Applying andragogy for integrating a MOOC into a formal online learning experience in computer engineering

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Abstract

In this paper, we present the results of a research experience of implementing andragogy in a learning environment designed to better meet the needs of adult learners studying part-time at a distance university. The learning environment was composed of a learning experience on a formal distance university online course that has been enriched with a non-formal component based on students' participation in a Massive Online Open Course (MOOC) related to the same topic. The non-formal experience was designed to consolidate the learning of specific content that involved difficult concepts and foster collaborative skills. The university online course is in the field of computer science and human-computer interaction. The instructional design, including the course assignments, has been guided by Knowles' principles of andragogy. Results from the data analysis of five years of academic results and student satisfaction has helped to understand the learning experience from including a MOOC in adult distance formal learning.

Keywords: MOOC, andragogy, formal learning, non-formal learning, blended learning, computer engineering, adult learners

1 Introduction

Europe 2020 Strategy invites European governments to collaborate with higher education institutions to promote innovation through more interactive and collaborative learning environments [1]. Furthermore, the Council of Europe's conclusions on the modernisation of higher education explicitly encourages the adoption of student-centred approaches, promoting the diversification of study modalities, and making effective use of information and communication technologies [2].

Indeed, the role of education has changed in recent years, as well as the emergence of different non-formal learning spaces as an extension and alternative to traditional forms of teaching and which has reconfigured the ways of understanding the learning experience [3]. At this point several authors [4,5] have analysed the benefits and limitations of mixing learning styles, highlighting that they incorporate greater flexibility in the presentation of content, and improve both the effectiveness and efficiency of the learning experiences, with some even allowing them to achieve a higher level of personalisation. Educational institutions are no longer the only place where learning occurs, and non-formal learning experiences outside them are gaining more importance and prominence [6].

In the case of adults, and part-time learners, the ideal learning model integrates a wide range of functions that empower learners with more control to participate in several formal and non-formal learning activities. The desired learning experience is an accessible combination of formal and non-formal learning with a student-centred focus

[7]. Formal learning refers to learning within an organised process (institutionalised, sequential, and standardised), carried out in schools, institutes, or universities, which meets learning goals, within a specific duration, with the inclusion of educational activities, and which concludes with a process of evaluation and certification [8]. While non-formal learning takes place in an educational activity carried out outside the educational system, which does not necessarily imply an educational pathway, which facilitates self-regulated learning, and may or may not be certified, although it is structured and may contain learning goals [3].

In addition, literature shows that non-formal learning is suitable for adult learners because they have self-autonomy and control over their learning experience [9]. This type of learning tends to take place in a more dynamic and personalised way than formal learning which facilitates adult learners to engage with the learning experience [10]). Since the first appearance of Massive Online Open Courses (MOOCs) in the higher education context, MOOCs have been integrated and transformed into several learning variations. By integrating formal traditional courses with non-formal learning approaches, MOOCs have expanded the possibility to provide learners with diverse experiences delivered through a mixture of learning modalities [11].

The National Distance Education University (UNED) is a public distance university for adult learning that combines learning modalities including virtual courses with face-to-face tutoring at the Study Centres (disseminated throughout the country). Knowles' principles of adult learning [12] are relevant to helping online educators create more meaningful adult learning experiences, such as better understanding of relevant concepts and as an aid in knowledge acquisition. In addition, non-formal education related to adult learning uses a variety of methods and contents [13], and they are generally activities that include the participation of students and contain examples of real-life learning.

In this research, we aimed to test the implications of the use of a MOOC (as non-formal learning) combined with a traditional online course (formal learning) using redesigned assignments guided by Knowles' principles of andragogy [12]. The objective was to improve the delivery and adapt the tasks and assessments to better meet the needs of the students in an online course about inclusive design within the computer engineering curricula and explore how that affects students´ academic results and satisfaction. Therefore, the research question (RQ) was:

- What are the academic and satisfaction implications of applying the andragogy model by including a MOOC in a distance formal learning course?

The research has involved the redesign of the assignments in the formal course and the analysis of students' academic results and satisfaction by comparing five academic years. In the next section, related work on principles of andragogy, adult learning, and the use of MOOCs in formal adult education is discussed.

2 Background and related work

UNED is the biggest distance education and research university in Spain. It has 61 campuses around the country, also, there are 14 foreign study centres, and three exam points, in thirteen countries in Europe, the Americas and Africa. The University awards undergraduate and postgraduate degrees, as well as non-degree qualifications such as diplomas and certificates, or continuing education units. UNED has two engineering schools offering a total of eleven grades, of which six are combined. The university had

119.671 undergraduate students while the School of Computer Science had 4157 students registered in 2022-2023[14].

The average age of students at UNED is 38 [15]) while at Engineering grades, the age is reported mostly in the range of 30 to 40 [16]. Students are part-time which challenges both retention and motivation [17,18]. To improve engagement in engineering studies, we explored the use of andragogy and MOOCs in higher education contexts to provide innovative learning strategies.

2.1 Adult learning theories: andragogy

Alkaabi [19] summarises some of the most important adult learning theories. Transformative learning theory is widely regarded as a prominent concept in adult education, Mezirow [20] introduced the term "transformational" to describe the experiences of adult learners suggesting that adults and children learn differently due to their maturity and life experiences, leading to more intricate frames of reference among adults. Kolb [21] introduced the theory of experiential learning. This theory asserts that learning fundamentally revolves around experiences. Knowledge is shaped through the conversion of experiences comprising a four-stage cycle that individuals engaged in learning must traverse: undergoing a concrete experience, contemplating that experience, constructing abstract conceptualisations and generalisations, and actively engaging in experiments to address a problem. According to Knowles [12], andragogy is the art and science of adult learning, referring to any form of adult learning as opposed to child learning (pedagogy) [22]. Knowles defined four basic principles about the characteristics of adult learners, which were later expanded with a fifth principle [22], intensively used in the literature [23,24]:

- **Self-concept.** As people mature, their self-concept becomes that of a self-directed person. For this reason, the learning experience must allow them to discover things and acquire knowledge for themselves, without depending on other people. However, they should also be offered guidance and help when they make mistakes during learning [25].
- **Adult learner experience:** As people mature, they accumulate an experience that becomes an increasing resource for learning. The learning experience should consider the backgrounds of the learners and build on them. Thus, learning materials and activities should allow for different types of prior experience [26] (e.g., experience with computers, prior studies, etc.).
- **Readiness to learn.** As people mature, their willingness to learn and develop their social roles increases.
- **Orientation to learning.** As people mature, their temporal perspective of applying knowledge changes, from the perspective of the future (professional, for example) to its perspective of immediate application. Therefore, the learning experience should be task-oriented, and useful, rather than promoting memorisation.
- **Motivation to learn.** As people mature, motivation to learn is a more personal matter.

Whilst the validity of the andragogical model (consisting of the above five principles) has been questioned [27], it has provided a useful framework of analysis in the context of face-to-face and blended learning to meet the needs of adult learners for professional development [28] and those studying part-time [25,29].

However, little has been researched about the use of the principles of andragogy in distance education. In the distance learning context, Youde [30] studied the application of andragogy in effective tutoring of adult learners studying part-time and found that the andragogical model offered a valuable analytical lens that was valuable to determine the factors that influence student perceptions of quality, which can in turn support practice for tutors and higher education institutions.

2.2 The use of MOOCs in formal adult education

There exist online platforms and courses, created as non-formal and collaborative learning environments which are free and contain multiple educational resources, such as MOOCs. Since 2009, several authors have reflected on pedagogical research experiences in which MOOCs are combined with formal courses [31], usually using a combination of learning experiences in which the formal part was carried out face-to-face, and the online component was developed online through the MOOC [32].

MOOCs offer learners the opportunities to study at their own pace, allowing learners to work online from home [33]. MOOCs also facilitate interaction with other learners in forums and collaborative tasks (peer-to-peer, P2P), stimulating the learning experience with interactive tests and non-formal activities [34]. The integration of MOOCs in university teaching appears to be converging to support other innovative learning experiences [31,35,36]. Different research experiences show two common types of combinations:

- University courses created encapsulating existing MOOCs [37–40].
- A formal course combined with a MOOC, using blended learning [32,41].

Other benefits of the use of MOOCs can be linked to self-regulated learning [10], and the discovery of the aspects such as open education and massive social interaction resulting from participation in the MOOC [9,29]. According to [42], if interactive learning takes place, then the increase in time spent studying online will be more beneficial. MOOCs support disabled learners by enabling them to study at their own pace and in their environments [43].

Distance universities offer adult learners [44] the possibility of not attending face-to-face, making their learning experience more flexible, considering that many of their students are part-timers. Thus, learning occurs at students' pace and is driven by their personal and professional interests [45,46]. Unfortunately literature [47,48] suggests that there is limited research that explores blended learning experiences which are both within online environments, and therefore identifying a gap in the literature. Next, we explain the methodology applied in this research article detailing the formal course, the MOOC, and how the redesign of assignments has involved the application of the principles of andragogy.

3 Methodology

The primary aim of this research was to apply the andragogy models and the use of non-formal learning to improve the delivery and to adapt the tasks and assessments to better meet the needs of the students in an undergraduate course about inclusive design within the computer engineering curricula [49]. As for the delivery, we incorporated a non-formal input of related content coming from an external MOOC into the syllabus. To offer students an open educational experience and to foster their knowledge-sharing and

collaboration with other peers. Regarding the intention of adjusting the activities and assignments, the five principles from Knowles' andragogy philosophy have been expounded and operationalised into a learning model to re-write the originals to make them closer to adult learners' experiences.

3.1 The formal course and the non-formal MOOC

The study presented in this research is contextualised on the course "Usability and Accessibility", a third-year optative course in the degrees of "Computer Engineering" and "Information Technology" in the School of Computer Science. The course introduces students to the concepts of usability and accessibility, guidelines for accessible user-interface design, the development of accessible webpages and the process and tools for evaluating their accessibility. The instructional design of the course focuses on raising students' awareness of usability and accessibility barriers. The objective is to train students in the design and evaluation of human-computer interfaces that guarantee the accessibility and usability of web-based systems. The course is assigned 6 European Credit Transfer and Accumulation System (ECTS), which implies 150 hours of study over the 14 weeks available for the course. The theoretical content is taught in a distance learning environment.

The MOOC selected to provide the non-formal learning experience is "Accessible Digital Materials" and is offered through UNED Abierta [50]. The quality of the MOOC was assured by the University policies [51]. MOOC creators had no connection with the Usability and Accessibility course. It was selected because of the overlap of several of the learning outcomes between both courses such as:

- Assess how accessible resources benefit all through greater ease of use and interoperability of web-based resources.
- Raise awareness on to how to eliminate barriers, avoiding them in the design stages.
- Acquire self-sufficiency in the production of accessible resources and the identification of accessibility barriers.

The course had a continuous assessment process, having two different assignments that are assessed beside the final exam: those are called PEC (Prueba de Evaluación Continua). PEC1 and PEC2 are the continuous assessment activities that contribute to the presential exam to the final grade of the course. The mapping between the syllabus of both courses for this research is summarised in Table 1. The PECs redesign was motivated by the launching of an updated version of Web Content Accessibility Guidelines (WCAG) [52] to the course and its intrinsic complexity.

Table 1. Syllabus mapping of formal and non-formal content.

FORMAL COURSE "Usability and Accessibility"	**NON-FORMAL COURSE** (MOOC on Accessible Digital Materials)
1. Basic concepts about usability and web accessibility	
2. Typology of web access for disabled users: Design for All	
3. Web Accessibility Initiative (WAI) and WCAG guidelines	1. WCAG guidelines 2. Accessibility of digital resources
FIRST ASSIGNMENT (PEC1)	
4. Advanced web accessibility evaluation tools	
5. User-centred web accessibility analysis methodology	
6. User modelling	
SECOND ASSIGNMENT (PEC2)	
PRESENTIAL EXAM AT STUDY CENTER	

For the application of the andragogy model, the theoretical contents were deployed as usual through the university's distance education platform (aLF.LRN) along with the proposed synchronous and asynchronous activities. The two main assignments evaluate the continuous assessment of students. Following Knowles principles, PEC1 is an introductory assignment to sensitise the accessibility barriers that disabled users face while dealing with technology, while PEC2 is an in-depth study about WCAG standards and students evaluate WCAG web accessibility on an existing web page. The content of these two assignments is detailed in Table 2.

Table 2. About the continuous evaluation assignments (PEC)

FIRST CONTINUOUS EVALUATION ASSIGNMENT (PEC1)	SECOND CONTINUOUS EVALUATION ASSIGNMENT (PEC2)
1. Awareness and sensitisation tasks that encourage the student to use the accessibility settings of the Operating Systems. 2. A search-based activity to find information on assistive technologies. 3. An activity focused on the principles of inclusive web design, where the student must design their website.	An accessibility evaluation of a website according to WCAG guidelines using a checklist. The evaluation implements a methodology to evaluate accessibility including: 1. An automated step (using open-source tools). 2. The manual revision of WCAG criteria.

To date, there are three co-existing versions of WCAG guidelines 1.0, 2.0, and 2.1, which are the universally accepted set of web accessibility standards. WCAG 1.0 was innovative and critically important when it was first developed in 1999 by the World Wide Web Consortium (W3C). However, the last two versions, WCAG 2.0 (2008) and 2.1 (2018) are organised differently, around four design principles (perceivable, operable, understandable, and robust) with guidelines with their conformance criteria verifiable at three differentiated levels (A, AA or AAA).

From a teaching perspective, version 1.0 contains simple guidelines, and is easy for students to understand, serving as a scaffolding for the knowledge of accessibility principles. And this was the content explained in the course until 2017. However, with the release of version 2.1, version 1.0 was no longer effective, and the course content became obsolete. The basis for determining accessibility compliance with the WCAG 2.0 (and 2.1) standard are success criteria that are not easy to teach by the course team and to learn by students without previous experience. A single accessibility barrier may be covered by more than one compliance criterion at different levels, which is an uneasy task to achieve and requires deep knowledge and experience working on practical examples [53]. For this reason, in addition to the pedagogical improvements in the course design, the course team decided to provide the students with tutorial support and a specific forum to facilitate their analysis and validation.

Given that the timing of the MOOC coincided with the completion of PEC2 (months of April and May), it was decided as a potential non-formal learning experience that would allow students of the course to benefit from participating in an open environment with social interaction with the rest of the MOOC participants. Also, the accessibility WCAG evaluation of the MOOC and its platform was incorporated into the new redesign of the PEC2 as a real practical case to evaluate.

Finally, to ensure that students have internalised the learning objectives included in PEC1 and PEC2, the final face-to-face exam contained a set of questions that coincide with the practical aspects worked through them. The way of examining is open-book (i.e., students can bring their notes and books to the exam), and students are asked to summarise the reflections and conclusions completed in the PECs for themselves. The

planning of the assignments is shown in Figure 1, each contributing different weightings in the final score: PECs 30%, exam 60% and forums participation 10%.

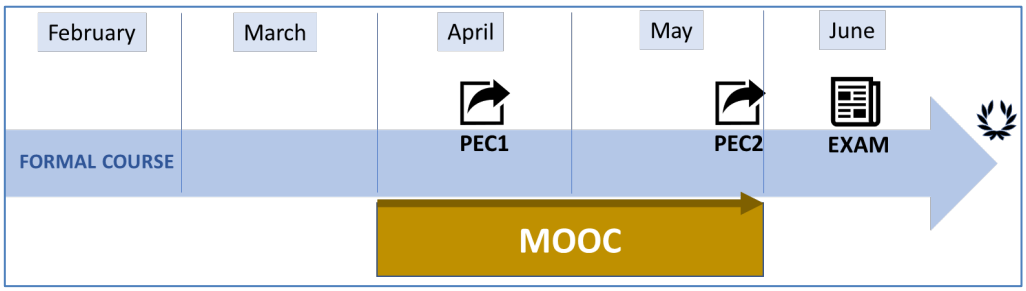

Figure 1. Planning of assignments

3.2 Applying andragogy to redesign the assignments

Youde [30] found that the predominant approaches to teaching and assessment adopted by tutors were mainly congruent with the andragogical model's core principles, which was in part due to the structured, assessment-driven learning environment, particularly the type of problem and case-based assessments undertaken by students. Moreover, the application of andragogy principles can improve the autonomy of adult learners and the connection with real-life applications of the course learning goals [22]. Finally, according to Capretz and Ahmed's [54] manifesto, the skill of evaluating the accessibility of web pages is one of the skills that computer engineering students must acquire.

With all the above, the andragogy principles have been chosen to redesign the course assignments considering the intended learning skills (see Table 3) are:

- **Self-concept. Create learning experiences that offer minimal instruction and maximum autonomy.** Adult learners learn most effectively when they are encouraged to explore a topic on their own as they use their prior knowledge. In this sense, two activities were included in PEC1 in which students select and design accessible resources based on their needs or curiosity and develop an accessible personal web page.
- **Adult Learner Experience. Include a wide range of instructional design models and theories in the learning experience to appeal to students with different levels of experience and backgrounds.** Adult learners have had more time to gain experiences throughout life and generally have a broader and more diverse knowledge base than young students, especially in terms of backgrounds and skills. Thus, in this experimentation, two models of instructional design (formal and non-formal) are proposed to the student to reinforce the learning of knowledge related to the WCAG accessibility standard in PEC2 and its application to the real world.
- **Readiness to learn. Use social media and online collaboration tools to link learning with social development**. As people age, they tend to gravitate more toward learning experiences that offer some social development benefits. In e-learning, social media and online collaboration tools help to incorporate this aspect into tasks. In the context of this work, participation in the MOOC to work on PEC2 motivates students to use social networks and online collaboration tools and link their learning with social development in a non-formal context.
- **Orientation to learning. Emphasise how the course will help solve some problems that an adult learner regularly encounters.** Adult learners prefer to

participate in online learning experiences that help them solve the problems they face regularly (here and now, and not in the future). The redesign of PEC2 emphasises this aspect because it helps students to understand and resolve accessibility barriers by offering examples and real-world scenarios.

- **Motivation to learn. Justify the benefits of each online course, module or educational activity.** Motivation is key for adult learners, in that sense, the new tasks designed in PEC1 of "putting oneself in the place of the other" help students to become aware and focus on the object of the course. Likewise, PEC2's tasks raise awareness of the technological barriers that disabled users must face and how engineering can reduce these barriers by implementing the Design for All principles [55].

Table 3. Summary of the redesign to the principles of andragogy

Content	Formal learning	Non-formal learning	Knowles principle
Basic concepts on usability and web accessibility	Simulation scenario with the accessibility settings included in the operating system.	Recognise and address the challenges faced by disabled users.	**Motivation to learn**
Typology of web access for disabled users: Design for All	Criteria for the selection of assistive technologies	Gain a better understanding of accessibility. Assess how accessible digital materials benefit all	**Self-concept**
WAI Initiative and W3C Guidelines	Development of an accessible personal website	Learn to create a personal website	**Orientation to learning**
MOOC - Accessible Digital Materials	Development of accessible digital resources	Social interaction in a mass environment	**Readiness to learn**
Advanced web accessibility evaluation tools	Advanced evaluation of web accessibility using automatic WCAG tools	Know how to remove barriers in product design processes	**Adult learner experience**
User-centred web accessibility analysis methodology	User-centred web accessibility methodology	Acquire self-sufficiency in the identification of accessibility barriers	**Orientation to learning**
User modelling	Design of user models adapted to the context of the use	Create designs by applying user models	**Adult learner experience**

3.3 Research design

In this study, we have used an exploratory research approach which involves conducting research that has not previously been studied in depth [56]. This type of research is usually conducted when the issue is novel, such as in this case of adapting non-formal learning into the context of formal distance learning with a particular focus on adult learners.

We have included a quasi-experimental design; this type of design is chosen when it is not feasible to conduct a true experimental study with a random sample and several assignments. A constraint in this study was to introduce a random student group and assignment when relying on an existing student group in formal distance learning [57]. For this purpose, the approach was to consider two groups of students from different academic years. One group included those who experienced the assignment under the original design, and the other group included those who experienced the assignment after it was redesigned. The comparison between these two groups, within a time frame, helps assess the impact of the redesign using as a dependent variable the academic results of students. We complement academic results with student satisfaction information; therefore, it can be considered as supportive secondary data.

For the research, a time frame of students from the last five academic years of the course has been considered - anonymised and aggregated. The first three editions (2014-2015, 2015-2016 and 2016-2017) is considered as a group that serves to contextualise the historical development of the data. The academic years (2017-2018 and 2018-2019) constitute the period in which the pedagogical experiment proposed in this work has been carried out, which includes the non-formal combination of the MOOC and the redesign of the PECs according to Knowles's principles of andragogy.

To answer the RQ "What are the academic and satisfaction implications of applying the andragogy model by including a MOOC in a distance formal learning course?": the data collection process was challenging due to the novelty of the approach, the methods used were those which were already in place to understand student learning experience. Therefore, the research data consisted of academic results and student satisfaction questionnaires.

- To compare the academic results, data from the last five academic courses have been used, and three sources of data have been considered: PEC2´s score (assignment that includes the MOOC), the score of the question in the exam linked to PEC2 and the final score in the course. For the analysis, two groups were considered: those who participated in the old version and those in the redesigned version, and the two academic years with the new version were compared. Data has been analysed using SPSS Statistics software using descriptive comparative and aggregated analysis, and inferences on population including means and variances for the two groups considered.
- Regarding the measurement of student satisfaction, students complete a satisfaction questionnaire at the end of each academic year, a questionnaire that is voluntary and designed by the quality office of UNED [14]. In this questionnaire, aspects such as grade appreciation, course appreciation, study time, tutor assessment, and course difficulty and interest are recorded. The feedback was considered and compared among the years where data was available. In this case, only descriptive analysis has been chosen.

3.4 Research sample

Table 4 shows the demographic data of the sample of students in each academic year (which can be disclosed in accordance with the Spanish data protection law (LOPD -15/1999 [58]). A quota sampling method was employed [59]. This approach which falls under non-probability sampling techniques (non-random), categorises the population into distinct, non-overlapping groups. Specifically, individuals were chosen from a predefined list (i.e., the students registered for the course). All students who were enrolled in the course and participated in all the assignments (i.e., PECs and exam) have been included in the sample; the total students enrolled are included in Table 4 in brackets (2014-2015 n=92, 2015-2016 n=69, 2016-2017 n=77, 2017-2018 n=52 and 2018-2019 n=33). When dividing by those for the study, the non-redesigned PECs include 2014-2017 n=238 while those with the new PECs are 2017-2019 n=85. The number of enrolled students has decreased in recent years, an aspect that is aligned with the increase in the cost of academic credits and the economic crisis [60] which has especially affected recruitment in university engineering degrees. The table below includes both groups for the study (in blue with the new redesigned assignment).

Table 4. Sample's demographic data

		Gender		Nationality		Age			
Year	**Students (Total)**	**Male**	**Female**	**Spanish**	**Non-Spanish**	**<= 25**	**26 - 35**	**36 - 45**	**>46**

2014-2017	**2014-2015**	238(260)	92 (98)	94.2%	5.80%	97.1%	2.9%	2.44%	5.66%	48.%	43.9%
	2015-2016		69 (72)	85%	15%	100%	0%	12.5%	47.22%	30.56%	9.72%
	2016-2017		77 (90)	85.9%	14.1%	94.1%	5.9%	14.44%	46.67%	34.44%	4.44%
2017-2019	**2017-2018**	85 (125)	52 (77)	89%	11%	92.7%	7.3%	20.78%	46.75%	25.97%	6.49%
	2018-2019		33 (48)	86%	14%	93%	7%	12.5%	43.75%	35.42%	8.33%

Data included in Table 4 such as gender, nationality and age are calculated for the selected students. The predominance of men (above 85% in the whole sample) has been already reported in Science, Technology, Engineering, and Mathematics (STEM) indicating a lack of gender equality [61]. Most of the students in the course had Spanish nationality. In the sample as can be noted that besides the first academic year, most participants (above 92% in the whole sample) are between 26 and 45 years old (above 43% from 2015-2016), something aligned with the University average age and the increasing popularity of Engineering degrees in students between 20 and 30 years [16].

4 Results

This section details both the academic results and student satisfaction to answer the RQ and to analyse the implications of applying the andragogy model and including a MOOC in a distance formal learning course.

4.1 Academic results

As reported in the methodology the final weightings in the course are PECs 30% (15% for each), exam 60% and forums participation 10%. The weight of PEC2´s question in the exam score is 50%, something that has been kept consistent during the five academic years reported for comparison. PECs and exams were graded on a scale of 0 to 10 using a pre-defined rubric agreed upon and validated by the course team. Table 5 details data on the five courses and groups by the three academic sources of data (PEC2, exam and final score) including the mean, standard deviation, and percentiles.

Table 5. Analysis disclosed by course, group, and results.

Course and group	2014-2015	2015-2016	2016-2017	**2014-2017**	2017-2018	2018-2019	**2017-2019**
N	92	69	77	**238**	52	53	**85**
PEC2							
Mean	5.09	7.25	8.91	**7.07**	7.21	7.38	**7.29**
Stand. Dev.	2.14	2.47	2.44	**2.35**	3.72	4.06	**3.89**
.25	3.33	5.00	8.3	**5.54**	5	5	**5**
.50	5	6.66	10	**7.22**	10	10	**10**
.75	5	10	10	**8.33**	10	10	**10**
Exam							
Mean	5.36	5.79	6.32	**5.82**	5.57	5.24	**5.4**
Stand. Dev.	1.85	1.98	1.92	**1.91**	2.08	2.24	**2.16**
.25	4	4.25	5	**4.41**	4	3.97	**3.98**
.50	5.27	5.7	6.5	**5.82**	5.2	5.1	**5.15**
.75	6.50	7.5	8	**7.33**	7	7.02	**7.01**
Final Score							
Mean	5.88	6.56	7.09	**6.51**	6.28	6.11	**6.19**
Stand. Dev.	1.47	1.82	1.84	**1.71**	2.17	2.67	**2.42**
.25	5	5.5	6.47	**5.65**	4.86	5.31	**5.08**
.50	5.8	7	7.25	**6.68**	6.56	6.94	**6.75**
.75	7	7.85	8.5	**7.78**	7.99	7.99	**7.99**

Table 6 details the two independent tests run. The comparison of means for the PEC2, exam and final score between the two periods includes two constraints, the first test uses a Levene test for equality of variances to know if the population variances or dispersions are equal or not. In the case of the final score its value is 0.23, we cannot

affirm that the variances are significantly different while in the PEC2 and final score p is less than 0.001 indicating evidence that the population variances differ.

The second test uses a t-test for equality of means between the two periods for PEC2, exam and final score. For the exam score equality of variances is assumed with a p equal to 0.09. In this case, it is possible to affirm at a 10% significance error that there is a difference between the scores of the two groups. Regarding PEC2 and the final score, p-values are both high (0.83 and 0.22) and cannot therefore affirm that the redesign has statistical significance to have influenced the final score.

Considering both tests we cannot confirm that the redesign has had a significant impact on the final score, they show variance in PEC2 and significance for the exam which is not decisive.

Table 6. Independent tests

	Levene test		**t-test**						
	F	p		t	p	Mean	Standard error	Inferior (95%)	Superior (95%)
PEC2	15.52	<.001	Equal variances assumed	-.24	.80	-.09	.37	-.82	.64
			Equal variances not assumed	-.21	.83	-.09	.41	-.91	.73
Exam	1.41	.23	Equal variances assumed	1.67	.09	.39	.23	-.06	.86
			Equal variances not assumed	1,62	.10	.39	.24	-.08	.88
Final Score	13.24	<.001	Equal variances assumed	1.37	.17	.31	.23	-.13	.77
			Equal variances not assumed	1.22	.22	.31	.25	-.19	.83

For the visualisation of descriptive results, box plots have been chosen to show the dispersion of students' scores expecting that the application of the andragogy model will lead to a better understanding of the main issues in the content of the course. If this occurs, then less dispersion would be found between students' PEC scores and the scores that the students achieve answering the related questions in the final exam.

Figure 2 shows the aggregate performance of the students in the two groups: courses 2014-2017, on the one hand, and courses 2017-2019, corresponding to experimentation, on the other. While PEC2 remain similar, at first glance, the added difficulty in the topic is reflected in a worsening of the median exam score, which drops by almost 1 point, as well as in the minimum and maximum marks. This is reasonable since during experimentation an exam question directly related to PEC2 and WCAG's new version has been included. Regarding the final score for the course, given that there are other weighted factors, as explained above, a greater dispersion of students' scores in the final score is observed, shown in the increase in the size of the box and the increase of the maximum value. After the redesign of the PECs, the students who perform well do better, and those who do poorly, have worsened their grades, although the median remains stable.

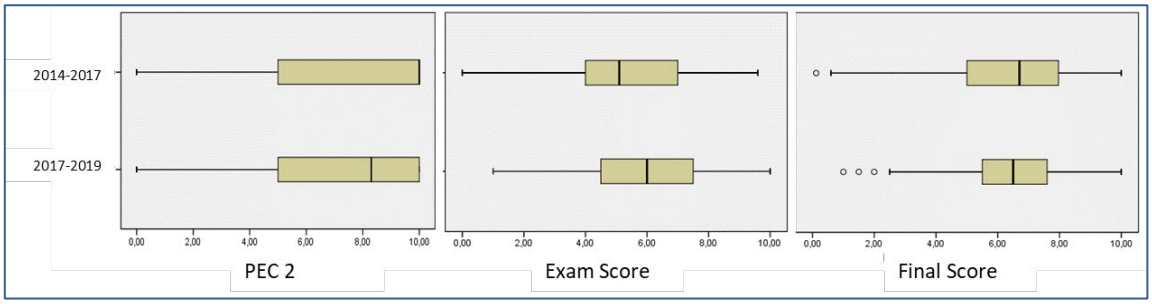

Figure 2. Aggregate student performance for the two groups

When observing the correspondence in students' performance in the exam and final score according to the development of PEC2, in Figure 3, it can be seen how the scores in the courses for both the exam and the final score associated with the experiment have improved. But, as reported in the aggregated data, there is less uniformity in performance: a few students do better, and others do worse with progress in the median value, between the first year of the experiment and the second. The redesign according to the application of the andragogy model shows a positive consolidation in the instructional design of the course.

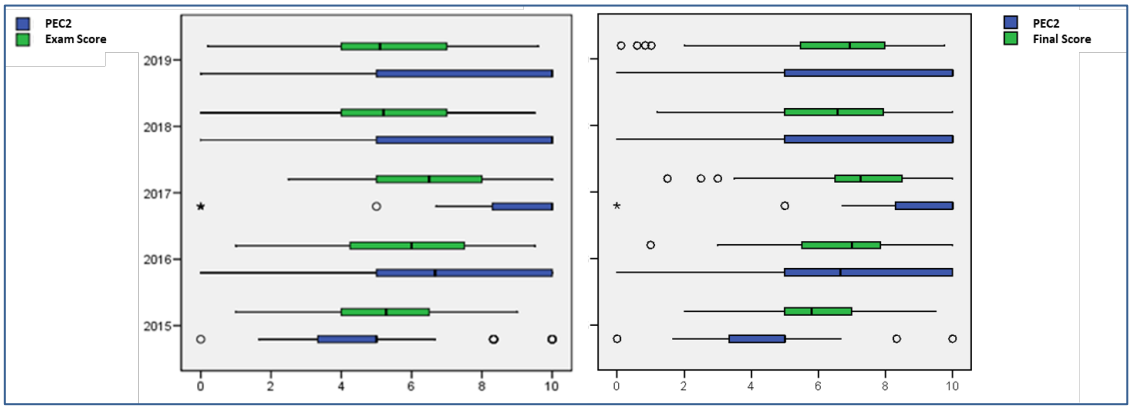

Figure 3. Comparison of student performance in PEC2, exam and the final score

The new version of PEC2 requires greater focus and knowledge of WCAG by the students and this is reflected in the scores. Now students must be more proactive in evaluating each of the accessibility success criteria using the new checklist [62]. It is a positive aspect of the redesign as the students learn how to use WCAG, but it requires a greater commitment on their part to invest more time in the activities.

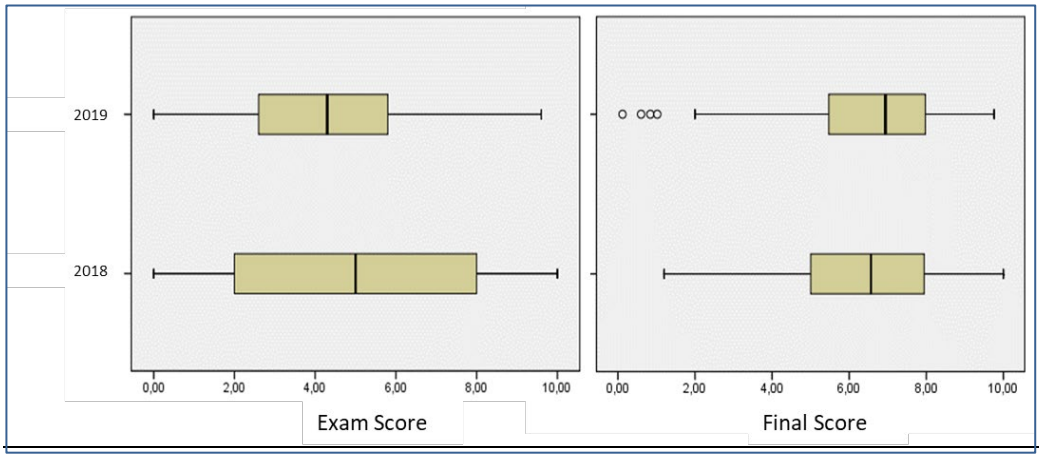

Figure 4. Comparison of student performance on exam and final scores

Figure 4 shows the box plots that indicate students' performance on the exam question related to PEC2 and the final score. The results show a slight decrease in the median value for the exam but also a more uniform behaviour of the entire sample of students, while that uniformity is confirmed in the final score.

4.2 Student satisfaction

The satisfaction questionnaire has 5 dimensions: grade appreciation, course appreciation, study time, tutor assessment, and course difficulty and interest. During the duration of this research study, the questionnaire was modified over the five academic years, making it difficult for us to compare historical data using all those dimensions. Table 7 shows the

data provided by the institutional statistical portal comparing course appreciation versus grade rating.

Table 7. Student satisfaction questionnaires

Course	Responses	Course appreciation	Average grade rating
2014-2015	5	75	74,91*
2015-2016	3	75	74,17*
2016-2017	9	75,69	64,71*
2017-2018	6	68,22*	66,71*
2018-2019	9	68,89**	66,45*

$p < 0.01$ **, $p < 0.05$ *

Data show that, in general, satisfaction with the course has been high, with a maximum on a scale of 100. The course is valued by the students considering the average value for the grade which in 2018-2019 was 66.45 but shows a decrease in the appreciation of university degree studies over the years. In the course, the increased complexity due to the new WCAG version included in the syllabus might have influenced student satisfaction. Satisfaction decreased over time, although a small improvement is observed in the last year, possibly because as it has been seen in the academic results, those who learn WCAG well, perform better and could be more satisfied.

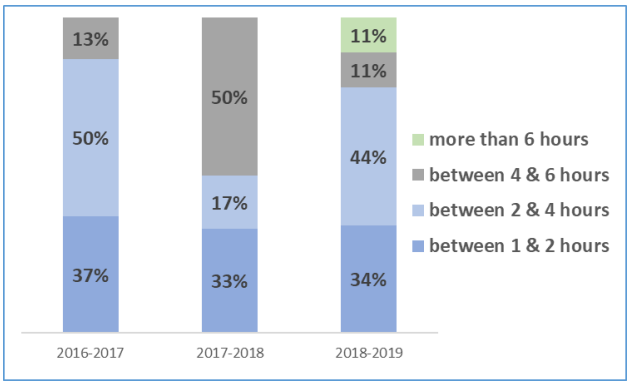

Figure 5. Hours studying the course weekly

During the last three academic years, when students were asked about the time spent weekly studying the course, an increase in the number of hours needed in the last two courses (between 4 and 6 hours or more than 6) was observed (Figure 5), which is related to the previous observation of the complexity of the redesigned PEC2.

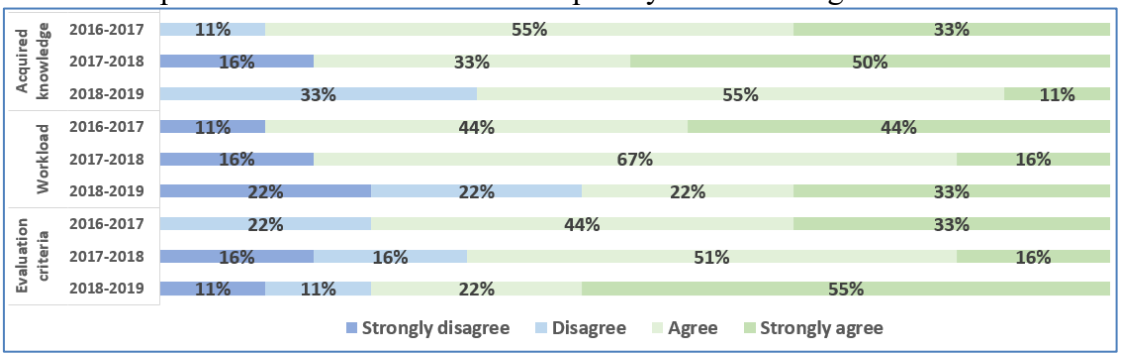

Figure 6. Acquired knowledge, workload, and assessment criteria

When responding to the questionnaire on acquired knowledge and workload (detailed in Figure 6), students show greater disagreement in the last two academic years concerning the previous year (2016-2017), students assume the course is more complicated and has a greater workload, but at the same time, they indicate a greater agreement with the assessment criteria.

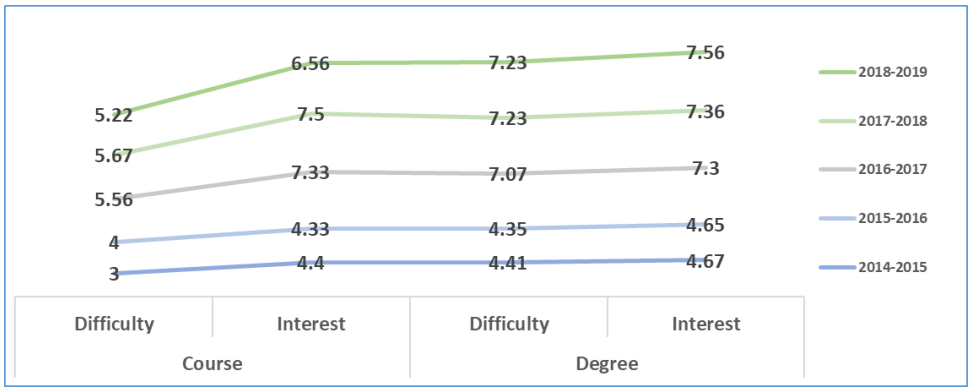

Figure 7. Students reported difficulty and interest (course left and degree right)

As reported in Figure 7, the students' difficulty in the course has increased in the last three years, and fell in the year 2018-2019 (5.22, on a scale of 10), which shows a similar trend at the degree level which has remained stable during the last few years. Student interest in the course remains quite high; the last academic year had a one-point difference lower (6.56) than the average value in the degree (7.56).

5 Discussion

The research reported has been carried out online and based on the participation of students in a MOOC. Data collection for this study was exploratory as per design [56]. For that purpose, we have used longitudinal methods [63], such as academic results and student satisfaction to understand the implications of applying the andragogy model in a non-formal MOOC within adult distance formal learning. To answer the RQ, this study has analysed both sources of data with varied success. We now discuss implications, and suggestions for design improvements, limitations of this research, and pointers for future research.

5.1 Academic and satisfaction implications of applying the andragogy model including a MOOC in a distance formal learning course

Regarding academic results (as shown in section 4.1), students' performance drops with the redesigned assignments. There is slight progress between the first year of the experiment and the second, and students who perform well tend to do better, and those who do poorly, have worsened their grades. With the redesigned assignments, a more uniform behaviour of the entire student sample exists. While previous research [23,24] in adult learning has not explored academic results, authors do emphasise the relevance of students' performance with principles such as "adult learner experience", "orientation to learn" and "motivation to learn". Those integrating blended experiences with MOOCs report the complexities derived from the experience of including two purposely different created resources, generally by different authors and contexts [39,41].

While student satisfaction results (section 4.2) indicate an increase in course satisfaction, it is not aligned with the appreciation of university degree studies over the years. Unfortunately, there is a problem of motivation in part-time distance learners [17,18]. The redesigned assignments require greater dedication and knowledge. Students acknowledge the course is more complicated and has a greater workload, but at the same time, they indicate a greater agreement with the assessment criteria. Greater dedication in assessment is something aligned with the "self-concept" and "readiness to learn" principles [23,24] and applied in qualitative and part-time research in adult learning [25,32]. However, it does remain a challenge in blended environments where different

methods among combinations are applied influencing the pedagogical approach of the formal learning course [32].

We acknowledge the limitations and criticism of andragogy principles with their particular use of context, which focuses on the context students bring from their experiences [64]. Although students' varied experiences may affect their views, we consider andragogy principles suited for adult learners as reported in the literature [30]. The study shows that it is worth integrating the knowledge and experience acquired in a non-formal MOOC-type course into formal courses, an aspect that has already been mentioned in the literature [32,41]. As in [10], non-formal re-learning takes place in a more personalised way which is critical for adult learners' engagement. Therefore, the integration must be motivated once the advantages and how to offer content and activities from a formal course to a MOOC are well-known.

5.2 Suggestions for design

Implications for practice indicate that including varied types of exercises is positive, but if those exercises are particularly complex, it may demotivate some of the students with less knowledge of the topic. Also, it is important to consider the student group, and in the case of adult learners, consider their varied backgrounds and needs [43]. In that sense, a theory to consider for further designs is service learning, which is an educational approach that combines academic instruction with meaningful community service. It is typically implemented in higher education institutions as a pedagogical strategy that integrates service to the community into the curriculum, allowing students to apply what they are learning to real-world situations while addressing community needs [65]. Table 8 summarises some of the key suggestions to consider for design using andragogy principles from our experience in the study presented.

Table 8. Summary of design suggestions for improvement

Content	Suggestions for design	Knowles principle
Basic concepts on usability and web accessibility	Include personal experiences from students and develop empathy	**Motivation to learn**
Typology of web access for disabled users: Design for All	Add multiple examples that can be linked to barriers found by the students for engagement	**Self-concept**
WAI Initiative and W3C Guidelines	Application of service-learning approaches to engage with local communities	**Orientation to learning**
MOOC - Accessible Digital Materials	Increase collaboration such as participation in forums	**Readiness to learn**
Advanced web accessibility evaluation tools	Link the activity with previous steps, selecting the same examples	**Adult learner experience**
User-centred web accessibility analysis methodology	Application of service-learning approaches to engage with local communities	**Orientation to learning**
User modelling	Build on the previous step to find community-based models	**Adult learner experience**

5.3 Limitations and Future Research

This study has important limitations considering its exploratory approach:

1. Time. This activity was time-consuming considering that adult learners are part-timers and are working at the same time, so engagement needs to be balanced.
2. Sample. The sample included is not randomised and we lack more information from the students other than sex, nationality, and age.

3. Analysis. The analysis of the data collected in the experiment lacks conclusive arguments to ensure that students experience in the MOOC was interactive, engaging and satisfactory.
4. Research tools. Using academic results and student satisfaction via a university survey may not be enough, considering the low participation in the second one.

In future research, several aspects could be enhanced, such as designing other types of non-formal learning activities, as well as, including ad-hoc questionnaires to measure the impact of non-formal activities on student learning experience (ease of use and usefulness), their emotional response (motivation and commitment), and contextualising service-learning in practice for the improvement of student engagement [66].

6 Conclusions

Mixing learning styles is complex [4], and this has been proven during the COVID-19 pandemic [67]. The experiment presented in this work has introduced a way to integrate the principles of andragogy to redesign adult learning in the context of distance education. Further, a non-formal learning activity can enrich the experience, something that while being reported in the literature [13,30] it is novel in distance adult learning.

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Ethical approval

The authors declare that the study had been approved by the Ethics Committee of UNED (UNED-2-ETSIIF-TFG-2022).

Data availability statement

Data will be made available on request.

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