Lessons from a Pandemic for the Future of Education
European Distance and E-Learning Network (EDEN) Proceedings
2021 Annual Conference | Madrid, 21-24 June, 2021
ISSN 2707-2819
doi: 10.38069/edenconf-2021-ac0020

OPEN EDUCATIONAL PRACTICES IN LEARNING AND TEACHING OF COMPUTER SCIENCE

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Abstract

This paper shows several actions that address the use and development of open educational resources (OERs) and the utilisation of open source machine virtualization tools for Moodle course instantiation in a Computer Science-based Teacher Training course. The training is dedicated to show the basic characteristics and tools present in e-learning environments and to transmit the knowledge to develop educational resources and personalize different learning environments. The learning activities have been designed following the constructive approach, in the form of practical tasks that ensure the training of students in the self-implementation and personalisation of e-learning courses embedded into virtual machines. Students learn how to do the pedagogical design, to set up a delivery, and perform to develop their own resources and re-use from others. Finally, students have to assess the quality of the OERs following the UNE71362 standard. As a transversal pedagogical objective of the Master's course, the learning aims to help the dissemination and awareness of the UNESCO's Sustainable Development Goal 4 (SDG4) which ensures inclusive and equitable quality education and fosters lifelong learning opportunities for all. In this sense, specific OER development for gender inclusion and accessibility for all learners has been promoted.

Introduction

Since the UNESCO Paris Declaration on OER (Open Educational Resources) adopted by the global community in June 2012, there have been a number of new developments, such as new authoring tools or distribution systems. Providing OERs and open software-based tools to the students also offer the flexibility of learning and benefits to all learners. The "open pedagogy" concept is closely associated with the creation, use, and sharing of open educational resources (OER). Weller (2013) states that open pedagogy "makes use of...abundant, open content (such as open educational resources, videos, podcasts), but also places an emphasis on the network and the learner's connections within it" (p.10). Or as Cronin (2017) has defined the related term "open educational practices," as "a broad

descriptor of practices that include the creation, use, and reuse of open educational resources (OER) as well as open pedagogies and open sharing of teaching practices" (p.16).

The "open" in open educational resources indicates that these materials are licensed with copyright licenses that provide permission for everyone to participate in the 5R activities – retain, reuse, revise, remix, and redistribute (Wiley & Hilton III, 2018). The Open Educational Quality Initiative (OPAL, 2011) defines open educational practices as "a set of activities around instructional design and implementation of events and processes intended to support learning. They also include the creation, use and repurposing of Open Educational Resources (OER) and their adaptation to the contextual setting. They are documented in a portable format and made openly available" (p.13).

In constructive learning (Connolly & Stansfield, 2007), students use technology tools to connect new information to their prior knowledge rather than to passively receive information. The Constructive characteristic describes learner-centred instruction that allows students to use technology tools to connect new information to their prior knowledge. This characteristic is concerned with the flexible use of technology to build knowledge in the modality that is most effective for each student.

In this work, the authors seek to help their students, (futurable teachers in secondary and high schools, to recognize the added-value derived from using and developing their own OERs and implementing their own course styles and personalization. This involves defining an OER value chain that will help stakeholders identify the various sub-systems in the chain that link the individual teacher's or learner's contribution relating to OER use. For constructive learning, all tasks defined to develop the different sub-systems allow students to use the proposed technology tools to connect the new content information to their prior knowledge and scaffold their new knowledge. Finally, following open pedagogy principles, a network to enhance learner's connections and peer-to-peer interaction has been implemented.

Implementation of AEi instructional design

Within the Spanish Education System, teaching in the field of Vocational Training requires obtaining a relevant qualification, which is embodied in the Master's Degree in Teacher Training for Compulsory Secondary Education and Baccalaureate, Vocational Training and Language Teaching. This degree consists of a set of subjects related to aspects of Education and Innovation, and another set of subjects related to specific topics of the specialty of Computer Science. This second group includes the subject Learning and Teaching of Computer Science (hereinafter, AEi), with a total load of 6 ECTS credits.

It is not only necessary to know and master the discipline of Computer Science, but the teaching staff must be able to assume the management of the teaching-learning process. That is to say, it is necessary to have the necessary knowledge to structure didactically the matter applying appropriate teaching methods. AEi instructional design has been structured mainly around this philosophy. Therefore, students are encouraged to personalize their own virtual-classroom, to develop their own learning resources and share them through an on-line repository, to complete the associated LOM (Learning Object Metadata), to package them under SCORM (Sharable Content Object Reference Model) standard, to re-use learning resources from other peers within a community of practice and to assess the quality level of their developed materials.

Thus, there are three main axes on which it should be possible to focus the effort to update the teaching of AEi:

- Virtualization: in many cases, the development of different Computer Science subjects requires the installation and configuration of different tools that are not always easy to implement and based in many cases on operating systems that are not within the reach of students for different reasons (for not being in the field of habitual use, for requiring certain hardware resources not available or other similar ones). That is why the existence of virtualized environments might be part of the solution to this problem.
- OERs: it is essential to focus the different subjects towards the development of a set of open educational resources that cover the entire discipline to be covered. In this open environment, the reuse of resources is more than desirable, so aspects such as platform interoperability and access to resource repositories are essential.
- Learning platforms or LMS: all of the above requires to be implemented in some LMS system that allows the development of a learning scenario that allows the distance development of the subject or subject in question. Among the different alternatives, Moodle is probably the most widespread platform in this field and allows the established objectives to be met.

Regarding the Constructive Learning descriptors defined in the Technology Integration Matrix (FCIT, 2005) by Harmes, Welsh, and Winkelman (2016) for the instruction of real-world skills, all of the above activities are included into level four: Adaptation Level, which main characteristics help the students to independently use the technology for building knowledge, with student choice and exploration:

- Students begin to use technology tools independently to facilitate construction of meaning. With their growing conceptual understanding of the technology tools, students can explore the use of these tools as they are building knowledge.

- The teachers create instruction in which their students' use of technology tools is integral to building an understanding of a concept. We, the teachers, give our students the access to technology tools (Virtual Machines-VM, and authoring tools) and guide them in exploring and choosing appropriate resources.
- Technology tools that facilitate the construction of meaning are available to students for conventional uses.

At the same time some characteristics of level 5 Transformation level have also been achieved, in particular:

- The setting includes robust access to a wide variety of technology tools, robust access to online resources and a specific community built in the on-line repository, and the ability to publish new content online.

The following sections will show the way in which AEi is articulated according to the three main axes indicated above.

Lab virtualization for Moodle instantiation

The virtues of using virtualization are widely known: simple, fast and efficient implementation of different work environments within the same computer, better use and exploitation of available resources, the possibility of distributing these environments in a simple manner and platform interoperability (Ogunyemi & Johnston, 2010).In this regard, platforms such as Oracle's VirtualBox and EMC Corporation's VMware are probably the two most widely used and widespread virtualization environments in the educational environment. But most of the Spanish autonomies educational authorities have opted for free operating systems based on Unix / Linux and that use VirtualBox as virtualization software already pre-installed in them (for example, MAX of the Community of Madrid or Lliurex of the Community of Valencia), so opting for this virtualization option has been considered the most interesting.

In the field of IT teaching in vocational training centres, one of the main handicaps that appear is the installation and configuration of different services in the classroom (web service, mail service, LMS service, etc.), that can be addressed in two ways:

- Virtualization from scratch: in this case, the development of the virtualized environment starts from scratch. A host operating system is installed and configured from scratch, and then a specific service is installed, along with its corresponding configuration.
- Virtualization by adaptation of a previous system: in this case, the starting point is either a host operating system that has already been installed, or even a system that already contains the desired service perfectly configured.

From the learner's learning point of view, virtualization from scratch gives the possibility to carry out the whole necessary process from the point of formulation of the need until the need (service) is covered and perfectly functional. On the other hand, virtualization by adaptation proposes a quick and transparent implementation of the service for the student. Thus, everyone will have a virtualized environment perfectly configured and in an optimal state of operation, in addition to having an identical configuration that can be easily managed by the teacher. The main disadvantage is that this system gives the student the feeling that he/she has a "black box" whose start-up process is unknown to him/her, and therefore, learning is reduced to its operation and maintenance, and not to the initial installation and configuration process. In AEi we have considered that applying the concept of reuse and refactoring to virtualization is a desirable aspect that should be worked on, so the course proposes the use of an already existing virtualized environment adapted to certain needs.

After these practical experiences, students are able to design other virtual machines to cope with other different areas of vocational training studies. For instance, they could easily develop new VMs for teaching Operating Systems, such as Windows or Linux / Unix, as there already exist pre-configured environments that can be selected to create a full virtual lab, avoiding many typical problems like administrative difficulties of software installation and usage (Stoker et al., 2013). Bitnami is a company dedicated to the packaging of different services using different distribution scopes. As they have many different types of solutions, all ready to use, it is possible that most of the academic services that are needed within the classroom already have an initial implementation in Bitnami that could be adapted and customized.

The practice proposed to AEi students has been the adaptation of a virtual Bitnami machine on VirtualBox that allows the development of a Moodle environment. Moodle LMS delivers a powerful set of learner-centric tools to build a collaborative learning environment that empowers both teaching and learning. This open-source platform is backed by a large community of developers and educators constantly looking for ways to enhance the online learning experience, and there exist a lot of plug-ins and add-ons that extend and customise the functionality of Moodle. The use of this open-source platform contributes to the development of cognitive interest and motivation of the students, developing critical, professional pedagogical thinking and many forms of practical skills of the future teachers (Mykolaiovych et al., 2018). Students can choose on their own, which subject (from vocational training studies) is going to be implemented, but they are requested to develop at least one full lesson, using all kinds of multimedia resources.

Open Educational Resources development, uploading into repository and re-useness

Nowadays learning environments include the use of educational resources present on the Internet, such as digital books, presentations, videos, podcasts, etc., which are already part of the day-to-day life in the virtual classrooms. The study carried out by the Open Research Hub (de Los Arcos et al., 2015) shows the high degree of use of these resources for educational purposes. A broader knowledge of the existence of OER repositories and specific norms to evaluate their quality, together with some basic notions of computing, would allow the educators to create or reuse educational materials with the assurance of intellectual property and adapted to the varied needs of their learners (Rodrigo & Tabuenca, 2020).

Procomún is one of these OER repositories, supported by Spanish Ministry of Education. It stores more than 95,000 OERs along with educators' experiences, constituting an intelligent, social and distributed network. The repository is destined mainly for educational purposes but is open to a wider audience. Everyone can search, consult and download OERs in different formats. A semantic layer has been built on top of the existing platform and the services offered have been expanded by working with structured and Linked Data within the framework of the semantic web standards. The incorporation of a faceted search engine allows the user to find educational objects by restricting the global set of results through multiple criteria or facets based on their reasoning. The other fundamental element of the Procomún space is the Social Network closely linked to educational resources built by educators themselves, enriched with a social labelling system, such as user votes, educational contexts, recommendations for use and links to specific learning communities.

The activities promoted in this work also try to diminish four of the revealed six tensions that drive developing practices around OER in adult learning (Falconer et al., 2013). In particular:

- Open versus free: Low awareness of licensing is pronounced among adult educators and lifelong learners; common practice is to use free (no cost) resources without worrying unduly about IPR. Therefore, IPR issues are explained in detail, and students have to fill in the related metadata in the LOM section.
- Traditional versus new approaches: The majority of OER providers have traditional Higher Education views of teacher-directed pedagogy that are out of line with the direction in which adult learning is heading. The findings raise the possibility that approaches that work well in a university context may be less appropriate elsewhere. Therefore, the activities shown in this paper try to enhance cross-sector

collaboration between universities and high schools that could lead to more effective use of the resources.

- Community versus openness: Community-building is seen by initiatives as essential for successful uptake of OER. Communities can raise awareness, spread practice, and boost confidence. In 2017, authors created a social community linked to the Procomún repository to create a community of practice amongst learners (see Figure 1). The objective of this community is to explore the extent to which educators enrolled in their HE teaching qualification in Computer Science ("Master in Secondary Education, Professional Training and Language teaching") achieve the skills to develop quality OERs.
- Mass participation versus quality: The ability of the masses to participate in production of OER – and a cultural mistrust of getting something for nothing – give rise to user concerns about quality. This is particularly significant given the low ability of lifelong learners to evaluate resources for themselves.

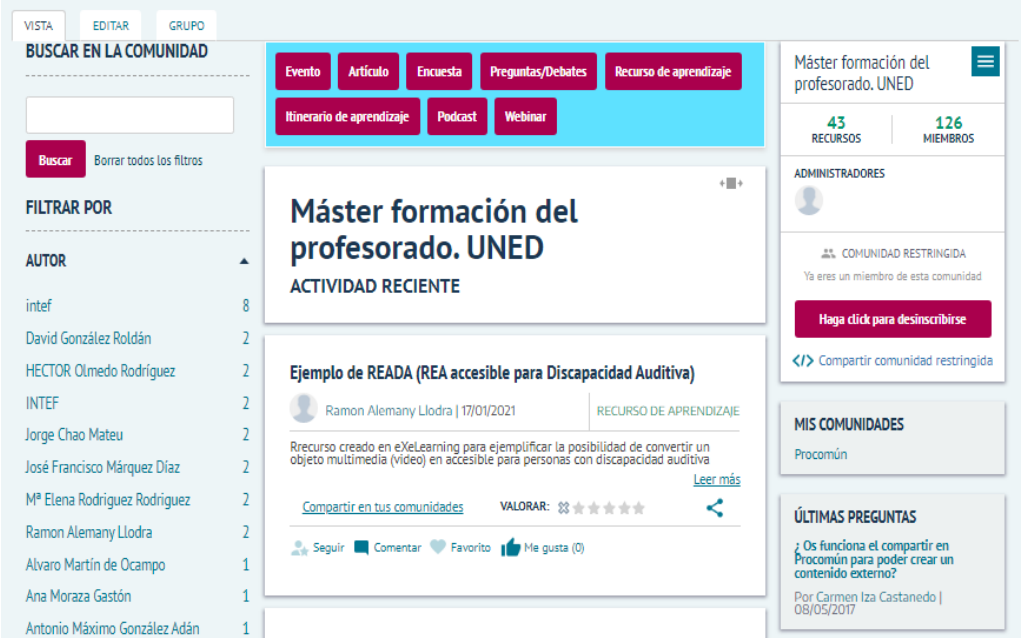

Figure 1. UNED's social community linked to the Procomún repository

Belief in quality is a significant driver for OER initiatives, therefore students are trained to assess their resources with the UNE71362 Quality for Digital Learning Resources standard (UNE, 2020). Learners are trained within the master programme to assess their OERs following this standard that covers indicators of technological, pedagogical and accessibility compliance (Moreno et al., 2019). Students can develop their own diagrams to organize data in a logical way, showing the level of achievement with each of the fifteen criteria:

- pedagogical: didactic description, quality of content, ability to generate learning, adaptability, interactivity and motivation);

- technical: format and design, reusability, portability and robustness;
- usability and accessibility: navigation, operability, accessibility of audio-visual content and accessibility of textual content.

In 2021, the social community comprises more than 126 members and hosts 43 new resources. Created by Computer Science learners using eXeLearning authoring tool connected to the Procomún, thus allowing direct publishing, metadata filling-in and specification of intellectual property. Some of the more recently developed resources are:

- A practical guide for educators that contributes to the dissemination of techniques for the creation and reuse of OERs for learners with hearing impairment.
- A case study for the use of Computer Vision techniques to improve the accessibility of visual OERs for learners with visual impairment.
- Three OERs based on the inquiry-based methodology to empower the presence of women in the field of Computer Science. The resources have been built around the biography of three well-recognised professionals: Hedy Lamarr, Joan Clarke and Evelyn Berezin.
- Two OERs based on project-based learning devoted to raising awareness among learners of the importance of equality in society, particularly in gender.

Discussion and Conclusions

This paper aimed to showcase several innovative experiences that have been tested at a course on Learning and Teaching of Computer Science at the Master's Degree for Teachers Training at Secondary, High School and Vocational Education Programs. It showed that inclusive and sustainable development goals are closer to being achieved through the dissemination of best practices for future teachers, although we have also found some facts to improve in the tools we used:

- There still exists a huge potential in the development of OERs for the Computer Science field in the Procomún repository. The resources mainly available are focused in Compulsory Secondary Education.
- There exists a huge potential in re-useness of the Procomún resources but there is still a lot of work to do on the use of Open Linked Data in OER repositories for improving the searches and recommendations for retrieving the best resources for each teacher and pedagogical context through the faceted search engines.
- Unfortunately, Procomún does not use accessibility metadata standards for labelling their resources, decreasing the potential of the amount of OERs hosted to be reused in educational contexts to address students with accessibility needs or special education needs.

- The use of standards, such as UNE 71362 to evaluate the quality of OERs, is beneficial for all stakeholders of the learning environment and assures a minimum level of quality and accessibility. In addition, this allows the comparison between equivalent OERs in order to get the most suitable one (depending on the subject or the object students) using certain quality parameters provided by UNE 71362.

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