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An Analysis and Comparison Between Moodle and edX Open-Source Solutions

Travaux de fin d'étude (TFE)

in view of obtaining a Diploma in Advanced Studies in Continuing Education in Higher Education and Education Technology

submitted by

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1 Introduction

The interaction between virtual platforms developed with systems like Moodle, highly implemented for virtual campuses in Higher Education, and the recent pedagogical model offered by the massive online open courses (MOOCs) phenomenon, based on the extensive and free training, offer new perspectives in the configuration of academic structures, teachers, and university scientists. In this context of virtuality and digitization of distance learning processes, and specifically in the field of Higher Education, the MOOC movement was born, which, as its initials indicate, is based on the training principles massive and free. Given the global context of the pandemic given by the COVID-19, the traditional education system rapidly moved to online platforms to continue with the learning process. Nevertheless, in most cases, the resources and tool provided by these platforms are limited. For that reason, it is important that the education systems move to more advanced tools to tackle the new expectations of students but also from teachers and lecturers. The goal of this thesis is to analyze and compare Moodle and the open-source educational platform developed by edX (Open edX[1]) towards the development of online campuses, instructor-led courses, degree programs, and self-paced courses using a single platform. At the end of this work, a set of guidelines and recommendation based on best practice of well-known platforms will be presented.

1.1 Status of Personal Experience

I currently work as a senior researcher in cognitive computing at the Human-IST Institute, University of Fribourg (UniFR), Switzerland, and an lecturer at the Lucerne University of Applied Sciences and Arts (HSLU). I was a visiting scholar at the University of Bern, an academic guest at the University of Zurich, and was, until October 2020, external researcher at the Universidad de Las Fuerzas Armadas (ESPE), Ecuador.

In terms of teaching and advising experience, I have always been committed to teaching courses ever since my doctoral studies, including Electronic Business (UniFR), Electronic Government (UniFR, ESPE), Business Information Analytics (HSLU), Human-Computer Interaction (EPFL), Databases (UniFR and HSLU), and Algorithmics (UniFR). Currently, I am the leading lecturer of the courses Introduction to Recommender Systems and Hands-On Recommender Systems, which are part of the Swiss Joint Master's in Computer Science at the Universities of Fribourg, Neuchâ-

[1] https://openedx.org

tel, and Bern. I am also the leading lecturer of the courses Data Ware House and Data Lakes (HSLU), Hands-On Visualization for Data Science (HSLU), and Database Management (HSLU).

Most of the courses I teach are face-to-face; nevertheless, during the world pandemic of COVID-19 and in the period of March 2020 to December 2021, all courses were given in online mode. Table 1 shows the list of courses, period of time, teaching method, and content management used. The teaching modes applied in the different course and presented in Table 1 are described in more detail as follows.

- **Face-to-face.** Lectures face-to-face means "being there" in class.
- **Face-to-face and online.** Given the COVID-19 pandemic, the course was partially face-to-face and was given online only during the lockdown.
- **Video lectures.** Given the technical problems presented during the COVID-19 pandemic, a new teaching method was designed to provide video lectures in advance and online sessions for Q&A.
- **Online lectures.** Given the COVID-19 pandemic, lectures were given online via streaming services like zoom or MS Teams.
- **Blended learning.** After several evaluations and the lessons learned from face-to-face, online lectures, and video lectures, the HSLU introduced a new methodology, so-called blended learning, that allows students to attend lectures face-to-face or online. This setup was focused on face-to-face students, so online students could not participate in discussions (questions by text messages or voice). The lecturer was not obligated to open discussions with online students in this setup.

In the work of Watson, 2008, the authors present a framework and define blended learning options and explore methods in which blended learning is being developed and how blended learning fits conceptions of online learning. However, despite different definitions of blended learning, many programs combine online teaching and face-to-face instruction in some way. The authors propose that the blending may be at the course level, combining online and non-online instruction within one subject. The approach presented in Figure 1 applies to most state-led supplemental online programs, such as Michigan Virtual School and Colorado Online Learning, some district programs, such as the Hamilton County Virtual School, and some consortium programs, such as the Massachusetts-based Virtual High School. The examples demonstrate that blended learning defines a significant continuum between fully online, at-a-distance, and face-to-face courses.

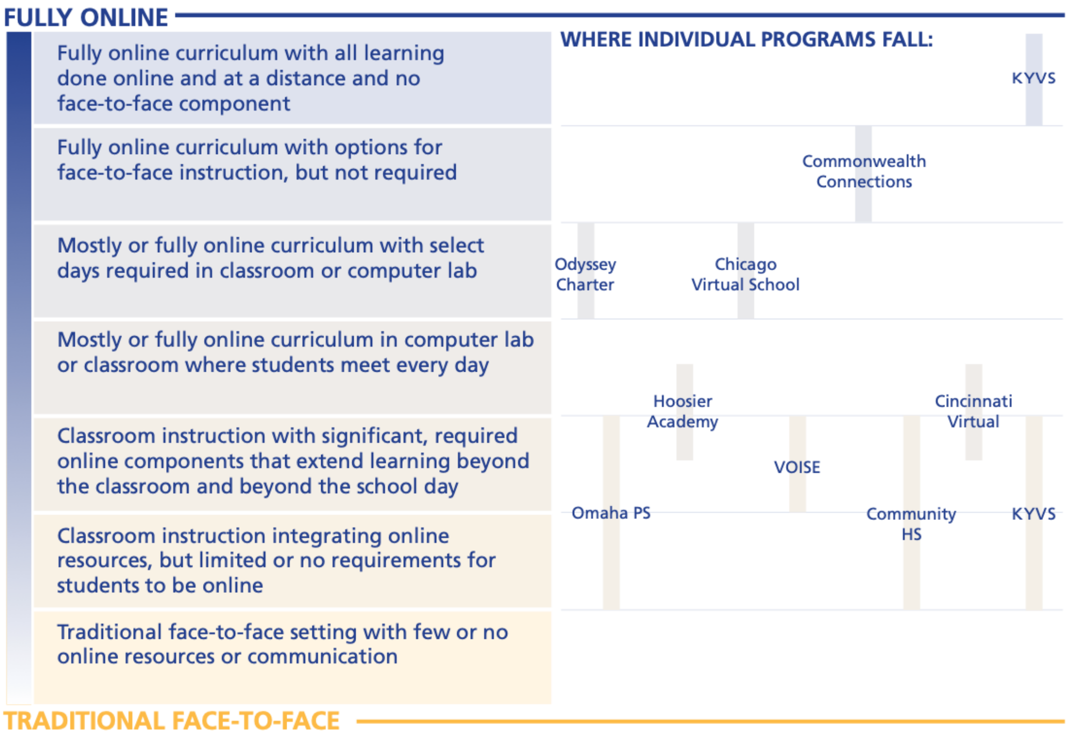


Figure 1 Blended Learning Continuum. Adapted from (Watson, 2008)

Table 1 Teaching Experience

Course	Institution	Teaching Mode	Technologies Used	Period	Evaluation (average)
Introduction to Recommender Systems	UniFR, UniNE, and UniBE	Face-to-face lectures	Moodle	2015-2019	6/7
Introduction to Recommender Systems	UniFR, UniNE, and UniBE	Face-to-face and online lectures	Moodle	2020	6.1/7
Introduction to Recommender Systems	UniFR, UniNE, and UniBE	Video lectures	Moodle	2021	4.1/7
Introduction to Recommender Systems	UniFR, UniNE, and UniBE	Face-to-face lectures	Moodle	2022	5.6/7
Database Management	HSLU	Online lectures	ILIAS	2020	3.96/5
Database Management	HSLU	Video lectures	ILIAS	2022	2.86/5
Data Warehouse and Data Lakes	HSLU	Blended learning (online and face-to-face at the same time)	ILIAS	2021-2022	4.36/5

The evaluations presented in Table 1 show that in two courses given at the UniFR and HSLU with the teaching mode "video lectures," provided to students instead of online or face-to-face lectures, show the lowest evaluations compared to other modes of teaching. It is essential to mention that those evaluations were during the world pandemic COVID-19, and most students had no course on campus. Additionally, the number of evaluations received in both cases was low (six evaluations for Introduction to Recommender Systems in 2021 and nine for Database Management in 2022).

Lessons Learned from Student Evaluations

The following hypotheses and interpretations are given to understand the discrepancies between the above evaluations. First of all, the COVID-19 pandemic took the entire world unprepared; the high education sector was not an exception. Indeed, the online programs and video courses were not planned and prepared in advance. Educators faced problems adapting their material and teaching methods and had to improvise in most cases.

A second hypothesis refers to the level of stress suffered during confinement. Several studies demonstrate the impact on student's health as presented in (Boukrim et al., 2021; Kilani et al., 2020; Oliveira et al., 2022). These hypotheses will be later on used to design and implement a blended learning solution at the HSLU on the pilot program introduced in Section chapter 5, which brings new environments and technology to improve the learning experience.

2 State-of-the-Art for Online Education

In the work of (Anderson, 2008), the authors show different views of the main pedagogical and course management possibilities and challenges introduced by the development of an online environment. This thesis uses these guidelines presented by (Anderson, 2008) to analyze both online learning open source solutions, Moodle and Open edX[2]. Nevertheless, future work should include further approaches and frameworks.

The use of delivery technology or the design of the instruction that improves learning has been debated in the last decades (Clark, 2001; Kozma, 2001). Web technologies provide efficient and timely access to learning sources. Nevertheless, (Clark, 1983) explains that technologies are simply ways that provide teaching but do not influence student achievement. In his analysis, the author's studies show that students are learning benefits from audio-visual or computer media, as opposed to conventional instruction. However, the same studies show that those benefits are not the medium but the instructional strategies and the learning materials.

An example of the above mention is the "Hole in the wall" experiment of 1999 (Mitra & Judge, 2004). The experiments of 1999 started with an Internet-connected computer embedded in a wall facing a slum in Kalkaji, New Delhi, India. Several studies showed that groups of children could learn by themselves when given access to the Internet. Children's academic development improved, and their learning interests increased with a significant decrease in school dropouts and an increase in school attendance. Soft skills, such as confidence, communication, and self-regulation, improved (Mitra & Dangwal, 2021).

Another example is the One Laptop per Child (OLPC) project[3]. It purposes facilitating access to technology to combat the educational gap with the most underprivileged children worldwide, understanding education as a powerful means toward social transformation.

In (Schramm, 1977), the authors describe how the content and instruction influence learning than by the type of technology used to deliver instruction. (Bonk & Reynolds, 1997) also indicates that online learning must create challenging activities to enable learners to create links from new to old information, acquire meaningful knowledge, and use their metacognitive abilities.

[2] https://openedx.org
[3] https://laptop.org

Additionally, (Kozma, 2001) claims that computers are required to get real-life instances and simulations to the trainee influenced by the medium. Nevertheless, the computer does not make students learn, but the creation of real-life models and the students' interaction. A computer system is the vehicle that delivers the processing ability and produces the teaching to students .

However, the learning materials must be appropriately designed to engage students and stimulate learning. Online learning provides diverse sources and media; nevertheless, it must follow a proper design (Rossett, 2002) including suitable material and support to students. In (Ring & Mathieux, 2002), the authors suggest that online learning should have high authenticity, interactivity, and collaboration. The authors discuss the educational theory for online learning materials and propose a model for online instruction based on educational theory.

Different terminologies are used for online learning, making it challenging to create a generic characterization. Many characterizations of online learning in the literature and definitions recall various practices and associated technologies. In the work of (Carliner, 2004), the author defines the term "online learning" as educational material offered on a computer. On the other hand, Khan, 1997 defines *online instruction* as an approach for providing education to a remote audience, using the World Wide Web (WWW) as a communication channel. Nevertheless, online learning implicates more than just the production and delivery of education materials using the WWW: the student and the education method should be the focus of online learning. As a result, the author defines *online learning* as the use of the Internet to access education materials; to interact with the content, the educator, and other students. It supports the learning process to acquire knowledge.

A model based on educational theory includes important learning components for designing online materials. Using Web-based content does not constitute online education. Online education occurs when students use the Web to go through the teaching sequence to complete different activities to acquire learning outcomes and objectives (Ally, 2002). Students should be able to choose among different strategies to meet their learning objectives. Figure 2 shows the components for the design of online learning materials according to (Anderson, 2008).

The elements presented in the model proposed by (Anderson, 2008) are briefly described as follows.

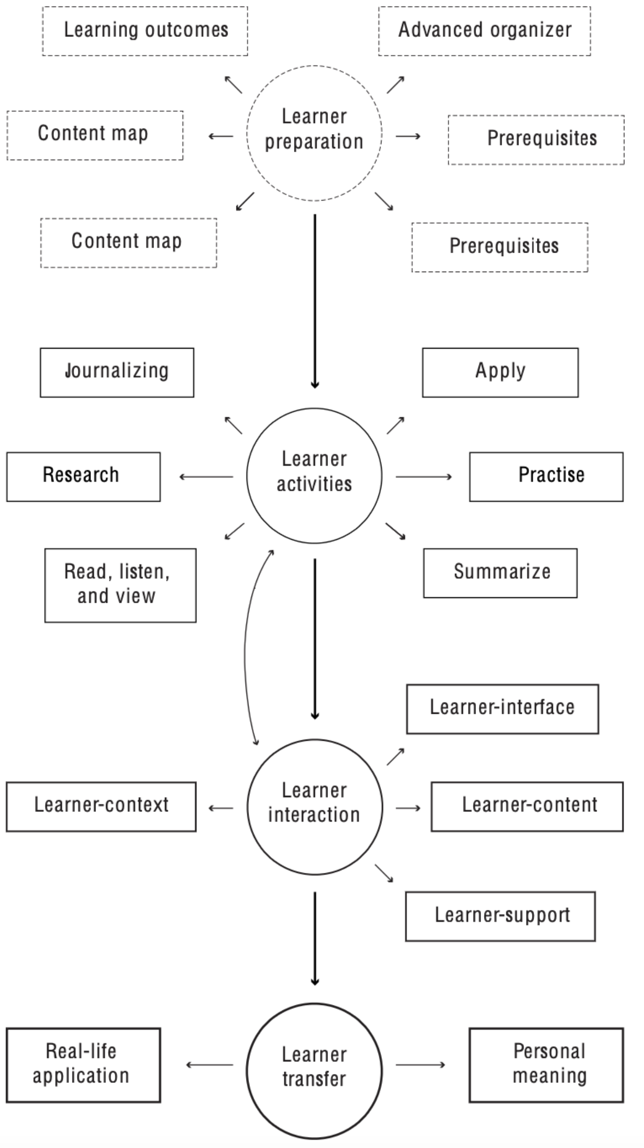


Figure 2 Components of effective online learning. Adapted from (Anderson, 2008)

Learner Preparation

Various pre-learning activities can be used to prepare the lesson and connect and motivate students to learn the online lesson. A concept map must be used to establish the existing cognitive structure, incorporate the details of the online lesson, activate students' existing structures, and give learners the "big picture." Learners should be advised of the lesson's education results to know what is expected to achieve the lesson outcomes. Learners must know the requirements to check whether they are ready for the assignment. A self-assessment should be provided at the beginning of the course to allow students to check whether they have the knowledge and skills acquainted with the online lesson. If students believe they have the knowledge and skills, they should be able to take the final test. Once students are prepared, they can conduct online learning activities.

Learner Activities

Online students have access to various learning activities (e.g., reading textual materials, listening to audio materials, or viewing visuals or video materials) to complete the lesson outcome and adapt to students' individual needs. Students can explore the Internet and access online information and libraries to obtain information. Preparing a learning journal will allow students to recall what they learn and provide meaning to the information. Exercises should be embedded throughout online lessons to establish the materials' relevance. Practical activities should be incorporated to let students monitor their performance. A resume should be provided to promote higher-level processing and to bring closure to the study.

Learner Interaction

Students will be involved in various interactions when they achieve the learning activities. Students need to be able to access online materials. The interface used to access materials should not overload students. Students should be able to interact with the content to construct the knowledge base. There should be an interaction between students, the student, the instructor, and the learner and experts to participate in shared cognition, form social networks, and establish a social presence. Students should be able to interact within their context to personalize information and construct meaning.

Learner Transfer

Opportunities should be provided for students to transfer knowledge to real-life applications to be creative and go beyond what was presented in the online lesson.

Designing and implementing a learning system has the main objective of promoting learning. Thus, before developing learning materials, instructors should know the learning principles, especially for online learning. Online learning materials should be based on learning theories, including instructional design, clear goals in mind, and clear and explicit intention to teach. Consequently, the delivery medium is not the determining aspect of the quality of education; instead, the course's design defines the learning's significance as mentioned in (Rovai, 2002).

The online learning designer must know the different approaches to pick the most appropriate instructional techniques. Learning strategies should be set to encourage learners, promote significant learning, facilitate interaction, and provide adequate feedback.

2.1 Online Learning and the COVID-19 Pandemic

COVID-19 as pandemic became a contemporary threat to society. This pandemic forced a transnational shutdown of daily activities, which includes educational activities. It has resulted in complex reactions of educational institutions, including high education, with online learning as the educational platform. The responses of educational institutions show that online learning differs from emergency remote teaching. Online learning is becoming more sustainable, while instructional activities will become more hybrid, given the challenges experienced during this pandemic (Adedoyin & Soykan, 2020). The work of (Pokhrel & Chhetri, 2021) reports on the impact of the COVID-19 pandemic on online teaching. The authors indicate that the lessons learned from the COVID-19 pandemic are that teachers and students/learners should be taught using different online educational tools.

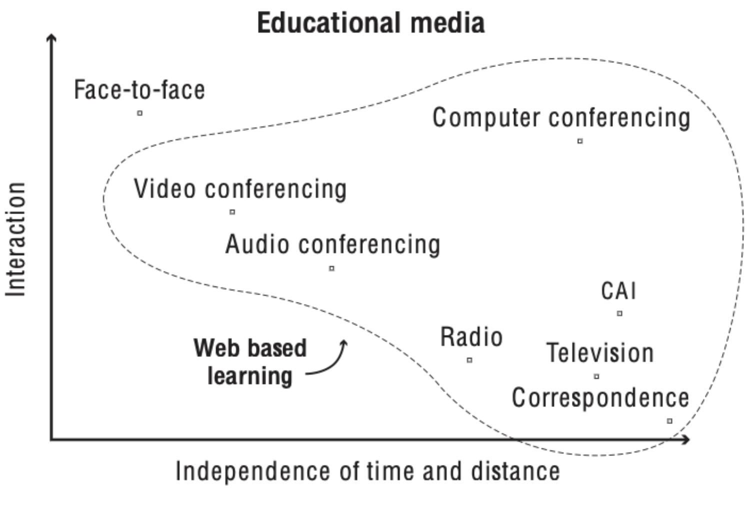


Figure 3 Attributes of educational media. Adapted from (Anderson, 2008)

Figure 3 shows the different types of media for distance education according to (Anderson, 2008). It highlights the time- and place-independence and support for interaction. It shows that the higher and richer the communication type, the more constraints it positions on independence. The figure shows the different forms of educational interaction supported by the use of the WWW to enhance classroom-based learning. On the other hand, the level of interaction depends directly on the actors that participate in the learning process. In the work of (Gilbert & Moore, 1998), the author presents the forms of interaction in distance education: student-to-student, student-to-teacher, and student-to-content. In the work of (Garrison, 1999) the list was extended to include other types of interation such as teacher-to-teacher, teacher-to-content, and content-to-content (see Figure 4).

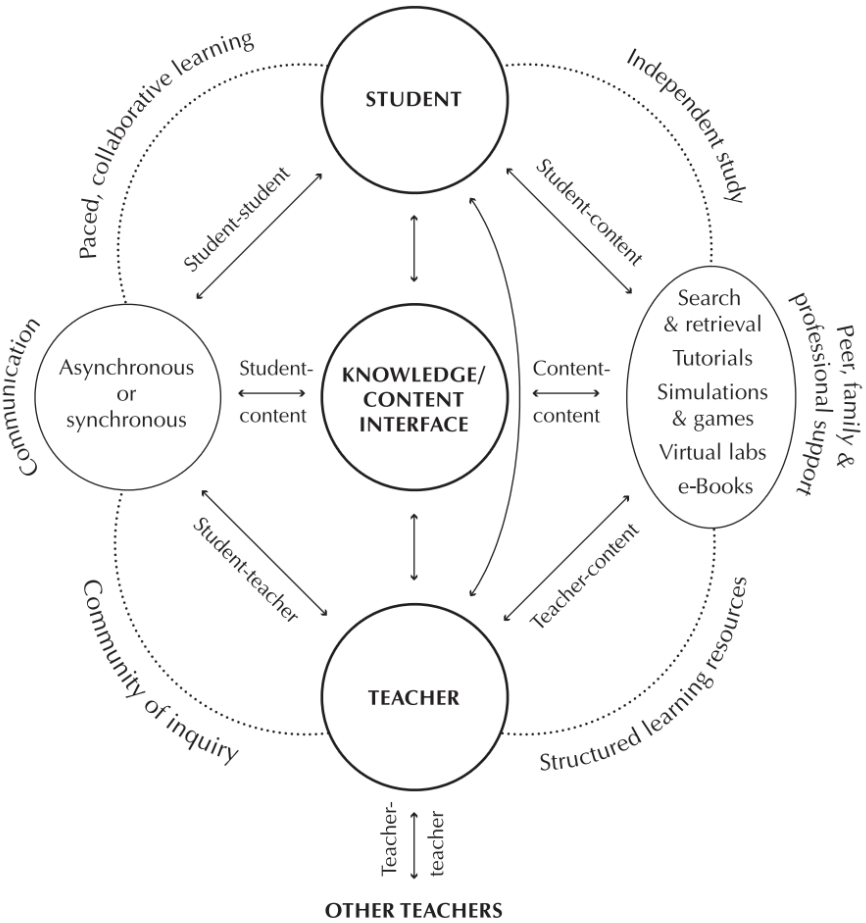


Figure 4 A model of online learning showing types of interaction. Adapted from (Anderson, 2008)

Student-to-Student Interaction.

This type of interaction is also defined as peer-to-peer interaction. Collaborative learning shows the potential of student-to-student interaction in cognitive learning tasks. It can also increase fulfillment and acquire social skills in education (Slavin, 2015). Peer interchange is essential to developing communities of learning (Wenger et al., 2002), allowing learners to acquire interpersonal skills and share knowledge with community members.

A personal example of this type of interaction within my personal teaching experience was applied in online lectures at the HSLU (refer to Table 1). In this context, students participating in group work had access to private breakout rooms via the Zoom platform to enhance peer-to-peer interaction.

Student-to-Teacher Interaction

This type of interaction is supported in online learning in different formats, including asynchronous and synchronous communication (e.g., text, audio, and video). The facility of such communication channels could overwhelm teachers with the number of student communications and increase students' expectations waiting for fast responses.

A personal example of this type of interaction within my personal teaching experience was applied in online lectures at the HSLU (refer to Table 1). In this context, students participating in group work had access to private breakout rooms via the Zoom platform. As a lecturer, I stay in the main room. In this context, students can always find support and discussion in the main room.

Student-to-Content Interaction

This type of interaction is essential in formal education. The WWW supports this type of interaction in more passive forms. It provides additional interaction opportunities, including micro-environments, virtual labs, computer-assisted tutorials, and interactive content. In the work of (Eklund, 1995), the authors present some advantages of such approaches including, 1) online or intelligent help channels, 2) adaptive interfaces, 3) adaptive advice (e.g., navigational use, Q&A, and help requested) , and 4) immediate feedback

Teacher-to-Teacher Interaction

This type of interaction provides professional development opportunities through communities of interest. These interactions facilitate educators to profit from knowledge expansion via discovery within the community of instructors.

Teacher-to-Content Interaction

This type of interaction concentrates on content creation and learning activities. It allows educators to observe and correct the content and activities as part of the learning process.

Content-to-content Interaction

This type of interaction is a new model of interaction. It proposes that content can also interact with other automated knowledge sources. The content generated also has the property of a constant auto-refresh and has the possibility of including other capabilities. Content-to-content interaction provides control of rights and facilitates tracking of content usage.

2.2 Open Educational Resources

Higher education institutions worldwide have used the Internet to develop teaching and learning methodologies in the last decades. Given the recent world pandemic of COVID-19, the use and impact of so-called open educational resources (OER) were crucial to assist students in their learning process. The potential and objectives are to prevent demographic, economic, and geographic educational limitations and promote accessible and personalized learning. The growth of OER delivers new possibilities for teaching and learning. Additionally, such technologies challenge traditional views about teaching and learning in higher education Yuan et al., 2008.

The term OER was first introduced at a conference in 2000 hosted by UNESCO to promote free access to educational resources. A general definition of OER is “digitized materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning, and research” (Peña-López et al., 2007). According to (Peña-López et al., 2007), in this definition, the term “resources” is not limited to content but comprises three areas, these are:

– **Learning material:** It refers to resources, including courses, course-ware, learning objects, content modules, collections, and journals.

– **Tools:** These refer to software and applications to support the development, use, reuse, and delivery of learning content. It includes searching and organizing content, content and learning management systems, online learning communities, and content development tools.

– **Implementation resources:** These refer to intellectual property licenses to promote the open publishing of materials and configuration principles, best practices, and localized content.

On the other hand, the Cape Town Open Education Declaration[4] supports the promotion of open education as “Educators worldwide are developing a vast pool of

[4] https://www.capetowndeclaration.org

educational resources on the Internet, open and free for all to use. These educators are creating a world where everyone can access and contribute to the sum of all human knowledge..." In order to accomplish these goals, three strategies have been proposed to increase the reach and impact of OER.

- Encourage educators and learners to participate in the emerging open education movement actively. Developing and applying open resources must be integrated, supported, and rewarded for education.
- OER should be shared through open licenses to facilitate anyone's use, revision, translation, improvement, and sharing. The publication of resources should be made in formats to facilitate the use and editing and accommodate various technical platforms.
- Governments, school boards, institutes, and universities should prioritize open education. Public educational resources should be targeted for OER. Additionally, accreditation programs and adoption processes should give priority to OER.

The declaration is already signed by individuals and organizations, including students, teachers, coaches, authors, academies, colleges, universities, publishers, associations, professional societies, policymakers, governments, and foundations worldwide. The OER initiative grows with the idea of continuing to evolve. Developing a shared vision and other implementation strategies around technology development, teaching, and learning practices are required to do so.

Openness and the Open Initiatives

The adoption of *openness* in education is based on knowledge disseminated and shared using Internet technologies to support society's development. Openness provides high availability, and few restrictions on resource use exist in various forms and domains. The concept of openness, from a technical perspective, is characterized by access to source code and access to interoperability standards. However, existing initiatives offer a basic level of openness *open* means "without cost"; nevertheless, it does not imply "without conditions."

The meaning of *open* is evolving and changes according to context, e.g., disseminating software source code, using and reusing content, and open access (OA) to publications. Some examples of OA intiatives are the Open Source Initiative (OSI)[5], Open Access (OA) Initiatives[6], and Open Content (OC) Initiative[7].

2.2.1 Discussion

Open standards are used to create open-source software with source code unrestricted to anyone as long as licensing terms are followed. It permits organizations, high education institutions, and individuals to collaborate, improve upon existing solutions, share best practices, and develop creative solutions.

Open-source initiatives and projects focus on learning management systems, assessments, degree programs, content, research, and more (e.g., Moodle and Open edX). Such initiatives create open communities to promote change, optimize operations, and better support high education.

Open-source projects in higher education should include essential elements such as those listed.

- **Standardized identity protocols**. It allows users to use the same profile and credentials across multiple systems.
- **Authentication protocols**. It allows secure access to online resources and data exchange using open tools and services.
- **Standardized data analytics**. It enables uniform measurement and evaluation across multiple systems.

One problem with using proprietary software is the complexity of meeting institutional requirements. On the other hand, open-source fits the needs better, providing considerable cost. Open-source goes beyond what is available and contributes to project enhancements supporting future endeavors.

The open-source concept supports the educational significance of information accessible to all. Nevertheless, successful open-source solutions design and implementation require a strategy and experience. To this end, strong expertise in IT in cooperation with other stakeholders is required to define goals and requirements. Furthermore, it requires students, faculty, and staff training to ensure a transition to open-source solutions.

[5] http://www.opensource.org/
[6] http://www.pubmedcentral.nih.gov/about/openaccess.html
[7] http://www.opencontent.org/

Open standards and open-source software are highly relevant to transformations in higher education. For the reasons mentioned above on open-source solutions in higher education, this thesis focuses on the comparison of two open-source solutions, Moodle (see Section 4.1) and Open edX (see Section 4.2).

3 Basic concepts of MOOCs

Massive open online courses (MOOCs) and their impact on educational technology have been studied since 2010. The open character of such platforms could attract students worldwide. Higher education institutions and their academics are developing their own MOOCs. International reports and academic articles describe the impact of MOOCs and how such platforms can support traditional education. In the work of Ebner et al., 2020, the authors tackle the question: “How can MOOCs be used in Higher Education learning and teaching scenarios and beyond?” and the authors identified how MOOCs are used for teaching and learning, illustrating that a MOOC can be “more than a MOOC.” The study shows that MOOCs are one of the critical drivers for open education using open educational resources. Finally, the authors conclude that using open licenses for MOOC resources potentiates learning and teaching strategies.

3.1 Impact of MOOCs

Open online learning (OOL) originated in the 1990s with e-mail-based courses (Smith et al., 1999). Further, OOL was presented as self-paced web-based courses in the late 1990s, and early 2000s (Mott & Wiley, 2009). Therefore, MOOCs were preceded by open online courses and the open educational resource (OER) movement. In the work of Bozkurt et al., 2018, the authors mention that the first open online course was “Connectivism and Connective Knowledge” organized by Stephen Downes and George Siemens in 2008. Additionally, the authors describe another type of MOOC, the so-called xMOOC. It highlighted the focus on providing content to a massive public audience. A highlight of MOOC growth was the calling of 2012 the “Year of the MOOCs” by the New York Times [8].

A decade later, MOOCs reached 220 million students. MOOCs providers launched over 3100 courses and 500 micro-credentials (Stracke et al., 2019). Initially, MOOC developers depended on universities to create courses. Nevertheless, that dependence is declining as more courses are created by corporations yearly, including Google, Microsoft, Amazon, and Facebook, among others. The percentage of new non-university courses is presented in Table 2.

[8] https://www.nytimes.com/2012/11/04/education/edlife/massive-open-online-courses-are-multiplying-at-a-rapid-pace.html

Table 2 Percentage of new non-university courses. Adapted from (Shah, 2021)

	2020	**2021**
Coursera	31%	39%
edX	16%	26%
FutureLearn	38%	51%

In 2020, a quarantine boost as an effect of the COVID-19 pandemic experienced by MOOC providers. This effect decreased in 2021, with 40M new learners compared to 60M in 2020.

In the last decade, MOOCs objective was to promote universal education for everyone. However, the purpose of "freedom" varied over time. MOOCs went from no revenue to making over half a billion dollars yearly. The videos, assignments, content, and certificates were free in the first versions of MOOCs. As MOOC providers focus on a revenue-driven business model, certificates are paid. In 2021, MOOC providers were looking outside universities to develop courses. The COVID-19 pandemic increased the adoption of online courses by the industry and governments.

A general definition MOOC comes from: massive, open, online, and course. Neverheless, inquiries have been introduced about each of the four terms and their definitions and interpretations Stracke et al., 2019.

1. **Massive**. As the number of MOOCs is growing, the number of students per course is decreasing. Nevertheless, most MOOCs registered more than several hundred users.

2. **Open**. This term does not refer to "Universal." A MOOC can be open to a community (e.g., a university). Nevertheless, it could also be restricted to outer users.

3. **Online**. This condition is almost always met. However, there are MOOCs distributed offline that lack online connectivity.

4. **Courses**. This term guides to a series of events with a fixed start date and end date. The cMOOC model refers to a course of lectures organized by students and offered by a lecturer (without assignments and grades). An xMOOCs model is a traditional model of educator-directed instruction. Nowadays, most MOOCs offer blended models over a short period.

To understand the impact of MOOCs, Table 3 shows the MOOC providers in terms of users and offerings. Additionally, Figure 5 shows that by the end of 2021, 19.4K MOOCs were announced by around 950 universities worldwide.

Table 3 MOOCs offerings[9]

	Learners	Courses	Microcredentials	Degrees
Coursera	97 million	6,0003	910	34
edX	42 million	3,550	480	13
FutureLearn	17 million	1,400	180	22
Swayam	22 million	1,465	0	0

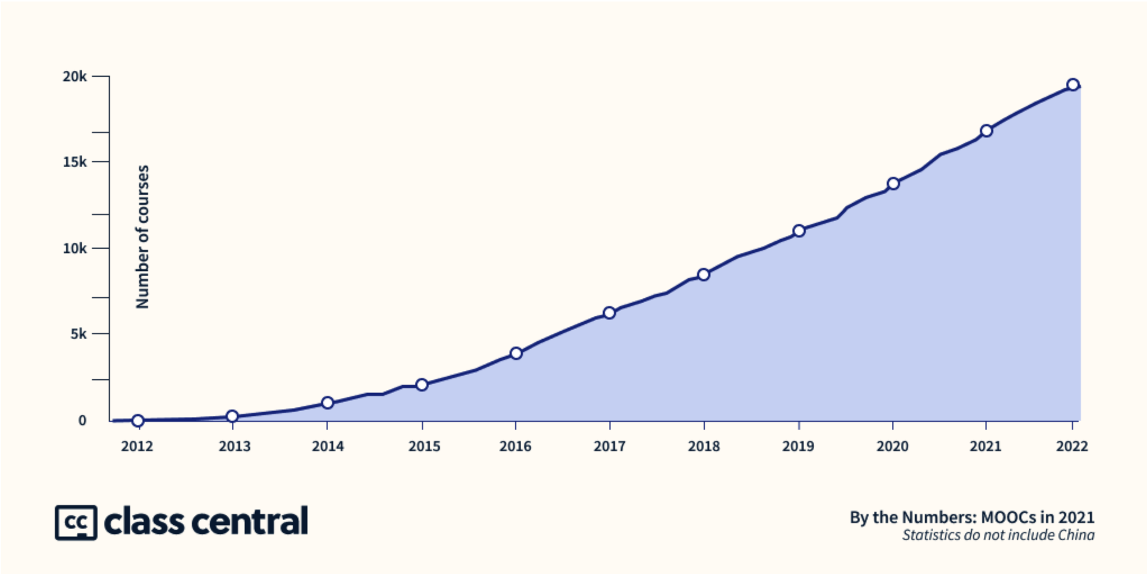


Figure 5 Growth of MOOCs[10]

3.2 Trends of MOOCs of Global and Regional Providers

The use of MOOCs creates new prospects in the scholarly landscape. Nevertheless, many studies report that students have already completed other certifications in high education and come from wealthy countries (Reich & Ruipérez-Valiente, 2019) with a focus on global MOOC providers (i.e., edX, FutureLearn, or Coursera), including higher education universities in the USA primarily in English. Numerous studies have discussed the effect of language and culture on learning, as presented in the work of Hunt and Tickner, 2015, as well as the country of origin of participants to behavioral patterns in the course (Z. Liu et al., 2016) and the social identity threat developing countries (Kizilcec et al., 2017).

According to Ruipérez-Valiente et al., 2020, research has been concentrated on English providers. However, there are also regional MOOC providers in other languages. In their work, the authors analyze thirteen MOOC providers worldwide. This study explores trends across various MOOC providers. The results register initial results of trends based on demographics, including country, level of education,

9 Source: https://www.classcentral.com/report/mooc-stats-2021/
10 Source: https://www.classcentral.com/report/mooc-stats-2021/

gender, and age of their students. The authors analyzed the data collected from twelve providers, including MITx[11] and HarvardX[12] (abbreviated as MITxHx), [13], openHPI[14], openSAP[15], OpenWHO[16], mooc.house[17], HEC Paris[18], UPValenciaX[19], UPVx [20], Edraak[21], XuetangX[22], and The ChineseMOOC[23]. This preliminary analysis conducted by Ruipérez-Valiente et al., 2020 uses the following elements: country, level of education, age, and gender. The forthcoming sections summarize the results of this study.

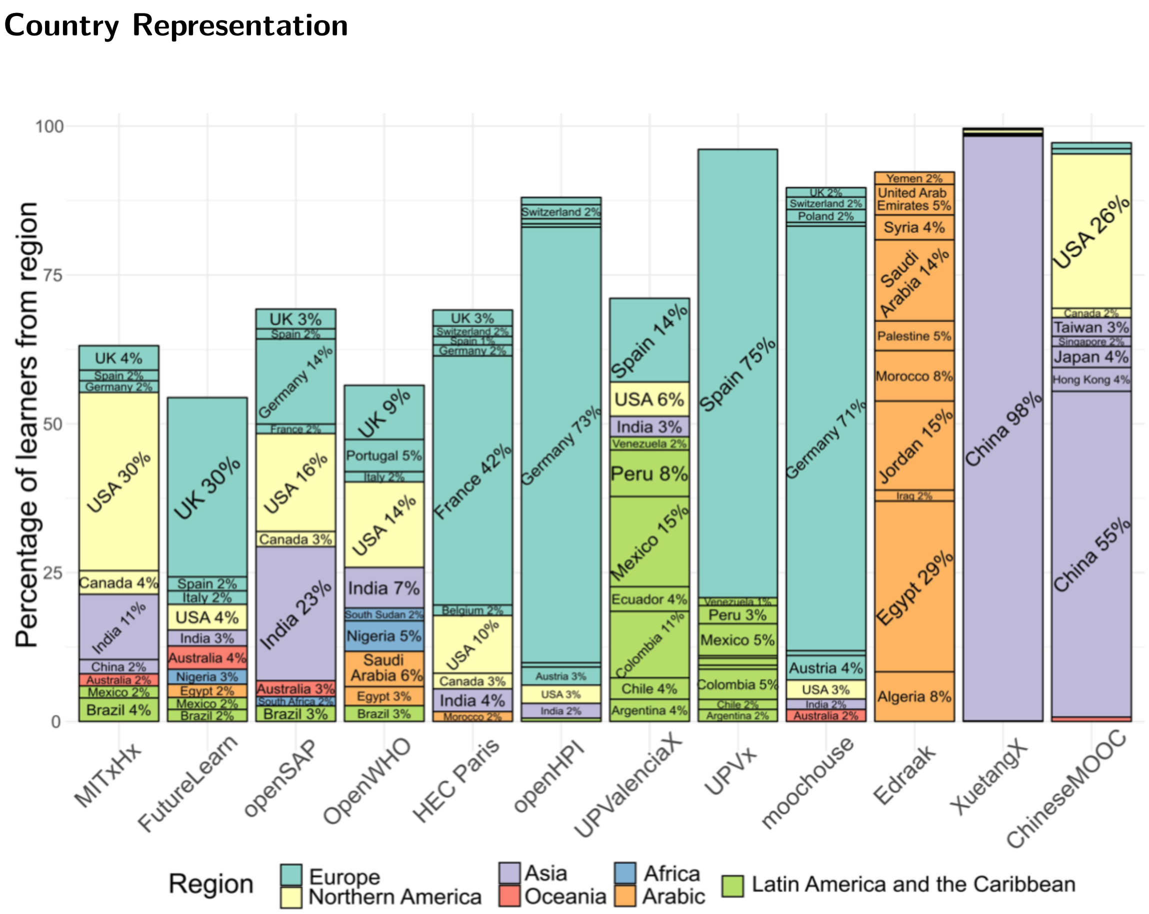


Figure 6 Top-ten countries in percentage per provider. Adapted from (Ruipérez-Valiente et al., 2020)

11 https://openlearning.mit.edu/courses-programs/mitx-courses
12 https://online.hbs.edu
13 https://www.futurelearn.com
14 https://open.hpi.de
15 https://open.sap.com
16 https://openwho.org
17 https://mooc.house
18 https://www.hec.edu/en/online-programs/moocs
19 https://www.edx.org/school/upvalenciax
20 https://www.upvx.es
21 https://www.edraak.org/en/
22 https://www.xuetangx.com
23 http://www.chinesemooc.org

Figure 6 shows the top-ten most representative countries of learners for each platform analyzed. The study shows that MITxHx and FutureLearn participate similarly from their home countries. The most representative countries are USA, UK, India, and Brazil. The providers that offer local language as well as English, the MOOC providers have students from the local region and other regions. These distributions show that global and regional providers have different missions and strategies to recruit learners from other regions.

Level of Education

Figure 7 shows the distribution of education levels among the different MOOC providers. The study presents four educational levels, Doctorate, Master's, Bachelor's, and High school. The reported trend includes higher education levels at a doctorate or master's level, as described in Chuang and Ho, 2020. On the other hand, MITxHx and FutureLearn show similar trends of students with a doctorate or master's. Another contrast is that UPVx attracts more educated learners from Spain and Latin America than UPValenciaX. The results of the demographic observations confirm the trends documented previously in the literature and open new questions on further variations.

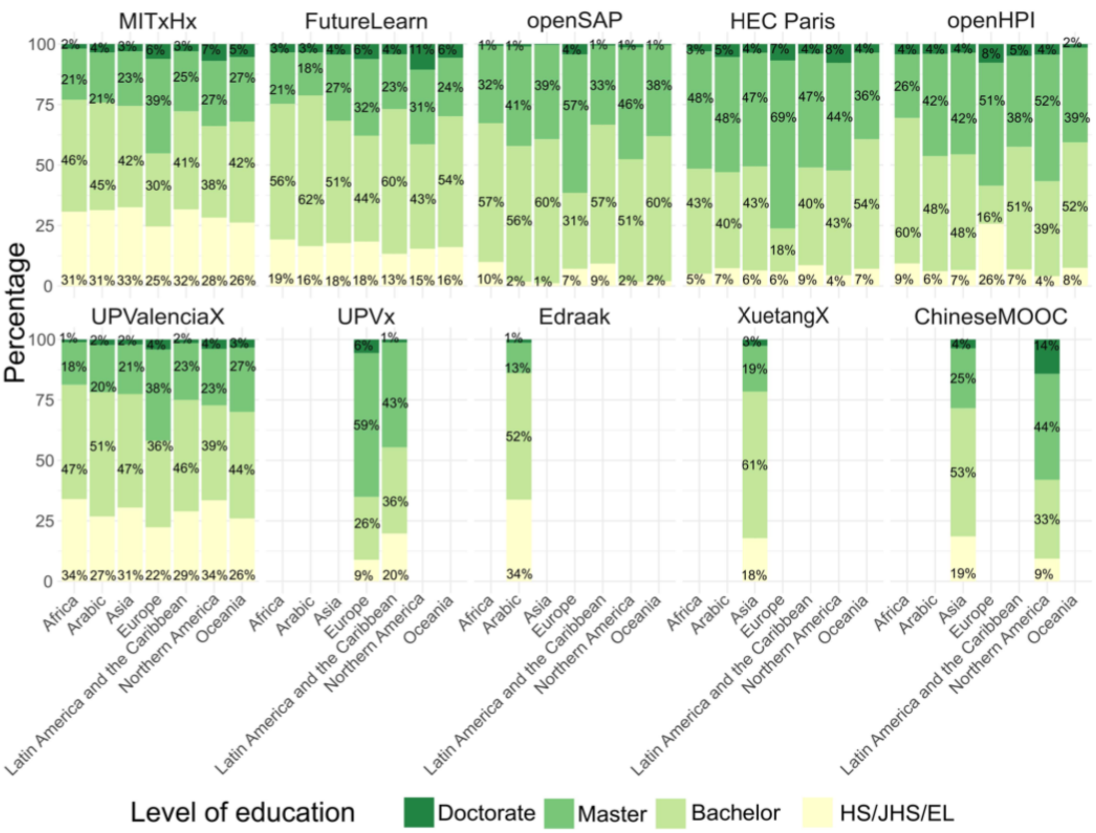


Figure 7 Level of education per provider and region. Adapted from (Ruipérez-Valiente et al., 2020)

Gender Distribution

Figure 8 presents the distribution of gender by region and MOOC provider. Gender gaps are reported with a higher proportion of male students in regions with lower development according to Chuang and Ho, 2020. Regions, including Europe and Northern America, have better gender distribution than African or Arab countries. The analysis does not exclude students who identify as fluid or non-binary.

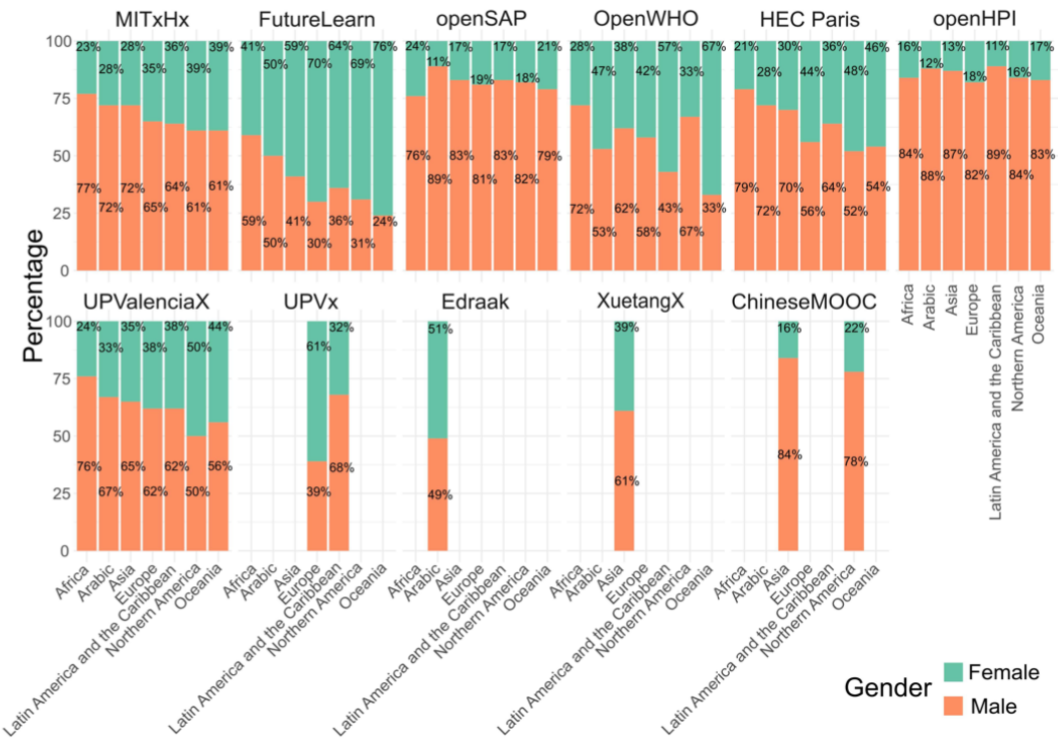


Figure 8 Gender distribution per provider and region. Adapted from (Ruipérez-Valiente et al., 2020)

Age Distribution

Figure 9 shows the age distribution by MOOC provider. The figure presents student groups of different age segments. The results show that the most common age component is 26 to 35 (except openHPI with 45 to 55 and Edraak with 18 to 25. The authors conclude that differences might be related to the age target of providers and their courses. On the other hand, regional variations might also be linked to digital literacy and level of knowledge of the English language across the ages.

3.3 Discussion

This section was dedicated to the impact analysis and presentation of trends in the use and application of MOOCs worldwide. The first part describes the historical devel-

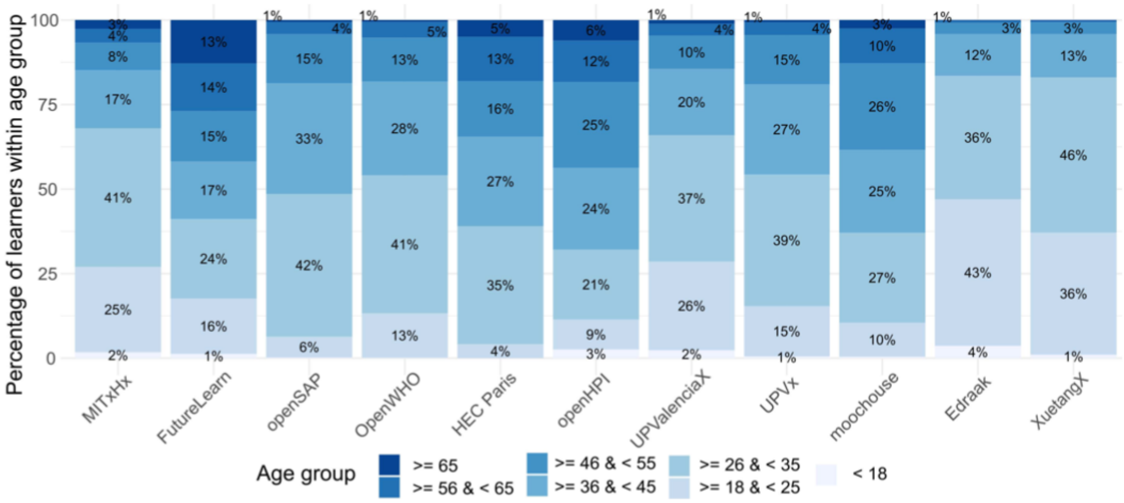


Figure 9 Gender distribution per provider and region. Adapted from (Ruipérez-Valiente et al., 2020)

opment of MOOCs from the initial courses supporting the original goals of MOOCS toward massive open online education. As described in 3.1, although MOOCs' use and applications expanded in the last decade, the objectives moved from open to a more revenue-driven approach.

Section 3.2 presents a MOOC cross-provider data analysis. MOOC platforms and courses have made substantial investments to enhance the overall ecosystem. The research study by (Ruipérez-Valiente et al., 2020) presents another perspective of MOOC providers. The authors' findings suggest that age, gender, level of education, and region provide helpful information about MOOCs learners and the value of providers for local and global populations. This work also shows that locality impacts platforms. The concentration of local students of MOOCs varies from 98% for XuetangX to 30% for global providers. The gender ratio indicates how MOOC platforms managed to attract diverse audiences. Previous education level across students demonstrates that MOOC providers generate interest across a broad audience of diverse prior education levels.

By understanding the goals and incentives of educated individuals performing lifelong education in MOOCs, it is possible to understand how MOOC providers are reaching students with a lower level of education interested in access to high-quality education. These elements are related to designing more fair and inclusive online learning experiences.

In section 3.2, the authors present the factors that affect the demographic differences across MOOC providers, including topics in the course catalog, instructional design, language, or location.

As described in the previous chapter regarding the use of open standards and open-source software (see Section 2.2), this chapter highlights the impact of MOOCs in higher education. Given these reasons, this thesis focuses on the comparison of two open-source solutions, Moodle (see Section 4.1) and Open edX (see Section 4.2). The former corresponds to one of the most important MOOCs providers.

4 Analysis of Moodle and Open edX

This work aims to determine whether open-source MOOCs (i.e., Open edX) could improve the learning experience if implemented in pure online learning using an open-source learning management system (LMS), i.e., Moodle[24] or ILIAS[25].

This section is dedicated to a comparison between two open-source solutions for High Education, Moodle[26] and Open EdX[27].

4.1 Moodle Open-Source

Moodle is an open-source learning management system developed with a general-purpose scripting language, PHP[28]), that is specifically developed for web development. Moodle is distributed under the GNU General Public License[29]. Moodle platform is used for learning environments for distance instruction, flipped classrooms, blended learning, and other online education projects in academies, universities, governmental, and other sectors.

4.1.1 Moodle Architecture

Moodle open-source is structured as an application core. Numerous plugins support the core to provide specific functionality. Moodle is designed to be extensible and customizable without the need to modify the core libraries to reduce the risk of problems during upgrading to a newer version. Moodle is based on the plugin architecture presented in Figure 11.

Core

Core libraries supply the base functionality of moodle as a system, and it is referred to as “core”. Core components are not optional and cannot be removed without damaging Moodle as a system.

24 https://moodle.org
25 https://www.ilias.de
26 https://moodle.org
27 https://openedx.org
28 https://www.php.net
29 https://www.gnu.org/licenses/gpl-3.0.en.html
30 Source: moodle.org

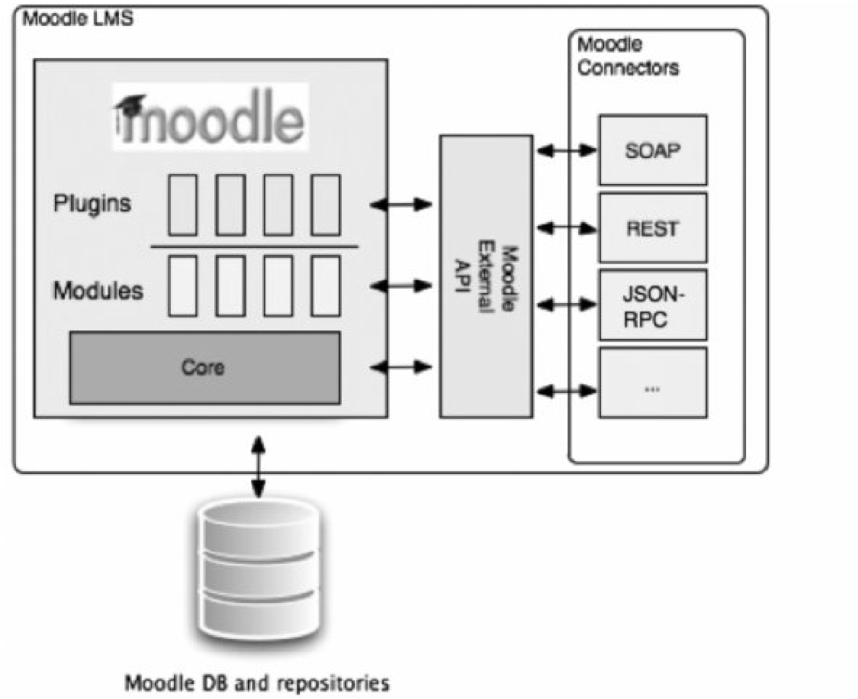


Figure 10 Moodle Architecture[30].

Subsystems

Subsystems are clusters of interconnected processes and classes and are part of the core. Subsystems are grouped following a logical structure. For example, Moodle version 3.1 includes 66 subsystems in the core.

Plugins

Plugins are optional features that can be added to the Moodle core to extend its functionality. The M from Moodle stands for "Modular," and most of the code in Moodle belongs to plugins. There are many different plugins available[31]. Each plugin variety expands core functionalities.

4.2 Open edX

Open edX is an open-source software platform developed by the edX[32] organization. edX is a massive open online course (MOOC) provider developed in collaboration between Harvard and MIT. The objectives pursued by edX are: 1) to provide access to high-quality education for everyone, everywhere, 2) enhance teaching and learning on campus and online, and 3) advance teaching and learning through research. edX

31 https://moodle.org/plugins/
32 https://www.edx.org

currently hosts online university-level studies in a broad spectrum of fields, including some courses free of charge. It also performs education-based research to analyze people who use the platform. edX operates on the Open edX open-source software distribution. On June 1, 2013, edX open-sourced the platform named Open edX to differentiate edX from the organization itself[33]. The source code used by Open edX can be found via GitHub distributions[34] [35].

4.2.1 Open edX Architecture

The most crucial component in the Open edX architecture[36] is the edx-platform[37]. It contains the learning control (Learning Management System (LMS)) and course authoring applications (Studio). This service is supported by a group of independent web services, so-called independently deployed applications (IDAs). This process helps edX to handle the complexity of the edx-platform for developers.

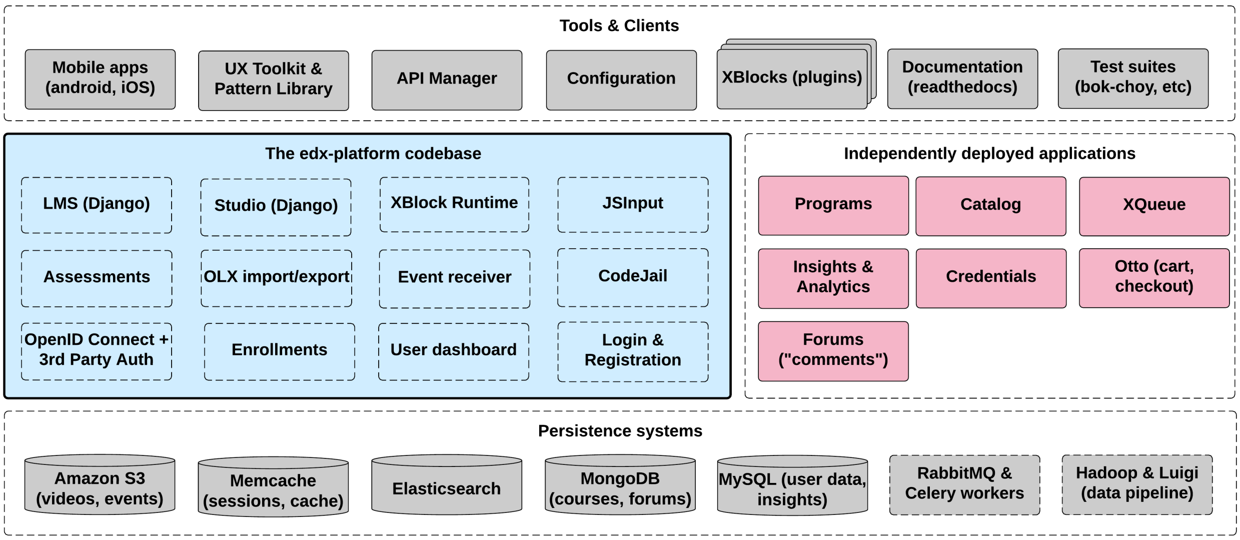


Figure 11 edX Architecture[38].

Learning Management System (LMS)

The LMS is the visible side for end users on the platform. Via the LMS, learners access the courses available. Open edX course material comprises mainly videos and problems to enable students to review their improvement during the course development. Administrators can use the LMS to accept new students, lead learner progress,

33 https://news.stanford.edu/news/2013/april/edx-collaborate-platform-030313.html
34 https://github.com/edx/
35 https://github.com/openedx/edx-platform
36 https://edx.readthedocs.io/projects/edx-developer-guide/en/latest/architecture.html
37 https://github.com/openedx/edx-platform
38 Source: https://www.edx.org

and generate reports. These processes can be controlled through the instructor dashboard (see Figure 12). The LMS uses several data stores, including MongoDB, with videos feed from YouTube or Amazon S3. Via the LMS, instructors can publish courses, discussions, manage teams, edit grades, and communicate with learners. On the other hand, students can review their profile and enrollment status and browse courses.

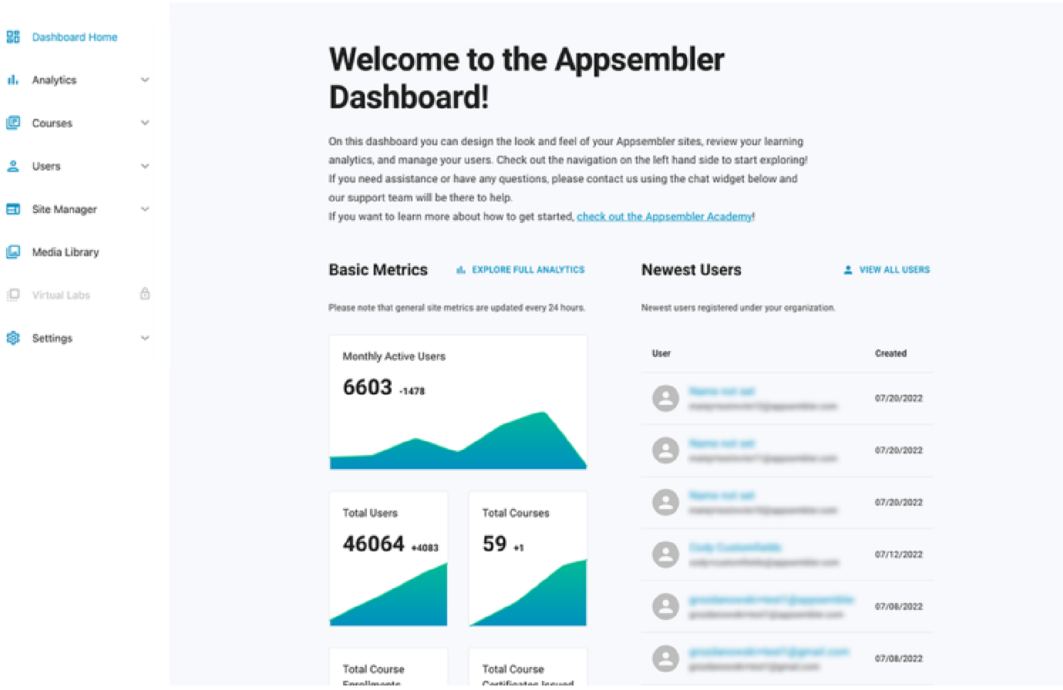


Figure 12 LMS dashboard[39].

Studio

Open edX Studio[40] is accessed via Web browsers by course administrators, instructors, and course authors. It allows the designing, creation, and management of courses. It also allows administrators via Studio to change the course schedule, define grading policies, and update course content, among others. The Studio can also be accessed via an Internet browser (see Figure 13).

4.3 Comparison of Moodle and Open edX

This section is dedicated to the analysis and comparison between Moodle and edX as Learning Management Systems (LMS).

39 Source: https://www.edx.org
40 https://studio.edx.org
41 Source: https://www.edx.org

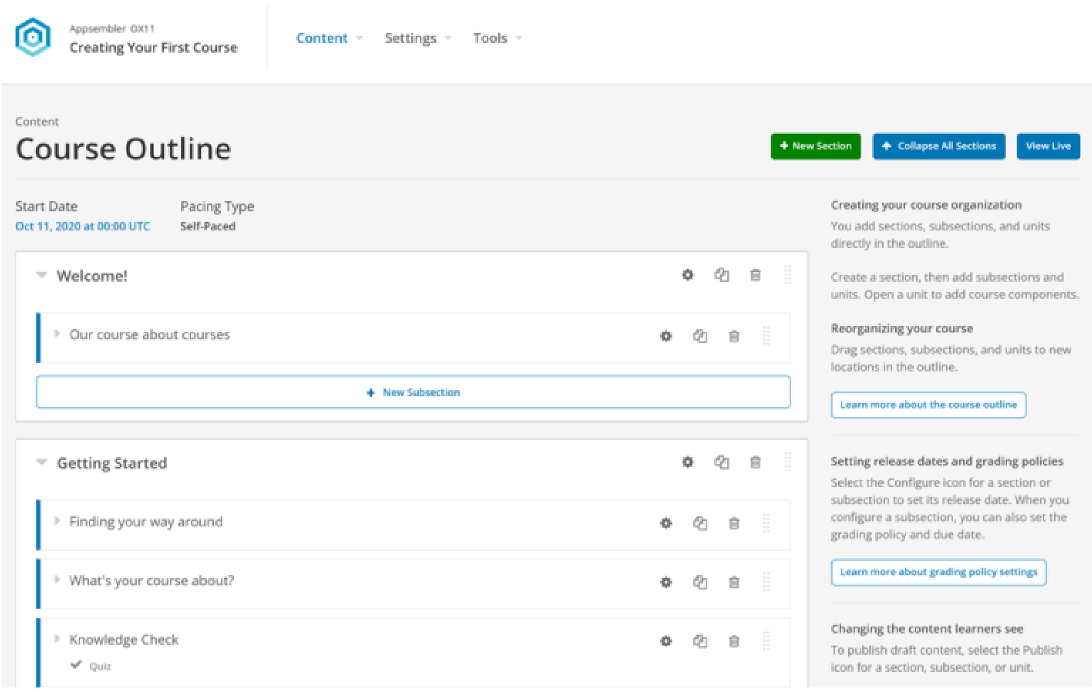


Figure 13 Open edX Studio[41].

4.3.1 Model

For the analysis and comparison between Moodle and edX on online blended learning, the learning/teaching event model presented by (Leclercq & Poumay, 2008) is used to compare which platforms services/plugins fulfill the model objectives. Figure 14 shows the elements of the model. A brief description of the elements described in the the learning/teaching event model are presented in the section bellow (Section 4.4).

4.4 Comparison

In this section, we use the Learning/teaching event model from (Leclercq & Poumay, 2008) to analyze whether the different plugins from Moodle[42] and features of Open edX[43] comply with the reference model.

Observation

We learn by observing other people's behaviors or phenomena, either directly or mediated. The teacher is responsible for the model (e.g., face-to-face, video, audio). From early childhood, we are "impregnated" with the accent of the speakers of our "mother tongue", the gestures of the people around us, and we proceed a lot by imitation. We do not imitate everything we see, fortunately, especially what we see

42 https://moodle.org/plugins/
43 https://openedx.org/the-platform/features/

Figure 14 Learning/teaching event model. Adapter from (Leclercq & Poumay, 2008)

on television. Table 4 presents the results of the element observation, more specifically on the use of live streaming.

Table 4 Observation

Type	Platform	List of Plugin/Extension	#
Live conference	Open edX	BigBlueButton, Collaborate, Zoom	3
	Moodle	Video Conference, Jitsi, Skype, LIVE-SCHOOL, ConfMan, BrainCert HTML5 Virtual Classroom, One-to-one, Quickom, meetzi-room, BabelRoom, alfaview classroom, Edumeet, netucate Activity	13

Reception

We learn by receiving message content whose transmission (oral or written) is the teacher's responsibility (which does not imply that he or she is the creator or even the producer). These messages are coded in a natural language. It implies that the learner and the instructor share the mastery of this (same) code. Most undergraduate courses operate in this essentially transmissive or "ex-cathedra" mode. Table 5 presents the results of the element reception. For simplicity purposes, this element focuses on video on demand and not other types of contents.

Exercise

We learn by practicing or exercising. It is the case for sensory-motor skills (e.g., driving a car, playing an instrument, writing, swimming). Intellectual skills also require

Table 5 Reception

Type	Platform	List of Plugin/Extension	#
Video	Open edX	Annoto: X-BLOCK Video Collaboration Solution, Brightcove Video, Brightcove video player, H5P, Ooyala video player, PuMuKIT2 Opencast Video XBlock, UniPlayer, Vimeo, Wistia, XBlock video with plugable backend, YouTube	11
	Moodle	Video Easy Filter, Videofile, Ensemble Video repository, Silverlight video embed filter, jwplayer filter CDN Video Filter, Kaltura Video Package, Interactive Content – H5P, Media Player, Eduplayer, MEDIAL TinyMCE Editor, MyTube, YouTube Anywhere, External Media	13

practicing to become automatic through repetition (e.g., performing arithmetic, algebraic or geometric operations, performing technical acts such as diagnostics). The teacher (or the coach) guides before, during, or after practice (i.e., criticism, correction). Table 6 presents the results of the element exercise. It focuses on group work possibilities offered by both platforms.

Table 6 Exercise

Type	Platform	List of Plugin/Extension	#
Group work	Open edX	Group Project, Google docs, imageannotation, notes	4
	Moodle	edu-sharing Workspace, Microsoft 365 Repository, OU blog, Onsite/Off-site	4

Exploration

We learn by exploration, by asking questions to the interlocutor (i.e., teacher, expert, museum guide), books in a library, or the Internet. The teacher's role in providing proper documentation towards exploration is to provide answers or resources, books, and exciting texts. Table 7 presents the results of the element exploration. It shows the different modules to access information via academic repositories.

Table 7 Exploration

Type	Platform	List of Plugin/Extension	#
Repositories-libraries	Open edX	Oppia explorations, filestorage, Bibblio XBlock, Recommender tool	4
	Moodle	Exabis Library, Sharedresources Library, Open-Source Physics, Authentication on www.iprbookshop.ru site, Shared Resource, OpenBiblio Block, Shared Resources Center, Shared Resources Tools, MEDIAL Repository Plugin for Moodle	13

Experimentation

We learn by problem-solving or experimentation when we make assumptions and test them. The coach's task is responsive, i.e., to place learners in a responsive environment (e.g., a chemistry or physics lab, a dissection room, a computer, or some museums). If the learner initiates the trials (and errors), they are problem-solving. If the trainer initiates them, they belong to practice guidance. Table 8 presents the results of the element experimentation in different domains.

Table 8 Experimentation

Type	Platform	List of Plugin/Extension	#
Labs and experimentation	Open edX	Jupyter, Drag And Drop problem, EOL Conditional, Oppia explorations, Schoolyourself XBlock	5
	Moodle	EJSApp, VlabEmbed, FLAX language learning, SageCell, DataPlus, Scratch embed	6

Creation

We learn by creating (oral or written reports, technical or literary procedures, objects, and images). The role of the instructor is to encourage, support, confront, and enhance the learner. Creation can be combined with imitation as long as it is somewhat detached from it. Table 9 presents the results of the element creation.

Table 9 Creation

Type	Platform	List of Plugin/Extension	#
Reporting	Open edX	Staff Graded Assignments	1
	Moodle	Configurable Reports, Assignment submission and export report, Accessibility Report	3

Debate

We learn through debate, confrontation with the ideas of others (socio-cognitive conflict), collaboration, or opposition (competition). This debate can be involuntary. It can be synchronous (in real time) or asynchronous (reading is not done at the time of writing). The Internet facilitates debates by allowing subsequent interactions. The teacher's role here is to lead or moderate the debate. Working in a group necessarily implies exchanges, debates, and the testing of our ideas to the criticism of others. Table 8 presents the results of the element debate and the plugins or features associated.

Table 10 Debate

Type	Platform	List of Plugin/Extension	#
Debate	Open edX	Discourse, Annoto: X-BLOCK Video Collaboration Solution	3
	Moodle	Debate, Course discuss, DisCourse, Forum discuss subscription	4

Meta-reflexion

We learn by reflecting on our cognition and learning, often called metacognition. The teacher's role here is co-reflection, metacognitive dialogue with the learner. Table 11 presents the results of the element meta-reflexion.

Table 11 Meta-reflexion

Type	Platform	List of Plugin/Extension	#
Reflexion	Open edX	None	3
	Moodle	SmartKlass Learning Analytics Moodle, MySmark EDU	13

4.5 Discussion

In the literature, several studies already tackle this problem. In the work of (Liapis et al., 2022), the authors present a comparative user experience (UX) evaluation between Moodle and Open edX. This work found that Open edX functions better than Moodle in almost every UX examined. The study presents that platform selection is affected by several factors, including non-technological, students' familiarity with the platform, and financial and human resources.

In the work of (Hu et al., 2017), the authors present a cross-platform learning analytics dashboard on Moodle and Open edX to observe learning progress outcomes. This work allows visualizing student interactions while using the platforms to help educators to monitor students' learning progress in the context of courses in a university in Hong Kong. Blagojević and Milošević, 2015 made a comparison between edX and Moodle MOOCs. The authors conclude that the main differences are based on the needs of educators and the different features provided by each platform.

Additionally, the work of (Z.-Y. Liu et al., 2020) presents an analysis of three Mooc platforms (i.e., Moodle, Open edX, and NEO LMS) following the criteria: system features, content creation, user management, content support, and reporting system. The study was conducted with forty instructors from Russian and Chinese universities. The authors concluded on the favorable advantages of such platforms on high education. In the work of Oktavia et al., 2018, the authors analyze the MOOC's features to determine the difference platform of edX and Coursera, given the number of learners using them. The study was performed at a private university in Indonesia using a quantitative approach to determine the contrast between edX and Coursera.

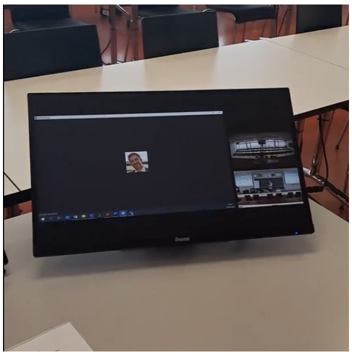
Moodle and Open edX are widely used worldwide by companies, instructors, schools, institutes, and universities. These platforms have tremendous potential for creating e-learning experiences providing excellent tools to enhance traditional classroom education via any e-learning system. This work includes a comparative study between Moodle and edX platforms and uses the Learning/teaching event model proposed by (Leclercq & Poumay, 2008). The first phase was based on the Architecture of both platforms. The second phase was based on comparing the different plugins and features of both systems to comply with the proposed model. In this work, it is possible to identify the most suitable choice of e-learning system depending on the number of available services. As a result of the comparison above, it is clear to see that Moodle offers more options in terms of plugins to tackle the specific need for e-learning.

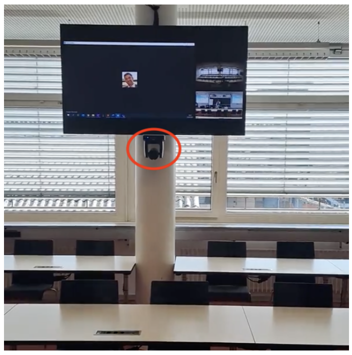
Nevertheless, in the above-mentioned academic studies, the authors also compare both platforms, and in the case of UX, Open edX presents better results. Future work should focus on an in-depth analysis of plugins and features in real scenarios. It is essential to mention that installing extra plugins and features requires granting permissions from IT departments but also depends on the running version of Moodle and Open edX, so not all plugins might be available for experimentation.

5 Blended Learning Pilot Course at HSLU

This section introduces a new method for blended learning (simultaneous online and face-to-face lecture) pilot program developed at the Lucerne University of Applied Sciences and Arts (HSLU) School of Business. The new setup is designed to tackle the problems presented in a first attempt of a blender learning as described in section 1.1. The pilot course (hands-on data visualization) is developed with new infrastructure to allow students to attend face-to-face and online. To improve the interaction of students taking the course online, the HSLU conditioned a room with dedicated equipment (i.e., front and back cameras, a sensitive microphone, and multimedia whiteboards). Figure 15, shows the setup of the room used for blended learning.


(a) Main screen


(b) Desktop screen


(c) Back camera pointing presenter


(d) Highly sensitive microphone


(e) Controller


(f) Whiteboard

Figure 15 Blended learning pilot course at HSLU. Technical setup

The main screen in the back of the room helps the lecturer visualize when a student online asks a question without losing eye contact with the in-site audience (see Figure 15a). Additionally to the back screen, the room provides a large desktop screen to help the lecturer read messages that can be posted by students online (see Figure 15b).

The back-camera view allows remote students to follow the classroom from the classroom perspective, and it is prepared with AI technology to zoom in and out and follow the lecturer during the course development (see Figure 15c).

One of the main problems for online students is the audio quality of the room. To tackle that problem, the room includes a highly sensitive microphone (see Figure 15d). It allows online students to capture the presenter's voice but also the entire audience of the room.

The room is provided with the central controller located on the presenter's desktop. It allows several quick configurations designed to facilitate various setups for the camera (i.e., zoom-in, zoom-out, tracking options) and audio inputs (i.e., presenter computer or sensitive microphone). The central controller is shown in Figure 15e.

Finally, the room includes an electronic withe-board that can be used to draw pictures, schemes, and other activities as part of the lecture. This device can save in different digital formats for the student to access these drawings in synchronous and asynchronous ways.

The final conclusion of this work is that to enable students that are part of a blended learning environment; it is essential to select the learning management system (i.e., Moodle, Open edX, or other MOOCs) as well as the plugins and features according to the educational program needs. The learning management system can be supported with the appropriate room configurations. Further studies should be focused on the evaluation of such room configurations.

Bibliography

Adedoyin, O. B., & Soykan, E. (2020). Covid-19 pandemic and online learning: The challenges and opportunities. *Interactive learning environments*, 1–13.

Ally, M. (2002). Designing and managing successful online distance education courses. *Workshop presented at the 2002 World Computer Congress, Montreal, Canada.*

Anderson, T. (2008). *The theory and practice of online learning*. Athabasca University Press.

Blagojević, M., & Milošević, D. (2015). Massive open online courses: Edx vs moodle mooc. *Proc. 5th International Conference on Information Society and Technology, Kopaonik, Serbia*, 346–351.

Bonk, C., & Reynolds, T. (1997). Learner-centered web linstruction for higher-order thinking, teamwork and apprenticeship (pp. 167-178). *1997). M/eb-BaSed In-SirICiOI), Educational Technology PubliCationS, EngleWOOd Cliffs, NeW JerSey.*

Boukrim, M., Obtel, M., Kasouati, J., Achbani, A., & Razine, R. (2021). Covid-19 and confinement: Effect on weight load, physical activity and eating behavior of higher education students in southern morocco. *Annals of global health*, *87*(1).

Bozkurt, A., Kilgore, W., & Crosslin, M. (2018). Bot-teachers in hybrid massive open online courses (moocs): A post-humanist experience. *Australasian Journal of Educational Technology*, *34*(3).

Carliner, S. (2004). An overview of online learning.

Chuang, I., & Ho, A. (2020). Mitx: Four years of open online courses—fall 2012-summer 2016. 2016.

Clark, R. E. (1983). Reconsidering research on learning from media. *Review of educational research*, *53*(4), 445–459.

Ebner, M., Schön, S., & Braun, C. (2020). More than a mooc—seven learning and teaching scenarios to use moocs in higher education and beyond. In *Emerging technologies and pedagogies in the curriculum* (pp. 75–87). Springer.

Eklund, J. (1995). Cognitive models for structuring hypermedia and implications for learning from the world-wide web. *Proc. of Ausweb95*.

Garrison, D. R. (1999). Will distance disappear in distance studies? a reaction. *Journal of Distance Education*, *14*(2), 10–13.

Gilbert, L., & Moore, D. R. (1998). Building interactivity into web courses: Tools for social and instructional interactions. *Educational Technology*, *38*(3), 29–35.

Hu, X., Hou, X., Lei, C.-U., Yang, C., & Ng, J. (2017). An outcome-based dashboard for moodle and open edx. *Proceedings of the seventh international learning analytics & knowledge conference*, 604–605.

Hunt, A., & Tickner, S. (2015). Cultural dimensions of learning in online teacher education courses. *Journal of Open, Flexible, and Distance Learning*, *19*(2), 25–47.

Khan, B. H. (1997). *Web-based instruction*. Educational Technology.

Kilani, H. A., Bataineh, M. F., Al-Nawayseh, A., Atiyat, K., Obeid, O., Abu-Hilal, M. M., Mansi, T., Al-Kilani, M., Al-Kitani, M., El-Saleh, M., et al. (2020). Healthy lifestyle behaviors are major predictors of mental wellbeing during covid-19 pandemic confinement: A study on adult arabs in higher educational institutions. *Plos one*, *15*(12), e0243524.

Kizilcec, R. F., Saltarelli, A. J., Reich, J., & Cohen, G. L. (2017). Closing global achievement gaps in moocs. *Science*, *355*(6322), 251–252.

Kozma, R. B. (2001). Robert kozma's counterpoint theory of "learning with media." *Learning from media: Arguments, analysis and evidence*, 137–178.

Leclercq, D., & Poumay, M. (2008). Le modèle des événements d'apprentissage-enseignement.

Liapis, A., Maratou, V., Panagiotakopoulos, T., Katsanos, C., & Kameas, A. (2022). Ux evaluation of open mooc platforms: A comparative study between moodle and open edx combining user interaction metrics and wearable biosensors. *Interactive Learning Environments*, 1–15.

Liu, Z., Brown, R., Lynch, C. F., Barnes, T., Baker, R., Bergner, Y., & McNamara, D. (2016). Mooc learner behaviors by country and culture; an exploratory analysis. *International Educational Data Mining Society*.

Liu, Z.-Y., Lomovtseva, N., & Korobeynikova, E. (2020). Online learning platforms: Reconstructing modern higher education. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(13), 4–21.

Mitra, S., & Dangwal, R. (2021). Evolution of the "hole-in-the-wall": A status review. *PROSPECTS*, 1–14.

Mitra, S., & Judge, P. (2004). The hole in the wall. *Dataquest India*.

Mott, J., & Wiley, D. (2009). Open for learning: The cms and the open learning network.

Oktavia, T., Prabowo, H., Supangkat, S. H., et al. (2018). The comparison of mooc (massive open online course) platforms of edx and coursera (study case: Student of programming courses). *2018 International Conference on Information Management and Technology (ICIMTech)*, 339–344.

Oliveira, A. P., Nobre, J. R., Luis, H., Luis, L. S., Albacar-Riobóo, N., Pinho, L. G., & Sequeira, C. (2022). Literacy and mental health of portuguese higher education students and their use of health promotion strategies during confinement in the covid-19 pandemic. *International Journal of Environmental Research and Public Health*, *19*(21), 14393.

Peña-López, I., et al. (2007). Giving knowledge for free: The emergence of open educational resources.

Pokhrel, S., & Chhetri, R. (2021). A literature review on impact of covid-19 pandemic on teaching and learning. *Higher Education for the Future*, *8*(1), 133–141.

Reich, J., & Ruipérez-Valiente, J. A. (2019). The mooc pivot. *Science*, *363*(6423), 130–131.

Ring, G., & Mathieux, G. (2002). The key components of quality learning. *ASTD Techknowledge 2002 Conference, Las Vegas*.

Rossett, A. (2002). Waking in the night and thinking about e-learning. *The ASTD e-learning handbook*, 3–18.

Rovai, A. P. (2002). Building sense of community at a distance. *International Review of Research in Open and Distributed Learning*, *3*(1), 1–16.

Ruipérez-Valiente, J. A., Jenner, M., Staubitz, T., Li, X., Rohloff, T., Halawa, S., Turro, C., Cheng, Y., Zhang, J., Despujol, I., et al. (2020). Macro mooc learning analytics: Exploring trends across global and regional providers. *Proceedings of the tenth international conference on learning analytics & knowledge*, 518–523.

Schramm, W. (1977). *Big media little media: Tools and technologies for instruction*. Sage Publications,

Shah, D. (2021). A decade of moocs: A review of mooc stats and trends in 2021. *Class Central*.

Slavin, R. E. (2015). Cooperative learning in elementary schools. *Education 3-13*, *43*(1), 5–14.

Smith, C. D., Whiteley, H. E., & Smith, S. (1999). Using email for teaching. *Computers & Education*, *33*(1), 15–25.

Stracke, C. M., Downes, S., Conole, G., Burgos, D., & Nascimbeni, F. (2019). Are moocs open educational resources? a literature review on history, definitions and typologies of oer and moocs. *Open Praxis*, *11*(4), 331–341.

Watson, J. (2008). Blended learning: The convergence of online and face-to-face education. promising practices in online learning. *North American Council for Online Learning*.

Wenger, E., McDermott, R. A., & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Harvard business press.

Yuan, L., MacNeill, S., & Kraan, W. G. (2008). Open educational resources-opportunities and challenges for higher education.

Declaration of Authorship

I hereby declare that, to the best of my knowledge and belief, this thesis titled *An Analysis and Comparison Between Moodle and edX Open-Source Solutions* is my own, independent work. I confirm that each significant contribution to and quotation in this thesis that originates from the work or works of others is indicated by proper use of citation and references; this also holds for tables and graphical works.

Fribourg, Switzerland, 11.11.2021

Luis Terán