Effects of New Supportive Technologies for Blind and Deaf Engineering Students in Online Learning

Concha Batanero, Luis de-Marcos, Jaana Holvikivi, José Ramón Hilera, and Salvador Otón

Abstract*—*Contribution: **A redesign of the Moodle platform to adapt digital educational content [learning objects (LOs)] to the specific needs of students with disabilities. The approach, extendable to a range of disciplines, was empirically tested with blind and deaf engineering students.**

Background: **Previous studies identified difficulties that blind and deaf students face in accessing digital content for learning. General guidelines and specific tools are available to help educators adapt digital content and existing learning platforms for access by students with varying abilities/capacities. Such tools are usually for a specific disability rather than a range of capacities, and few provide empirical evidence of effectiveness.**

Intended Outcomes: **The engineering-related digital content adapted using the techniques described in this paper should enable blind and/or deaf students to use an oscilloscope, understand communication channels, and distinguish the different types of telecommunication networks.**

Application Design: **The Moodle learning platform was adapted using existing e-learning accessibility standards so that digital LOs could be automatically presented in formats accessible to blind and/or deaf students. This model is extendable for other types of disabilities, helping educators adapt existing content for access by students with differing capacities. The teacher adds content (in non-auditory and non-visual formats to describe content otherwise inaccessible to deaf or blind students) and students upload reusable profiles/metadata describing their specific accessibility needs to connect to suitably adjusted content.**

Findings: **Learning improvement with the adjusted platform was evaluated via multiple choice pre- and post-tests. Students' learning performance improved significantly across all groups: blind (45%), deaf (46.25%) and deaf-blind (87.5%).**

***Index Terms*—Accessibility, accessible education, distance learning, educational technology, learning management systems, students with disabilities.**

I. INTRODUCTION

WITH the advent of the Internet and the development of new technologies, society has changed. People now interact and communicate differently. Web pages and online applications have spread rapidly, transforming human activities. Education is no exception in this regard: the emergence of online or e-learning has facilitated the development of new learning methods wherein educational resources are presented via the Web. In this paper, e-learning is broadly defined as "all forms of electronic supported learning and teaching, which are procedural in character and aim to effect the construction of knowledge with reference to individual experience, practice and knowledge of the learner" [1].

Interest in online teaching has increased gradually. Initial educational experiences date back to 1996 [2]. Research studies indicate e-learning has progressed, [3]–[5], and now has two main advantages over traditional forms of learning: (1) course content can be accessed anywhere, any time; (2) students can access information, such as comments and teachers' answers, as often as necessary. These advantages are partially facilitated by learning objects (LOs), which can be used as building blocks of e-learning actions. LOs have attracted much research attention in the field of education, and numerous definitions have been suggested [6], [7]. In this paper, LOs are understood as digital self-contained and reusable educational resources with a clear learning objective. LOs are particularly interesting to support students with different capacities because they can contain a diversity of digital assets that present learning content in different formats, like audio, video or text. They also facilitate including additional material such as text descriptions. All this is offered in self-contained portable units of learning.

The virtual nature of learning platforms and LOs can then be leveraged to improve accessibility. The concept of accessibility has been of interest in recent years to standardization organizations [8], [9], and to scholars [10]. Accessibility features have been applied to the new technologies, and especially to Web applications, leading to the emergence of standards for Web accessibility [11]–[13]. Many countries have passed laws that set these standards and require compliance [14]–[19].

Various initiatives [20], [21] have focused on making engineering curricula accessible to hearing- and visually-impaired students. However, other studies in this area conducted in the U.K. [22], and USA [23] show that students with different capacities have difficulties with technical environments in higher education. In this paper, the term "different capacities" is preferred for its positive connotations, compared to the negative connotations associated with the term "disabilities". The objective of this paper is to assess whether the learning performance of blind and deaf students improves with the

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use of an adapted learning platform in communications and computer engineering. This paper contributes to the knowledge base by empirically analyzing the effectiveness of the adaptation. The rest of the paper is structured as follows: Section II reviews the state of the art in accessibility studies and standards, along with the rationale for this study. Section III describes the procedure to access the adapted LOs. Section IV describes the experimental study conducted. Results and discussion are presented in Sections V and VI respectively. Section VII presents conclusions.

II. Related Work

Research on accessibility in higher education is in its preliminary stages. The results of studies regarding the accessibility of university Web pages [24], [25], indicate that the level of accessibility is limited in higher education in particular, and in education as a whole. First, a study of over 100 major research universities [24] revealed that although all universities' websites were visually accessible, these Web pages provided only a partial level of accessibility. In another study, websites' home pages and top-pages (pages of the first level in the hierarchy of navigation) were examined [25], showing that higher education websites became progressively less accessible for hearing- and visually-impaired students as the websites gradually included newer technologies and Web gadgets. A detailed, comprehensive study analyzed the accessibility level of the websites of international universities included in a number of different ranking systems [26], examining the implementation of the recommendations defined in the Web Content Accessibility Guidelines (WCAG 2.0) [11]. Although results showed an improvement in accessibility, this was still not enough to ensure that students with different capacities have full access to information.

An excellent example of website accessibility is provided by the plug-ins of the Moodle learning platform that help people with different capacities to access information. Among other features, these plug-ins offer the possibility of configuring font size and type or converting textual content to speech. Nevertheless, they are insufficient to attain full accessibility. Utility of learning platforms would be significantly enhanced if students with different capacities could access the LOs offered in online courses. For this reason, learning platforms must be adaptable to the personal needs and preferences of users. The procedure for effective adaptation is outlined in the ISO and IMS standards [27] and [28], and is based on accessibility metadata. In a previous study [29], metadata were related to Web content accessibility levels A, AA, and AAA to determine the degree of accessibility of adapted learning platforms. To develop effective accessible learning content, it is essential to develop tools that simulate different capacities. Such tools allow the actors involved in education to experience the limitations of a given environment, highlighting deficiencies that have to be addressed and promoting more efficient ways to analyze and design learning materials. Noteworthy in this respect is the DIAS [30] tool, which simulates visual, auditory, physical and cognitive impairment.

Despite advances in Web accessibility, the level of adaptation required by accessibility standards is difficult to implement. Consequently, the level of accessibility for information in current learning platforms is low or non-existent. Among the most affected educational disciplines are telecommunications and computer engineering, because they involve laboratory work and learning materials consisting of graphs, charts, and programs, materials more difficult for students with different capacities to access. As a result, blind and deaf students are currently deprived of access to such degree courses.

Numerous sets of accessibility standards have been created and adopted to provide guidance on accessibility in e-learning [31], [32]. Two that focus on a model for adapting an educational platform, by automating the process that adapts information according to the sensory needs of the student, are the ISO/IEC 24751 (Individualised adaptability and accessibility in e-learning, education, and training) [27] and the IMS recommendation "Access for All v.3.0" [28]. These two are very similar, although IMS provides more technical detail than ISO. Both ISO and IMS rely on two different data models to help adapt LOs to individual students' needs. The first data model defines student preferences (PNPs, or Personal Needs and Preferences), while the other describes educational resources (DRD, or Digital Resources Description) using accessibility metadata, to enable the selection of resources which meet student preferences [33]. ISO/IEC data models provide many details that are difficult to implement. The IMS Global Learning Consortium issued a third version of the specification [28] that accounts for the complexity of ISO/IEC data models and the difficulties involved in implementing the ISO standard. This new IMS version simplifies the ISO standard and provides technical details on implementation in order to provide a starting point for adapting learning platforms.

A few research studies detail the adaptation of learning platforms based on various versions of the standards. For instance, in [34] an adaptation of the platform aTutor is proposed to achieve compliance with the IMS "Access for All v1.0" [35], [36] and ISO/IEC 24751 standards. Another example is an adaptation of the Moodle platform consistent with the IMS "Access for All v2.0" specification [37]. These papers present the forms that students and teachers would need to fill out to build the student's personal accessibility profile and the description of the LOs respectively.

In 2014, the authors of the present paper reported an adaptation of the Moodle learning platform [38], in line with the IMS "Access for All v3.0" specification and with numerous significant improvements over the 2.0 version. Screenshots of the forms and a working example of the application were provided, along with a list of the adaptations detected by the plug-in for a person with hearing problems.

Another study conducted in ten U.S. states explored student-identified barriers to the access and use of educational support, and the influence that these barriers have in subsequent employment [23]. The study revealed that students with different capacities experienced difficulties in getting support and accommodation, and highlighted the need to implement awareness-raising programmes for teaching staff, peers, and employers to decrease discriminatory attitudes and improve outcomes for these students.

This paper presents the results of the testing of a Moodle learning platform adapted to the PNPs of individual students. This contribution to education research, applied to telecommunications and computer engineering, is an empirical study to check the effectiveness of the newly adapted Moodle learning platform that conforms to the latest version (3.0) of IMS specification. It also presents a simple architecture to facilitate extension. Blind, deaf and deaf-blind students tested the adapted learning platform. To the best of the authors' knowledge, there are no similar research studies in communication and computer engineering or other educational disciplines.

III. Adaptation Process

The Moodle platform was selected based on a study of existing platforms [39]. The adaptation is programmed in PHP and relies on a MySQL database that stores both DRDs and student PNPs [40]. This database facilitates communication between the Moodle platform and any LO repository.

To convert a LO into an LO accessible in accordance with ISO and IMS standards [27] and [28], the content author must build and upload adapted LOs onto the learning platform, as well as the original LO [38]. The content author must also upload the accessibility metadata for each LO (including adaptations). When they sign in the learning platform, students must enter their PNPs, which detail the sensorial access mode, preferred language or possible health risks caused by LOs. Lastly, when students select the resource they want to access, the plug-ins perform a search (filtering by student PNPs) for adaptations available for the selected LOs. The results are shown as adaptations that meet students' PNPs, which can be opened or downloaded.

IV. Empirical Study

A. Research and Learning Objectives

This empirical study aimed to assess the learning performance of blind and deaf telecommunications and computer engineering students using both a non-adapted learning platform and the adapted learning platform. Learning performance was operationalized by means of computer-based assessments. Students with different capacities were asked to use the Moodle platform and complete the assessments. This study explores the research question of the effectiveness of online access to educational information for people with different capacities.

Research Question: How do the adapted platform and/or the adapted LOs impact the learning performance of blind, deaf and deaf-blind students?

To address the research question, the learning outcomes were identified and subsequently assessed for the learning objectives that students will.

1. Know how to use the oscilloscope.
2. Know and distinguish the different types of telecommunication networks.
3. Demonstrate knowledge of communication channels.

Learning objectives are based on core concepts for telecommunication and computer engineering.

TABLE I
Participants in the Study

Group	Number of students	Age range
Blind students	10 (3 women, 7 men)	27-50
Deaf students	10 (4 women, 6 men)	24-55
Deaf-blind students	3 (3 men)	30-50

B. Participants

The study was conducted with three groups of students with different capacities (blind, deaf and deaf-blind). The participants' degree of blindness and deaf-blindness was 100%; their demographic information is summarized in Table I. Most of the students were not frequent users of computers, although one 27-year-old blind student had completed a computer science degree and was simultaneously studying for a Master's degree and working. He and two other students were in their mid-twenties. Ages of other participants ranged from 30 to 50.

Four people provided the students with tutoring regarding on the pedagogic and technical aspects during the learning process and examination. Pedagogical support covered the learning materials (i.e., the engineering contents and the assessment) and content adaptation (e.g., how to access LOs adapted to a specific capacity). Technical support helped resolve any issues with the learning platform (e.g., login), installation and configuration of specific software (e.g., screen readers) and hardware (e.g., braille devices).

C. Materials

The educational materials related to technical undergraduate courses in telecommunications and computer engineering were selected to help students meet the learning objectives. These materials usually present greater problems of accessibility and are often of a practical nature; for example, engineering students must learn how to install and control specific devices. Introductory contents were selected from the first year program of telecommunications and computer engineering. Contents before the adaptation of the learning platform were presented using two video tutorials, which included visual and auditory information related to the use of an oscilloscope, and the topology and operation of communication networks. LOs complied with the IMS "Access for All" recommendation.

The new version of each video tutorial on the platform included the following adaptations: (1) an audio description for the visually impaired; (2) captions for the hearing impaired; (3) sign language for the hearing impaired; (4) long description of the images for those with visual impairments, as these can be converted to audio by a screen reader; (5) long description of both images and audio for those with visual and auditory impairments. A screen reader and a braille device translates the text to braille for deaf-blind students.

Learning outcomes were assessed using multiple choice questions divided in two groups according to the type of access (visual or auditory) required to answer each question. Answering the first group required vision, and the second group required hearing. Groups of questions were used to analyze the results of visually impaired and hearing-impaired

TABLE II
ASSESSMENT TEST QUESTIONS

Questions	Sensory modality	Topic
1. Where are the three red buttons of the waveform generator located?	Visual	Oscilloscope
2. On which side is the connector that connects the oscilloscope to the waveform generator?	Visual	Oscilloscope
3. How many channels of communication, shown as arrows, appear for a full duplex communication between transmitter and receiver?	Visual	Communication Networks
4. How many layers does the OSI protocol have?	Visual	Communication Networks
5. Which is the function of the six grey buttons of the waveform generator?	Auditory	Oscilloscope
6. What value can be measured when pressing the F2 key of the oscilloscope?	Auditory	Oscilloscope
7. What is the classification of computer networks according to their scope?	Auditory	Communication Networks
8. How many protocols of communication are presented?	Auditory	Communication Networks

students according to the type of access needed to answer it. Table II shows the questions, the sensory mode needed to answer each of them, and the associated learning topic. The questions assess the concepts addressed by the specific objectives.

D. Procedure

A pre- and post-test study was conducted to assess the impact of the adapted platform in learning performance, comparing the results of original and the adapted Moodle platform.

Before administering the tests, the computers to be used were inspected to ensure assistive technologies (screen reader and braille) and Internet connection were in working order. Also, tutors were informed of the initial procedure that students should follow so that they could provide the appropriate support. The initial procedure consisted of three steps: (1) students received their usernames and passwords to access the platform; (2) students, helped by the tutors, created and activated their PNP profiles; and (3) students signed in and accessed the LOs.

Students first accessed two non-adapted LOs and answered the questions about the content presented in the LOs, Table II. Then they accessed the same educational materials, but this time using the adapted learning platform, and answered the same questions. If a student answered a question incorrectly before the adaptation and then answered the same question correctly after the adaptation, this would indicate that the student understood the learning content presented in a form accessible to her capacities. All students took the pre-test three times to check if they learned by repeating the questions, i.e., to assess any skew in results. There was a break of 30 minutes between each test. Finally, after another break of 30 minutes, students accessed the adapted material, and they immediately took the post-test, Fig. 1. Students could take as much time as they wanted to complete the test. All students used the same procedure, took the tests individually, and did not have access to the answers after the pre-tests. There were no specific hardware elements in the learning environment except for the braille device the deaf-blind students used.

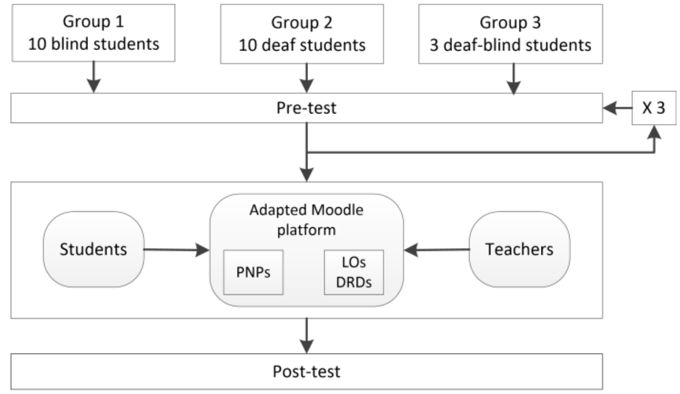

Fig. 1. Stages of the experiment.

TABLE III
RESULTS FOR THE BLIND GROUP

Aid	Pre-test Mean	Pre-test SD	Pre-test Med	Post-test Mean	Post-test SD	Post-test Med	Sig.* W	Sig.* p
Vision	0.2	0.42	0.0	3.7	0.48	4.0	-2.88	.00
Hearing	3.7	0.48	4.0	3.8	0.42	4.0	-1.00	.31
Overall	3.9	0.74	4.0	7.5	0.53	7.5	-2.89	.00

* Significance of the Wilcoxon signed-rank paired test

V. RESULTS

The empirical study was run during winter 2014. Results of the second pre-test and the results of the statistical analysis of the quantitative data are reported here. Each correct answer received one point.

A. Learning Performance

Given the size of the sample, and providing that data did not follow a normal distribution, non-parametric tests were preferred. The Wilcoxon signed-rank test was used since the data were paired. The null hypothesis assumes that the students get the same marks in both pre- and post-test.

1) Blind Students: Table III presents the average scores of blind students. The average was very low for questions that required vision to answer. The difference between pre- and post-test was statistically significant ($W = -2.879$, $p = .004$). Therefore, the null hypothesis was rejected, since it was demonstrated that there were differences in the scores. Contrastingly, the average was high in questions that could be answered by being able to hear, since blind students had no problem obtaining the information ($W = -1.000$, $p = .317$). As a result, the null hypothesis was accepted, and it was confirmed that there were no differences in the score among the pre- and post-test for blind students for this type of question.

TABLE IV
RESULTS FOR THE DEAF GROUP

Aid	Pre-test			Post-test			Sig.*	
	Mean	SD	Med	Mean	SD	Med	W	p
Vision	3.7	0.48	4.0	3.8	0.42	4.0	-1.00	.32
Hearing	0.1	0.32	0.0	3.7	0.48	4.0	-2.91	.00
Overall	3.8	0.63	4.0	7.5	0.53	7.5	-2.87	.00

* Significance of the Wilcoxon signed-rank paired test

TABLE V
RESULTS FOR THE DEAF-BLIND GROUP

Aid	Pre-test			Post-test			Sig.*	
	Mean	SD	Med	Mean	SD	Med	W	p
Vision	0.3	0.58	0.0	3.7	0.58	4.0	-1.63	.10
Hearing	0.0	0.00	0.0	3.7	0.58	4.0	-1.63	.10
Overall	0.3	0.58	0.0	7.3	0.58	7.0	-1.60	.11

* Significance of the Wilcoxon signed-rank paired test

Finally, for the overall score statistical differences (W = − 2.889, p = .004) were found supporting rejection of the null hypothesis and suggesting the existence of differences between pre- and post-test scores. The analysis of the data in the pre-test and the post-test showed an improvement in learning performance by blind students of 45%.

2) Deaf Students: A similar analysis was performed for deaf students, Table IV. As expected, the mean for questions that required hearing was very low (0.10) for deaf students, in contrast with the corresponding value on Table III (3.70). Significant differences were found in the overall score (W = −2.871, p = .004), showing a considerable improvement in learning performance (46.25%). Also as expected, the mean for the questions that required vision to be answered correctly was 3.70, because these students can see. Comparing this mean with the corresponding value on Table III (0.20) shows that it is much higher, and this difference makes sense, because deaf students have no problems accessing visual information.

3) Deaf-Blind Students: Statistically speaking, the overall level of significance was low due to the very small size of this particular group, Table V. The improvement in score for the hearing-related questions was significant at the p = .01 level, and this was also the case for vision-relented questions. Yet, because the sample size was so small, the statistical procedures did not detect a significant difference in the overall scores for the three students who were both deaf and blind. Although the level of statistical significance was p = .11, which is just shy of the accepted standard of p = .10, the 87.5% improvement in score can, nonetheless, be considered to be of practical significance. The levels of significance found (W = −1.633, p = .102; W = −1.633, p = .102; W = −1.604, p = .109) suggest that important differences occurred for these students between the pre- and post-tests. Simply put, on the pre-test, the blind-deaf students did not score well since they had neither the vision nor hearing necessary to access content that was presented. When accessible material was available to them, these students improved in both categories, with an overall improvement of 87.5% between pre-and post-tests.

Results were similar in pre- and post-test for the three groups of students (blind, deaf and deaf-blind). In the pre-test blind students didn't correctly answer the questions that required the aid of vision. Similarly, deaf students struggled with questions that required hearing to be answered, while deaf-blind students failed to answer all the questions. Contrastingly, in the post-test, learning performance improved significantly for the specific questions that targeted the different capacities of each group of students (blind, deaf and deaf-blind). Fig. 2 illustrates the rise in overall scores between pre- and post-test for each group.

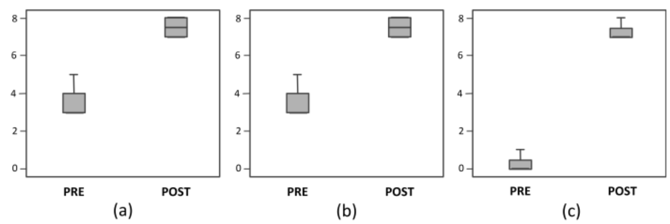

Fig. 2. Boxplots the overall score for (a) blind, (b) deaf and (c) deaf-blind students for pre- and post-test.

VI. DISCUSSION

This section addresses the initial research question, "How do the adapted platform and/or the adapted LOs impact the learning performance of blind, deaf and deaf-blind students?". On the pre-test questions that required vision, blind students obtained very low mean scores. Similarly, students with hearing difficulties obtained very low mean scores in the pre-test for questions that require auditory aid. At this pre-test stage, the deaf-blind students answered almost every question incorrectly. In contrast, on the post-test, the mean scores of all the students were high across all types of questions.

Table III shows that mean scores pre-test and post-test were 0.2 and 3.7 respectively for blind students. The difference in the mean scores was significant for the final mark (W = −2.879, p = .004) obtained for the first type of questions, but not for the second type of questions (W = −1.000, p = .317). A similar result can be seen in Table IV for deaf students, but in this case, the difference in the mean scores was statistically significant for the second type of questions (W = −2.913, p = .004).

The mean overall scores were 3.9 and 7.5 for blind students in the pre- and post-test respectively, and 3.8 and 7.5 for deaf students. This indicates that using the adapted platform yielded a 45% and a 46.25% improvement in the results obtained by the blind and deaf students respectively. Furthermore, the difference in the mean scores was statistically significant for the final mark. Results then suggest that individuals with vision or hearing impairments presented a similarly good performance when using the LOs of the adapted learning platform. The benefit was even greater for the deaf-blind students, who obtained final mean scores of 0.33 and 7.33 for pre-test and post-test, respectively, Table V, indicating an improvement of 87.5%. Because this group is so small (n=3), achieving statistical significance is difficult, but in this case, practical significance is clear. The level of improvement in this study reveals the potential for achieving positive results by creating adapted LOs for deaf-blind students. Without adaptation, the students could not access any of the information, whereas the braille device and long adapted descriptions provided access to all the LO content, meaning that students were able to learn and meet the learning objectives as assessed by a multiple-choice test. Results then suggest that the answer to the initial research question is that the adapted learning platform and LOs influence the learning performance of students with different capacities in telecommunications and computer engineering.

Braille devices are essential for deaf-blind students to receive any information. They are especially useful in engineering studies because they represent a suitable method for describing mathematical formulas.

This study has two threats to validity: (1) using the same questions in the pre- and post-test and (2) the number of students in the sample. For the first, students with different capacities could not answer the questions in the pre-test because they could not get the information. For example, if a student is asked to add the numbers 2 and 3, but she cannot see the numbers, it would be impossible for her add them, even if the pre-test is repeated multiple times. So, students could not learn from repeating the test. The pre-test was repeated three times to check whether students obtained similar scores. A closer inspection of results taking into consideration that questions were the same in the pre- and post-test suggests that the students knew the answers after the post-test because they used the adapted platform. Using the same questions also precludes the possibility that students could previously know the answer if a different question was used in the post-test. As for the second threat, the number of students is below the benchmark value of thirty required to have statistical validity. However, a sample of twenty-three students may be acceptable considering that it is hard to find engineering students with different capacities. Furthermore, the sample included blind, deaf and blind-deaf students. Nevertheless, the results of this study are not conclusive because of this limitation. Future experiments may consider larger representative samples to provide further generalization.

VII. Conclusion

Education is a fundamental element in people's lives, but it is hard to find groups of people with different capacities in order to conduct a study with a representative sample of the population. For instance, technical studies such as engineering present a higher degree of inaccessibility, and typically have fewer students with different capacities. There is also a wide range of different capacities, which becomes even wider if the level of disability is considered. All this complicates designing and building adaptations for the LOs, while the lack of specific data renders work in this field even more difficult. This study focused on students with different vision and hearing capacities.

Technological accessibility, or e-accessibility, has evolved primarily from webpage accessibility. Adapting learning platforms improves e-accessibility and accessibility in the educational environment. However, several technical issues should be considered to adapt a learning platform, including the nature of the learning objects (LOs) and their adaptations, the accessibility metadata provided for LOs and their adaptations, and students' personal needs and preferences (PNPs). In order to use an adapted platform, content creators must produce and upload adaptations of LOs, and they also have to fill out accessibility metadata. In addition, students must provide their PNPs in their profile.

The adapted platform and the adapted LOs used in this study provide a complete learning experience to blind and deaf students. A pre- and post-test study was conducted to compare the learning performance of a non-adapted Moodle learning platform with an adapted version of the platform. Results suggest that the learning performance of students of telecommunications and computer engineering improved noticeably using the adaptable platform. In the pre-test blind students could not answer questions that required the aid of vision to be answered, but they passed in the post-test. Similarly, deaf students failed to answer questions that need auditory aid in the pre-test, but they obtained remarkably good scores in the post-test. Results of deaf-blind students improved for both types of questions. Blind and deaf students presented an improvement of 45% and 46.25% respectively in their learning performance, while deaf-blind students obtained an improvement of 87.5%.

Results of the experiment then suggest that accessible online education helps students of telecommunications and computer engineering with different capacities in having a positive influence in their learning performance.

Future work includes running experiments with larger samples to generalize the results. Also, participants in this study had a high degree of disability. Future studies could address the relationship between learning and the degree of disability in accessible learning environments. Finally, this study focused on learning in communication engineering and computer engineering. However, the supportive technologies and the adaptation process presented here are neutral. They can be extended to other domains, including disciplines that are particularly challenging to students with specific needs like mathematics or linguistics, since courses on these subjects require more detailed adaptations of the LOs.

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