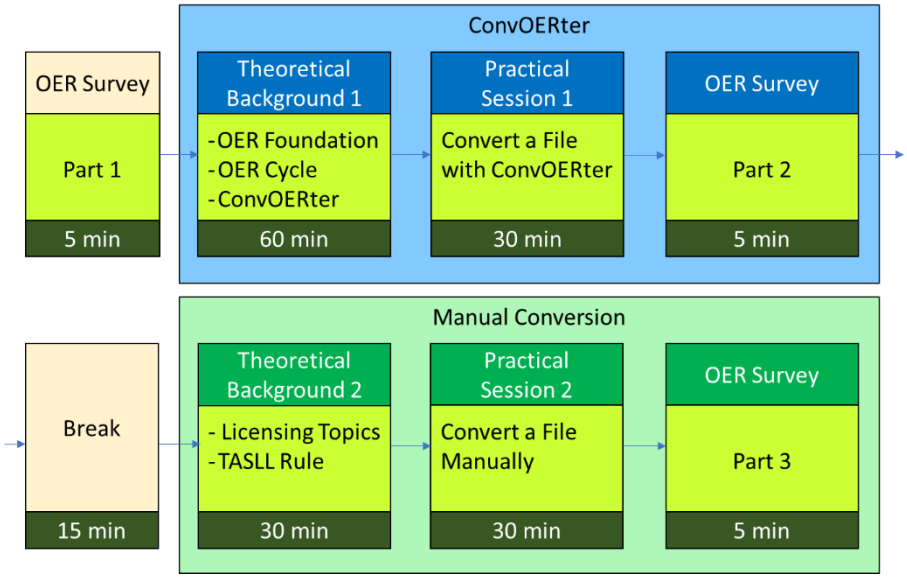

Figure 55: The structure of Scenario-B or Cross-Design workshops.

The same method, as described in the previous subsection, has been used to share the survey link with the participants. Finally, the participants have been asked, whether they have any open questions or matter to be discussed. Figure 55 shows the structure of Scenario-B or Cross-Design workshops.

Cross-Design workshops included three workshops; where two of them were held online and one was held in presence. Table 9 shows some statistics about these workshops such as: number of participants, number of participants filled out the survey completely, number of manual-uploaded files and number of uploaded files processed using convOERter.

Table 9: Some details about the participation in Cross-Design Workshops

Workshop code	Date	Number of participants	Survey completely filled out	Manual file uploaded	convOERter file uploaded
ORCA-CD-1	10.10.2022	11	9	8	10
AVEI-CD-2	07.11.2022	9	6	6	5
MONT-CD-3	17.11.2022	7	4	4	3
	sum	**27**	**19**	**18**	**18**

As can be seen from the Table above some participants again did not upload their files or answer the survey completely. This was, as mentioned previously, due to participants' unfamiliarity with sciebo or internet connection troubles that delayed uploading or downloading the files or sometimes hinder the whole conversion process. These issues have been reported by the participants and will be addressed in detail when discussing study limitations in the upcoming sections. In the remaining part of this section, some results related to Cross-Design workshops will be introduced. Further investigations and outputs will be presented in section 8.3.

PROCESSING TIME

Continuing the work that has been done for analysing the results of Normal-Design workshops, the same procedure was applied to analyse the Cross-Design workshops. Accordingly, the total processing time needed to convert and upload the files in both practical sessions (manual and convOERter) and the average time per image were calculated as introduced previously in subsection 8.1.1. The results of the average processing time per image for each workshop are shown in Figure 56.

PARTICIPANTS' PROFICIENCY AND RECOMMENDATIONS

Another parameter that has been considered during the evaluation is how far the participants will recommend the further use of the tool for converting the educational materials. As presented previously in subsection 8.1.1, the analysis has been done taking participants' proficiency in OER into account.

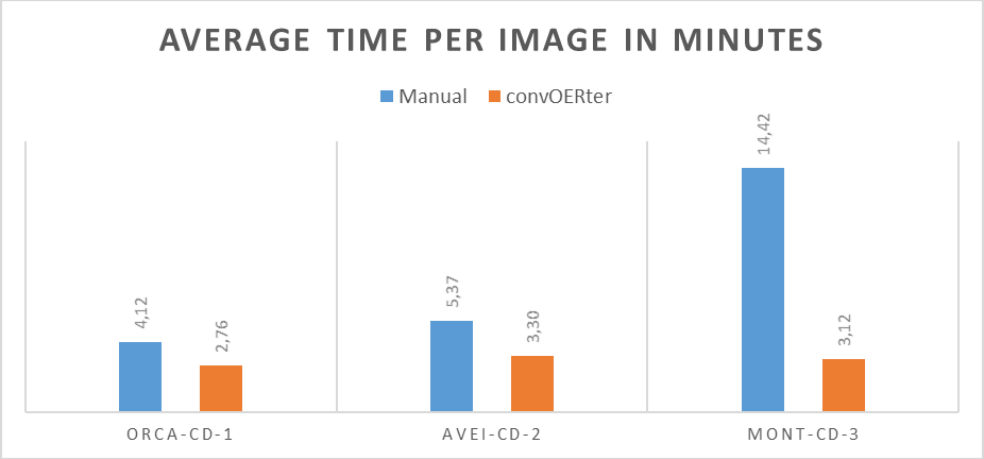

Figure 56: Average time per image for both practical sessions in Cross-Design workshops

The proficiency was determined by the participants by filling the first part of the survey. Further information about the survey questions and its structure will follow in section 8.4. Figure 57 shows the proficiency of the participants for all Cross-Design workshops and Figure 58 shows the relationship between participants' proficiency and recommending the tool.

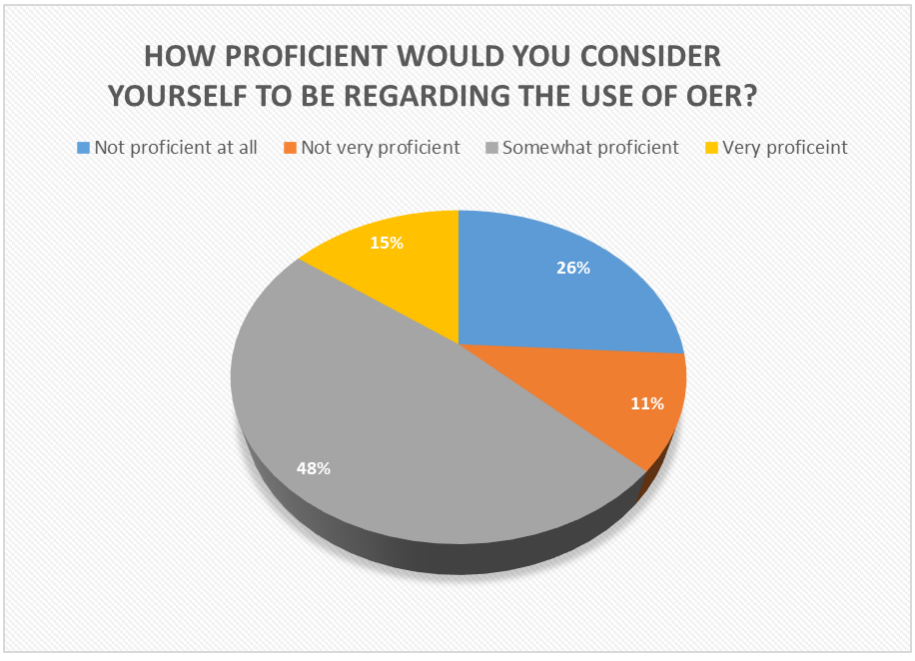

Figure 57: Participants proficiency in OER for all Cross-Design workshops

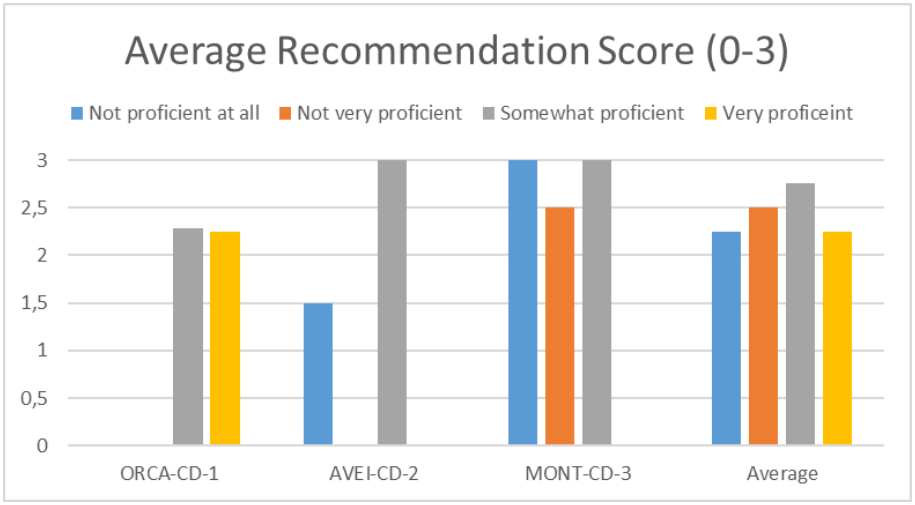

Figure 58: Average Recommendation Score of convOERter based on participants' proficiency in Cross-Design workshops

As can be noticed from Figures 57 and 58, the tool was mostly recommended from the most representative category in this series of workshops, which is the "somehow proficient" participants. Surprisingly, it can be observed, that the "not proficient at all" and the "very proficient" participants gave approximately the same average recommendation score. This might indicate that the tool was equally supportive for both the "not proficient at all" and for the "very proficient" participants. Further details and discussion about the relationships between participants' proficiency and recommending the tool will be presented in subsection 8.4.2.

8.1.3. Scenario C- Short-Design Workshops

The third type of workshops was offered during the period from late October to late November 2022. In this compact format, offered in a 90-minute time slot, only one session using convOERter was conducted. The workshops have been structured as follows: after welcoming the participants and presenting the workshop agenda, the participants have been asked to fill out the first part of the survey, as it was the case in Normal- and Cross-Design workshops. After that, the OER concept and terminologies, including OER motivations, challenges and the OER-Cycle have been presented (see subsection 2.2.4).

Subsequently, the participants have been introduced to some available tools used for producing OER. Next, the motivation for developing a tool for converting already existing materials have been clarified. Then, the tool has been presented and its functionalities has been illustrated using a demo video. Followed by that, the practical session started, where the participants have been requested to download a file from the shared-cloud storage (sciebo) and use convOERter to convert the file semi-automatically into OER. At the end, the link to the second part of the survey has been shard with the participants to provide their feedback about the semi-automatic conversion process. In this session, the same procedure was used as in the first part of

the Cross-Design workshops (see subsection 8.1.2). Figure 59 shows the structure of Scenario C- or Short-Design Workshops.

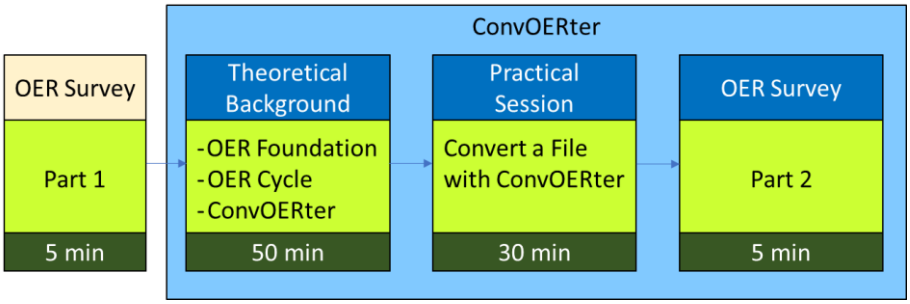

Figure 59: Structure of scenario C or Short-Design Workshops

Three workshops of this design have been held. Table 10 shows some statistics of this series of workshops. Since this workshops included only "convOERter" practice sessions, there was no inputs and statistics regarding manual conversion, as it was the case with the Normal- and Cross-Design workshops.

Table 10: Some details about the participation in Short-Design Workshops

Workshop Code	Date	Number of Participants	Survey completely filled out	Manual file uploaded	convOERter file uploaded
CAMP-SW-1	25.10.2022	8	5	_	6
BRIDG-SW-2	03.11.2022	5	4	_	4
DIDAKT-SW-3	25.11.2022	7	5	_	2
sum		**20**	**14**	**_**	**12**

PROCESSING TIME

The total processing time for the semi-automatically converted file using convOERter in addition to the average time for processing each image individually were calculated. Figure 60 shows the average time for processing each image in Short-Design workshops.

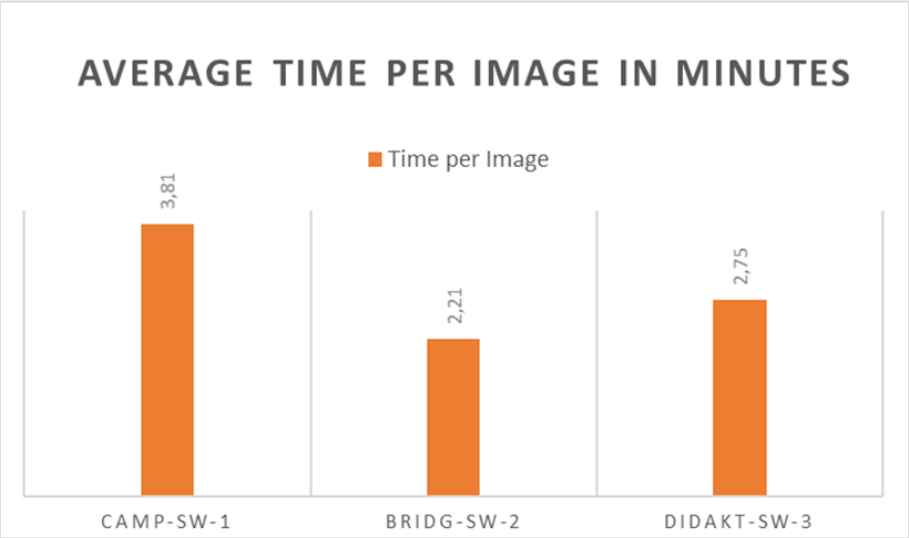

Figure 60: Average time per image for convOERter practical session in Short-Design Workshops

Later, the processing time of this series of workshops for the automatic conversion will be combined with the processing time of the first practical session from the Cross-Design workshops, where convOERter was the first practical session. Afterwards, the combined time will be compared to the processing time of the second practical session of the Normal-Design to identify whether there has been a learning effect. The detailed evaluation process and results will be illustrated in section 8.3.

PARTICIPANTS' PROFICIENCY AND RECOMMENDATIONS

The participants' proficiency and the recommendation of the tool while considering the proficiency were analysed as in Scenario A and B. Determining the degree of the proficiency has been done subjectively by the participants themselves by filling out the first part of the survey as it was the case in the previous two scenarios. Further information about the survey structure will follow in section 8.4.1. Figure 61 shows the proficiency of the participants for all Short-Design workshops and Figure 62 shows the relationship between participants' proficiency and recommending the tool.

As can be seen from the two Figures, the tool has been recommended the most from the "somehow proficient", who represented 1/4 of the participants. The second category, who recommended the tool was the "non-proficient at all", who represented 1/2 of the participants. The interpretation for that could be, that the tool was a valuable assistance for the non-proficient as well as for the proficient participants.

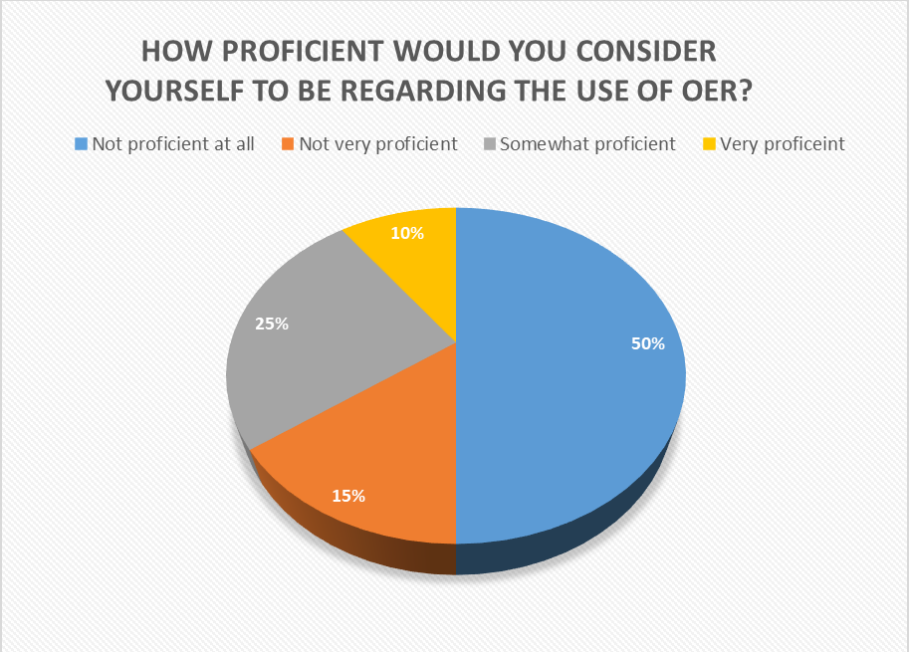

Figure 61: Participants proficiency in OER for all Short-Design workshops

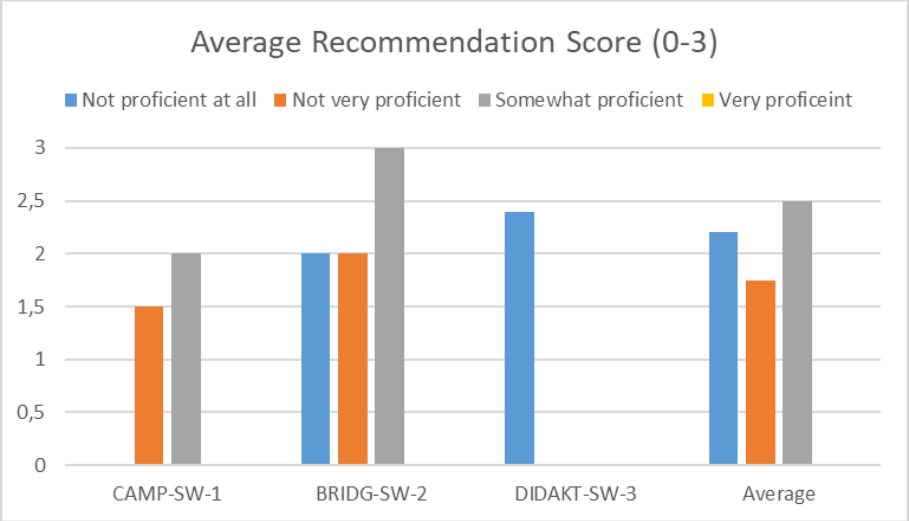

Figure 62: Average Recommendation Score of convOERter based on participants' proficiency in Short-Design workshops

8.2. Evaluation Method

In this thesis, two evaluation methods were adopted to compare the manual and semi-automatic conversion processes. The first evaluation method considered the workshop types (Normal-, vs. Cross-Design) and is based on comparing the manual converting session in Normal-Design workshops with their counterpart in Cross-Design workshops in addition to comparing the semi-automatic conversion process in both types of workshops. For this comparison, descriptive statistics (Marshall and Jonker, 2010) has been used (i.e. Mean, Median, Standard deviation as well as Minimum and Maximum values of the respective data sets). Figure 63 displays an abstract illustration for this type of evaluation.

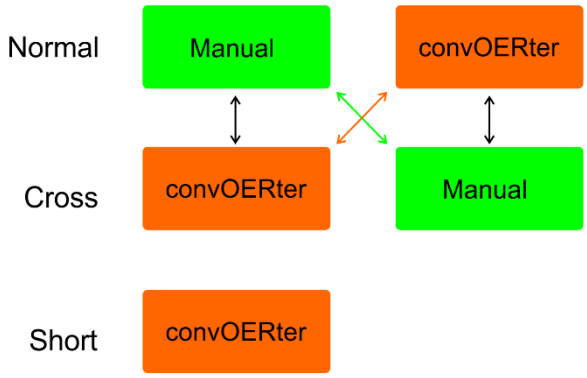

Figure 63: Abstract structure of the first evaluation method

The second evaluation method considered the order of practical sessions (convOERter-First vs. convOERter-Second). It is based on using inferential statistics (Bhandari, 2020) to compare convOERter sessions in Cross- and Short-Design workshops vs. convOERter sessions in Normal-Design workshops in addition to comparing the manual session in Normal-Design vs. the manual session in Cross-Design workshops. Accordingly, the processing time and quality data collected from convOERter sessions

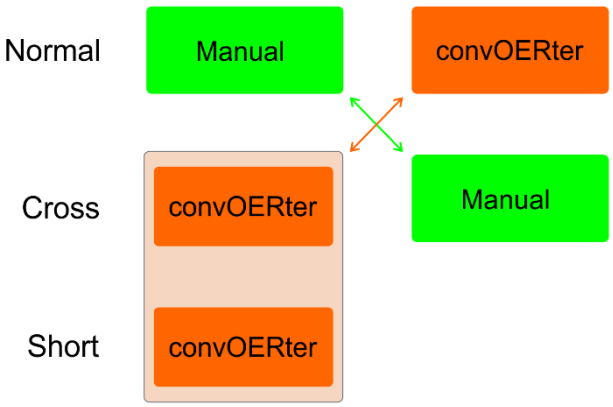

Figure 64: Abstract structure of the second evaluation method

in Cross- and Short-Design workshops were combined and compared with the data collected from convOERter sessions in Normal-Design workshops as can be seen in Figure 64. Additionally, inferential statistics were applied to examine, if there is a significance statistical difference between performing the manual conversion before and after using convOERter. The reason for conducting this comparison is to examine if there was any significance statistical difference caused by switching the order of conversion sessions and by performing the conversion twice within the workshops.

8.3. Evaluation Results

After introducing the settings of each type of the conducted workshops and highlighting the evaluation procedure, the results of investigating and analysing the data gathered from theses workshops will be introduced. To evaluate our concept and answer the research questions presented in section 1.3, the mixed method approach (George, 2021) has been applied. Accordingly, the data have been analysed quantitatively and qualitatively. The quantitative analysis has been done mainly using the open-source statistics program JASP[63] and partially using Microsoft Excel 2016[64]. Whereas, the qualitative investigation has been accomplished manually, since the amount of collected qualitative data was not huge.

Descriptive statistics have been performed to analyse the data quantitatively, since they are well suited for comparing and summarising quantitative data (Marshall and Jonker, 2010). Descriptive statistics are used to describe the basic features of the data in a study and provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of analysing the data quantitatively (Trochim, n.d.).

Additionally, inferential statistics have been run to test if there was any learning effect caused by performing the conversion twice within a workshop. Inferential statistics is the process of analysing the data to make statements about unknown population parameters, to answer a research question, or to tell us whether the experimental hypothesis is likely to be true. So, it can help researchers confirm or reject their experimental predictions (Field and Hole, 2002). Choosing the statistical test to be performed depends on the sample size, the distribution of data and the hypothesis to be tested. Generally, parametric (when data is normally distributed) or non-parametric tests (when the data does not have a normal distribution) are used to measure the differences between two groups (Sen, 2020). In this thesis, the following tests were run to test if there was a significance statistical difference between performing the manual and semi-automatic conversions in the first or second practical session.

- Shapiro-Wilk test: to check if two groups have normally distributed data.
- Levene's test: to check for the homogeneity of variance for two groups.

[63] https://jasp-stats.org/, accessed 09.03.2023
[64] https://www.microsoft.com/de-de/microsoft-365/excel?rtc=1, accessed 09.03.2023

- Mann-Whitney test: is the non-parametric alternative for the T-test that should be considered if Shapiro-Wilk test was significant (i.e. if the data is not normally distributed)
- Welche's test: this is the adjusted t-statistics to be considered if Levene's test was significant

In this section, we will elaborate on analysing the data quantitatively to answer the second sub research questions, which is: "How can the semi-automatic conversion of educational materials facilitate the production of OER in comparison to manual conversion in terms of licence quality, conversion speed, and the total efficiency?" Accordingly, the results of analysing the time required for processing the files manually and semi-automatically using convOERter will be presented. Furthermore, the results of investigating the licence quality of images as well as documents for the manual and the semi-automatic conversion processes will be introduced. Afterwards, the processing time, image licence quality and the number of converted images will be considered to calculate the total efficiency of both conversion processes.

The results of the qualitative analysis, which is based on investigating the survey, will be presented in the following section to answer the third sub research question, which is: "Do proficiency & previous knowledge influence the speed and quality of converting educational materials into OER?" Answering these two sub-questions along with the first one answered in Chapter 6 will enable answering the main research question: "**Can a technical assistance tool support the production of OER by converting images in existing educational materials into OER?**"

8.3.1. Processing Time

As stated previously, two evaluation methods were used to compare the manual and the semi-automatic conversion processes. The first one is based on the workshop type and the second on the order of the practical conversion sessions (see section 8.2). In this subsection, the first parameter used to answer the second sub research question will be introduced and analysed, which is the time required to process the images manually and semi-automatically.

To accomplish that, the processing time for each uploaded file has been calculated. As stated in subsection 8.1.1, the total processing time has been calculated by subtracting the starting point from the upload timestamp associated with each uploaded file. Next, each uploaded file has been investigated to determine the number of converted or licenced images. Subsequently, the average processing time for each image has been calculated by dividing the total processing time by the number of licenced images if the whole file wasn't licenced, and by the (number of licenced images + 1) if the file was licenced. Tables 11 and 12 present an overview about the total processing time and the number of converted images manually and semi-automatically for each workshop type respectively.

Table 11: Processing time manual vs convOERter by workshop type

	Processing Time Manual			Processing Time convOERter		
	Normal Design	Cross Design	Short Design	Normal Design	Cross Design	Short Design
N[1]	21	18	-	24	18	12
Median	26.000	18.500	NaN	12.000	18.000	16.000
Mean	25.190	19.556	NaN	12.125	16.389	16.167
Std. Deviation	8.721	7.390	NaN	3.481	4.960	3.614

1: N is the number of participants who uploaded their files

Table 12: No. of converted images manually vs. convOERter by workshop type

	No. of Manually Converted Images			No. of convOERter Converted Images		
	Normal Design	Cross Design	Short Design	Normal Design	Cross Design	Short Design
N	21	18	-	24	18	12
Median	5.000	5.000	NaN	5.000	5.000	5.000
Mean	4.476	3.667	NaN	4.958	4.611	4.583
Std. Deviation	1.167	1.645	NaN	0.204	0.979	0.900

With these two parameters (total processing time and number of converted images) in addition to checking if the whole file was licenced, the time per image was calculated for each uploaded file. It should be noted again that the calculation has been done by investigating each uploaded file separately and examining the number of converted images in addition to checking whether the whole file has been licenced or not. As the participants had to license 5 images and the file, the total number of tasks to be achieved was 6. Accordingly, the time per image was calculated by dividing the processing time by the number of achieved tasks. Accomplishing all tasks means that the time per image was calculated by dividing the processing time by 6. However, accomplishing 4 tasks (e.g. licensing only 4 images manually) means that the processing time was divided by 4. According to this rule, the time per image has been calculated for all uploaded files.

Table 13: Time per image manual vs convOERter by workshop type

	Time per Image Manual			Time per Image convOERter		
	Normal Design	Cross Design	Short Design	Normal Design	Cross Design	Short Design
N	21	18	-	24	18	12
Median	4.830	4.330	NaN	2.000	3.085	2.670
Mean	5.957	6.828	NaN	2.042	2.971	3.098
Std. Deviation	4.218	6.151	NaN	0.607	0.830	1.431

Table 13 displays an overview about the time per image for both conversion sessions according to workshop types and Figure 65 presents them graphically using an interval plot.

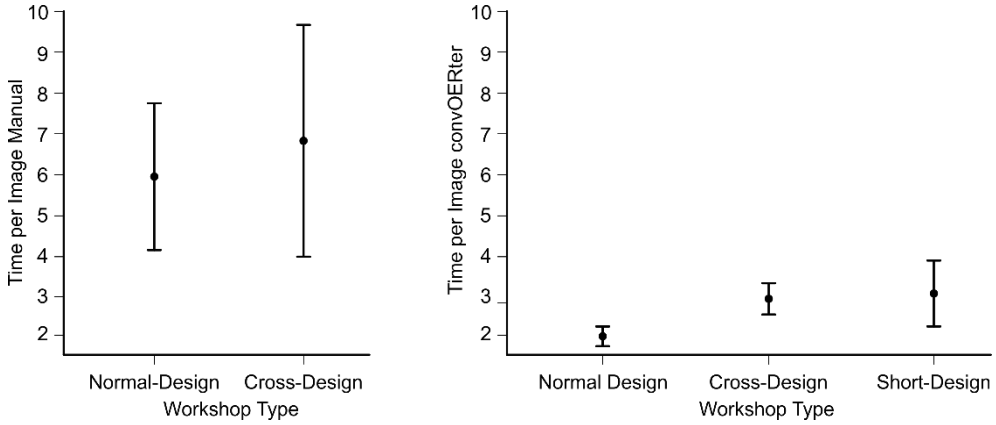

Figure 65: Time per image manual vs convOERter by workshop type

As can be noticed from the above Table and the Figure, there was a noticeable improvement in the average processing time for each image using convOERter compared to the manual conversion in both workshop types (Cross- and Normal-Design). Additionally, it can be noticed that the average number of converted images using convOERter was more compared to manually converted images. Further, it can be noticed that the participants in Normal-Design workshops were slightly faster in converting their files using convOERter compared to their counterparts in Cross-Design workshops. This could be due to the experience gained from the first practical manual session.

In order to examine if there was any potential learning effects caused by performing the conversion process twice during the Normal-Design and Cross-Design workshops (convOERter then manual and vice versa) and to consider all types of workshops in the evaluation process, the second evaluation method presented in section 8.2 (i.e. order of practical sessions) were adopted. As illustrated previously, this method based on using inferential statistics to compare convOERter sessions in Cross- and Short-Design workshops vs. convOERter session in Normal-Design workshops in addition to compare the manual session in Normal-Design vs. the manual session in Cross-Design workshops. The data gathered from convOERter sessions in Cross- and Short-Design workshops were combined under the category convOERter-First and compared with data from Normal-Deign workshops, where convOERter was used in the second practical session. The order of manual sessions in Normal- and Cross-Design was considered in the comparisons. The manual session in Cross-Design workshops was renamed manual-First, and in Normal-Design, manual-Second. Table 14 shows an overview of the average processing time per image according to the order of practical sessions and Figure 66 presents them graphically using an interval plot.

Table 14: Average processing time per image by practical session order

	Time per Image Manual		Time per Image convOERter	
	Manual First	Manual Second	convOERter First	convOERter Second
N	21	18	30	24
Median	4.830	4.330	3.000	2.000
Mean	5.957	6.828	3.021	2.042
Std. Deviation	4.218	6.151	1.089	0.607

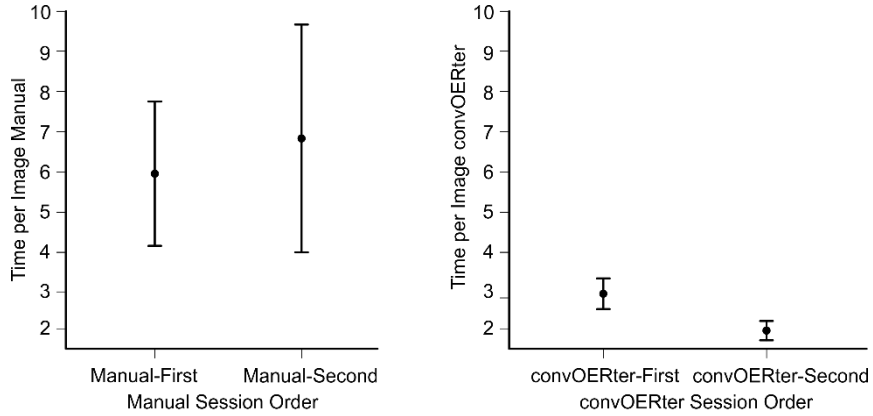

Figure 66: Interval plots for time per image of both conversion processes by practical session order

As can be seen from the Table and the Figure, the time needed for processing each image semi-automatically using convOERter was less compared to the manual conversion for both settings (convOERter-First and convOERter-Second). As such, the average time required to process an image using convOERter after the manual conversion, was less compared to the time consumed, when it was the first practical session. This can be interpreted due to the experience gained from the manual conversion.

In order to test this hypothesis and to examine if there was a statistical significance difference or any learning effect caused by repeating the conversion process during the Normal- and Cross-Design workshops, the second evaluation method mentioned in section 8.2 was applied. In order to choose the appropriate t-test, a normality assumption check and a test of equality of variances have been accomplished. Accordingly, a Shapiro-Wilk test of normality and Levene's test of equality of variances have been conducted respectively. Tables 15 and 16 present the results of assumption checks for the manual conversion of those two categories.

The result of running Shapiro-Wilk test shows that the assumption of normality is violated and both groups Manual-First and Manual-Second are not normally distributed (Shapiro-Wilk, $p < 0.05$).

Table 15: Results of running test of normality for the manual conversion

Test of Normality (Shapiro-Wilk)			
		W	p
Time per Image Manual	Manual-First	0.774	< .001
	Manual-Second	0.725	< .001
Note. Significant results suggest a deviation from normality.			

Table 16: Results of running test of equality of variance for the manual conversion

Test of Equality of Variances (Levene's)				
	F	df_1	df_2	p
Time per Image Manual	2.946	1	37	0.094

Whereas running the Levene's test to check for the equality of variances revealed that there is no difference in variance and the assumption of homogeneity of variance was not violated (Levene's test, $p > 0.05$). Accordingly, the Mann-Whitney U test was performed to test if there was any statistical difference between accomplishing the manual conversion in first practical session or in the second one. The results of running the Mann-Whitney U test are shown in the following table.

Table 17: Results of running Mann-Whitney U test for accomplishing the manual conversion in first practical session vs. in the second one

Independent Samples T-Test						
	W	df	p	Hodges-Lehmann Estimate	Rank-Biserial Correlation	SE Rank-Biserial Correlation
Time per Image Manual	192.50	--	0.933	0.064	0.019	0.186
Note. For the Mann-Whitney test, effect size is given by the rank Biserial correlation.						
Note. Mann-Whitney U test.						

As can be seen from the Table, there was no significant difference between the two groups, who converted their files manually before and after using convOERter ($U = 192.500$, $P = 0.933$). This means that the participants who converted their files manually in the second practical session after using convOERter in the first practical session were not significantly faster compared to the participants, who converted their files manually in the first practical session.

To test if there is a significance statistical difference between using convOERter before or after the manual conversion, the same procedure was performed. Firstly, we checked the normality assumption and the equality of variances by running Shapiro-Wilk test and Levene's test respectively. The results of running both tests for convOERter-First and convOERter-Second groups are shown in the Tables 18 and 19 respectively.

Table 18: Results of running test of normality for convOERter conversion

Test of Normality (Shapiro-Wilk)			
		W	p
Time per Image convOERter	convOERter-First	0.880	0.003
	convOERter-Second	0.952	0.300
Note. Significant results suggest a deviation from normality.			

Table 19: Results of running test of equality of variance for convOERter conversion

Test of Equality of Variances (Levene's)				
	F	df_1	df_2	p
Time per Image convOERter	3.022	1	52	0.088

The Shapiro-Wilk test shows that the assumption of normality was violated for the convOERter-First group (Shapiro-Wilk, $p < 0.05$). However, the Levene's test to check for the equality of variances showed that there was no difference in variance and the assumption of homogeneity of variance was not violated (Levene's test, $p > 0.05$). The Mann-Whitney U test was performed to test if there was any statistical difference between accomplishing the conversion using convOERter in the first practical session and in the second one. The results of the Mann-Whitney U test are shown in the following table.

Table 20: Results of running Mann-Whitney U test for accomplishing the conversion using convOERter in first practical session vs. in the second one

Independent Samples T-Test						
	W	df	p	Hodges-Lehmann Estimate	Rank-Biserial Correlation	SE Rank-Biserial Correlation
Time per Image convOERter	582.50	--	< .001	1.00	0.618	0.158
Note. For the Mann-Whitney test, effect size is given by the rank biserial correlation.						
Note. Mann-Whitney U test.						

Running the Mann-Whitney U test for time per image using convOERter indicated that there was a statistical significance difference between converting the files using convOERter after converting them manually compared to using convOERter in the first practical session ($U = 582.500$, $p < 0.001$) with a large effect ($r = 0.618$). The graphical presentation for both conversion processes is shown in Figure 67.

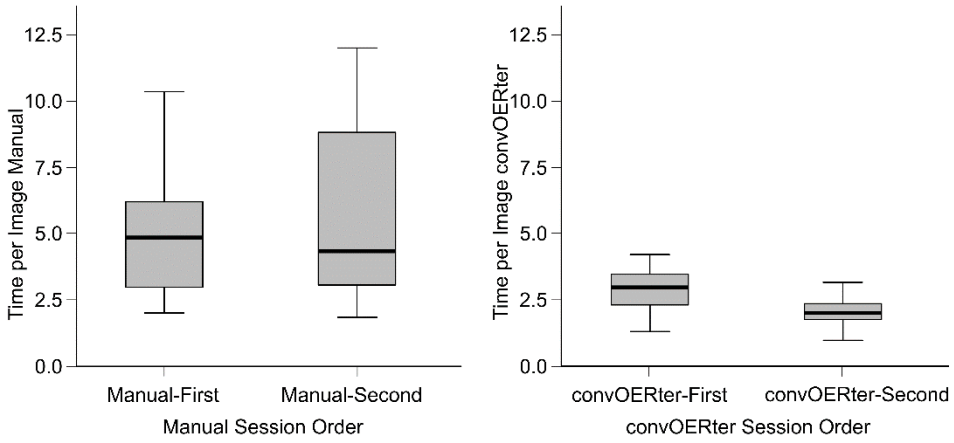

Figure 67: Box plots for time per image of both conversion processes by practical session order

In summary, the use of convOERter in the second practical session after the manual conversion in the first practical session significantly reduced the time required to process the images using convOERter. However, converting the files manually in the second practical session after using convOERter in the first practical session has no noticeable effect on reducing the time required to manually process the files. These results are logical as using the manual process first, may have increased sensitivity of the participants for the complexity of the task e.g. searching for an image, manually gathering the citation, or licences relevant data.

8.3.2. Licence Quality

In addition to analysing the time needed to process the files manually and semi-automatically using convOERter and to answer the second part of the second sub research questions (presented in section 1.3), the quality of the licences for the substituted images and the quality of the licence for the overall document were investigated. In order to examine the quality of the images' licences, all uploaded files have been examined and the number of images substituted and licenced under Creative Commons have been checked, if they are correctly licenced according to the TASLL rule. As convOERter can do this process automatically, every substituted image was licenced directly according to the TASLL rule. Therefore, the percentage of correctly licenced images using convOERter, among the substituted ones, was 100%. However, this percentage varied for the manual substituted files. To be able to compare the quality of the licenced images, a quality score for each image has been calculated.

The quality score have been calculated as follows: An image that is fully licenced according to the TASLL rule (i.e. all five elements were considered) counts as one point, whereas an image licenced under a Creative Commons with a missing element of the TASLL rule such as not linking the licence or attributing the author etc. will lose 0.2 for each missing element. Quality percent was then calculated by dividing the quality score by the number of images that were substituted by the participant. Any missing or unchanged images in the submitted files were not considered in the quality measurements. Since the file to be converted contained five images, the maximum score

for fully and correctly licenced images according to the TASLL rule was five and the minimum score was zero. Accordingly, the score for the quality of manually licenced images ranged from 0-5 and the percentage of correctly licenced images ranged from 0-1, where 1= 100%.

In addition, the quality of the overall licence of a document was examined, taking into account the following elements which are required for a document to be correctly licenced: whether the licence is correctly declared, the author is mentioned, and whether logos are excluded from the licence. If all the required elements are present, 3 points are given. If one element is missing, one point is deducted. According to this scheme, each uploaded file was examined and checked whether it was completely and correctly licenced according to the TASLL rule and the criterion mentioned above.

In the following, the quality of the licenced images as well as the quality of the licenced files for the manual and semi-automatic conversion processes classified by the type of the workshop (Normal- vs. Cross-Design) will be discussed. Then, inferential statistics will be performed to investigate, if there is any significance statistical difference between the quality of documents licences when running convOERter as first practical session or as a second practical session.

QUALITY OF IMAGES LICENCES

Table 21 introduces an overview of the percent of correctly licenced images for both sessions, the manual and semi-automatic conversions, classified by the workshop type. Whereas Figure 68 displays a visual presentation using an interval plot for the same percent for both conversion sessions.

Table 21: An overview of the ratio of licenced images according to TASLL rule for both sessions by workshop type

	Ratio of Manual Licence Quality			Ratio of convOERter Licence Quality		
	Normal Design	**Cross Design**	**Short Design**	**Normal Design**	**Cross Design**	**Short Design**
N	21	18	-	24	18	12
Median	1.000	1.000	NaN	1.000	1.000	1.000
Mean	0.775	0.835	NaN	1.000	1.000	1.000
Std. Deviation	0.285	0.269	NaN	0.000	0.000	0.000
Minimum	0.270	0.200	∞[a]	1.000	1.000	1.000
Maximum	1.000	1.000	-∞[a]	1.000	1.000	1.000
[a] Infimum (minimum) of an empty set is ∞, supremum (maximum) of an empty set is -∞.						

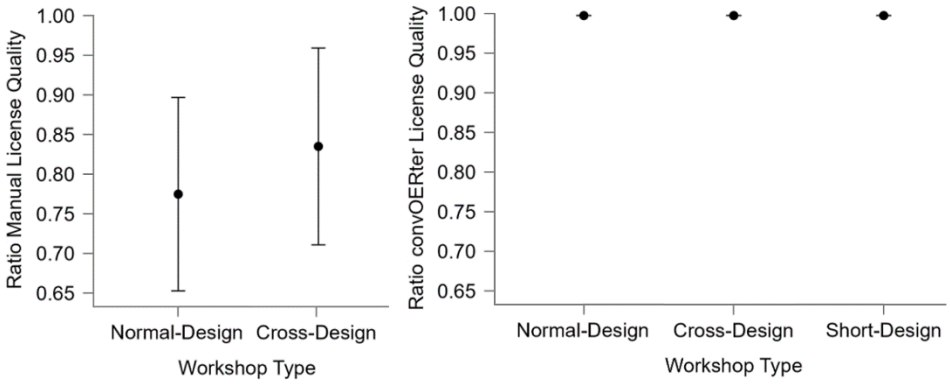

Figure 68: Visualization of the licenced images according to TASLL rule for both sessions by workshop type

As can be clearly noticed from the Table and the Figure, there was an enhancement on the average ratio of correctly licenced images according to TASLL rule using convOERter compared to the manual conversion in both types of workshops. The average ratio of image licences using convOERter was 1 or 100% in all workshops. The reason is that convOERter licenses the images automatically according to the TASLL rule. It can be seen that the average quality ratio of the licenced images within the Cross-Design workshops in the manual conversion was better compared to the Normal-Design workshops. This could be due to the learning experience gained from using convOERter during the first conversion session. This has been also noticed while exploring the licenced files, where some participants have applied convOERter method to license their images.

QUALITY OF DOCUMENT LICENCE

The second criteria to compare the quality of the licences is to investigate the quality score of the final licence for the whole files for the manual and semi-automatic conversions classified by the workshop type. The procedure used to calculate the quality score has been introduced earlier in this subsection. Table 22 shows an overview of the descriptive statistics (mean, median, standard deviation, minimum and maximum) for the correct licenced files for both sessions (manual and semi-automatic) classified by the workshop type and Figure 69 displays the interval plots for the quality of licenced files for both conversion sessions.

As can be noticed from the Table and the Figure, there was an enhancement in the mean quality score of the licences generated by convOERter compared to those added manually in both workshop types. The quality score for semi-automatic licenced files produced by convOERter ranged from 2.0-3.0, where 3.0 is the highest or the best score. This means that all important elements to license a file (licence, author, excluding the logos) have been addressed correctly. However, the average quality score for the manual added licences ranged from 0-3, where zero means that the file was not licenced correctly (without considering any of the three above-mentioned criterion).

Table 22: An overview of the score of quality files licences for both sessions by workshop type

	Manual Doc. Licence Quality			convOERter Doc. Licence Quality		
	Normal Design	**Cross Design**	**Short Design**	**Normal Design**	**Cross Design**	**Short Design**
N	15	12	-	24	18	12
Median	1.000	2.500	NaN	2.000	2.500	3.000
Mean	1.467	2.333	NaN	2.333	2.500	2.583
Std. Deviation	0.640	0.888	NaN	0.482	0.514	0.515
Minimum	1.000	0.000	∞[a]	2.000	2.000	2.000
Maximum	3.000	3.000	-∞[a]	3.000	3.000	3.000
[a] Infimum (minimum) of an empty set is ∞, supremum (maximum) of an empty set is -∞.						

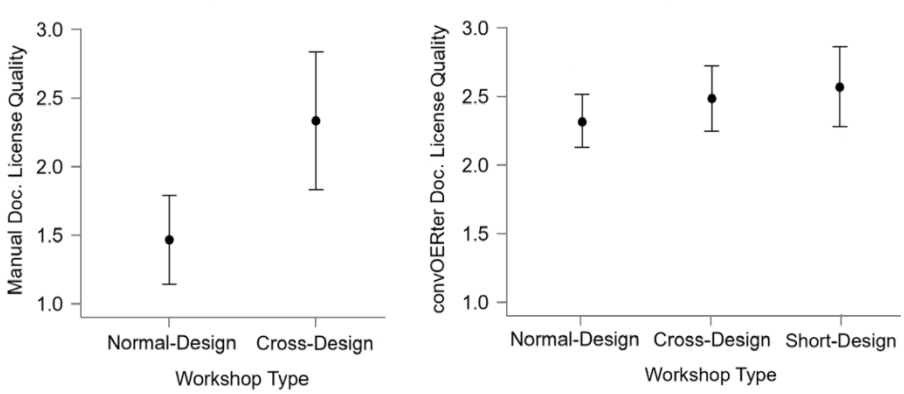

Figure 69: Interval plots of the score of quality files licences for both sessions by workshop type

It can be noticed also that the files licenced manually within the Cross-Design workshops have in average better-quality scores compared to those licenced within the Normal-Design workshops. This can be due to the experience gained using convOERter during the first conversion session. This has been also observed while exploring the licenced files, it was found that some participants have applied convOERter method to license their documents.

In order to consider all offered workshops in the evaluation process and to examine if there were any potential learning effects (on enhancing the quality of files licences) caused by repeating the conversion process during the Normal-Design and Cross-Design workshops (convOERter then manual and vice versa), the second evaluation method presented in section 8.2 was adapted (i.e. the order of practical sessions). Accordingly, the quality score for the licenced files gathered from convOERter sessions in Cross- and Short-Design workshops were combined under the category convOERter-First and compared with quality file scores from Normal-Deign workshops, where convOERter was used in the second practical session. The order of manual sessions in Normal- and Cross-Design was considered in the comparisons as stated previously,

where the manual session in Cross-Design workshops is renamed Manual-First and in Normal-Design to Manual-Second. Table 23 displays the quality files licence scores according to the order of practical sessions and Figure 70 presents them graphically using an interval plot.

Table 23: An overview on the quality files licences scores according to the order of practical sessions

	Manual Doc. Licence Quality		convOERter Doc. Licence Quality	
	Manual First	Manual Second	convOERter First	convOERter Second
N	15	12	30	24
Median	1.000	2.500	3.000	2.000
Mean	1.467	2.333	2.533	2.333
Std. Deviation	0.640	0.888	0.507	0.482
Minimum	1.000	0.000	2.000	2.000
Maximum	3.000	3.000	3.000	3.000

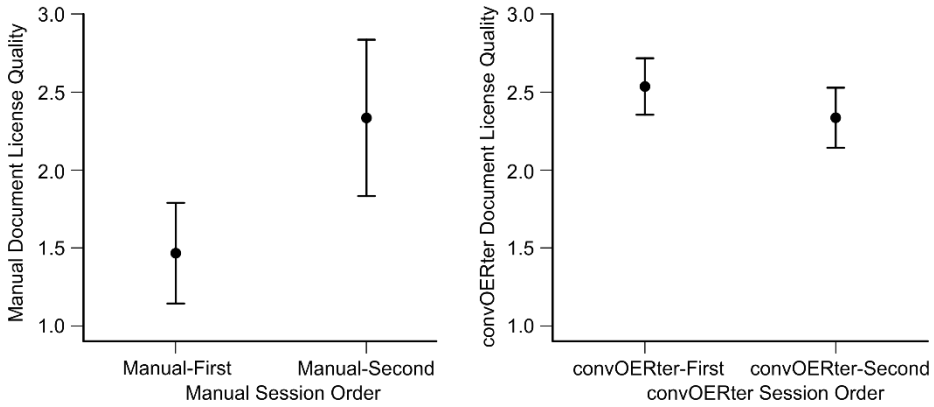

Figure 70: An interval plot for quality files licences scores according to the order of practical sessions

As can be noticed from the Table and the Figure, there was a noticeable improvement on the average manual document licence quality after using convOERter in the first practical session. On the other hand, there was no improvement or even a slight degradation in the document licence quality when convOERter was used after the manual conversion. This indicates that there is no positive effect concerning licence quality when using convOERter after the manual conversion.

In order to test if there is a significance enhancement on the quality of documents licences caused by performing the conversion sessions twice within the workshops, an Independent Samples T-Test was performed. Before running this test, the assumption checks for the normality and equality of variances must be performed. Accordingly, a Shapiro-Wilk test of normality and Levene's test of equality of variances have been conducted respectively. Tables 24 and 25 presents the results of running the assumption

checks for the manual conversion sessions and Tables 26 and 27 introduces the results of running the assumption checks for convOERter sessions.

Table 24: Results of running test of normality for the manual document licence quality

Test of Normality (Shapiro-Wilk)			
		W	p
Manual Document Licence Quality	Manual-First	0.713	< .001
	Manual-Second	0.716	.001
Note. Significant results suggest a deviation from normality.			

Table 25: Results of running test of equality of variance for the manual document licence quality

Test of Equality of Variances (Levene's)				
	F	df_1	df_2	p
Manual Document Licence Quality	0.435	1	25	0.516

Table 26: Results of running test of normality for convOERter document licence quality

Test of Normality (Shapiro-Wilk)			
		W	p
convOERter Document Licence Quality	convOERter-First	0.637	< .001
	convOERter-Second	0.598	< .001
Note. Significant results suggest a deviation from normality.			

Table 27: Results of running test of equality of variance for convOERter document licence quality

Test of Equality of Variances (Levene's)				
	F	df_1	df_2	p
convOERter Document Licence Quality	3.152	1	52	0.082

The result of running Shapiro-Wilk test for both categories (manual- and convOERter Document Licence Quality) shows that the assumption of normality is violated and both categories are not normally distributed (Shapiro-Wilk, $p < 0.05$) for the groups within the two categories. Whereas running the Levene's test to check for the equality of variances revealed that there is no difference in variance and the assumption of homogeneity of variance was not violated (Levene's test, $p > 0.05$) for both categories. Accordingly, the Mann-Whitney U test was performed to test if there was any statistical difference on the quality of documents licences between the first and second conversion sessions. The results of running Mann-Whitney U test for the manual and convOERter document licence quality are shown in the following table and illustrated graphically using box plots in Figure 71.

Table 28: Results of running Mann-Whitney U test for the manual and convOERter document licence quality

Independent Samples T-Test						
	W	**df**	**p**	**Hodges-Lehmann Estimate**	**Rank-Biserial Correlation**	**SE Rank-Biserial Correlation**
Manual Document Licence Quality	35.50	--	0.005	-1.000	-0.606	0.224
convOERter Document Licence Quality	432.0	--	0.148	1.438×10^{-5}	0.200	0.158
Note. For the Mann-Whitney test, effect size is given by the rank biserial correlation.						

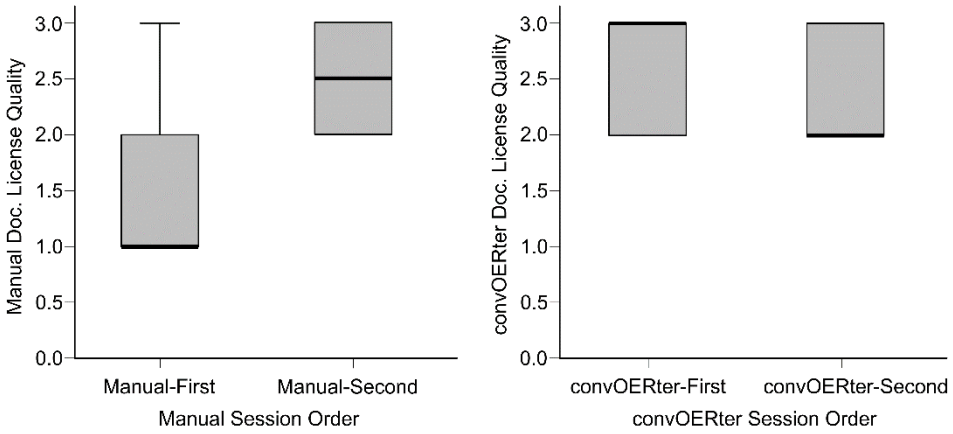

Figure 71: Box plots of convOERter and manual documents licence quality based on practical session order

As can be seen from the Table and the Figure above, the results of running Mann-Whitney test for the manual and convOERter document licence quality were not statistically significant (Manual Document Licence Quality, $U = 35.500$, $p = 0.005$; convOERter Document Licence Quality, $U = 432.000$, $p = 0.148$). This means that converting the materials manually after converting them semi-automatically using convOERter and vice versa doesn't significantly affect the licence quality of converted document. Although it has been noticed, while investigating the processed files, that some participants in Cross-Design workshops (convOERter then manual conversion) applied convOERter method to license their documents, this has not been confirmed to be statistically significant.

8.3.3. Total Efficiency

In order to calculate the total efficiency of licensing images for both conversion processes (i.e. manual vs. semi-automatic) to depict if there was a substantial enchantment when using convOERter to convert the files, the three previously introduced parameters (time per image, number of licenced images and quality of image licences) were considered. The formula was derived by combining these three

parameters. Since the efficiency is proportional to the number of images and the quality of the converted images, and inversely proportional to the time required, the following formula was determined:

$$Efficiency = \frac{number\ of\ licenced\ images \cdot quality\ of\ image\ licence}{time\ per\ image}$$

According to this formula, the efficiency for each uploaded file (manually and semi-automatically) has been calculated. Table 29 presents an overview of the manual and convOERter efficiency according to the workshop type and it is illustrated graphically using an interval plot in Figure 72.

Table 29: An overview of the manual and convOERter efficiency according to workshop type

	Manual Efficiency			convOERter Efficiency		
	Normal Design	**Cross Design**	**Short Design**	**Normal Design**	**Cross Design**	**Short Design**
N	21	18	-	24	18	12
Median	0.810	0.915	NaN	2.500	1.625	1.880
Mean	0.808	0.901	NaN	2.686	1.742	1.799
Std. Deviation	0.496	0.804	NaN	0.965	0.777	0.846
Minimum	0.050	0.030	∞[a]	1.330	0.250	0.290
Maximum	2.000	2.730	-∞[a]	5.000	3.750	3.750
[a] Infimum (minimum) of an empty set is ∞, supremum (maximum) of an empty set is -∞.						

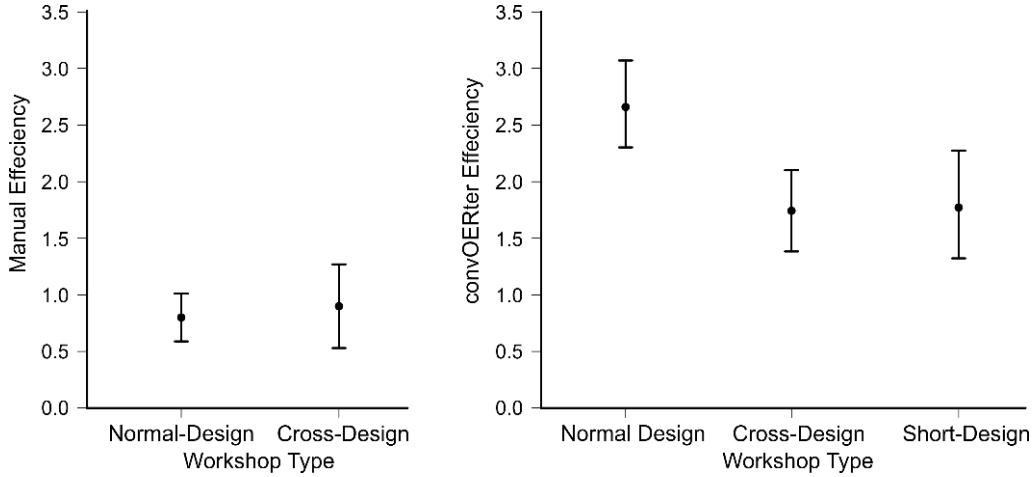

Figure 72: An interval plot for the manual and convOERter efficiency according to workshop type

It can be noticed from the descriptive statistics in the Table and the Figure above, that there was a remarkable enhancement in the total efficiency in both workshop types when using convOERter in comparison to the manual conversion. This could be a good indication to which extent has convOERter enhanced converting already existing materials into OER in comparison to the manual conversion.

8.4. Survey Analysis

As mentioned earlier, a three-part survey was conducted to gather participants' feedback on manual and semi-automatic conversion, as well as some demographic data about the participants. The survey has been discussed with colleagues at the Learning Technologies Research Group of RWTH Aachen University, who have provided their comments and feedback to the survey. In the following two subsections, the structure of the survey and its three parts will be introduced. Then the qualitative results and findings will be discussed, which are mainly related to the participants' feedback, recommendations and suggestions about the tool.

8.4.1. Survey Structure

In order to gather and analyse participants' feedback regarding the tool and the two practical sessions, it was necessary to document that using a questionnaire or a survey. The online survey tool (Limesurvey[65]) was used to host the intended questions. As mentioned previously, the survey consisted of three parts that were linked together by asking each participant to generate a participant code. The participant's code was generated as follows:

- First letter of your father's first name (A-Z)
- First letter of your mother's maiden name (A-Z)
- Day of your own birthday as two digits (01-31)
- Day of your father's birthday as two digits (01-31)

The participants have been asked to generate this code at the beginning of the workshop, at the end of the first practical session, and the end of the second practical session. The participants feedback was extracted as an excel sheet and concatenated together using the participant code. A list of all questions for the three parts of the survey can be found in the Appendices D, E, and F respectively.

The survey questions have been formulated and structured to provide us with detailed feedback about the manual and semi-automatic conversion in addition to an overview about the participants pre-knowledge and experience in the domain of OER. This information enabled us to understand the relationship between users' pre-experience and recommending or using the tool, which will facilitate determining the target group that could benefit the most from the tool. Additionally, the survey included open-ended questions, which have been used to collect participants suggestions regrading enhancing the tool or the problems they faced when using the tool. In the following subsection, the qualitative results of the survey will be presented concentrating mainly on recommending the tool and users' feedback to enhance the tool.

8.4.2. Survey Results and Findings

The collected responses from all participants in all types of workshops (Normal-, Cross, and Short-Design) have been analysed to determine the target group that would benefit

[65] https://www.limesurvey.org/en/

from the tool. The analysis has been done taking participants' pre-experience into account. Additionally, participants' feedback to open-ended questions have been investigated to determine the advantages and drawbacks of both manual and semi-automatic conversion processes.

In the following, the aspect of determining the target group that could benefit the most from the tool, and the aspect concerning the participants' feedback will be introduced.

1. Utilizing the tool

The survey involved questions requesting the participants to determine the degree of their proficiency and experience in the domain of OER. This has been done using 4-Point Likert Scale ranges from "non proficient at all" to "very proficient" for specifying the proficiency. Table 30 introduces a mapping between 4-Point Likert Scale and participants' proficiency.

Table 30: Mapping Likert Scale to the degree of proficiency

Likert Scale Point	Participants Degree of proficiency
0	Non proficient at all
1	Not very proficient
2	Somewhat proficient
3	Very proficient

Furthermore, it contained questions regarding whether the participants would recommend the tool for converting already existing materials. The answers of both types of questions were mapped in order to determine whether the tool would be recommended or used by the experts or by the beginners. Additionally, the calculated processing time per image and the document licence quality for the manual and convOERter sessions have been mapped to the degree of proficiency stated by the participants in the survey. Table 31 shows the degree of recommending the tool according to participants' proficiency.

Table 31: Average recommendation scores (0-3) of convOERter according to participants' proficiency in OER

	How likely is it that you would recommend the convOERter tool to colleagues who want to convert material into OER?			
	0	**1**	**2**	**3**
N	15	17	30	10
Median	3.000	2.000	3.000	2.500
Mean	2.267	2.176	2.467	2.400
Std. Deviation	0.884	0.728	0.629	0.699
Minimum	1.000	1.000	1.000	1.000
Maximum	3.000	3.000	3.000	3.000

Recommendation and probability scores:
0: Highly unlikely
1: Unlikely
2: Probably
3: Very Likely

By examining the Table, it can be noticed that the average recommendation of "proficient" participants (degree of proficiency 2 and 3) was more than the "non-

proficient" users and "the non-proficient at all". This was a positive implication, since the OER-experienced participants know the potential overhead of producing or converting the materials manually. Accordingly, they recommended convOERter and emphasized (through their recommendation) that the tool would be a valuable addition to their colleagues or to the OER-community.

Furthermore, the participants were asked if they would use the tool in the future to convert their materials into OER. The proficient participants stated again they would use the tool in the future as indicated from the average probability scores in Table 32. This also could be interpreted as a positive attitude, as the tool may motivate the OER proficient people to convert their educational materials into OER.

Table 32: Probability scores of using convOERter classified according to participants' proficiency in

	How likely is it that you would use the convOERter tool in the future to convert your material into OER?			
	0	**1**	**2**	**3**
N	15	17	30	10
Median	2.000	2.000	2.000	2.000
Mean	1.933	2.059	2.300	2.200
Std. Deviation	0.799	0.748	0.794	0.789
Minimum	1.000	1.000	0.000	1.000
Maximum	3.000	3.000	3.000	3.000

To further analyse participants' responses regarding the manual and semi-automatic conversion process, the participants were asked to provide their ratings regarding the complexity of finding suitable CC images in the OER portals and licensing the document manually. Moreover, they were asked to provide their feedback on how convOERter supported them in licensing the images and the documents. The responses were mapped to 4-Point Likert Scale (0-3), as can be seen on the side note and correlated to participants' proficiency as illustrated in the following two Tables.

Table 33: Average complexity scores (0-3) of finding CC images and manually licensing the files according to participants' proficiency in OER

	How complicated was finding a suitable CC image in the given OER portals?				**How complicated was manually converting the document into OER?**			
	0	**1**	**2**	**3**	**0**	**1**	**2**	**3**
N	8	12	23	11	8	12	23	11
Median	2.000	1.500	2.000	1.000	2.000	2.000	2.000	1.000
Mean	1.625	1.333	1.565	0.909	1.875	1.667	1.609	1.182
Std. Deviation	0.518	0.985	0.945	0.539	0.354	0.651	0.656	0.603
Minimum	1.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000
Maximum	2.000	3.000	3.000	2.000	2.000	2.000	3.000	2.000

Degree of complexity:
0: Very simple
1: Rather simple
2: Rather complicated
3: Very complicated

Table 34: Average support scores (0-3) of convOERter in licensing images and files according to participants' proficiency in OER

	To what extent did the convOERter tool help with licensing the individual images?				To what extent did the convOERter tool help with licensing the document?			
	0	**1**	**2**	**3**	**0**	**1**	**2**	**3**
N	15	17	30	11	15	17	30	11
Median	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
Mean	2.400	2.647	2.467	2.727	2.400	2.588	2.667	2.364
Std. Deviation	0.737	0.493	0.629	0.467	0.828	0.618	0.547	0.809
Minimum	1.000	2.000	1.000	2.000	1.000	1.000	1.000	1.000
Maximum	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000

Degree of tool's support:
0: Not helpful at all
1: Not very helpful
2: Rather helpful
3: Very helpful

As can be seen from the two Tables, the complexity of finding the appropriate CC images and licensing the files manually differs among participants. As the "very proficient" participants stated that it is not much complicated (Mean<1.0) to find CC images, the "non-proficient participants" reported a higher degree of complexity (Mean>1.5) for the same task. The same applied for manually converting the document into OER, where the "non-proficient" stated the highest average degree of complexity for converting the documents in comparison to the "proficient participants". In terms of whether convOERter is helpful in licensing images and documents, there was no obvious correlation between participants' proficiency and the level of support. However, all categories of participants indicated that convOERter provides a good level of support (mean >=2.3).

2. Participants' proficiency and conversion efficiency

In the following, a correlation between participants' proficiency and the processing time (time per image), the quality of documents licences, the number of converted images for both conversion sessions and the total conversion efficiency will be introduced and discussed. Next, participants' responses grouped by their level of proficiency, on the extent to which convOERter tool was helpful in converting the given file into OER are highlighted.

Table 35 displays an overview on the processing time per image for the manual and semi-automatic conversion processes classified according to participants' proficiency.

Table 35: Time per image in minutes for the manual and semi-automatic conversion processes according to participants' proficiency

	Time per Image Manual				Time per Image convOERter			
	0	**1**	**2**	**3**	**0**	**1**	**2**	**3**
N	8	7	17	7	11	8	26	9
Median	6.170	4.170	4.830	2.500	2.330	2.000	2.835	2.170
Mean	8.053	7.063	6.774	2.713	2.290	2.146	2.761	2.834
Std. Deviation	6.169	6.242	4.865	0.905	0.867	0.866	0.799	1.697
Minimum	3.400	2.800	2.800	1.830	1.000	1.000	1.170	1.330
Maximum	22.00	20.00	21.00	4.330	4.000	4.000	4.200	7.000

As can be seen from the examination of average processing time per image, the more experienced participants were, the faster they were at manually converting their materials (images). This seems logical, as manual conversion requires specific skills or expertise in where to find appropriate resources (images), how to license them correctly, and experience in dealing with Creative Commons licences and the TASLL rule. However, when examining the time per image for the convOERter sessions, it can be noted that the differences in the processing time between different groups of participants have been minimized and all groups of participants processed their images faster, especially the non-proficient ones. The interpretation of this is the functionality provided by convOERter, which enables converting the materials without pre-knowledge in OER. Accordingly, it can be concluded, that convOERter would be a great assistance tool for the non-proficient users and a helpful or supportive tool for the proficient ones.

Additionally, the relationship between participants' proficiency and the quality of the licenced documents has been investigated. Table 36 shows the results of mapping the degree of participants' proficiency in the manual and semi-automatic conversion sessions to the licence quality of the processed files. Here, we can also notice that proficient participants generated the best licence quality of manually generated documents. This also can be attributed to their pre-experience and knowledge in the field of OER. Using convOERter has not only minimized the differences among the quality licence scores of generated documents, but also improved the licence quality for all participants, especially the non-proficient ones.

Table 36: Document licence quality for the manual and semi-automatic conversion processes classified by participants' proficiency

	Manual Document Licence Quality				**convOERter Document Licence Quality**			
	0	**1**	**2**	**3**	**0**	**1**	**2**	**3**
N	5	3	12	7	11	8	26	9
Median	1.000	1.000	2.000	2.000	2.000	2.000	2.000	3.000
Mean	1.200	1.333	1.917	2.429	2.364	2.375	2.423	2.667
Std. Deviation	0.447	0.577	0.996	0.535	0.505	0.518	0.504	0.500
Minimum	1.000	1.000	0.000	2.000	2.000	2.000	2.000	2.000
Maximum	2.000	2.000	3.000	3.000	3.000	3.000	3.000	3.000

Another aspect that has been considered to draw a relationship between the degree of the participants' proficiency and the outputs achieved in the practical sessions is the number of processed images. As can be observed form Table 37, the proficient participants were able in average to convert the maximum number of images manually. Using convOERter supported the non-proficient participants notably and enabled them to convert a higher number of images. Further, there was an enhancement on the average number of processed images when using convOERter compared to the average number of manually converted images for other categories of participants.

Table 37: Number of processed images for the manual and semi-automatic conversion processes classified by participants' proficiency

	No. of Manually Licenced Images				No. of convOERter Licenced Images			
	0	**1**	**2**	**3**	**0**	**1**	**2**	**3**
N	8	7	17	7	12	9	26	9
Median	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Mean	4.250	4.143	3.647	5.000	4.583	4.889	4.846	4.667
Std. Deviation	1.488	1.574	1.579	0.000	1.165	0.333	0.368	1.000
Minimum	1.000	1.000	1.000	5.000	1.000	4.000	4.000	2.000
Maximum	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000

As a final comparison, the total efficiency (introduced in subsection 8.3.3) for both conversion processes were mapped to the participants' degree of proficiency. The results are displayed in Table 38. It can be seen that the very proficient participants were the most efficient in converting their images manually. Using convOERter not only increased their efficiency, but also the efficiency of all other categories, especially the non-proficient. This can be seen by observing the improvement in the descriptive statistics values in the Table below.

Table 38: Total efficiency for the manual and semi-automatic conversion processes classified by participants' proficiency

	Manual Efficiency				convOERter Efficiency			
	0	**1**	**2**	**3**	**0**	**1**	**2**	**3**
N	8	7	17	7	11	8	26	9
Median	0.810	0.740	0.710	1.150	2.140	2.500	1.775	2.310
Mean	0.735	0.826	0.663	1.464	2.409	2.630	1.952	2.127
Std. Deviation	0.517	0.617	0.439	0.950	1.294	1.131	0.745	0.983
Minimum	0.030	0.050	0.040	0.330	0.250	1.000	0.950	0.290
Maximum	1.470	1.670	1.470	2.730	5.000	5.000	4.290	3.750

The preceding comparisons and discussions conclude that convOERter is a valuable addition for the non-proficient people interested in OER and a good support for the proficient people in converting images into OER. This was also underlined by the participants' answers to the question "To what extent can convOERter support converting files into OER?". Participants' responses are shown in Table 39, which indicates that all categories of participants rated this positively (Mean > 2.0).

Table 39: Participants' responses to which extent can convOERter support in converting the files into OER

	To what extent did the convOERter tool help with the conversion of the given file into OER?			
	0	**1**	**2**	**3**
N	15	17	30	11
Median	2.000	2.000	2.500	3.000
Mean	2.267	2.294	2.400	2.364
Std. Deviation	0.799	0.772	0.675	0.809
Minimum	1.000	1.000	1.000	1.000
Maximum	3.000	3.000	3.000	3.000

Degree of tool's support:
0: Not helpful at all
1: Not very helpful
2: Rather helpful
3: Very helpful

3. Participants' feedback to open-ended questions

Within the three parts of the survey, the participants were requested to answer three open-ended questions. The questions were oriented to collect participants' feedback concerning the manual and semi-automatic conversion as well as gathering their suggestions regrading enhancing the functionality of the tool. Filling out these questions was optional. Accordingly, some participants responded and answered the questions and some did not. Fifty responses have been gathered in total for the three questions as can been seen in the following table.

Table 40: Total responses to the open-ended questions

Question	Number of Answers
Do you have any further feedback or comments regarding the manual conversion of files into OER?	8
Do you have any feedback or suggestions on the functionality and user-friendliness of the convOERter tool?	33
Do you have any further feedback or comments regarding the semi-automated conversion of material into OER?	9

All participants' answers for each question have been classified and analysed. Since the number of questions and the number of answers were not high, the analysis has been done by hand and no software tool has been used for this qualitative investigation. The procedure used for this investigation is to inspect each answer, find the main keyword or keywords, collect similar keywords together and group them in categories. This process has been repeated for the three questions. Participants' responses to the first and second questions (manual conversion and convOERter) and the number of answers for each feedback (in brackets) has been collected and summarized in Table 41.

In addition to collecting participants' feedback to the manual and convOERter conversion, the participants were asked to provide their suggestions or ideas for improving the functionality of the tool in future development iterations. All suggestions have been analysed, filtered out and summarized as follows:

- Further options to edit the images such as brightness, saturation, etc.
- Support of more formats.
- Auto-Complete search terms while typing.
- Preview the whole document after replacing the images.
- Feedback after uploading the file.
- Built-in translator for keywords.

Table 41: Participants' responses regrading manual conversion and convOERter

Do you have any further feedback or comments regarding the manual conversion of files into OER?	
Pro	**Con**
Manual conversion is not very complicated (3)	Manual conversion takes a lot of time (3) Requires extra skill and knowledge (2)
Do you have any feedback or suggestions on the functionality and user-friendliness of the convOERter tool?	
Pro	**Con**
Automatic attribution works well (3) Saves a lot of time (1) Very Helpful Tool (2) Functionality works impressively well good work (2)	Licence should be chosen at the end (1) Image order should match slides (1) Tool has some minor issues (4) Automated keyword generation / image suggestion & recognition does not work well (3) Issues when uploading images from computer (1) Search function needs to be improved and include more portals (12)

8.5. Discussion and Limitations

The accomplished study presented in pervious sections to determine the effectiveness of convOERter compared to the manual conversion shows that convOERter can facilitate converting already existing materials by accelerating the conversion process and enhancing the quality of materials' licences (images as well as the complete documents). Additionally, the results emphasize that the tool would be a valuable addition to the community, especially for users less experienced with OER. However, the study presented some limitations and difficulties, which must be mentioned and should be taken into consideration in future research.

One of the challenges during the preparation for the study was finding sufficient number of participants. Many potential candidates from different educational institutions were

contacted and 14 OER-Workshops were planned. However, as mentioned previously, only 11 workshops have taken place and the other workshops have been cancelled due to low number of participants and due to internet connectivity problems. This limited having an adequate number of participants to evaluate the concept which would have been more representative. In addition, the three-hour duration of the workshops presented another challenge, as even fewer people were willing to take three hours to participate in the workshops. Accordingly, the extended workshops have been redesigned and shortened to offer the Short-Design workshops (i.e. 90-minutes workshops).

Another problem that needs to be highlighted, and that can also occur in many research studies or experiments, is that not all participants took part seriously or effectively in the study and fully completed the designated tasks (In this case: filling out the three parts of the survey, converting the files manually and with convOERter, and uploading the processed files in sciebo). Table 42 shows the total number of participants in all workshops and how many of them participated actively in the study. Active participation means that the participant has at least filled out the survey or processed at least one file and uploaded it to sciebo. As can be seen from the Table, only about 60% of the participants have uploaded the convOERter-files successfully and about 74% of all the participants have filled out the survey completely. This could be due to participants' unfamiliarity with sciebo system or internet connectivity problems, which delayed accordingly up- or downloading the files. As a result, valuable data has been lost.

Table 42: An overview about the active participation in the workshops

Workshop code	Number of particip.	Number of active particip.	Survey compl. filled	Manual-File uploaded	convOERter File uploaded	Both files uploaded
JTEL-ND-1	8	5	5	4	3	3
EXACT-ND-2	5	5	4	3	4	3
TUG-ND-3	16	15	15	5	7	5
EXACT2-ND-4	8	5	5	5	4	4
FNMA-ND-5	6	6	6	5	6	5
ORCA-CD-1	11	11	9	8	10	8
AVEI-CD-2	9	9	6	6	5	5
MONT-CD-3	7	7	4	4	3	3
CAMP-SW-1	9	8	5	No files	6	x
BRIDG-SW-2	5	5	4	No files	4	x
DIDAKT-SW-3	7	7	5	No files	2	x
Total	91	83	68	40	54	36

Furthermore, a limitation that needs to be addressed is the method used to calculate the files processing times. Here, the processing time was considered to be the duration for downloading the file, converting it, and uploading it to the shared-cloud storage.

However, as we had no control over the participants' actions between down- and uploading the files, the processing times may include time not spent on the conversion but anything else. In the future, this may be handled differently by considering tool log data for convOERter sessions and applying further control procedures for the manual sessions. Also, having two execution settings (online and in-person) may have resulted in slight differences in processing times. While the participants in the online workshops received the links (to the survey, the tool, and the files) via the video conferencing chat, participants in in-person workshops received the same links in a printed format (see Appendix L).

In conclusion, the presented study provided answers to the formulated research questions, and its results showed that convOERter would be a helpful tool for the OER community of experts and beginners. However, we strongly recommend to extend and strengthen the findings by conducting further studies with OER-interested people from different fields (e.g. school teachers) and/or using real educational materials. For future work, it is planned to further develop and extend the tool functionality, so that it could be possible to process more file types, use more extensive search options, and support further image processing.

Chapter 9. Conclusions and Future Work

In this Chapter, the work presented in this thesis is concluded and the major findings are summarized. Then, the main scientific contributions and responses to research questions are highlighted. Finally, the potential future work is outlined and further research directions are suggested.

9.1. Conclusions

Open Educational Resources are considered essential building blocks in educational systems as they facilitate free access to learning and teaching materials. Based on an extensive literature review and a practical experience gained from working on OER projects, the challenges still face the deployment of OER and a potential research gap has been addressed.

This thesis addresses the challenge of the lack of technical tools for converting existing educational materials into OER. Accordingly, a web-based tool (convOERter) has been deigned, implemented and evaluated. The concept of the tool is based on reading a file, extracting all images and semi-automatically replacing them with OER compliant images. The current version of the tool handles images because they are the most used resource according to a pre-survey conducted with educators at an early stage of the research.

The tool was initially developed and incrementally improved in several test iterations within OER preliminary-workshops held internally at RWTH Aachen University and internationally at several universities and conferences. Feedback from the participants of these workshops was taken into account in the further improvement of the tool until reaching a stable version that has been used later in the evaluation process.

An evaluation system was developed and integrated into the tool to track its usage. The system enables tracing user actions and collecting users' feedback directly from within the tool. The evaluation system gave us insights on how the tool is used, the drawbacks that could be improved, and the future development of the tool.

To assess the effectiveness of the tool in converting materials into OER semi-automatically in comparison with the traditional manual conversion, a series of evaluation workshops have been designed and conducted. In the theoretical part of these workshops, the basics of OER, the fundamentals of converting a document manually according to the TASLL rule and the concept of converting a document semi-automatically were introduced. In addition, the participants performed two practical tasks: converting a file into OER manually and semi-automatically using convOERter. The order of the practical tasks was interchanged in some workshops to investigate whether there was a learning effect. At the beginning of the workshops and after each practical session, the participants were requested to fill out a survey to collect their

feedback on the manual and the semi-automatic conversion and to get some information about their background on OER.

The collected data from the survey and the converted files were analysed and interpreted. The results show that using convOERter noticeably enhances processing time, licence quality of images and files, as well as the total conversion efficiency. Moreover, analysing participants survey responses revealed that all categories of participants regardless of their proficiency in OER, would recommend the usage of the tool. This implies that convOERter would be a helpful tool for the OER community whether experts or beginner to produce more OER.

9.2. Contributions

The contribution of this dissertation can be classified into theoretical and practical contributions. Both are related to and derived from the research questions. Firstly, the theoretical and practical contributions are summarized. Then, the answers to the introduced research questions are highlighted.

Theoretical and practical Contributions

This dissertation provides a thorough review of various research areas related to the field of OER. The major adjacent research areas that have been addressed are: OER Recommender Systems, OER Certification, and OER Quality. Followed by that an examination of previous research and existing applications related to OER tools have been analysed. Depending on this analysis, the open questions and research gap have been identified and the solution in the form of developing an OER conversion tool has been proposed.

From the practical point of view, this dissertation introduces a novel tool that facilitates converting existing resources into OER. The tool has been tested and used by many educators and OER enthusiasts in various OER workshops and universities. In addition, the functionality of the tool in comparison to traditional manual conversion was evaluated in user study conducted in 2022. The overall results show that the tool would be a valuable addition to the OER community, especially for people, who have no or little experience in OER.

Answering the research questions

This dissertation addressed three sub-research questions that led to answering the main research question. In the following, the three sub-research questions are highlighted and the corresponding work performed in addition to the results obtained are summarized. The main research question is then revisited and the overall contribution is briefly outlined.

The first sub-research question (S-RQ1) addressed the concept and the design of the technical tool that can support educators in converting their materials into OER. This question has been answered in Chapter 6, where the tool concept and design as well as the implementation has been introduced. Identifying the concept of the tool based

mainly on the theoretical analysis of the current research in OER and addressing the gap of converting existing materials into OER. The design of the tool, on the other hand, is based on a more practical approach where the known tools that can support producing OER were investigated and a preliminary survey was conducted to identify the real needs of the community.

The second sub-research question (S-RQ2) considered the effectiveness of semi-automatic conversion of educational materials into OER compared to the manual conversion in terms of licence quality, conversion speed, and the total efficiency. To answer this question, a comparative user study was conducted by offering a series of OER workshops and analysing the data collected in these workshops. The results show that converting the documents semi-automatically using the tool enhanced the licence quality of images and files, reduced processing time and improved the total efficiency of the conversion process. This question has been answered in Chapter 8, which presented and discussed the evaluation workshop design, the execution setup, and final evaluation results.

The third sub research question (S-RQ3) examined if there is a relationship between the proficiency in OER and the efficiency of converting the materials semi-automatically or manually into OER. This question has been answered in section 8.4.2, where a thorough investigation of participants' responses to a dedicated survey has been conducted and mapped to their performance in practical sessions in the workshops. This investigation enabled understanding the relationship between participants' proficiency in OER on one hand and their recommendations regarding using the tool and the overall performance on the other hand. As a result, answering this question provided some insights into the target group that could benefit most from the tool.

The work done within the three sub-research questions enabled answering the main addressed research question: "Can a technical assistance tool support the production of OER by converting images in existing educational materials into OER?", which is the goal of this dissertation.

9.3. Future Work

Despite the contributions achieved in this thesis and answering the addressed research questions, there are many research directions and further developments that could be conducted in the future. The scope of the future work can be divided into the following three directions: Improving the functionality of the tool, further OER research in the area of technical support, and extending the user study conducted in this dissertation. In the following, these directions will be elaborated.

IMPROVING THE FUNCTIONALITY OF THE TOOL

As mentioned earlier, convOERter has been tested in many OER workshops and used by the community by distributing the tool link in many portals. This allowed gathering feedback from the participants regarding the tool functionality. The collected feedback

addressed many issues and can be used in the future development of the tool to improve its functionality.

One of the frequent requests of the participants is to extend the number of search engines and improve the search function so that it would be possible to search in more image portals (not only in Flickr and Openverse) and thus increase the possibility of finding more suitable images. Moreover, the participants suggested adding more options for editing the images like brightness and saturation or deleting the image. Other suggestions were related to support more file types such as pdf, as they are commonly used in educational contexts. To get an overview of the edited file, participants also suggested adding a feature to preview the entire document before saving it. However, one of the most frequently expressed requests is to consider other elements such as icons beside images.

From the administrator's perspective, we are planning to enable the users to save their files temporarily and continue editing them later. Additionally, as it was observed that excluding the logos from the licences has been forgotten by most users, a confirmation message can be added to ask the users whether they have excluded the logos. In addition, convOERter can be further developed to enhance the image recognition by using Artificial Intelligence (AI).

Moreover, the evaluation system presented in section 7.2 can be further improved by introducing a user login mechanism and using user IDs to identify the specific user logs and track the usage of the tool. This will enable collecting data regarding the actual use of the tool and tracking how users utilize the tool over time (Shetty, 2022). Additional updates can be made to the system dashboard, where further analysis periods can be provided, along with support for downloading analysis visualization data in other formats (Shetty, 2022). Further suggestions concerning the evaluation system can be found in the master thesis of Shetty in (Shetty, 2022).

FURTHER OER RESEARCH IN THE FIELD OF TECHNICAL SUPPORT

Extensive research has been accomplished so far in the field of OER as has been previously demonstrated in Chapter 3. However, further investigations can still be conducted especially in the field of technical support for producing OER. The work done in this dissertation represents an initial step to consider already produced educational materials. Nevertheless, further research can be conducted to examine the long-term effect of convOERter on facilitating the production of OER and motivating educators to produce more OER and thus expanding the educational material pool.

Other studies can be conducted to analyse the effect of other technical tools on improving the utilization of OER. As such, OER workshops can be conducted with these tools and their effects can be tested. As a long-term study, the participants' activities in the field of OER can be observed or they could be interviewed to analyse the effect of the respective tool(s) on enhancing the utilization of OER.

EXTENDING THE USER STUDY

As discussed in section 8.5, the user study conducted in this dissertation has some limitations and potential for improvement. For example, the study can be extended and repeated under different conditions. One of the possible scenarios is to perform the study with real educational materials and to investigate the impact of using convOERter.

Further scenarios include replicating the study with a different target group(s). Since the current study was conducted with educators and OER interested people at universities, further runs can be conducted with schoolteachers. This would allow for further feedback on the tool to be gathered and for additional OER topics to be addressed from a different perspective.

In summary, convOERter is a novel tool for converting educational materials into OER. The research conducted in this dissertation represents initial steps to analyse the efficiency of semi-automatic conversion of educational materials. Accordingly, further research can be performed in the domain of the (semi-)automatic conversion and future studies can be conducted to examine the impact of technical tools on enhancing the utilization of OER.

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Appendix B: Pre-Survey Questions-Paper-based

Survey on Utilizing OER in Higher Education[66]

1. **What is your function at your university/college?**
   - ☐ Professor
   - ☐ Lecturer
   - ☐ Research Assistant
   - ☐ Student
   - ☐ Other:_____

2. **How many years have you been teaching?**
   - ☐ Less than 1 year
   - ☐ 1 to 3 years
   - ☐ 4 to 6 years
   - ☐ 7 to 10 years
   - ☐ Over 10 years

3. **How is your course structured?**
   - ☐ Full-time face-to-face
   - ☐ Part-time face-to-face
   - ☐ Full Time Online
   - ☐ Part-Time Online
   - ☐ Other: _____

4. **In which subject area(s) do you teach?**
   - ☐ Computing and Information Science
   - ☐ Psychology and Philosophy
   - ☐ Religious Studies
   - ☐ Social Science
   - ☐ Languages & Linguistics
   - ☐ Natural Science
   - ☐ Mathematics
   - ☐ Arts
   - ☐ Literature
   - ☐ History & Geography

[66] The original survey was created by OER Hub-Research and is licenced under Creative Commons CC BY 4.0. It was translated and edited by Lubna Ali for further use. The survey serves the PhD project of Lubna Ali.

- ☐ Economics, Business & Management
- ☐ Applied Science, Technology, Engineering
- ☐ Medicine
- ☐ Health & Social Care
- ☐ Educational Science
- ☐ Sports
- ☐ Special Education
- ☐ Other (please specify): _____

5. For which of the following purposes have you used educational resources in the context of your teaching/training??

- ☐ To prepare my lectures
- ☐ To get new ideas and inspiration
- ☐ To supplement my existing lessons or coursework
- ☐ As 'assets' (e.g. images or text extracts) within a classroom lesson
- ☐ To give to learners as compulsory self-study materials
- ☐ To give to learners as optional self-study materials
- ☐ To provide e-learning materials to online learners
- ☐ To compare them with my own teaching/training materials in order to assess the quality of my materials
- ☐ To broaden the range of my teaching methods
- ☐ To broaden the range of resources available to my students
- ☐ To enhance my professional development
- ☐ To stay up-to-date in a subject or an area
- ☐ To learn about a new topic
- ☐ To engage my students more in a topic area
- ☐ To connect with teachers or learners who have similar interests
- ☐ Other (please specify): _____

6. Do you use Materials from the internet for your teaching?

- ☐ Yes
- ☐ No

7. Do you use OER in your teaching?

- ☐ Yes
- ☐ No

If you answered question 7 with **NO**, skip the following questions and continue with question 15.

8. Which, if any, of the following types of OER have you used for teaching/training?

- ☐ Open textbooks
- ☐ Whole course
- ☐ Elements of a course (e.g. a module/unit)
- ☐ Videos
- ☐ Audio podcasts
- ☐ Images
- ☐ Infographics
- ☐ Interactive games
- ☐ Lectures
- ☐ Lesson plans
- ☐ Tutorials
- ☐ Quiz questions
- ☐ E-books
- ☐ Data sets
- ☐ Learning tools, instruments and plugins
- ☐ Other (please specify): _____

9. Which OER repositories or educational sites have you used?

- ☐ iTunes / iTunesU
- ☐ YouTube / YouTubeEdu / YouTubeSchool
- ☐ TED-Talks / TED-Ed
- ☐ Merlot
- ☐ OpenLearn
- ☐ Khan Academy
- ☐ Jorum
- ☐ Curriki
- ☐ CK-12
- ☐ Wikibooks
- ☐ MIT Open Courseware
- ☐ Creative Commons
- ☐ Saylor Academy
- ☐ Massively Open Online Courses (MOOC) (z. B. FutureLearn, MITx, Coursera usw.)
- ☐ I have not used any of these sites
- ☐ I don't know any of these sites
- ☐ Other (please specify): _____

10. In which ways, if any, do you share information about the OER that you find? (Select all that apply)

- ☐ Via email
- ☐ Via a mailing list
- ☐ Via a social network (e.g. Facebook, Google+, MySpace, Beebo)
- ☐ Via blogging (e.g. Wordpress, Blogger)
- ☐ Via a video site (e.g. YouTube, Daily Motion, Vimeo)
- ☐ Via an internet forum
- ☐ Published on a personal website
- ☐ Via microblogging (e.g. Twitter, Tumblr)
- ☐ Via image sharing services (e.g. Flickr, Instagram, Pinterest)
- ☐ Via cloud-based storage (e.g. Dropbox, Google Drive)
- ☐ Via podcast
- ☐ Via virtual learning environment (VLE) (e.g. Moodle. Blackboard, ILIAS)
- ☐ Via intranet
- ☐ In person
- ☐ I don't share information about OER
- ☐ Other sharing method (please specify): _____

11. Which challenges, if any, do you most often face in using OER? (Select all that apply)

- ☐ Knowing where to find resources
- ☐ Finding suitable resources in my subject area
- ☐ Finding resources of sufficiently high quality
- ☐ Finding resources that are up-to-date
- ☐ Finding resources that are relevant to my local context
- ☐ Getting work colleagues/managers to accept the use of open educational resources
- ☐ Not being skilled enough to edit resources to suit my own context
- ☐ Not knowing whether I have permission to use, change or modify resources
- ☐ Not having enough time to look for suitable resources
- ☐ Missing/needing the support of a tutor or teacher to help me work through open course materials
- ☐ Not knowing how to use the resources in the classroom
- ☐ Not having enough time/opportunities to experiment with using open educational resources in the classroom
- ☐ Lacking institutional support for the use of open educational resources
- ☐ Resources that are not based on professional standards or regulations
- ☐ Orientation towards recognition and/or certification
- ☐ Doubts about the quality of open educational resources
- ☐ Lack of knowledge about the licensing of own materials
- ☐ Other (please specify): _____

12. Which of the following factors would make you more likely to select a particular resource when searching for open educational content?

- ☐ Evidence of interest in that resource (e.g. lots of downloads)
- ☐ The resource being recently created, uploaded or updated
- ☐ The resource being easy to download
- ☐ A description of learning objectives or outcomes being provided
- ☐ The resource being created/uploaded by a reputable/trusted institution or person
- ☐ The resource having a Creative Commons license
- ☐ The resource having an open license allowing adaptation
- ☐ The length/complexity of the resource
- ☐ Use of interactive or multimedia content (e.g. video or quiz) in the resource
- ☐ Positive user ratings or comments about the resource
- ☐ Personal recommendation
- ☐ Having previously used this resource successfully
- ☐ The resource being relevant to my particular interests/needs
- ☐ The resource featuring a catchy title or attractive image(s)
- ☐ A detailed description of the resource content being provided
- ☐ Other (please specify): _____

13. In your experience, do any of the following aspects of OER help improve retention for students who are at risk of dropping out of their course of study?

- ☐ Reduced cost of study materials
- ☐ Wider range of learning methods
- ☐ Materials can be used flexibly
- ☐ Materials can be accessed at any time
- ☐ Materials can be adapted to suit student needs
- ☐ Use of resources for improving study skills
- ☐ Materials are available in different languages
- ☐ Other (please specify): _____

14. Has the use of OER affected your sharing practices?

- ☐ No
- ☐ Yes, How? _____
- ☐ Not sure

15. Does your institution have policies for creating and/or using OER?

- ☐ Yes
- ☐ No
- ☐ Don't know
- ☐ Further comments:

  _____

16. **An international platform for finding and spreading OER is/ would be interesting for me:**
    - □ Yes
    - □ No
    - □ Don't know

17. **A tool for the automation/partial automation of the creation and editing of OER would be interesting for me:**
    - □ Yes
    - □ No
    - □ Don't know

18. **Would you (re-)use OER in the future?**
    - □ Yes
    - □ No
    - □ Don't know
    - □ Further comments: _____

Thank you for your participation!

Appendix C: Pilot Study Survey Questions-Tool

Questionnaire: The OER Converter

Demographic Questions:

1. **What is your age?**
   - ☐ 20 - 29 years old
   - ☐ 30 - 39 years old
   - ☐ 40 - 49 years old
   - ☐ 50 - 59 years old
   - ☐ 60 - 69 years old
   - ☐ 70 - 79 years old

2. **What gender do you identify as?**
   - ☐ Male
   - ☐ Female
   - ☐ Diverse

3. **Which field do you work in?**
   - ☐ Computer Engineering / Information Science
   - ☐ Psychology and Philosophy
   - ☐ Theology / Religious Studies
   - ☐ Social Studies
   - ☐ Language Studies and Linguistics
   - ☐ Natural Sciences
   - ☐ Mathematics
   - ☐ Art
   - ☐ Literature
   - ☐ History and Geography
   - ☐ Economy, Business & Management
   - ☐ Other: _____

General Questions regarding OER

1. **Have you published OER-Material before?**
   - ☐ Yes
   - ☐ No

2. **If yes, in what format?**

   _____

3. **A challenge when creating OER-Documents is finding suitable images**
   - ☐ Agree
   - ☐ Disagree

4. **If you have transferred existing documents into OER before, which problems did you encounter?**
   - ☐ I have not transferred any documents into OER yet
   - ☐ Finding comparable images was a challenge
   - ☐ The licensing was unclear
   - ☐ Other: _____

5. **How often do you generally create OER documents?**
   - ☐ Never
   - ☐ At least twice a year
   - ☐ At least twice a month
   - ☐ At least twice a week

6. **Do you use OER material for teaching purposes?**
   - ☐ No (Please skip question 7)
   - ☐ Yes

7. **The material you used was…**
   - ☐ newly created by you
   - ☐ adapted from existing documents
   - ☐ created by someone else

Tool-specific Questions

1. **The tool's User Interface is**
   - ☐ user-friendly
   - ☐ not user-friendly

2. **When using the tool, which problems did you encounter?**

_____

_____

_____

8. **The tool should support the following formats:**
   - ☐ .doc, .docx (Word Documents)
   - ☐ .ppt,. pptx (Power Point)
   - ☐ .tex (LaTeX)
   - ☐ .odt (OpenOffice Text)
   - ☐ .odp (OpenOffice Presentations)

- ☐ .pages (Pages)
- ☐ .keynote (Keynote)
- ☐ Other: _____

9. The tool can be a valuable help in transferring documents into OER

- ☐ Agree
- ☐ Disagree
- ☐ Unsure

10. Using the tool motivates me to transfer existing documents into OER

- ☐ Agree
- ☐ Disagree

11. At any point while using the tool I knew what to do

	1	2	3	4	5	
Agree						Disagree

12. The recommended images were

- ☐ Suitable
- ☐ Unsuitable

13. Using the tool was generally

- ☐ Agree
- ☐ Disagree
- ☐ Very Easy
- ☐ Easy
- ☐ Moderately Difficult
- ☐ Rather Difficult
- ☐ Difficult

14. Additional Ideas or Suggestions

_____

_____

_____

Appendix D: First Survey Questions-Evaluation

Dear participants,

As part of my dissertation, I would like to evaluate the effect of technical support on converting educational materials into OER.
Therefore, I would be very grateful if you would complete the following survey.

Please note that your information will be anonymous.

Thank you very much for your participation!

Sincerely,
Lubna Ali

This is the first part of the survey. It contains questions regarding our workshop task (converting a document into OER using convOERter). We appreciate your feedback!

section A: Participant Code

A1.
Please enter your Participant Code below. Your personal Participant Code is structured as follows:

First *letter* of your father's first name (A-Z) *First letter* of your mother's maiden name (A-Z) Day of your own Birthday as two digits (01-31) Day of your father's birthday as *two digits* (01-31) e.g. If your father's name is "Klaus", your mother's maiden name is "Schmidt", your birthday is on 20th May 1989 and your fathers birthday is on 15th January 1963, your code is KS2015.

Participant Code:_____

section B: Personal Questions

B1. What is your current position at the University?

- □ Professor
- □ Lecturer
- □ Research Assistant
- □ Student
- □ Other

B2. How many years have you been teaching?

- □ I have not taught yet
- □ Less than 1 year
- □ 1 – 3 years

- ☐ 4 – 6 years
- ☐ 7 – 10 years
- ☐ More than 10 years

B3. What subject area(s) do you teach / study in?

- ☐ Mathematics
- ☐ Natural Sciences
- ☐ Medicine
- ☐ Health and Social Care
- ☐ Applied Science, Technology and Engineering
- ☐ Psychology and Philosophy
- ☐ Religious Studies
- ☐ Social Sciences
- ☐ History and Geography
- ☐ Educational Sciences
- ☐ Special Education
- ☐ Language and Linguistics
- ☐ Literature
- ☐ Arts
- ☐ Economics, Business and Management
- ☐ Sports
- ☐ Other: _____

section C: Questions regarding OER

C1. Do you have any previous experience with Open Educational Resources (OER)?

- ☐ I have personal experience with the concept of OER
- ☐ I have heard of OER before this course, but not worked with it
- ☐ I have no experience with OER prior to this course

C2. How proficient would you consider yourself to be regarding the use of OER?

- ☐ Very proficient
- ☐ Somewhat proficient
- ☐ Not very proficient
- ☐ Not proficient at all

C3. Have you produced your own OER before?

- ☐ Yes
- ☐ No

C4. Which Licence(s) have you chosen for the OER you produced?

- ☐ CC BY - author attribution
- ☐ CC BY-SA - distribution under same license

- ☐ CC BY-ND - no derivatives
- ☐ CC BY-NC - non-commercial
- ☐ CC BY-NC-SA - non-commercial and distribution under same license
- ☐ CC BY-NC-ND - non-commercial and no derivatives
- ☐ I'm not sure

C5. Would For which of the following purposes have you used OER in the context of your teaching or training? *

- ☐ To prepare lectures or courses
- ☐ To collect new ideas and inspiration
- ☐ To supplement existing lessons or courses
- ☐ To provide learners with additional self-learning material
- ☐ To compare them with my own teaching / training material in order to assess the quality of my own material
- ☐ To broaden the range of resources available to my students
- ☐ To enhance my professional development
- ☐ To stay up-to-date in a subject / subject area
- ☐ To connect with teachers or learners with similar interests
- ☐ None of the above
- ☐ Other: _____

C6. Which (if any) of the following resources have you used before for teaching / preparing teaching material? *

- ☐ Open Textbooks
- ☐ Videos
- ☐ Audio Podcasts
- ☐ Images
- ☐ Infographics
- ☐ Games
- ☐ Lesson Plans
- ☐ Tutorials
- ☐ Quiz Questions
- ☐ e-Books
- ☐ Data Sets
- ☐ Exercise Sheets
- ☐ Learning Tools, Instruments or Plugins
- ☐ Other: _____

C7. Which challenges do you think hinder the proper deployment of OER in (higher) education? *

- ☐ Knowing where to find suitable resources
- ☐ Finding resources of sufficiently high quality
- ☐ Finding up-to-date resources
- ☐ Getting work colleagues / managers to accept the use of Open Educational Resources
- ☐ Lack of skills to edit resources to suit specific purposes

- ☐ Knowing whether one has permission to use, change, or modify resources
- ☐ Lack of time to look for suitable resources
- ☐ Lack of institutional support for OER use
- ☐ Lack of knowledge about licensing of own material
- ☐ Lack of tools for producing OER
- ☐ I'm not sure
- ☐ Other: _____

C8. Have you ever considered converting your existing educational material into OER? *

- ☐ Yes
- ☐ No

C9. Have Are you familiar with tools that could help you create OER? *

- ☐ Yes
- ☐ No

C10. Which tools for the creation of OER do you know of? *

_____

_____

_____

C11. Which file formats do you generally use within your educational practices?

- ☐ Power Point-Presentations (.ppt, .pptx)
- ☐ Word Documents (.doc, .docx)
- ☐ Open Office Presentations (.odp)
- ☐ Open Office Text Documents (.odt)
- ☐ PDF Files (.pdf)
- ☐ Text Files (.txt)
- ☐ HTML Files (.html)
- ☐ MP3 Audio (.mp3)
- ☐ MP4 Video (.mp4)
- ☐ Windows Media Video (.wmv)
- ☐ Other: _____

C12. Which file formats do you generally use within your educational practices?

- ☐ .png
- ☐ .jpeg / .jpg
- ☐ .bmp
- ☐ .wmf

- □ .gif
- □ .psd (Photoshop Format)
- □ I don't usually pay attention to image format types
- □ Other: _____

Thank you for completing the first part of our survey!
You will be redirected to the second part of the survey at a later point during the workshop.
We appreciate your feedback!
The survey serves the PhD project of Lubna Ali.

Submit your survey.
Thank you for completing this survey.

Appendix E: Survey Questions-convOERter Session

This is the second part of the survey. It contains questions regarding our workshop task (converting a document into OER using convOERter). We appreciate your feedback!

section A: Participant Code

A1.
Please enter your Participant Code below. Your personal Participant Code is structured as follows:

First *letter* of your father's first name (A-Z) *First letter* of your mother's maiden name (A-Z) Day of your own Birthday as two digits (01-31) Day of your father's birthday as *two digits* (01-31) e.g. If your father's name is "Klaus", your mother's maiden name is "Schmidt", your birthday is on 20th May 1989 and your fathers birthday is on 15th January 1963, your code is KS2015.

Participant Code:_____

section B: Feedback regarding your Workshop task - Conversion using the convOERter tool

B1. Were you able to convert the entire document into OER?

- □ Yes
- □ No

B2. Were you able to license the entire document under Creative Commons (CC)?

- □ Yes
- □ No

B3. How many images did you successfully convert into OER? 'Successfully' in this case means you found the OER image and were able to add its license.

B4. To what extent did the convOERter tool help with the conversion of the given file into OER?

- □ Very helpful
- □ Rather helpful
- □ Not very helpful
- □ Not helpful at all

B5. To what extent did the convOERter tool help with licensing the document?

- □ Very helpful
- □ Rather helpful

- ☐ Not very helpful
- ☐ Not helpful at all

B6. To what extent did the convOERter tool help with licensing the individual images?

- ☐ Very helpful
- ☐ Rather helpful
- ☐ Not very helpful
- ☐ Not helpful at all

B7. Which difficulties did you face while converting the file into OER using the convOERter?

- ☐ Finding a suitable CC image in the given OER portals
- ☐ Knowing how to use the tool
- ☐ Understanding the tool's procedure
- ☐ Lack of user-friendliniess in the tool's interface
- ☐ Other: _____

B8. Would you consider the convOERter tool as a suitable tool to convert existing educational material into OER, as opposed to manually converting the documents?

- ☐ Definitely
- ☐ Maybe
- ☐ Unlikely

section C: Future Work with OER

C1. How likely is it that you would use the convOERter tool in the future to convert your material into OER?

- ☐ Very Likely
- ☐ Likely
- ☐ Unlikely
- ☐ Highly Unlikely

C2. How likely is it that you would recommend the convOERter tool to colleagues who want to convert material into OER?

- ☐ Very Likely
- ☐ Likely
- ☐ Unlikely
- ☐ Highly Unlikely

C3. Do you think that the convOERter would be a beneficial addition for the OER community?

- ☐ Yes

- ☐ No
- ☐ I'm not sure / I don't know

C4. Please select all of the following statements you would agree with:

- ☐ I would prefer to create new OER from scratch
- ☐ I would prefer to convert existing material into OER
- ☐ I would prefer to use the convOERter to convert material into OER
- ☐ I would not consider producing OER myself
- ☐ I am unsure about how I feel about producing my own OER

C5. Do you have any feedback or suggestions on the functionality and user-friendliness of the convOERter tool?

_____

_____

_____

C6. Do you have any further feedback or comments regarding the semi-automated conversion of material into OER?

_____

_____

_____

Thank you for completing the second part of our survey!

You will be redirected to the third and final part of the survey at a later point during the workshop.

We appreciate your feedback!

The survey serves the PhD project of Lubna Ali.

Submit your survey.
Thank you for completing this survey.

Appendix F: Survey Questions-Manual Session

This is the third part of the survey. It contains questions regarding your workshop task (manually converting a document into OER).

We appreciate your feedback!

section A: Participant Code

A1.

Please enter your Participant Code below. Your personal Participant Code is structured as follows:

First *letter* of your father's first name (A-Z) *First letter* of your mother's maiden name (A-Z) Day of your own Birthday as two digits (01-31) Day of your father's birthday as *two digits* (01-31) e.g. If your father's name is "Klaus", your mother's maiden name is "Schmidt", your birthday is on 20th May 1989 and your fathers birthday is on 15th January 1963, your code is KS2015.

Participant Code:_____

section B: Feedback regarding your Workshop task - Manual Conversion

B1. Were you able to convert the entire document into OER?

- ☐ Yes
- ☐ No

B2. Were you able to license the entire document under Creative Commons (CC)?

- ☐ Yes
- ☐ No

B3. How many images did you successfully convert into OER? 'Successfully' in this case means you found the OER image and were able to add its license.

B4. How complicated was finding a suitable CC image in the given OER portals? *

- ☐ Very complicated
- ☐ Rather complicated
- ☐ Rather simple
- ☐ Very simple

B5. Which difficulties did you face while converting the file into OER? *

- ☐ Finding a suitable CC image in the given OER portals
- ☐ Licensing the found images correctly (according to the TASLL rule)

- □ Manually adding the licenses for each image
- □ Licensing the whole document
- □ Other: _____

B6. How complicated was manually converting the document into OER? *

- □ Very complicated
- □ Rather complicated
- □ Rather simple
- □ Very simple

B7. Would you be willing to manually convert your existing educational material into OER? *

- □ Very likely
- □ Probably
- □ Unlikely
- □ Highly unlikely

B8. What kind of support services or tools would you like to have at your institution in order to increase the use / efficiency of OER?

_____

_____

_____

B9. Would you be interested in having access to a tool that can support / (semi-) automize the conversion of a file into OER? *

- □ Yes
- □ No

B10. Do you have any further feedback or comments regarding the manual conversion of files into OER?

_____

_____

_____

Submit your survey.
Thank you for completing this survey.

Appendix G: List of Publications

- Ali, L., Röpke, R. & Bergner, N. (2018). OER-Sensibilisierung und Qualifizierung in der MINT-Lehrerbildung der RWTH Aachen. In: Projekte der BMBF-Förderung OERinfo 2017/2018. Sonderband zum Fachmagazin Synergie. Universität Hamburg, pp. 156–163.

- Ali, L. & Schroeder, U. (2019). A TOOL TO ENHANCE THE UTILIZATION OF OER IN HIGHER EDUCATION. EDULEARN19 Proceedings, pp. 7321–7325.
  DOI: https://doi.org/10.21125/edulearn.2019.1752

- Ali, L. (2019). Developing Methods to Automate the Utilization of OER in Higher Education. In: Zender, R. (Hrsg.), Beiträge der Doktorandenkolloquiums zur DELFI 2019. Bonn: Gesellschaft für Informatik e.V.. Berlin. 43727. https://dl.gi.de/handle/20.500.12116/31057

- Ali, L., Aufdermauer, P., Röpke, R. & Schroeder, U. (2020). Ein Webbasiertes Tool zur Konvertierung von Bildungsmaterialien in OER. In: Zender, R., Ifenthaler, D., Leonhardt, T. & Schumacher, C.(Hrsg.), DELFI 2020 – Die 18. Fachtagung Bildungstechnologien der Gesellschaft für Informatik e.V.. Bonn: Gesellschaft für Informatik e.V., pp. 387–388.

- Ali, L. & Schroeder, U. (2020). A Technical Solution to Support Converting Educational Resources to OER. In: Proceedings of EdMedia + Innovate Learning, pp. 939–943. Online, The Netherlands: Association for the Advancement of Computing in Education (AACE)

- Ali, L., Werkes, R., Röpke, R. & Schroeder, U. (2020). Der Einsatz von Open Educational Resources im Informatikunterricht- Praxisbeispiel an der RWTH Aachen. In: Thomas, M. (Hrsg.) & Weigend M. (Hrsg.), Mobil mit Informatik: 9. Münsteraner Workshop zur Schulinformatik, Books on Demand, Norderstedt

- Ali, L. & Schroeder, U. (2021). Producing OER with convOERter. First Evaluation and Feedback. In Gabellini, Cinzia, Gallner, Sabrina, Imboden, Franziska, Kuurstra, Maaike, Tremp, Peter, 2021. Lehrentwicklung by Openess – Open Educational Resources im Hochschulkontext. Dokumentation der Tagung vom 06. März 2021. Zenodo.
  DOI: https://doi.org/10.5281/ZENODO.5004445

- Ali, L., Tuan, T., Röpke, R. & Schroeder, U. (2021). A digital educational game for practicing OER editing. In: Proceedings of the 18th International Conference on Cognition and Exploratory Learning in the Digital Age; (CELDA2021) virtual; 13 - 15 October 2021; proceedings / edited by Demetrios G. Sampson; Dirk Ifenthaler; Pedro Isaías, pp. 319–322.

- Ali, L., Werkes, R., Röpke, R. & Schroeder, U. (2021). Quality Model for OER: Feedback from Computer Science Students in Teaching Programs. EdMedia + Innovate Learning, Jul 06, 2021 / Editors: Theo J. Bastiaens, pp. 743–747. United States: Association for the Advancement of Computing in Education (AACE).

- Ali, L., Knight, C. & Schroeder, U. (2022). Open Educational Resources in Higher Education: Two Approaches to Enhance the Utilization of OER. International Journal of Innovative Teaching and Learning in Higher Education 3, pp. 1–14.
  DOI: https://doi.org/10.4018/IJITLHE.313374

- Ali, L., Phung, Q., Röpke, R. & Schroeder, U. (2022). A Digital Educational Game for Practicing OER. In: Proceedings of the 19th International Conference on Cognition and Exploratory Learning in the Digital Age: (CELDA2022): November 8 - 10, 2022 / edited by Demetrios G. Sampson, Dirk Ifenthaler and Pedro Isaías, pp. 313–316.
  DOI: https://doi.org/10.33965/CELDA2022_202207C042

- Ali, L., Judel, S., Shetty, D. & Schroeder, U. (2023). An Evaluation System to Trace the Usage of the OER Conversion Tool (convOERter). In: Viberg, O., Jivet, I., Muñoz-Merino, P., Perifanou, M., Papathoma, T. (eds) Responsive and Sustainable Educational Futures. EC-TEL 2023. Lecture Notes in Computer Science, vol 14200. Springer, Cham.
  DOI: https://doi.org/10.1007/978-3-031-42682-7_60

- Ali, L., Röpke, R. & Schroeder, U. (2023). A Comparative Study on Converting Educational Materials into OER: convOERter vs. Manual. In: Proceedings of the 15th International Conference on Education Technology and Computers (ICETC 2023): September 26-28, 2023/ Barcelona Spain, pp. 168–174.
  DOI: https://doi.org/10.1145/3629296.3629322

- Ali, L., Phung, Q., Röpke, R. & Schroeder, U. (2024). A DIGITAL EDUCATIONAL GAME FOR PRACTICING OPEN EDUCATIONAL RESOURCES. In Sampson, D., Ifenthaler, D. & Isaias, P. (Eds.), Smart Learning Environments in the Post Pandemic Era. Springer (in publication).

Appendix H: Supervised Thesis

Aufdermauer (2020): Bachelor thesis „Webbasiertes Analysetool zum Ersetzen von Medienelementen“. RWTH Aachen University

Tran (2021): Bachelor thesis „Developing a Framework for Practicing OER Editing in Online Workshops“. RWTH Aachen University

Faraji (2021): Master thesis „Developing a Quality Evaluation Model to Support Identifying High Quality Images and Videos from OER Repositories“. RWTH Aachen University and TIB – Leibniz Universität Hannover

Phung (2021): Bachelor thesis „Developing a Framework to practice OER Cycle in Online Workshops Based on a Digital Learning Game“. RWTH Aachen University

AlKayyal (2021): Bachelor thesis „Design and Implementation of a Mobile Application to Enhance the Perception of OER“. RWTH Aachen University and GUtech Oman

Shetty (2022): Master thesis. „Design and implementation of an evaluation system for OER conversion tool (convOERter)“. RWTH Aachen University

Schmitz (2023): Bachelor thesis. „Entwicklung eines Moduls für die Förderung der Nutzung von OER in der Oberstufe mit Hilfe einer Web Applikation“. RWTH Aachen University

Appendix I: Screenshots of the Tool Beta Version

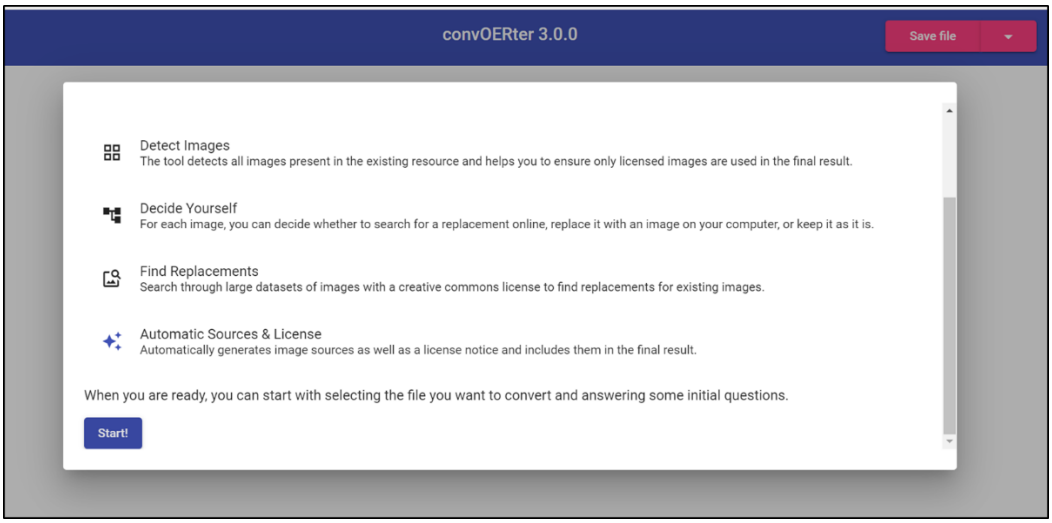


Figure 73: Screenshot of the main page of convOERter Beta version

Figure 74: Screenshot of convOERter Beta version of choosing a file and licence

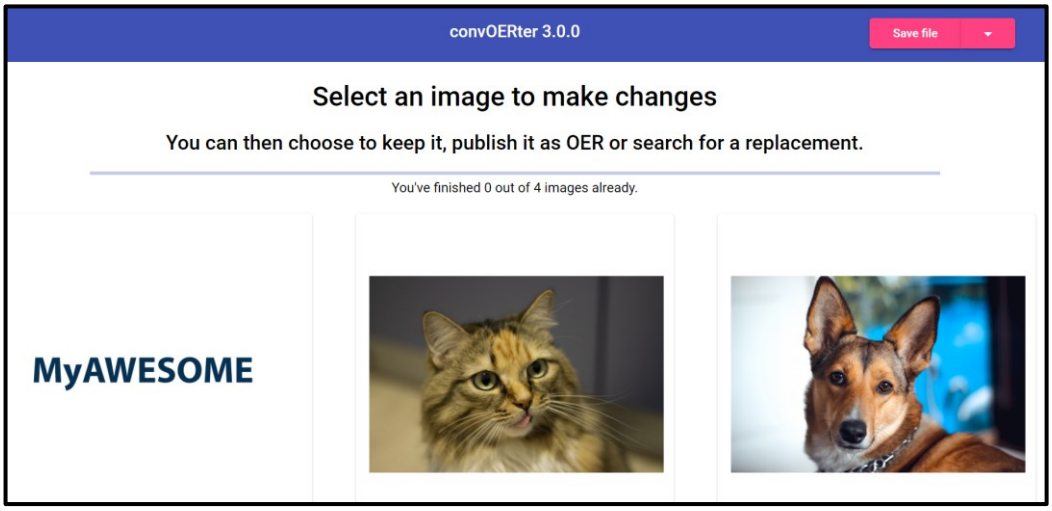


Figure 75: Screenshot of convOERter Beta version displaying non-OER images

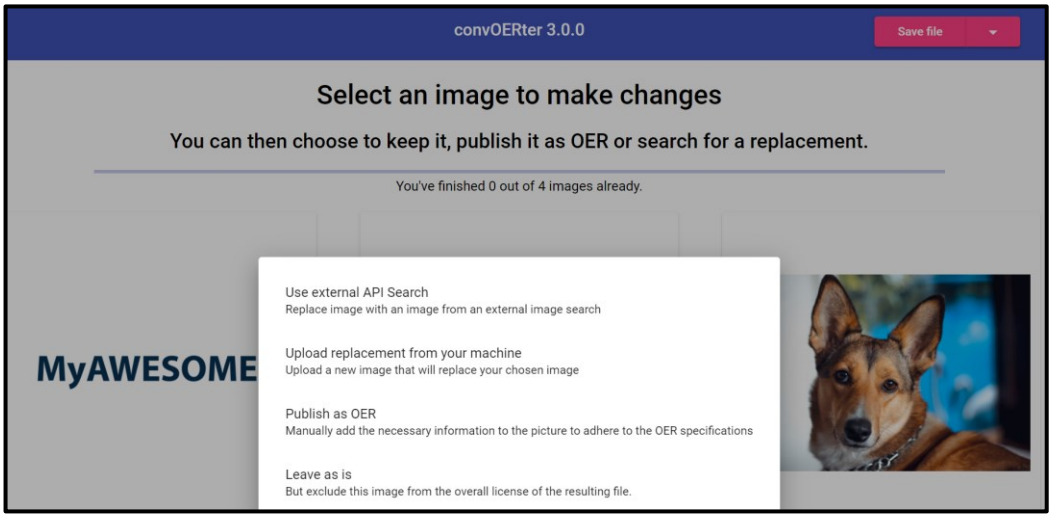


Figure 76: Screenshot of convOERter Beta version showing different options to edit the image

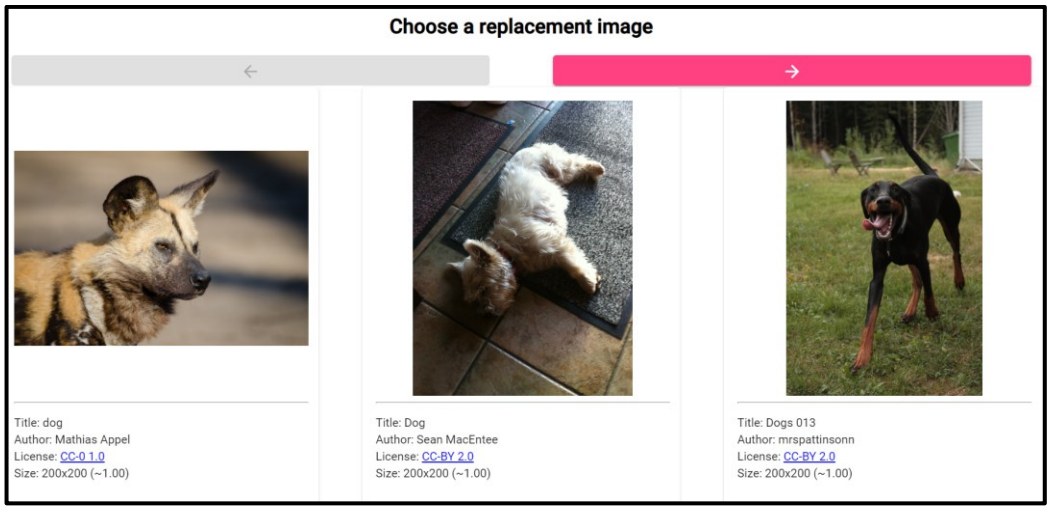


Figure 77: Screenshot of convOERter Beta version displaying images from OER-portals with CC licences

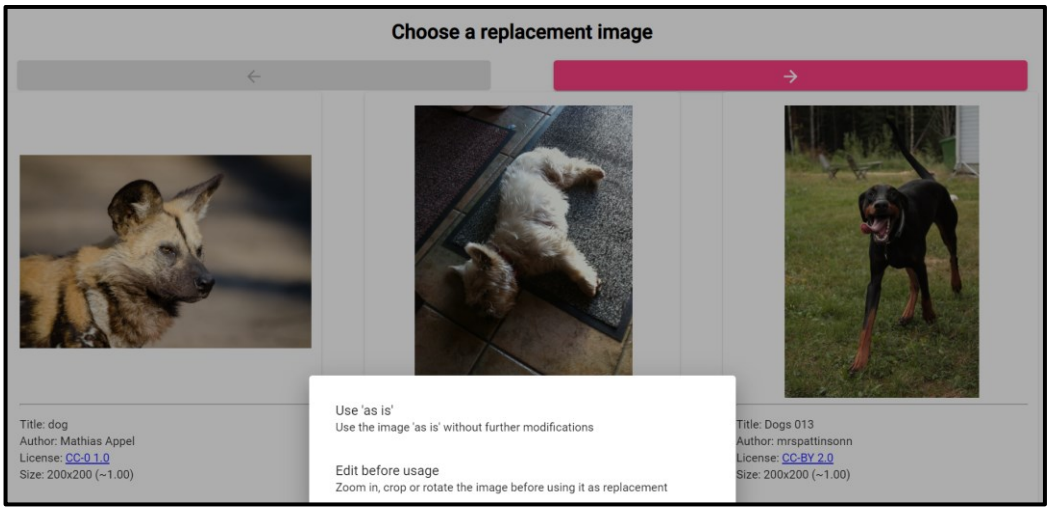


Figure 78: Screenshot of convOERter Beta version displaying options to edit the image

Figure 79: Screenshot of convOERter Beta version showing editing an image

Figure 80: Screenshot of convOERter Beta version showing the final step of saving the file

Figure 81: Screenshot of the edited file displaying the reference number added to an image

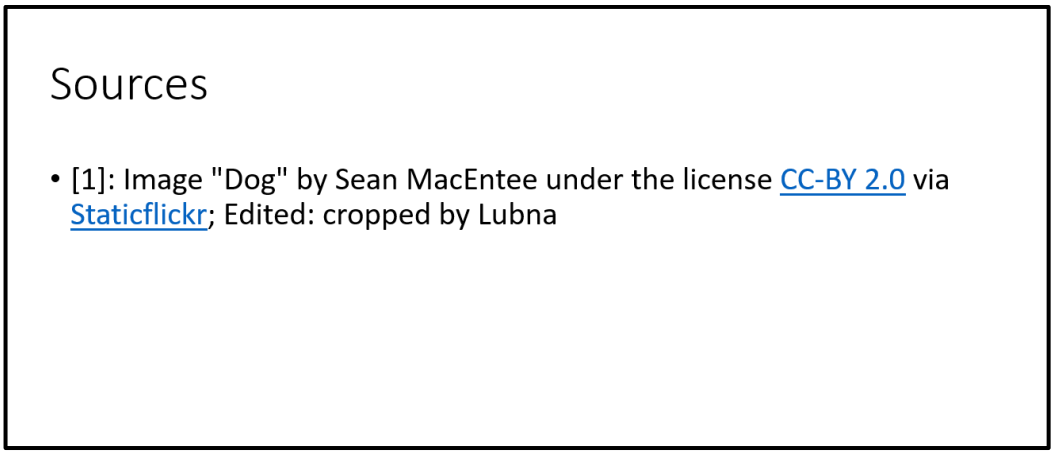


Figure 82: Screenshot of the edited file displaying the added slide for licensing the images

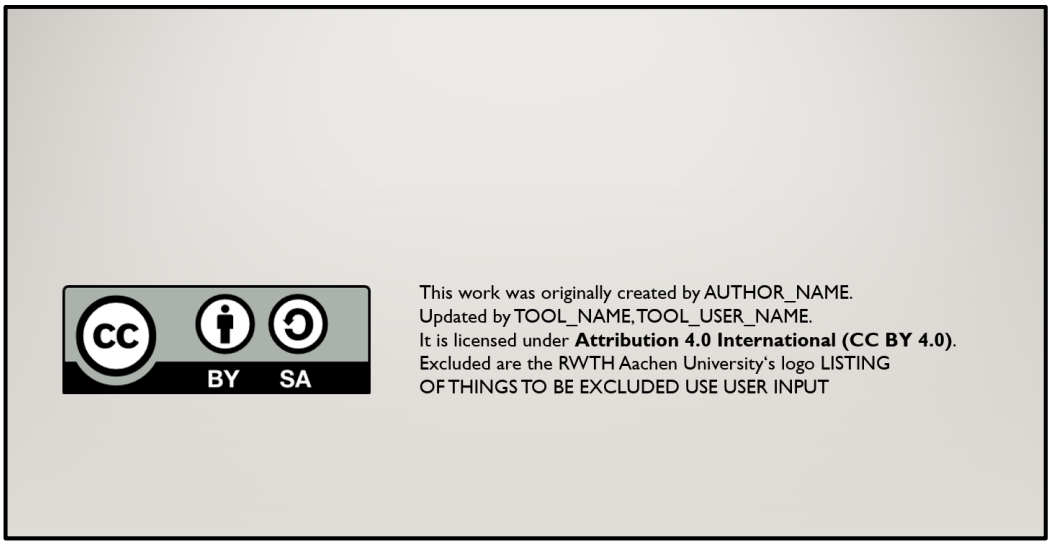


Figure 83: Screenshot of the edited file showing the added slide to license the file and excluding the licence

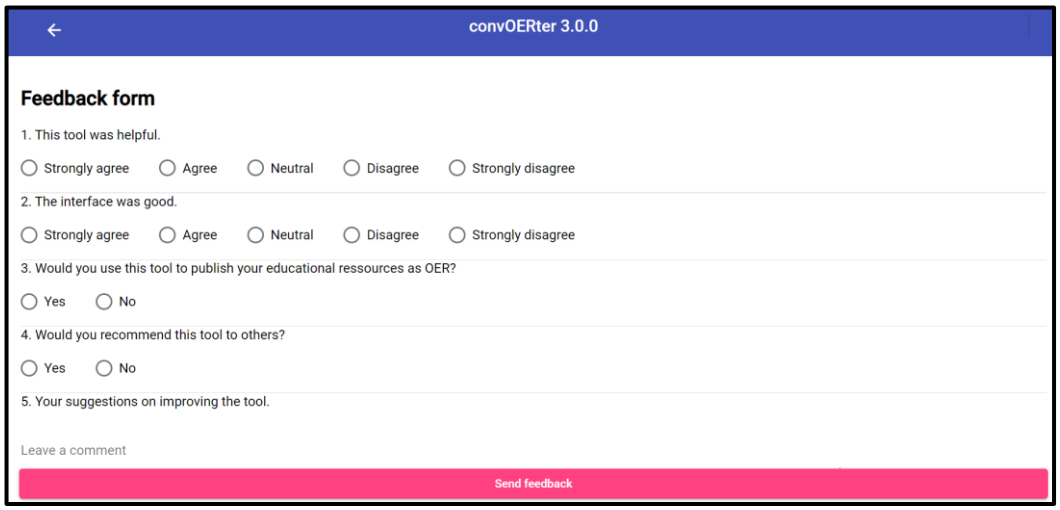
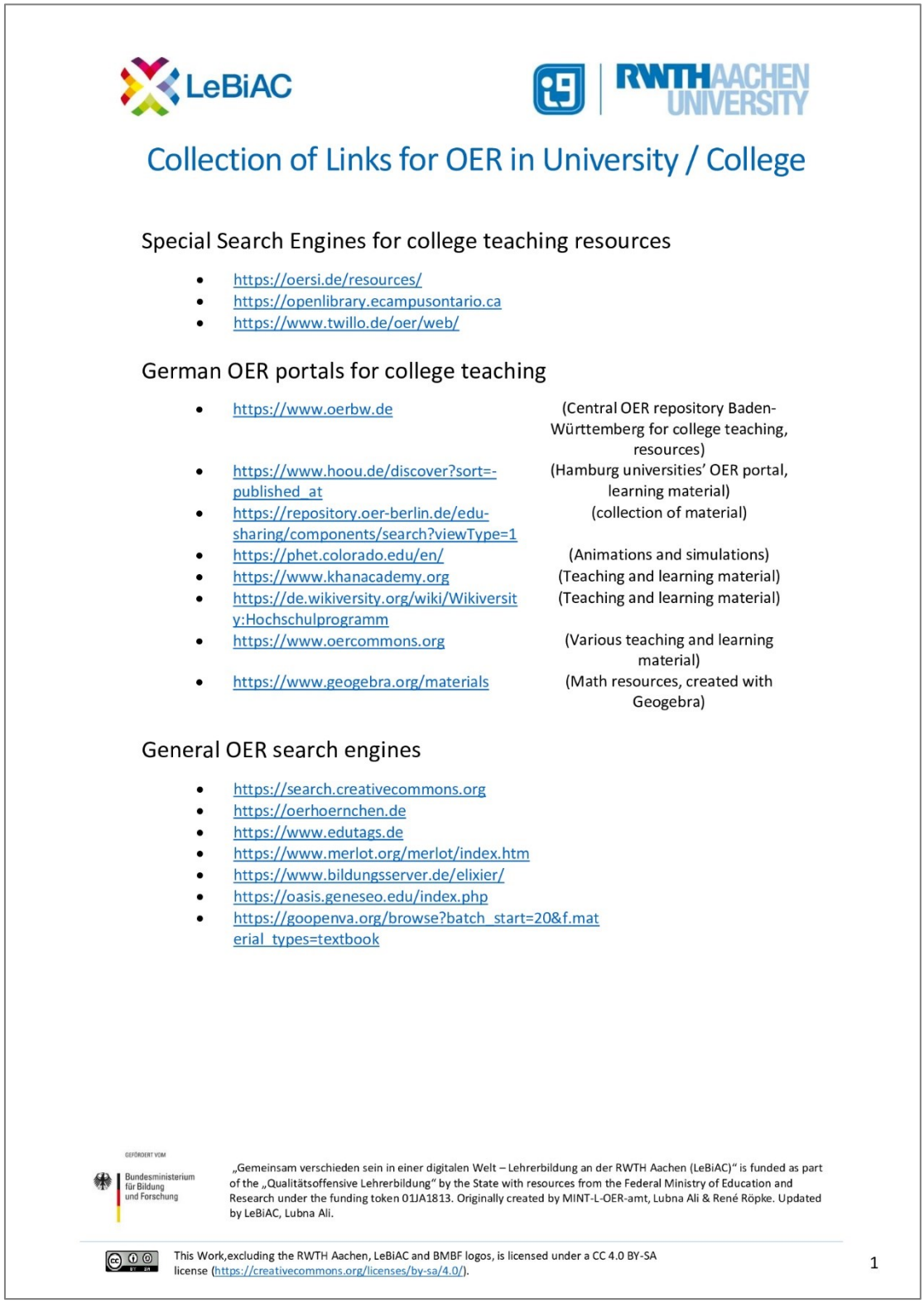


Figure 84: Screenshot of convOERter Beta version showing the feedback form integrated within the tool

Appendix J: OER Handouts



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Collection of Links for OER in University / College

Special Search Engines for college teaching resources

- https://oersi.de/resources/
- https://openlibrary.ecampusontario.ca
- https://www.twillo.de/oer/web/

German OER portals for college teaching

• https://www.oerbw.de	(Central OER repository Baden-Württemberg for college teaching, resources)
• https://www.hoou.de/discover?sort=-published_at	(Hamburg universities' OER portal, learning material)
• https://repository.oer-berlin.de/edu-sharing/components/search?viewType=1	(collection of material)
• https://phet.colorado.edu/en/	(Animations and simulations)
• https://www.khanacademy.org	(Teaching and learning material)
• https://de.wikiversity.org/wiki/Wikiversity:Hochschulprogramm	(Teaching and learning material)
• https://www.oercommons.org	(Various teaching and learning material)
• https://www.geogebra.org/materials	(Math resources, created with Geogebra)

General OER search engines

- https://search.creativecommons.org
- https://oerhoernchen.de
- https://www.edutags.de
- https://www.merlot.org/merlot/index.htm
- https://www.bildungsserver.de/elixier/
- https://oasis.geneseo.edu/index.php
- https://goopenva.org/browse?batch_start=20&f.material_types=textbook

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1

Image search engines

https://www.google.com/imghp?as_st=y&tbm=isch&as_q=&as_epq=&as_oq=&as_eq=&imgar=&imgcolor=&imgtype=&cr=&as_sitesearch=&safe=images&as_filetype=&tbs=sur:cl	(modified Google search: filters in CC licenses)
https://morguefile.com/search/CC/	(automatic search in flickr for CC licensed images)

Image portals

https://www.kisscc0.com	(CC0 1.0)
https://pxhere.com/	(CC0 1.0)
https://flickr.com/	(various, including ≠ CC)
https://purepng.com	(CC0 1.0)
https://openclipart.org	(CC0 1.0)
https://publicdomainvectors.org	(CC0 1.0)
http://bilder.tibs.at/	(CC BY-NC-SA 3.0 AT)
https://thenounproject.com	(CC BY)
https://www.publicdomainpictures.net/en/index.php	(CC0 1.0)
https://commons.wikimedia.org/wiki/Main_Page	(various CC)
https://stocksnap.io	(CC0 1.0)
https://www.europeana.eu/de	(various, including ≠ CC)
https://openphoto.net	(various, including ≠ CC)
https://stocksnap.io	(CC0 1.0), includes ads for paid images)

Videos

https://vimeo.com/creativecommons	(various CC)
https://www.youtube.com/	(exceptions under CC)
https://av.tib.eu/subjects	(various CC)

Music

https://www.medienpaedagogik-praxis.de/kostenlose-medien/freie-musik	(Overview of portals for free music)
http://www.ccmixter.org/	(CC, NC sometimes removable with TuneTrack)
http://freemusicarchive.org/	(various CC)
http://free-loops.com/	(when named: various CC)
https://cc0.oer-musik.de/	(CC0 1.0)
https://www.jamendo.com/start	(various CC)

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Textbooks

• https://open.umn.edu/opentextbooks/	(various CC)
• https://de.wikibooks.org/wiki/	(CC BY SA 3.0)
• https://cnx.org/browse	(various CC)
• https://openstax.org	(CC BY 4.0)
• https://most.oercommons.org	(search engine)
• https://oer.galileo.usg.edu	(search engine)
• https://open.bccampus.ca	(search engine)
• https://www.openedmb.ca	(portal, verified books and more)
• https://oer-obp.pubpub.org/pub/wac0y6kx/release/12	(overview)

Geometry, Algebra and Tables

• https://www.geogebra.org	(free software)

Presentations

• https://de.slideshare.net	(various, few under CC)

Simulations

• https://phet.colorado.edu/	(CC BY 4.0)

Maps

• https://www.openstreetmap.de/	(CC BY-SA 2.0)
• http://www.ginkgomaps.com/index_de.html	(CC BY 3.0)

Lectures

• https://openlearnware.tu-darmstadt.de (inkl. Vorlesungsvideos)	(OER durch CC-Lizenzen)
• https://ocw.mit.edu/index.htm	(CC BY-NC-SA 4.0)
• https://open.umich.edu/find/find-open-educational-resources	fast ausschließlich (CC BY 4.0)
• https://oyc.yale.edu/courses	Fast ausschließlich (CC BY-NC-SA 3.0 US)
• http://www.open.edu/openlearn	(CC-Lizenzen)
• https://slidewiki.org/	(Präsentationen erstellen)

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(Newspaper) articles

- http://openlib.tugraz.at (CC licenses)
- https://www.europeana.eu/de/collections/topic/18-newspapers (Public Domain)

Tools for OER creation

- https://oer.schule/oer-tools/ (Overview)
- https://lizenzhinweisgenerator.de/ (Automatic licensing information for Wikipedia, Wikimedia Commons)
- http://ccmixer.edu-sharing.org/ (CC compatibility test)
- http://www.imagecodr.org/ (automatic source attribution for Flickr images in HTML-Code)
- https://h5p.org/ (MIT license, creation of interactive material)
- https://slidewiki.org/ (creation of presentation)

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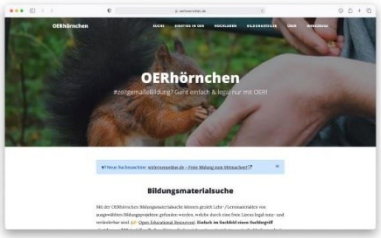
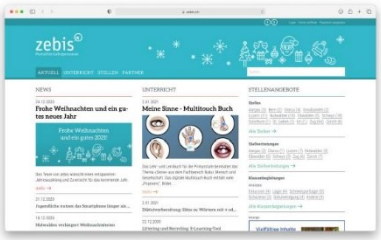
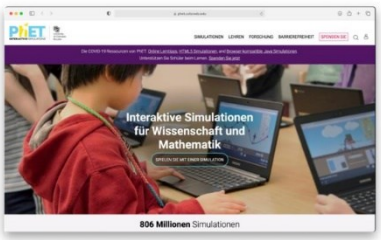
General OER Portals and Search Engines

Portal	Description
	**OERhörnchen** https://oerhoernchen.de/ • Creates specific Google search queries to find OER • Freely choose which pages to search • Choose various CC licenses
	**zebis.ch** https://www.zebis.ch • Swiss OER Platform • Multitude of reviewed teaching material • Several subjects with lots of material
	**PhET- Interactive Simulations** https://phet.colorado.edu/ • Interactive simulations for STEM teaching • Didactically verified simulations for use in teaching
	**zum.de** https://unterrichten.zum.de/wiki/Hauptseite • OER material for learning and teaching • Interactive exercises • Broad selection of subjects

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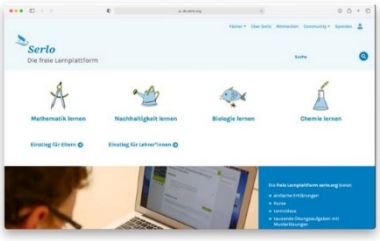	**Serlo - Die freie Lernplattform** https://de.serlo.org • Free learning material • explanations, courses, study videos and exercises • STEM subjects
	**Medienportal Siemens-Stiftung** https://medienportal.siemens-stiftung.org/de/home • Verified OER teaching material • STEM content
	**edeos – Digital Education** https://edeos.org/kostenlose-erklaervideos/ • Tutorials, Scripts and teaching material
	**mundo.schule** https://mundo.schule/ • Verified free educational material • OER search engine

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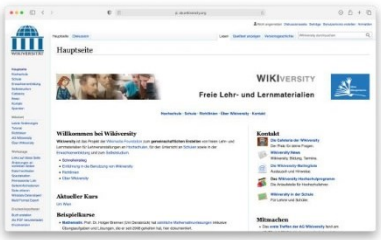	**WIKIversity** https://de.wikiversity.org/wiki/Hauptseite • Free teaching and learning material • Structured in a Wiki • For school and college
	**memucho** https://memucho.de • Interactive learning content • Broad range of subjects • For school and college
	**SlideWiki** https://slidewiki.org • Portal for free presentations • Broad range of topics
	**Learning Resources Exchange** http://lreforschools.eun.org/web/guest • OER search engine • Broad range of subjects

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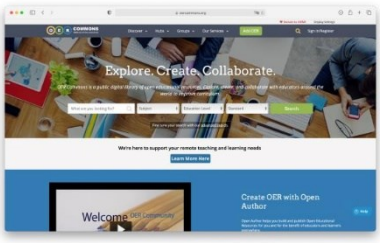
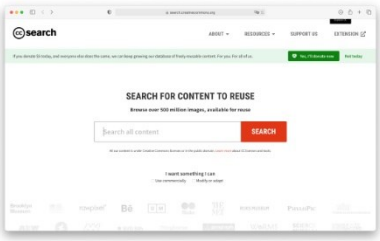
	**OER Commons** https://www.oercommons.org • OER search engine • Broad range of subjects
	**CCSearch** https://search.creativecommons.org • Search engine for CC licensed images • Automatically searches a multitude of portals • Various file types
	**Elixier** https://www.bildungsserver.de/elixier/ • OER search engine • editorially selected and reviewed content • OER for school work
	**Khan Academy** https://khanacademy.org • lessons for self-learning or to use in class • Verified by experts

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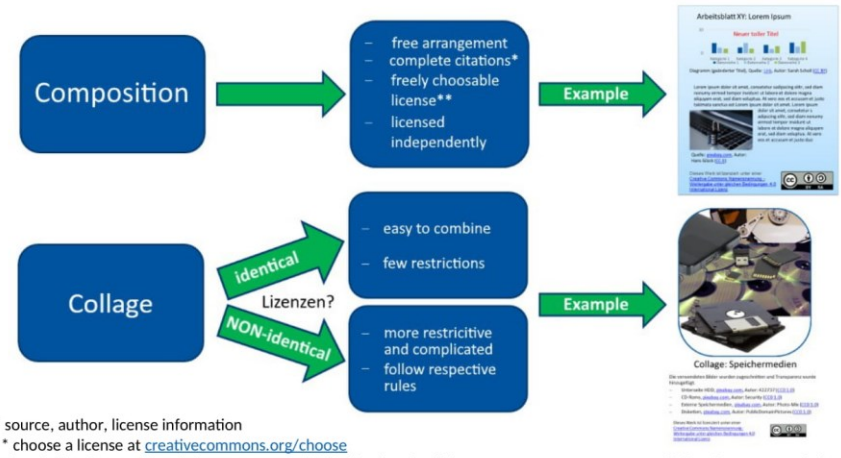
Editing OER

When creating and editing OER, one can use other OER. If two or more OER are being used to create new OER, there are two kinds of editing: OER compositions and compilation of material in a collage (see illustration)



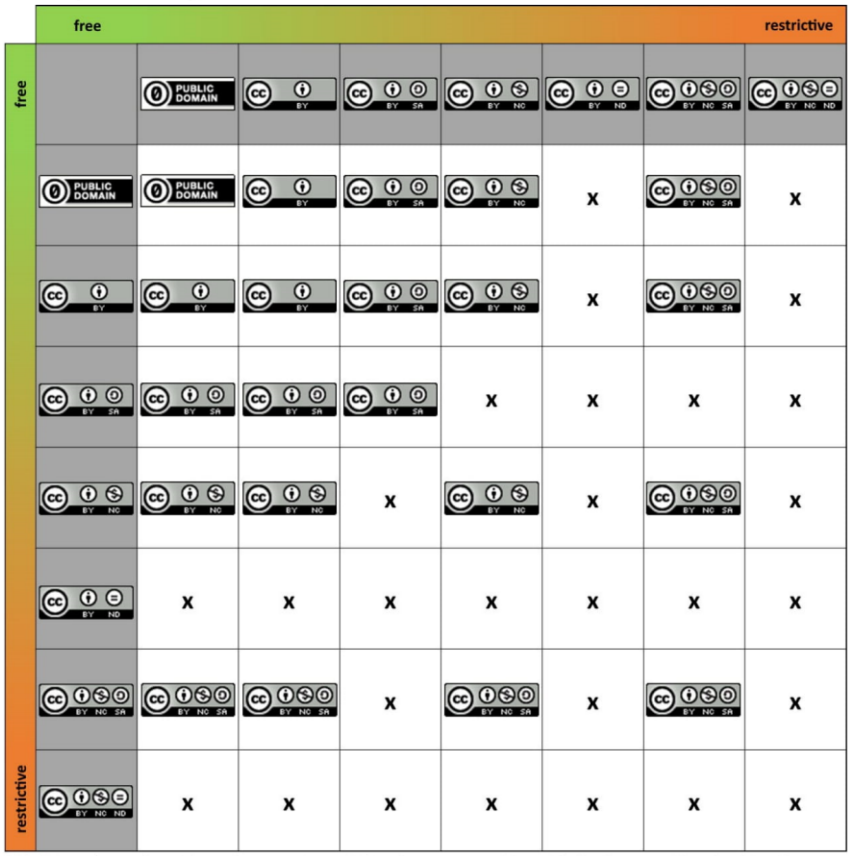
* source, author, license information
** choose a license at creativecommons.org/choose

The following table elaborates on which kinds of editing an OER are seen as editing in terms of the Creative Commons (CC) licenses. Especially OER used under the licenses CC BY-ND and CC BY-NC-ND does not permit editing.

Editing	NOT Editing
• colour changes • changes in aspect ratio • extracts / excerpts / croppings • changes in playback speed (video, music) • textual changes • deletion, addition or insertion of video clips • translation into different languages	• adding frames to images / graphics • changes in size that do not affect aspect ratio • juxtaposition • changes in font style or size

MINT-L-OER-amt, Lubna Ali & René Röpke

Compatibility of different Creative Commons licenses



This table shows the different ways of combining two or more OER with their respective Creative Commons (CC) licenses. When creating a collage of OER, the license compatibility must be considered.

An example for visualisation purposes:

Take an image under CC BY and a table under CC BY-NC. Now, both OER are edited (e.g., the image is cropped, and the table is reduced by one column). Now, the image is added into a column in the table and this collage (table with image) is published as new OER.
This new OER can be published under CC BY-NC (see table above). Stricter licenses, like CC BY-NC-SA or CC BY-NC-ND are applicable. Because of the edit, it is impossible to publish the new OER under looser licenses, such as CC BY or CC0.

MINT-L-OER-amt, Lubna Ali & René Röpke

Collection of Links all around OER

Finding OER

Search Engines for free Media

- https://search.creativecommons.org
- https://oerhoernchen.de
- https://oer.schule
- http://www.bildungsserver.de/elixier/
- https://www.edutags.de

Image Search Engines

- https://www.google.com/imghp?as_st=y&tbm=isch&as_q=&as_epq=&as_oq=&as_eq=&imgar=&imgcolor=&imgtype=&cr=&as_sitesearch=&safe=images&as_filetype=&tbs=sur:cl
- https://morguefile.com/search/CC/

Images

• https://www.kisscc0.com	(CC0 1.0)
• https://pxhere.com/	(CC0 1.0)
• https://flickr.com/	(various, including ≠ CC)
• https://purepng.com	(CC0 1.0)
• https://openclipart.org	(CC0 1.0)
• https://publicdomainvectors.org	(CC0 1.0)
• http://bilder.tibs.at/	(CC BY-NC-SA 3.0 AT)
• https://thenounproject.com	(CC BY)
• https://www.publicdomainpictures.net/en/index.php	(CC0 1.0)
• https://commons.wikimedia.org/wiki/Main_Page	(various CC)
• https://stocksnap.io	(CC0 1.0)
• https://www.europeana.eu/de	(various, including ≠ CC)
• https://openphoto.net	(various, including ≠ CC)

Popular sources for free images include portals like Pixabay (https://pixabay.com), Pexels (https://pexels.com) or Unsplash(https://unsplash.com).
Unfortunately, the images on these websites are not published under Creative-Commons-Licenses, but instead under the portals' individual licenses. This stands in contrast to the UNESCO's definition of OER, especially regarding commercial use.

The following (German) article explains this conflict:

- https://open-educational-resources.de/pixabay-und-co/?fbclid=IwAR3TyFXV2Jnqs8VqHOVqRXDwyu84QsKEiv5WTUCFUJySdhtrBpH8fxwB2gE

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Videos

• https://vimeo.com/creativecommons	(various CC)
• https://www.youtube.com/	(exceptions under CC)
• https://av.tib.eu/subjects	(various CC)
• https://www.tagesschau.de/multimedia/video/creativecommonsdossier-101.html	(CC BY-NC-ND 4.0)

Music

• https://www.medienpaedagogik-praxis.de/kostenlose-medien/freie-musik	(Overview)
• http://www.ccmixter.org/	(CC, NC partially removable with TuneTrack)
• http://freemusicarchive.org/	(various CC)
• http://free-loops.com/	(If indicated: various CC)
• http://cc0.oer-musik.de	(CC0 1.0)
• https://www.jamendo.com/start	(various CC)

Textbooks

• https://open.umn.edu/opentextbooks/	(various CC)
• https://de.wikibooks.org/wiki/	(CC BY SA 3.0)
• https://cnx.org/browse	(various CC)
• https://openstax.org	(CC BY 4.0)

Geometry, Algebra and Tables

• https://www.geogebra.org	(free software)
• https://www.geogebra.org/materials	(free materials)

Presentation

• https://de.slideshare.net	(various, few under CC)

Simulation

• https://phet.colorado.edu/	(CC BY 4.0)

Map Material

• https://www.openstreetmap.de/	(CC BY-SA 2.0)
• http://www.ginkgomaps.com/index_de.html	(CC BY 3.0)

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Lectures

• https://openlearnware.tu-darmstadt.de (incl. Lecture recordings)	(OER with CC-Licenses)
• https://ocw.mit.edu/index.htm	(CC BY-NC-SA 4.0)
• https://open.umich.edu/find/find-open-educational-resources	almost entirely (CC BY 4.0)
• https://oyc.yale.edu/courses	almost entirely (CC BY-NC-SA 3.0 US)
• http://www.open.edu/openlearn	(CC-Licenses)

(Newspaper) Articles

• http://openlib.tugraz.at	(CC-Licenses)
• https://www.europeana.eu/de/collections/topic/18-newspapers	(Public Domain)

Creating OER

• https://lizenzhinweisgenerator.de/	(automatic licensing tips for Wikipedia, Wikimedia Commons)
• http://ccmixer.edu-sharing.org/	(CC compatibility testing)
• https://www.tutory.de/	(create worksheets)
• http://www.imagecodr.org/	(automatic source references for Flickr images in HTML code)
• https://h5p.org/	(WITH License, create interactive material)
• https://slidewiki.org/	(create presentations)

Help regarding OER and Virtual/ Augmented Reality

- Virtual und Augmented Reality - Landesmedienzentrum Baden-Württemberg (lmz-bw.de) (German)
- Open Up - Conversations on Open Education for Language Learning (utexas.edu) (English)

Official OER Search Engine by the State NRW

- http://www.learnline.schulministerium.nrw.de

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German Language OER Portals

• https://www.zebis.ch	(teaching material)
• https://www.geogebra.org/materials	(Math material, created with GeoGebra)
• https://phet.colorado.edu/de/	(animations and simulations)
• https://www.lehrer-online.de	(teaching material, few under CC)
• https://www.zum.de/portal/	(teaching material)
• https://de.serlo.org/	(learning management system)
• https://l3t.tugraz.at/index.php/LehrbuchEbner10	(Textbook for learning and teaching using technology)
• http://offene-naturfuehrer.de/web/	(biology teaching material)
• https://de.khanacademy.org	(teaching and self-learning material)
• https://medienportal.siemens-stiftung.org/	(inspected MINT teaching material)
• http://edeos.org/downloads-erklaervideos-unterrichtsmaterialien	(tutorials and teaching material)
• https://mundo.schule/	(search engine for teaching material)
• https://edulabs.de/oer/	(lesson ideas)
• https://www.hoou.de/discover?page=4&types=material	(teaching material)
• https://de.wikiversity.org/wiki/Hauptseite	(teaching and learning material)
• https://commons.wikimedia.org/wiki/Main_Page	(images)
• https://memucho.de/	(self-learn material)
• https://slidewiki.org/	(create, find and share presentations)

International OER Portals & Search Engines

• https://phet.colorado.edu/	(animations and simulations)
• https://openstax.org	(free High School textbooks and course material)
• http://lreforschools.eun.org/	(teaching material)
• https://www.oercommons.org	(various teaching material)
• https://en.wikiversity.org/wiki/Wikiversity:Main_Page	(teaching and learning material

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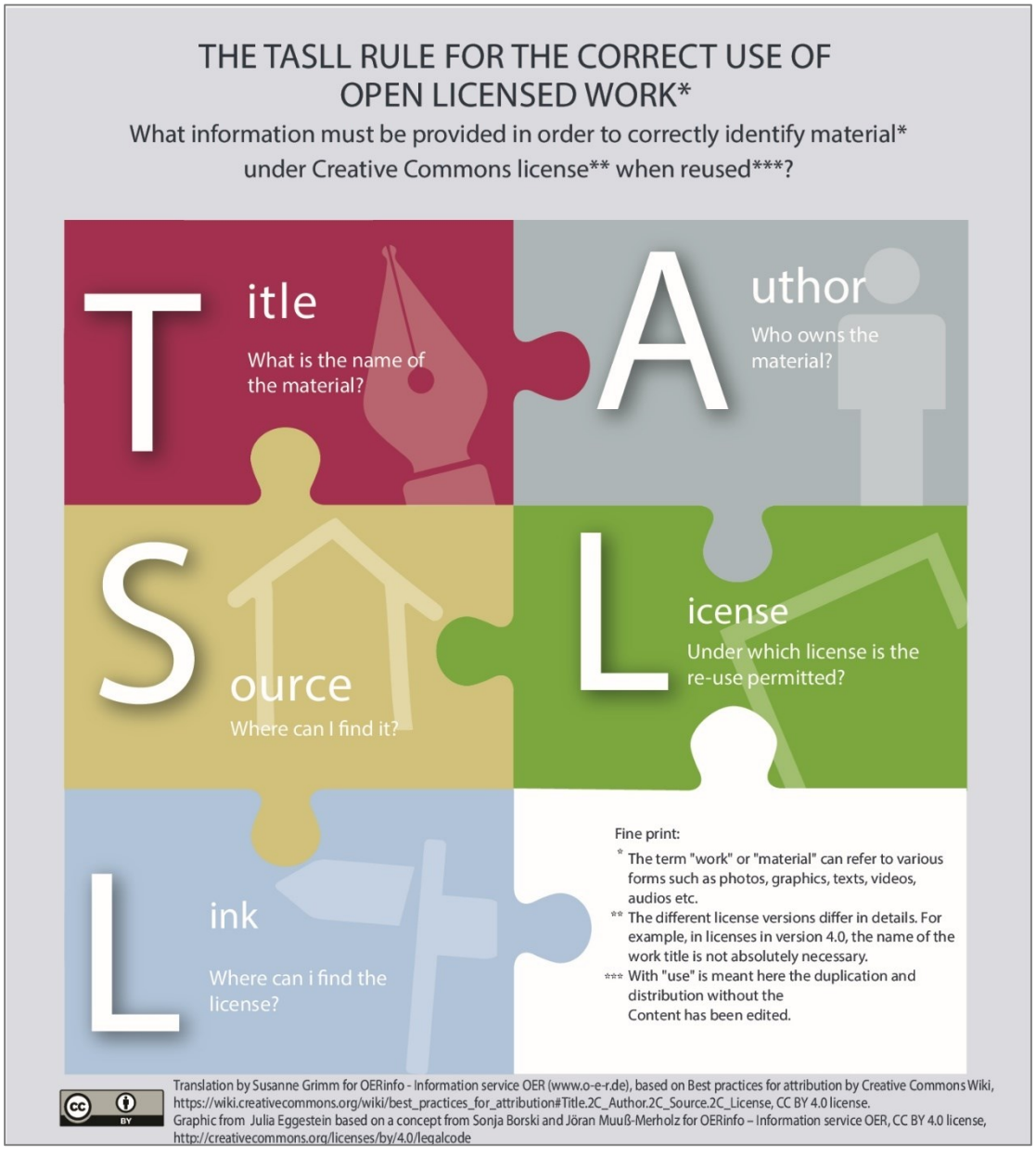
4

Appendix K: The TASLL Rule



Appendix L: Task Sheets for Practical Sessions

Convert a file manually

1. Download File A or File B from: https://rwth-aachen.sciebo.de/s/TtQYulMaDjY09FZ
2. Convert the file to OER:
    a. Substitute the images with Creative Commons (CC) ones from one of the OER portals
    b. Tip: You can refer to one of these portals:
        i. https://www.kisscc0.com/
        ii. https://pxhere.com/
        iii. https://flickr.com/
        iv. https://search.openverse.engineering/
    c. License each image according to the TASLL rule
    d. License the whole file under CC by choosing an appropriate license from: https://creativecommons.org/choose/?lang=en
    e. Save the new file under the name: File (A/B)_OER_Man_YourParticiapntCode
3. Upload the converted file to: https://rwth-aachen.sciebo.de/s/pOATdVSmJB4aY6q
4. The max. time allocated for this task is 30 minutes
5. Now: Please fill out survey-part 2: https://survey.elearn.rwth-aachen.de/index.php/791976?lang=en

Convert a file using convOERter

1. Download File A or B from: https://rwth-aachen.sciebo.de/s/TtQYulMaDjY09FZ
   - If you have chosen File A during the previous practical session, please choose B and vice versa.

2. Convert the file to OER:
   a. Visit convOERter link: https://convoerter.elearn.rwth-aachen.de/en/
   b. Convert the file to OER using convOERter
   c. When you've done, save the converted file under the name: File(A/B)_OER_Con_YourParticiapntCode

3. Upload the converted file to: https://rwth-aachen.sciebo.de/s/NfKTIEXcTZKM9JW
4. The max. time allocated for this task is 30 minutes
5. Now: Please fill out survey-part 3: https://survey.elearn.rwth-aachen.de/index.php/65268?lang=en

Appendix M: Overview on OER Projects

OER INTERNATIONALLY

IDAHO STATE UNIVERSITY (USA)[67]

The university implemented an OER initiative. A committee comprising representatives from various university departments was formed to develop an OER Plan. The plan recommended ongoing support for existing OER and low-cost resources, as well as updates to the class registration system to include course markings indicating the use of OER. The university aimed to promote and support the inclusion of OER in evaluation and promotion guidelines, identify courses with a high return on investment for OER implementation, address misconceptions about OER, and encourage faculty and administration to prioritize affordability. The university also planned to continue the proposal-based program for course material affordability projects and expand professional development opportunities related to affordable course materials. Moreover, the university's OER initiative focused on fostering awareness and adoption of OER, promoting affordability, and integrating OER considerations into various aspects of the university's operations.

ATHABASCA UNIVERSITY (CANADA)[68]

Athabasca University has embraced OER and highlights their benefits in terms of accessibility, improved student performance, cost savings, and their appeal to informal learners. They provide resources like the OASIS OER search tool and Symbaloo, a dashboard tool for curating and organizing OER. The university also offers an online course on openness in distance education. The goals of implementing OER include disrupting traditional education practices and promoting openness in content, data, and access. The university recognizes the importance of open licensing expertise for K-12 education.

NORTH TEC (NEW ZEALAND)[69]

This university's OERu initiative seeks to democratize education globally by providing free access to high-quality courses created by renowned institutions. Learners can study independently, online, with the option to pursue formal academic credit at a fraction of traditional tuition costs. OERu courses are designed for flexibility and include micro-courses. The initiative fosters a global learning community and aims to reduce financial barriers while expanding educational opportunities. It offers a Certificate Higher Education in Business and opportunities for transfer credits. Two engagement

[67] https://www.isu.edu/oer/, accessed 10.12.2022
[68] https://bolt.athabascau.ca/index.php/oer/, accessed 10.12.2022
[69] https://oeru.org/, accessed 10.12.2022

options—self-directed interest and learning for credit—are available, making education accessible and affordable for all.

Harvard Graduate School of Education (USA)[70]

This university offers a comprehensive guide on OER, emphasizing their pivotal role in bridging the gap between traditional educational practices and the potential of technology and the Internet for more affordable and effective teaching and learning. The guide underscores the importance of OER in eliminating barriers to education, enhancing student performance, leveraging technology for improved learning outcomes, and ultimately contributing to a brighter educational future. While primarily intended as an introductory resource for educators and students within the Harvard Graduate School of Education, the guide elucidates the key principles of OER, including their "5Rs" (Retain, Reuse, Revise, Remix, Redistribute), and provides insights into finding, creating, evaluating, and incorporating these open educational materials into classrooms.

Massachusetts Institute of Technology (MIT), (USA)[71]

The university has embraced OER and provides various resources and tools for finding open access articles. They recommend platforms such as CORE, Digital Commons Network, Google Scholar, Unpaywall (both the Simple Query Tool and Browser Extension) to search for specific articles available in open access versions. The university encourages the use of OER for creating MOOC content and conducting workshops for individuals not affiliated with the institution. The summary emphasizes the availability and benefits of OER, along with the limitations of Google Scholar's search refinement abilities. The goals of the university include promoting access to educational resources and supporting teaching and research through the utilization of OER.

University of Oxford (GB)[72]

The Sesame project at the University of Oxford's Department for Continuing Education aims to create sustainable OER from their weekly class program. Initially designed for class support, the project's overarching goal is to provide free, accessible educational materials to global adult learners and educators. The platform, open.conted.ox.ac.uk, offers diverse resources without registration, accompanied by valuable information on OER and open licensing. Its mission is to democratize education, benefiting students, tutors, and lifelong learners, with ongoing development efforts to ensure its continued relevance and impact.

OER Africa[73]

This compilation highlights various OER initiatives in Africa and their respective countries of operation. These initiatives encompass a range of areas, including institutional initiatives, OER repositories/portals, advocacy/awareness-raising efforts, OER

[70] https://guides.library.harvard.edu/c.php?g=1179619&p=8623793, accessed 10.12.2022
[71] https://libguides.mit.edu/oer, accessed 10.12.2022
[72] https://open.conted.ox.ac.uk/, accessed 10.12.2022
[73] https://oerafrica.org/oer-initiatives-africa, accessed 12.12.2022

development, policy implementation, research, and professional development. The initiatives aim to enhance access to quality education, support teacher training, promote open learning principles, and facilitate the use and impact of OER in African higher education institutions. However, the overarching goal is to improve educational policy, practice, and research by fostering the creation, sharing, and utilization of OER.

University of the Witwatersrand, Johannesburg (South Africa)[74]

This university has developed a LibGuide on OER to provide educators and students with access to free and open educational materials. The guide includes resources such as guidelines, websites, articles, course content, and teaching resources. It also covers topics like OER policies, research processes, and subject-specific OER. The goal of the LibGuide is to promote the use of OER in teaching and learning. It highlights the importance of checking licenses and conditions of use for OER, as they may vary. The guide also addresses common myths and misconceptions about OER. The overall purpose is to support the adoption and understanding of OER within the university community.

University of Pretoria (South Africa)[75]

The University's adaptation of OER is evident in their Education Open Resources Guide, which aims to promote sustainable education through the utilization of OER. The guide includes a FAQ section, information on the "post-truth era" and "fake news," and resources on Creative Commons licences. Various definitions of OER are provided from reputable sources like UNESCO and Creative Commons. The University's Faculty of Education also offers an Education Library, which supports the use of OER in subjects like Early Childhood Education and Science, Mathematics, and Technology Education. The overall focus is on raising awareness about OER, providing access to relevant resources, and fostering the integration of OER in educational practices.

University of Nairobi (Kenya)[76]

This project, supported by UNESCO, focused on OERization at the University of Nairobi in Kenya. The objective was to promote the use of OER by OERizing four pilot courses. The project aimed to enhance accessibility and create locally relevant and valuable courses. The courses selected for OERization covered various disciplines and were uploaded to the OERCommons platform. The project was part of UNESCO's efforts to assist educational planners and develop policies for effective use of technology and OER.

National University of Singapore (Singapore)[77]

The university is embracing OER by providing an overview of OER basics, integration into modules, and the effectiveness of free resources compared to textbooks. The university offers an OER Starter Kit, aimed at instructors new to Open Education, covering topics such as copyright, finding, teaching, and creating OER. The integration process involves

[74] https://libguides.wits.ac.za/c.php?g=145371&p=952294, accessed 12.12.2022
[75] https://library.up.ac.za/c.php?g=1091594, accessed 12.12.2022
[76] https://www.unesco.org/en/articles/oerisation-university-nairobi-kenya, accessed 12.12.2022
[77] https://libguides.nus.edu.sg/OER, accessed 12.12.2022

steps like searching for relevant OER, assessing learning objectives, utilizing library materials, and seeking librarian assistance. Research indicates that OER can be as effective and of the same quality as traditional textbooks, offering cost-saving alternatives for students. The goal of the university is to promote the use of OER and support educators in accessing, incorporating, and potentially creating OER.

TU GRAZ[78]

The University of Technology Graz (TU Graz) has actively pursued a comprehensive OER policy with the primary goal of promoting the creation and dissemination of OER. Within the TU Graz TeachCenter, certified instructors can leverage a dedicated OER plugin to manage and publish openly licenced educational materials, which are then automatically shared on OERhub.at for wider accessibility. The initiative underscores the significance of appropriate licensing and aims to encourage instructors to obtain OER certification through in-house training. By simplifying the process of sharing educational content and enhancing discoverability, TU Graz is committed to advancing OER adoption and fostering a culture of open education.

OER IN GERMANY

UNIVERSITY OF COLOGNE (OPEN COURSES AND OER FOR TEACHING STUDENTS)[79]

Several courses are offered by the university that focuses on the design and reflection of future-proof, digital/hybrid teaching. The courses consist of various modules that cover topics such as the basics of digital education, the impact of digitization on teachers and students, critical evaluation of digital learning materials, and practical lesson planning. The university also promotes the use of OER and provides free learning modules to enhance teachers' digital and pedagogical skills. The goals of the course are to empower teachers to plan and implement effective digital/hybrid teaching sequences and foster sustainable education.

UNIVERSITY OF POTSDAM[80]

The "BrandenbOERg" project, funded by the Ministry of Science, Research, and Culture in Brandenburg, aims to promote the use of OER in Brandenburg's higher education institutions and prepare a state-wide OER standard. In Phase I of the project, recommendations are developed for the state of Brandenburg and its universities. The project involves several universities in Brandenburg and focuses on documenting OER-related services and technical infrastructure. It also accompanies multiple teaching projects that create OER materials to gain insights into the production and use of OER, while documenting existing infrastructure and identifying challenges and potentials. The ultimate goal of Phase I is to provide recommendations to the state and universities for strategies to

[78] https://telucation.tugraz.at/en/oer-tc-en/, accessed 12.12.2022
[79] https://digilehre.zflkoeln.de/, accessed 12.12.2022
[80] https://www.uni-potsdam.de/de/oer/brandenboerg, accessed 12.12.2022

foster OER production and motivate educators to publish educational materials under open licences.

Christian-Albrechts-Universität zu Kiel (Explanation fOERde)[81]

The scientific research project called fOERde explores the use of OER as a means of effective teaching and learning. The project aims to demonstrate how principles of teaching and instructional design can be implemented using OER, focusing on key approaches to successful education. The materials provided on the fOERde platform are exemplary in nature and centre on learning impulses, learning support, and learning development in digital environments. The project seeks to bridge the gap between scientific research and educational practice by translating scientific findings into practical approaches, reflecting on existing methods through a scientific lens, and fostering collaboration between educators and researchers. The project acknowledges the limitations of not aiming to create a comprehensive curriculum but rather serving as prototypes for further development through cooperation. The fOERde platform provides a space for active collaboration among teachers, learners, researchers, and educational institutions, promoting the use, creation, and sharing of OER for STEM (Science, Technology, Engineering, and Mathematics) education, school lessons, university teaching, and extracurricular learning.

University of Bremen[82]

The ProOER project aimed to promote the development of OER competencies within the university. The project integrated OER into existing information, advisory, and qualification measures, as well as e-learning platforms, through collaboration with stakeholders such as e-learning experts, academic staff, and study centres. The project encompassed four main actions: integration into established processes, inclusion in funding opportunities for e-learning scenarios, expanding e-learning platforms to support OER, and conducting an accompanying evaluation and development of an OER policy recommendation for the University of Bremen.

FU Berlin[83]

This scientific research project explored the utilization of OER as freely available educational materials that can be integrated into learning systems. The project compiled a selection of OER in a wiki-based workshop and provided guidelines for properly citing and integrating these resources. The study emphasized the importance of considering licence conditions when embedding OER and highlighted repositories and search engines for targeted searches. The main goals were to enhance access to educational materials and promote their widespread distribution.

[81] https://oer.uni-kiel.de/, accessed 12.12.2022
[82] https://www.uni-bremen.de/zmml/projekte/abgeschlossene-nationale-projekte/prooer, accessed 20.12.2022
[83] https://www.cedis.fu-berlin.de/online-lehren-lernen/lerninhalte-bereitstellen/bereitstellen/070_oer_einbinden.html, accessed 20.12.2022

TU Dortmund[84]

The scientific research project conducted a workshop on teaching and learning with OER. The workshop aimed to educate participants on finding and integrating OER into their teaching while ensuring compliance with licensing regulations. It also explored the benefits and drawbacks of OER, their impact on teaching and learning, and the benefit for educators. The workshop discussed considerations when using, developing, and publishing OER, and provided guidance on creating and sharing one's own OER. The goals included promoting the use of OER, fostering collaboration among teachers, and facilitating the dissemination of knowledge.

Goethe University of Frankfurt am Main[85]

The scientific research project, titled "Elective Module Media Production (WM30): OER - Find, Use, Produce," aimed to educate university teachers and academic staff on the creation and utilization of OER. The project comprised two online presence parts, with corresponding online phases. Participants gained an understanding of OER's legal background, characteristics, and reasons for their use. Practical exercises were conducted to teach participants how to find and create OER, ensuring compliance with open licensing requirements. The project's goal was to equip educators with the knowledge and skills to produce and incorporate OER into their teaching practices. The project utilized Moodle and Zoom platforms for asynchronous and synchronous sessions, respectively. The project had a participant limit of 16 and required active engagement for approximately 3-4 hours.

University of Bonn[86]

The University of Bonn Graduate School of Education is actively promoting OER by facilitating both their utilization and creation. Their primary objectives include encouraging the integration of OER into teaching and learning practices, ensuring accessibility to high-quality educational materials, and nurturing a culture of knowledge sharing. The university underscores the correct use of openly licenced materials, emphasizing the importance of proper citation and adherence to specified usage guidelines. Lecturers are provided with comprehensive resources, tips, and links for effectively incorporating OER into their courses, understanding diverse licensing options, and crafting and disseminating OER through Confluence. In alignment with UNESCO's definition, the University of Bonn's commitment to OER encompasses a wide range of educational materials, from individual resources to entire courses or textbooks, with the fundamental principle of free access, use, modification, and redistribution under open licences.

[84] https://hd.zhb.tu-dortmund.de/weiterbildung/workshop-portal/details/lehren-und-lernen-mit-open-educational-resources-3-21938/, accessed 20.12.2022
[85] https://www.studiumdigitale.uni-frankfurt.de/58727581/Open_Educational_Resources, accessed 20.12.2022
[86] https://www.bzh.uni-bonn.de/de/fuer-lehrende/oer-an-der-uni-bonn, accessed 2.12.2022

Leibniz University of Hannover[87]

The university project focuses on the adoption of OER in teaching materials design. Teachers often seek online resources like worksheets, scripts, or learning videos, but legal restrictions hinder their immediate use. The project established the "OER-Portal Niedersachsen" to facilitate the creation and compilation of high-quality course materials for teachers. The portal offers material hosting, search functionality, legal, quality, and didactic support. Workshops and consultations are provided to assist teachers and student assistants in developing OER and digitizing teaching units. The project's goals include promoting OER adoption, providing technical knowledge, and enhancing skills in dealing with OER.

Hamburg Open Online University (HOOU)[88]

HOOU's key objectives include learner-centricity, academic rigor, inclusivity for diverse audiences, and a commitment to openness through OER. The project emphasizes learner-oriented, problem-solving, and collaborative learning experiences, fostering scientific thinking and creativity. It aims to engage not only traditional university students but also wider civil society in meaningful academic discussions. HOOU's dedication to openness is evident in its use of open source software, open licences, and an inclusive approach to content accessibility. Through these guiding principles, HOOU seeks to provide open, digital educational resources that promote academic excellence and facilitate broad access to quality learning materials, aligning with UNESCO's definition of OER.

University of Leipzig[89]

University of Leipzig event titled "Presentation of the OER Platform EDUdigitaLE," the joint project "PraxisdigitaliS" by the University of Leipzig and TU Dresden showcased the results of their three-year endeavour to embed digital competencies in teacher training. The event aimed to explore the diverse aspects of "digitization in teacher education" through the presentations of sub-projects and working groups. The specific focus was on the OER platform EDUdigitaLE, which provides freely available and customizable teaching and learning materials, fostering collaboration and knowledge sharing among teachers, trainee teachers, and students. The workshop highlighted the culture of sharing and the potential of OER in transforming teaching practices and promoting up-to-date, multidimensional instruction. The goal was to inspire educators to integrate OER into their teaching and facilitate discussions on the benefits of sharing resources.

[87] https://www.uni-hannover.de/de/universitaet/profil/ziele-strategien/open-science/open-educational/, accessed 20.12.2022
[88] https://www.hoou.uni-hamburg.de/, accessed 20.12.2022
[89] https://www.zls.uni-leipzig.de/forschung-und-projekte/praxisdigitalis/vortragsreihe-2023, accessed 20.12.2022

OER AT RWTH AACHEN UNIVERSITY

ANDI[90]

The "ANDI" (ANatomieDIgital) project, funded by the Ministry of Culture and Science and the Digital University NRW from April 2022, aims to create an immersive virtual learning application for medical students and professionals. A collaboration between anatomical institutes from Aachen, Bonn, and Cologne, and the Audio-visual Media Centre Aachen, the project's key objective is to facilitate a comprehensive understanding of human anatomy, bridging theory with practical skills and clinical competencies. The ANDI learning app will enhance independent, interprofessional learning, promoting longitudinal knowledge and skills integration. Upon project completion, the app will be freely available on ORCA.nrw.

FAIBLE[91]

FAIBLE is a project focused on the development of OER for computer science didactics, in response to the growing demand in secondary education. It aims to provide content that bridges subject-specific and educational science content for effective teacher training. The initiative brings together several universities to develop flexible resources adaptable to various teaching scenarios and levels. Future work involves integrating these resources into each institution's curriculum.

BIOLABSIM[92]

The "BioLabSim" project, a collaborative effort between RWTH Aachen University, the Westphalian University, and the Rhine-Waal University of Applied Sciences, aims to address the evolving needs of biotechnology and biology students in the face of increasingly complex experimental data. With modern biotechnical research generating vast and intricate datasets, the project focuses on equipping students with essential digital skills for data analysis. To bridge the gap between university teaching and real-world automation, the project develops interactive digital worksheets, utilizing a virtual organism model to simulate diverse biotechnological work processes. These modular worksheets, designed for both in-person and distance learning, empower educators to tailor their teaching. Supported by OERContent.nrw and the Ministry of Culture and Science of North Rhine-Westphalia, the project fosters a collaborative approach to biotechnological data analysis, facilitating learning in the digital age.

[90] https://www.medfak.uni-bonn.de/en/faculty/news/oercontent-nrw-two-projects-of-the-faculty-of-medicine-receive-funding, accessed 20.12.2022
[91] https://learntech.rwth-aachen.de/cms/LearnTech/Forschung/Projekte/~tdwpn/FAIBLE-Fachdidaktik-Informatik-in-Baust/?lidx=1, accessed 10.01.2023
[92] https://www.iamb.rwth-aachen.de/cms/iamb/Forschung/Blank-Lab/~tyihi/BioLabSim/, accessed 10.01.2023

ALFDYN[93]

The Adaptive Learning Environment in Dynamics (ALFDYN) project, funded by the OERContent.nrw program (04/2022 - 03/2024), is a cooperative initiative involving multiple institutions including TU Dortmund, TH Cologne, University of Duisburg-Essen, RWTH Aachen, and Ruhr West University of Applied Sciences. The project aims to design a personalized learning environment to enhance student learning in dynamics by offering diverse learning formats and employing a diagnostic tool that identifies learning barriers and behaviours. Through self-tests and student feedback, the platform continues to evolve, making it a dynamic learning resource. The system involves a stepwise learning approach, dividing the course into eight segments, each culminating in an assessment that guides the subsequent learning path. Various learning formats are offered based on student progress and learning style. As of February 2023, the materials for the first segment, "Kinematics of the mass point," are complete. The project impacts around 1000 students and can be considered a promising step toward innovative digital teaching.

[93] https://bmsd.ab.tu-dortmund.de/en/forschung/projekte/alfdyn/, accessed 10.01.2023