# Ensuring diverse user experiences and accessibility while developing the TeSLA e-Assessment System

**Tarja Ladonlahti, Merja Laamanen, Sanna Uotinen**

The TeSLA project, with its new, innovative approaches for e-assessment, offers a great possibility for increasing the educational equality and making higher education studies available for all. It has been estimated that 10–15% of students in higher education institutions have some disabilities or special educational needs. At online universities or in online programmes, the number is even higher. These numbers emphasise the importance of the universal design for learning as a leading principle while developing the digital learning environments and e-assessment procedures. In this chapter, we describe the key elements of ensuring the accessibility of the TeSLA e-assessment system during the TeSLA project. In the cooperation among seven universities participating in TeSLA pilots, different national or institutional rules and ways of meeting the students' individual needs have been recognised. The main goal of the project, in terms of accessibility, has been developing an instrument that is accessible and easy to use for all types of students. We also discuss technical and pedagogical solutions that support use of the TeSLA e-assessment system by diverse students.

**Keywords:** accessibility, usability, disability, special educational needs, student with special educational needs or disabilities (SEND student), user experience

## 1. Introduction

Higher education programmes supported by systems like TeSLA will offer new opportunities for all students to study in online environments and increase educational equality and make higher education studies available for all. Hopefully, it will open new possibilities for students with special educational needs or disabilities (SEND students) to participate in education. The TeSLA project has a strong commitment to considering the accessibility issue, meaning that SEND students are included as potential users of the TeSLA system. This commitment follows the EU action to promote inclusive education and lifelong learning for students with disabilities (European Commission 2010).

*Accessibility* means that 'people with disabilities have access, on an equal basis with others, to the physical environment, transportation, information and communications technologies and systems (ICT) and other facilities and services' (European Commission 2010). In the TeSLA context, accessibility is seen in relation to e-learning. It means that learners are not prevented from accessing technologies, content or experiences offered by technologies on the grounds of their disability (see Seale & Cooper 2010).

The accessibility issue is highly topical at present. In 2016, the European Parliament approved the directive on making the websites and mobile apps of public sector bodies (including public universities and libraries) more accessible, ensuring that people with disabilities would have better access to them. It has been recognised that EU member states have had different approaches to and legislation on accessibility and disability issues: Some have underlined anti-discrimination laws, while others have focussed on public procurement or detailed technical requirements (European Commission 2015). Following the directive, new national laws and regulations related to new directives should have come into effect in September 2018 (Directive [EU] 2016/2102). This means a big change for public universities, especially if the strict national legislation related to accessibility has been missing. Higher education institutions can no longer ignore the accessibility issue related to online education.

When the TeSLA project started, there were no common EU legislations for accessibility, and the national laws varied greatly. However, website accessibility has long been an EU policy priority. It can be seen as an obvious part of the growth of 'e-government services'. While evaluating the development of e-government schemes, Easton (2013) states, 'The ability to harness technology's potential to enhance the relationship between the individual and the State can, without a policy focus on inclusion, strengthen existing socio-economic divides and exclude already marginalized groups'. Applying this idea to the educational framework, this could mean that, in strengthening the role of the technology in education, without inclusive practices and accessibility guarantees, in contrast to the original goal, we may promote the marginalisation of SEND students.

Accessible e-learning is not an independent pedagogical or technological issue. Even in the educational context, it has a strong reliance on many social phenomena. According to Seale (2006), the development of accessible e-learning is a practice that can and should be mediated. A contextualised model of accessible e-learning practice in higher education considers the following factors:

- All the stakeholders of accessibility issues in a higher education institution (students, lecturers, learning technologists, support workers, staff developers, managers);
- The context in which to operate: drivers (legislation, guidelines and standards) and mediators (stakeholders' views of, e.g. disability, accessibility, integration and segregation, responsibility, community and autonomy); and
- How the relationship between the stakeholders and context affect their responses and the accessible e-learning practices that develop.

In the beginning of the project, it seemed obvious that, to be able to establish the best practices, the universities participating in the TeSLA pilots needed to find a common core and build a variety of local, good practices around it. Still, the main goal or outcome of the project, in terms of accessibility, was developing an instrument that is accessible and easy to use for all types of students. By adapting the idea of Seale's (2006) original 'contextualized model of Accessible E-learning Practice in Higher education', we describe the complexity of elements encountered at the institutional level during the pilots (see Fig. 1). Figure 1 visualises the complexity of the factors recognised during the TeSLA pilots while piloting the TeSLA e-assessment system and its accessibility.

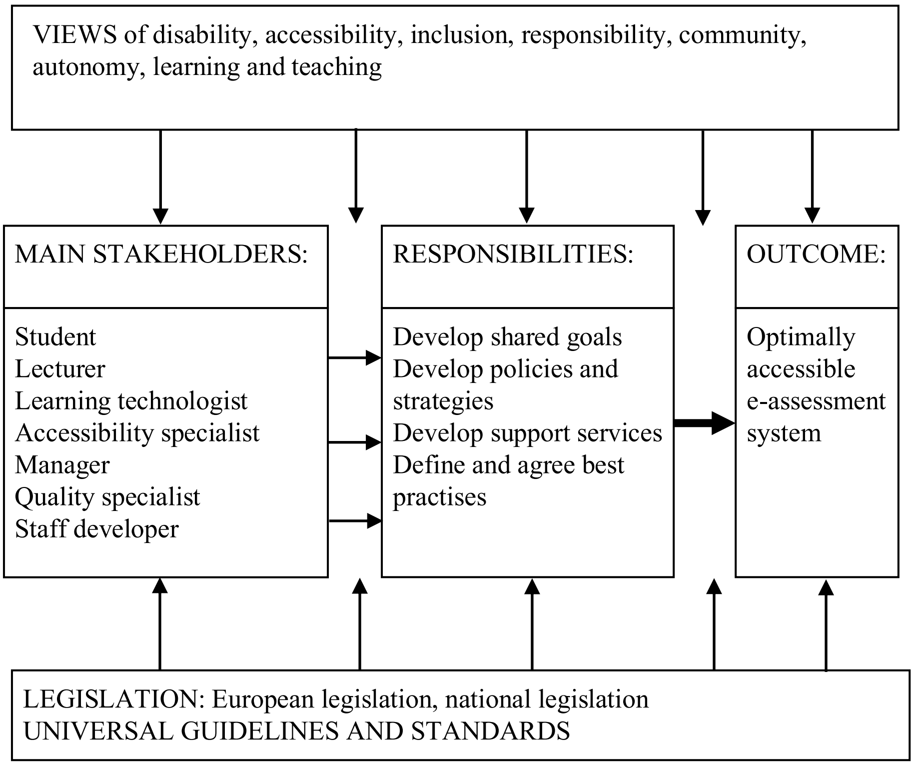



**Fig. 1.** Dimensions of accessible e-learning practices in the context of TeSLA e-assessment system

The common European legislation and national legislation of higher education institutions in partner countries offer the basic guidelines for the accessible e-learning practices. In the following sections, we discuss the dimensions included in Fig. 1. First, we describe the effects of e-learning on SEND students and how we ensured a wide variety of user experiences and participation of SEND students while piloting the TeSLA e-assessment system. We also discuss how to recognise students' diversity and organise support for them based on the literature and pilot experiences. Accessibility of the TeSLA e-assessment system is strongly related to the online course design and learning environment; therefore, the main elements of accessible online education are also defined. Finally, we describe the general accessibility guidelines and design of the method used during the pilots. We also give some examples of why it is important to use various methods to ensure the accessibility of a system like TeSLA.

Accessibility can be seen from the three following points of view: accessibility by everyone, using any technology and allow access in any environment or location (Seale 2006, pp. 28–29). In this chapter, accessibility is discussed by focussing on the user perspective (accessibility by everyone). It should be noted that the use of mobile devices is not included in the TeSLA technology developed during this project.

## 2. Effects of e-learning on students with special educational needs and disabilities

While discussing the effects of e-learning on students with disabilities, Seale (2006) points out many positive outcomes, including flexibility and adaptability, access to inclusive and equitable education, access to learning experience, empowerment, independence and freedom. In contrast, according to this researcher, the main negative element seems to be inaccessible design. Even if students with disabilities access the virtual learning environments (VLEs), there may still be accessibility issues with the content, including activities, resources, collaboration and interaction tools (Kent 2015). Accessibility and usability are critical for online student success (Betts et al. 2013). Usability can be defined as the 'extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use' (ISO 9241, 2010).

When sites are correctly designed and developed, all the users have equal access to information and functionality. In terms of accessibility, it is a question of technology and pedagogy, including at least the course design, study materials and assessment. At the beginning of the project, the consortium agreed that the TeSLA system should be developed from its inception to be accessible for all students. This means that the system is regularly tested using automated tests and assistive technology, as well as by a variety of students. In the TeSLA project, technological developers were responsible for developing the accessible instruments and accessible system. Students and staff of the pilot institutions had a role as users, testing and giving the feedback on the technological solutions that were established. Still, the higher education institutions had an important and essential role in building up the context to their VLEs and realising accessible course design.

During the project, the data on disability issues were collected from seven pilot universities, namely the Open University of Catalonia (UOC), Open University of the Netherlands (OUNL), Sofia University (SU), Open University United Kingdom (OUUK), Technical University of Sofia (TUS), Anadolu University (AU) and University of Jyväskylä (JYU). It is worth clarifying that there were some differences between the TeSLA pilot universities: Some were traditional universities, selecting their students in one way or another; others, especially the open universities, were open to all students. Some of the pilot universities were fully online universities, while some combined face-to-face, online, and blended learning modes. The student profiles in the pilot universities also differed. The common element for all the pilot universities was that the pilots were mainly implemented in real educational environments with real assessment activities.

The pilot universities' expectations for the TeSLA system concerning the support of students with disabilities were mainly related to the flexibility of assessment modes through improved student identification and the recognition of authorship of a student's work. In practice, for example, this meant possibilities for taking an exam at home, without traveling to the university campus. The TeSLA system was also expected to improve study opportunities, with the possibility of offering all the activities online and making them available for all, regardless of the student's location. In addition to offering the option for traditional exams, the TeSLA system is considered to provide possibilities for a wider variety of assessment modes (e.g. continuous and formative assessment instead of summative assessment). The psychological stress or discomfort caused to students by recording exams or assessments was mentioned as a possible challenge emerging from TeSLA. Regarding assessment, Ball (2009) points out that there are many standards relating to technical aspects of screen assessment and the accessibility and usability of onscreen material but no standards for the accessibility testing of assessments. He underlines the aspects of security and reliability in assessment design. As a part of the e-assessment system, some of the pilot universities highlighted the alternative use of different biometric identification instruments. This seemed to be an important and essential element when developing the TeSLA system for all.

## 3. Ensuring a wide variety of user experiences during the pilot

According to the ISO 9241 standard, user experience refers to the perceptions and responses that result from the use and/or anticipated use of a product, service or system. The concept refers to experience in a broad sense, including all the persons' emotions, beliefs, perceptions, preferences, physical and psychological responses, behaviours and accomplishments that occur before, during and after use (ISO 9241, 2010).

The process of ensuring a wide variety of user experiences, meaning especially students with a variety of abilities and using a variety of assistive technologies, can be described as encompassing the following actions:

1. Recognising the SEND students to ensure the variety of use experiences during the pilots (by the local method in every pilot institution);
2. Understanding the context and variety of practices related to accessibility and support for SEND students in pilot universities (by questionnaires for local pilot leaders, who were in charge of the pilot implementation);
3. Taking care of the accessible course design and local virtual VLE (locally in institutions);
4. Implementing accessibility tests by staff (in two pilot institutions);
5. Asking about the students' attitudes and experiences after using TeSLA (questionnaires and local focus groups);

6. Observing and video recording students and screen recording while testing the system (at one of the pilot universities); and
7. Interviewing SEND students during the pilot (at four of the pilot universities).

After all these actions, feedback was given to the technical developers of the TeSLA system.

## 4. How to recognise students' diversity

It is widely understood that, in the field of inclusive education, there is a challenging dilemma: On the one hand, we know how stigmatising the different categories of SEND are, but on the other, we need them, especially to allocate or prioritise support. Individualistic models of disability are based on the construction that the problems and difficulties that disabled people experience are a direct result of their individual physical, sensory or intellectual impairments. The currently widely accepted social model of disability underlines that it is not the individual with a disability that needs to be changed, but rather, the society. The social model of disability argues that disability is located "in social practice" rather than "an individual body". A person may have a certain impairment, but it is the influence of decisions made by society that causes it to be a disability (see Oliver 1996; Seale 2006).

Disability is activated differently online compared with face-to-face meetings. On the one hand, impairments that may encounter significant disabling environments in face-to-face meetings may have less of an effect when using the internet. On the other, some impairments may find a different appearance or meaning in online environments, and thus, online environments can be significantly disabling (see Ellis & Kent 2011; Goggin & Newell 2003).

It is estimated that about 80 million people in the European Union (EU) have a disability that ranges from mild to severe. They are often prevented from fully taking part in society because of the environmental and attitudinal barriers (European Commission 2010). There are no exact international data on students with disabilities or educational challenges enrolled in higher education. It has been estimated that 10–15% of students in higher education institutions have some disabilities or special educational needs. In online universities or online programmes the number is even higher. As an example, in Finland, according to the results of a national survey among Finnish higher education students, the proportion is 8.2% (Kunttu, Pesonen & Saari 2016). Estimated amounts of students with disabilities at the pilot universities varied from 0.8 to 8.5% of all students. Some of the universities did not give any number because no reliable data exist.

In the beginning of the project, there were two main recommendations for the TeSLA system development process, which were as follows:

1. Representatives of SEND students should be included in the TeSLA system development process to help developers see the system and accessibility from the perspective of end users; and
2. Pilots should be designed so that pilot groups of users testing the TeSLA system include students with disabilities. These data on user experience are

the only way to obtain the relevant data and feedback for accessibility of the TeSLA system.

The first task was recognising and including these students in the pilots. According to the pilot universities, it was always the student's responsibility to report on his/her special educational needs or other needs for individual study arrangements. In many countries, it is not permitted to ask if students have a disability. Institutions can only share the information for the students in terms of how to notify the organisation and instructors if they require individual arrangements. In some other countries, students are already asked about disabilities during registration. It is clear that there is also a group of students who never disclose their disabilities or special educational needs (see also Crichton & Kinas 2013). They either need no individual arrangements or they have developed successful coping strategies independently; alternatively, they may want to hide their problems for fear of stigma (see Pirttimaa, Takala & Ladonlahti 2015). Roberts, Crittenden and Crittenden (2011) find that most students with disabilities choose not to reveal their disability. According to these researchers, the students did not even request accommodations to help with access to the course material that was presented in an inaccessible format. This phenomenon means that students with disabilities can become invisible online. The problem of discovering those who have special educational needs was also mentioned as a challenge by pilot universities. This challenge is especially evident in situations where the adaptations required are not disclosed or recognised in advance. Some students prefer not to disclose their disabilities even when asked, or they do not want to be recognised as SEND students at all.

There are many ways of categorising impairments and disabilities. During the pilots, the students were asked to describe their special educational needs or disabilities to make sure that a variety of end users participated in the pilots. Please see Table 1 for the categories used in the pilots and the amount of SEND students participating in the largest pilot, pilot 3.

**Table** 1. SEND students with various disabilities or special educational needs participating in pilot 3

| Category | *N* |
|---|---|
| Blind or partially sighted | 25 |
| Deaf or hearing loss | 57 |
| Restricted mobility or motor disability | 91 |
| Specific learning difficulty (e.g. dyslexia) | 77 |
| Chronic illness | 101 |
| Psycho-social problems | 82 |
| Some other disability, special educational need or exceptional life situation | 81 |
| Prefer not to say | 34 |

It is worth recalling that SEND students are a widely divergent group. It was highly important for the project to ensure the participation of diverse students in the pilots, including students with different types of learning difficulties, life situations and ways of communicating, as well as using different types of assistive technology. Because of the wide variety of instruments in the TeSLA system, the experiences and attitudes towards the use of single instruments varied, depending partly on the students' disabilities (Noguera et al. 2018; Peytcheva-Forsyth, Yovkova & Aleksieva 2019; Peytcheva-Forsyth, Yokova & Ladonlahti 2017). There is not one right way to meet the e-learning needs of such a diverse group of people. Moreover, the recent literature has recognised disabled students as individuals who reflect different experiences (Crichton & Kinash 2013).

## 5. Importance of accessibility and disability regulations and practices in higher education institutions

While considering accessibility in e-assessment, Ball (2009) states that organisations' managements should ensure a clear accessibility policy and training to ensure compliance; moreover, they should create a process to guarantee that the policy and training will be successfully implemented. Rice and Carter (2015) state that many online educators are unaware of their legal responsibilities for students with disabilities. National laws give the boundary conditions for higher education institutions. If laws are binding, it may be unnecessary to create local regulations. All the universities participating in the TeSLA pilots had some local regulations or guidelines concerning accessibility or support to students with disabilities, although they varied significantly. They often contained principles and guidelines for admission examinations, implementation of exams and web accessibility guidelines. In addition, the importance of promoting employee awareness, guidance for faculties and development of the staff's competence was recognised.

The pilot universities described a wide range of persons, groups, teams and services managing the accessibility issue and individualised study arrangements. This partly appears to be a strength, but as Asuncion et al. (2010) observed, it may also create disagreement about who is responsible for such tasks—disability service providers, e-learning professionals or professors and lecturers. These researchers ultimately recommended establishing a role for an e-learning accessibility specialist to oversee these elements. At least, educational institutions should have a common understanding of who is responsible and whom students should contact. Creating a role for an e-learning accessibility specialist, adopting e-learning accessibility guidelines and improving staff training are some of the research-based recommendations for universities in terms of improving the accessibility of e-learning environments (Asuncion et al. 2010).

All the pilot universities described how accessibility issues are considered in the organisations. In addition to creating organisational accessibility policies and guidelines, universities named persons and teams responsible for accessibility issues at many different organisational levels. They also offered support and services for students with disabilities. Still, there was concern about the accessibility issue involving shared responsibilities and a multidimensional network of agents and teams. As examples of the authority and good practices related to accessibility at the pilot universities, the following were mentioned:

- Managerial support;
- Multilevel responsibilities;
- Contact persons for students with special educational needs and disabilities;
- Centralised student support or advisory services;
- The inclusion of the accessibility perspective in all types of different groups in universities;
- Representatives of students or the student union in teams and groups;
- A wide perspective on the accessibility issue, encompassing the built environment, VLEs and websites;
- A full-time planning coordinator; and
- Utilising the expertise of the whole personnel.

The role of the institution is significant when building up practices related to the accessibility policy. Services and accessible learning environments for SEND students must be guaranteed, not only in the guidelines and recommendations, but also in practice. It has been pointed out that it is sometimes it easier to create recommendations and guidelines than make them come true in practice. However, while having some challenges with accessibility in e-learning environments, it is important to make all the necessary guidance, tutoring and support available for students.

The role of the institution seems to be important because it can elicit students' trust, especially when offering new study modes. Levy et al. (2011) noticed that there is a need for awareness raising and increased user support when integrating biometrics in e-learning systems in universities. Their study indicated that learners of online courses are more willing to provide their biometric data when provided by their university compared with the same services provided by a private vendor. The same phenomena were recognised during the TeSLA pilots. In terms of students' attitudes and trust in the use of TeSLA instruments, they saw them as quite safe and trustworthy because the biometric data were collected by the local higher education institution.

## 6. The wide variety of individual arrangements in the pilot universities

To be entitled to individual study arrangements, the pilot universities required a medical certificate from the student. In some cases, an expert report from a psychologist or special education teacher was accepted. In many countries, privacy regulations forbid sharing information about medical diagnoses, but an official document about the disability is needed. Sometimes, a medical certificate was required only if the study arrangements needed complex adjustments. Usually, the certificate only included the medical diagnosis or official document about the disability, not pedagogic suggestions in the study context. A gap between the expert's report and student's wishes was sometimes recognised. To reach a successful learning experience, it is important to listen to the student's perspective whenever possible and when it follows the rules of the university.

The question of how the information about students' disabilities should or could be shared is a sensitive one. Some institutions have developed a process where, to the extent permitted by the student, information about the recommendations of individual arrangements is shared in a centralised manner. Thus, the student does not need to go through the same process in different units and with every teacher.

The universities involved in the TeSLA project offered various adaptations or individualised differentiations for SEND students. The main categories found were as follows:

- Information and study guidance;
- Alternative modes of study (e.g. flexibility in schedules, virtual exams);
- Alternative or adapted study materials (e.g. audio recordings, audiobooks, assistive technology);
- Alternative course completion or exam arrangements (e.g. exams at home, extended time slots);
- Use of an assistant, resource teacher or invigilator;
- Extra support from tutors;
- Alterations made in the physical environment (e.g. ramps, separate exam rooms, special lighting);
- Use of special tools and devices; and
- Discounts in certain cases.

Some universities had specified guidelines or good practices related to certain types of disability (physical disabilities, visual disabilities, hearing disabilities, dyslexia, ADHD, mental disorders).

The pilot universities described their multidimensional practices and large number of staff members connected to the disability issue. They also described the challenges they still had while organising services and responsibilities concerning individual study arrangements. It was stated that more information and knowledge are needed. It seems obvious that there is a need for enhancing staff awareness about the students' diversity and individualised arrangements (including the TeSLA system), but at the same time, clearly allocating the persons responsible for the issue in practice.

OUUK has reported encouraging experiences with the work of the accessibility specialists appointed in every faculty (Slater et al. 2015). An individual responsible for accessibility issues has an important role in increasing disability awareness and supporting the staff responsible for curriculum content. Embedding accessibility into curriculum design and production is often the point where help is needed. When an accessibility specialist is named for each unit of the organisation, it is possible to work proactively and focus on the right questions (see Slater et al. 2015).

Students with a disability may perceive their disability to have a negative effect on their ability to be academically successful. They may not disclose the disability because they do not know what accommodation to ask for. Many of the pilot universities considered the TeSLA system as an opportunity for students to have an e-exam at home or any other place. A couple universities mentioned that students may have a personal assistant, resource teacher or invigilator. It was also mentioned that a student using the TeSLA system while taking an e-examination at home may require another person's assistance.

It was clear at the beginning of the pilot that universities using the TeSLA system must provide sufficient instructions and guidelines and offer the required guidance, support and services for users of the TeSLA system. The instructions and guidelines should be accessible for all.

## 7. Building up the accessible online education and e-assessment

The European school system has a long history of segregation of students with disabilities. While promoting the importance of individualised arrangements, it is worth remembering that we have a strong commitment to inclusive education (European Commission 2010). This means that we should avoid segregation, discrimination and useless 'special or individualized arrangements'. This should result in preferring accessibility and design for all principles when planning study and assessment modes for all courses. However, some of the practices are still based on segregating the students with disabilities from others (e.g. studying alone with alternative materials or taking an exam). As an example, the OUUK is committed to inclusivity and they aim to improve accessibility for disabled students and deliver an equivalent study experience to that of non-disabled students. Students' needs are included already at the design rather than when students are already studying (Slater et al. 2015). The social construction of knowledge, meaning of interaction on learning and its practical applications, such as peer tutoring, group discussions and co-operational learning, are widely accepted ways of studying, and they are also used as a part of continuous and formative assessment. To support equal study opportunities, students with disabilities should be included and supported to participate in regular student groups. While building up new educational practices, it is good to be aware of one's role as a potential creator of disability.

Roberts, Crittenden and Crittenden (2011) suggest that courses should be designed to be accessible from the beginning. Making accommodations for students with disabilities often occurs only after a student has disclosed his/her documented disability. This means adjusting the design of the existing course and is more reactive in nature. This leads to a design–redesign approach (Roberts, Crittenden & Crittenden 2011). Implementing universal design principles from the beginning avoids costs caused by the redesign and serves to include those students who would otherwise be excluded by an unwillingness to request accommodations.

While evaluating accessibility of the TeSLA system, it is important to understand that all the integrated technology (e.g. web browsers, VLEs) affect the end user experience. Therefore, it is also recommended to regularly evaluate the accessibility of the VLEs. Good educational design and accessibility for study and assessment modes are important for SEND students. At the same time, it is important to keep in mind that taking care of those aspects usually means good education and good practices for other students as well. Macy, Macy and Shaw (2018) state that this is a theme that runs throughout the educational literature.

## 8. Universal design for learning

The variety of higher education students' abilities and characteristics emphasises the importance of the universal design for learning (UDL) as a leading principle while developing the digital learning environments and e-assessment procedures. According to Rose and Meyer (2006), the UDL provides the framework for creating more robust learning opportunities for all students. It is an inclusive approach to course development and instruction that underlines the access and participation of all students. It builds on the work of Vygotsky and later advances of neurosciences elucidating how the brain processes information (see more Rose & Meyer 2006). UDL offers three guiding principles for developing curricula that eliminate barriers to learning, build on student strengths and abilities and allow different ways to succeed. For teachers and course design, the UDL method offers three guiding principles, which are as follows:

1. Supporting diverse recognition networks. From the teacher's perspective, this means providing multiple examples, highlighting critical features, providing multiple media and formats and supporting background context. Moreover, it means that various ways of acquiring information and knowledge are recommended and allowed;
2. Supporting diverse strategic networks. This means providing flexible models of skilled performance, providing opportunities to practice with supports and ongoing and relevant feedback and offering flexible opportunities for demonstrating skills. In addition, it represents alternative ways for students to demonstrate what they know; and
3. Supporting diverse affective networks. This means offering choices of learning context, content and tools, offering adjustable levels of challenge and multiple ways to be successful. Moreover, it means engagement to tap into students' interests and appropriate challenges to motivate students to learn (Coyne et al. 2006; Macy, Macy & Shaw 2018).

Flexibility and different assessment modes should be described when there are possibilities for adaptations. The aim should be that the needs of all students, including the disabled students, are always considered at the initial stage of course design (Slater et al. 2015). Designing a product or system with disability in mind will better serve the needs of all users, including those who are not disabled. It is good to remember that convenience, adaptability and flexibility are some of the reasons why SEND students are looking for online courses as an opportunity to participate in higher institution studies (see Jacko et al. 2015). Still, many of the online educators lack the required knowledge related to online accessibility (Macy, Macy & Shaw 2018).

Usually, students' first contact with a course is the syllabus. The written syllabus has an important role, especially for students studying single courses at open universities. It is important to describe the competences and basic requirements concerning the specific course and program. Several pilot universities underlined that the basic requirements for all students are equal.

Griful-Freixenet et al. (2017) find important individual differences regarding learning needs and preferred learning approaches among all students. They report differences among students labelled with the same disability type. Furthermore, they argue that the traditional model of providing retrofitting accommodations depending on the student's disability type is inefficient. Instead of this, they advocate a high number of accommodations being incorporated into the design of the syllabus for all students, regardless of disability, right from the start.

When designing a new syllabus and its material, whenever possible, it is important to choose e-material from the publishers, which offers accessible electronic content. One incoming challenge is open resources, which are increasingly being incorporated in courses. This implies having less control over reviewing and ensuring that these resources accomplish the accessibility standards.

## 9. Universal design for learning implementation for online courses

It is widely recognised that online educators lack sufficient knowledge on how to ensure the accessibility of online courses or online education. Some guidelines recommended as UDL implementation tips are available in the literature (see Dell, Dell & Blackwell 2015; Macy, Macy & Shaw 2018); these are as follows:

1. Create content first and then design the course;
2. Provide simple and consistent navigation;
3. Include an accommodation statement;
4. Use colour with care;
5. Choose fonts carefully;
6. Model and teach good discussion etiquette;
7. Choose content management system tools carefully;
8. Provide an accessible document format;
9. Convert PowerPoint to HTML;
10. If the content is auditory, make it visual; and
11. If the content is visual, make it auditory.

This list has proven to be useful when giving a wide perspective on course design. The accommodation statement and good discussion etiquette are important tools for supporting students' participation.

Slater et al. (2015) highlight that, whenever possible, the aim is to use original course material produced in an accessible way. When this is not an option, an alternative learning material or experience must be provided. The pilot universities reported use of several different VLEs and alternative or adapted study materials (e.g. audio recordings, audiobooks, assistive technology). However, they also experienced a lack of accessible learning materials (e.g. audiobooks involving symbols and different letters, specialised software and hardware for different groups, accessible material including mathematical formulas, guidelines on how to create accessible learning resources). Slater et al. (2015) also point out that there are significantly different accessibility issues in different subject areas. In this study, an example mentioned by one pilot university was audiobooks involving mathematical symbols. The developed web content accessibility guideline (WCAG; see section 10) offers detailed guidance on how the four design principles (perceivability, operability, understandability, robustness) should be considered when creating accessible content (WCAG 2.1).

In addition to the accessibility of study materials, the TeSLA system and platform for examinations or assignments should be accessible. Thomson et al. (2015) present some basic rules for lecturers to follow. Moreover, having reviewed the literature, Macy, Macy and Shaw (2018) state that there are strategies that can be easily implemented to promote student success. Elements from the two sets of rules are combined in Table 2.

**Table 2.** Elements and recommendations for teachers to follow while designing an accessible online course

| Topic | Recommendation |
|---|---|
| Colour | Do not use colour alone to convey information.<br>Ensure that the text colour has sufficient contrast to the background colour (see details in WCAG). |
| Page content | Structure content semantically in HTML so that assistive technology (screen reader) users can reach the content and navigate effectively.<br>Avoid automatic slide transitions and use simple slide transitions when possible. Complex transitions can be distracting. |
| Tables | Add definition of column and row headers into the tables that are used for data. Header attributes can help define table headers. |
| Presentation slides | Check the reading order of the textboxes that are not part of the native slide layout. A screen reader usually reads these last.<br>Avoid automatic slide transitions and use simple slide transitions when possible. |
| Images | Add alternative texts to images that alert the student to the image content.<br>Add closed captioning. It provides text to visual content. |
| Font | Use easy-to-read fonts.<br>Ensure that the font size is sufficient.<br>Use one font type throughout.<br>Limit the use of bold, italics or CAPS. |
| Audio | If there is embedded audio, ensure that a transcript is included. |
| Multimedia | If there is embedded video, ensure that the video is captioned and the player controls are accessible.<br>Captions should include the spoken text and sounds that are important for understanding (laughter, applause, music). |
| Authentic assessment | Assessments challenge students to demonstrate their ability to apply and synthesise course content.<br>Ensure communication with students about what they have learned.<br>Use innovative assessment modes, for example, multimedia presentations, oral presentations, etc. |
| Auto-testing tools | There are many auto-testing tools to integrate with the existing system.<br>The system shows the accessibility challenges and offers recommendations for correcting the issue. |

There are some interesting tools for automated accessibility checking. As already stated, accessibility issues should be considered from the beginning of the product development process. Developers should utilise guidelines and good practices, consult usability experts and use automated tests. It is recommended to employ practical rather than simulated tests, as the simulated environment may not reflect how individuals work in practice (Ball 2009; Kent 2015). It is also recommendable to include users with disabilities in the development process and testing of products (including software) at the earliest stages. Disability rights organisations are also active on this issue (Kent 2015).

## 10. Web content accessibility guidelines

WCAG are widely used as design principles for making web content more accessible. All the pilot universities were familiar with these guidelines. During the TeSLA project, the current version was WCAG 2.0; version 2.1 was published in 2018. Following the recommendations, the guideline will make web content accessible to a wide range of students with disabilities (including visual, auditory, physical, speech, cognitive, language, learning and neurological disabilities) and more usable for all other users as well (WCAG 2.1). Twelve WCAG design guidelines are based on the following four principles of accessibility:

- Perceivability (users must be able to perceive the information and user interface components);
- Operability (users must be able to operate the interface);
- Understandability (users must be able to understand the information, as well as the operation of the user interface); and
- Robustness (users must be able to access the content as technologies advance).

Testable success criteria are provided for each guideline described above. To meet the variety of needs of different groups and different situations, three levels of conformity are defined, which are as follows: A (lowest), AA and AAA (highest).

The desired level of WCAG for the TeSLA system, including instructions and guidelines for the users, was AA. Some pilot universities have set that level as their standard, so the TeSLA system should align with this and not restrict opportunities for their students. According to the pilot universities, there were differences in achieving the desired WCAG level. For example, one university offered a detailed description of the functionalities implemented to ensure easy access to all the contents. In contrast, another university stated that there were many challenges in achieving accessibility. Some stated that, instead of the desired WCAG level, they had prepared standards for the quality of e-learning resources, including the web content accessibility of all types of e-resources. Every distance learning course had to meet these standards.

**Table 3.** WCAG 2.1 web content accessibility principles and guidelines

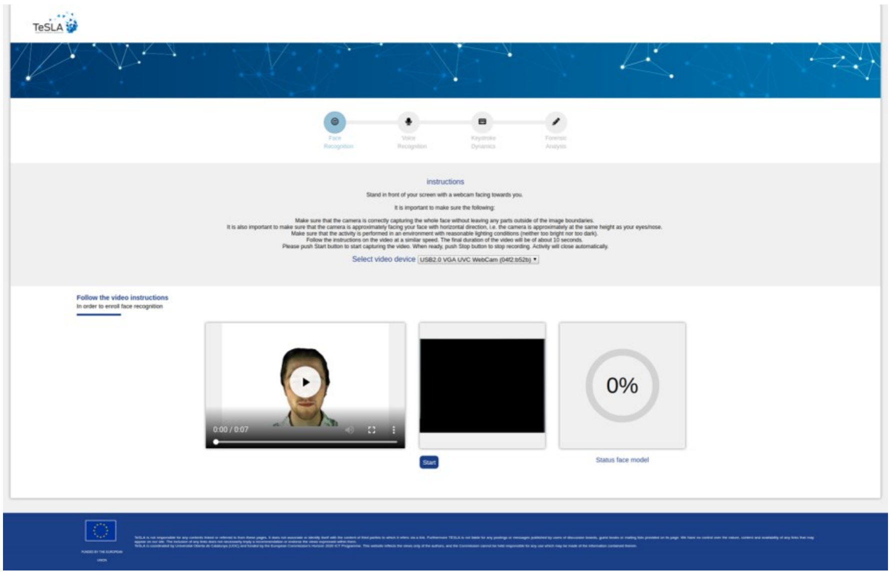
| Principle/Guideline | Content | Description |
|---|---|---|
| PERCEIVABILITY | Text alternative | Provide text alternatives for any non-text content so that it can be changed into other forms needed, such as large print, braille, speech, symbols or simpler language. |
| | Time-based media | Provide alternatives for time-based media. |
| | Adaptable | Create content that can be presented in different ways (e.g. simpler layout) without losing information or structure. |
| | Distinguishable | Make it easier for users to see and hear content, including separating foreground from background. |
| OPERABILITY | Keyboard accessible | Make all functionality available from a keyboard. |
| | Enough time | Provide users enough time to read and use content. |
| | Seizures and physical reactions | Do not design content in a way that is known to cause seizures or physical reactions. |
| | Navigable | Provide ways to help users navigate, find content and determine where they are. |
| | Input modalities | Make it easier for users to operate functionality through various inputs beyond the keyboard. |
| UNDERSTANDABILITY | Readable | Make text content readable and understandable. |
| | Predictable | Make webpages appear and operate in predictable ways. |
| | Input assistance | Help users avoid and correct mistakes. |
| ROBUSTNESS | Compatible | Maximise compatibility with current and future user agents, including assistive technologies. |

It is important to remark that even content that conforms at the highest level (AAA) will not be accessible to all users. There are also studies showing the limitations and lack of detailed research, for example, concerning user experiences of problems (see e.g. Petrie & Kheir 2007). Additional information on WCAG levels can be found in the *Guide to understanding and implementing Web Content Accessibility Guidelines 2.1* (W3Cc).

## 11. Accessibility test implemented by pilot university staff

While evaluating the accessibility of the TeSLA system, it is important to understand that all the integrated technology (e.g. web browsers, VLEs) affects the end user's experience. While the march of technology is rapid, it is recommendable to evaluate the accessibility of the VLEs regularly. This was only implemented in a couple pilot universities. More commonly, it was evaluated occasionally or while developing or acquiring new tools. As a good practice, it was also mentioned that every technological project should fulfil the Web Accessibility Initiative (WAI) standards and all learning objects should be evaluated by experts.

During the pilot, there were two options for integrating the TeSLA enrolment tool into the organisation's VLE. Either it could be integrated into the VLE (e.g. Moodle) or it could be used as an external tool via a Learning Tool Interoperability (LTI) integration. LTI is a standard that links content and resources to learning platforms. The accessibility evaluation discussed in this section focussed on LTI enrolment for two reasons. First, TeSLA was running on different versions of Moodle in the pilot institutions, but the LTI enrolment was identical for all institutions and users (see Fig. 2). Second, the accessibility of the LTI enrolment is crucial for SEND students using the TeSLA system.




**[Insert Figure2.jpg** - LTI user interface of the face recognition instrument's enrolment **here]**

**Fig. 2.** LTI user interface of the face recognition instrument's enrolment.

The aim of the accessibility test was to test TeSLA's LTI enrolment version using the following three methods: 1) navigation by tabbing (tab, shift + tab, enter, space bar); 2) using a screen reader (JAWS 2018); and 3) the WAVE Chrome extension, which enables evaluating web content for accessibility issues directly within the browser.

The TeSLA system was tested using Windows 10 and three versions of Chrome. Web browsers are constantly developing software, and new versions are launched frequently. Chrome was selected because, at the point of testing, it was by far the most popular web browser across platforms (desktop, tablet, mobile). According to w3counter.com, Chrome's market share was 55.2% in June 2018.

There are several automated tools for evaluating the accessibility of web content (e.g. WAVE, Siteimprove and Axe). WAVE was selected because it is free of charge and easy to use. However, automated tools can only identify a certain amount of errors. Only humans can determine whether specific web content is accessible. Therefore, we also need user testing and accessibility evaluation. TeSLA enrolment was also tested by a usability/accessibility specialist.

The general findings of TeSLA's LTI enrolment's accessibility evaluation concern the enrolment of all instruments. These accessibility tests were conducted at the end of pilot 3 in June 2018. The test report was shared for the whole project, but especially, for the technical developers. The tables below present the test results. The findings and recommendations are copied directly from the WAVE reports.

**Table 4.** General findings related to the accessibility of enrolment of the TeSLA instrument and the recommendations for improvements

| Feedback provided by WAVE | Recommendation by WAVE |
|---|---|
| Images miss the image alternative text. Each image must have an alt attribute. Without alternative text, the content of an image will not be available to screen reader users or when the image is unavailable.<br>- TeSLA logo on the upper left corner<br>- Buttons (Face Recognition, Voice Recognition, Keystroke Dynamics and Forensic Analysis)<br>- Start and stop buttons<br>- EU flag on the footer | Add an alt attribute to the image. The attribute value should accurately and succinctly present the content and function of the image. If the content of the image is conveyed in the context or surroundings of the image, or if the image does not convey content or have a function, it should be given empty/null alternative text (alt=""). (High priority) |
| The instructions are justified. Large blocks of justified text can negatively impact readability due to varying word/letter spacing and 'rivers of white' that flow through the text. | Remove the full justification from the text. (Medium priority) |
| The enrolment page has no headings. Headings (<h1>-–<h6>) provide important document structure, outlines, and navigation functionality to assistive technology users. | Provide a clear, consistent heading structure, generally one main heading and subheadings as appropriate. Except for very simple pages, most webpages should have a heading structure. (Medium priority) |
| The language of the document is not identified. Identifying the language of the page allows screen readers to read the content in the appropriate language. It also facilitates automatic translation of content. | Identify the document language using the <html lang> attribute (e.g. <html lang="en">). (High priority) |
| Contrast is very low on the icons (Face Recognition, Voice Recognition, Keystroke Dynamics and Forensic Analysis).<br>- Foreground colour: #b5b5ba<br>- Background colour: #eeeeee | Increase the contrast ratio of the icons. (High priority) |
| **Tester's comment** | **Tester's recommendation** |
| Before finishing the enrolment of all four instruments, the user can exit the enrolment only by clicking the back button of the web browser as many times as needed to get back to Moodle view. For screen reader users or those navigating with tabs, this is too difficult. | Add an exit button to the enrolment view. (High priority) |
| When navigating by tabbing, the user interface does not clearly indicate when the Start or Stop button is activated. The thin blue frame does not stand out from the blue button. The frame is so thin that it is impossible to notice the difference. | The frame should be of a different colour than the button or much thicker to stand out. (High priority) |

All the instruments were tested separately. The tester recognised some good solutions while testing the enrolment of the face recognition instrument. Elements had individual buttons; this was good because the user could navigate without the mouse. The user interface asked for permission to use the web camera on a popup. This was also a good solution because it was easy to access via the screen reader or tabbing. There were many challenges as well. (See Tables 5–8 and the comments and recommendations for the enrolment of each instrument.)

**Table 5.** Comments and recommendations for face recognition enrolment

| Feedback provided by WAVE | Recommendation by WAVE |
|---|---|
| Web camera's user interface lacks alternative text. | Add an alt attribute to the web camera screen. (High priority) |
| Tester's comment | Tester's recommendation |
| Web camera is always active when the user is on the face recognition page. This happens even when the user has not activated face recognition. | The web camera should be active only when the user has activated it by pressing the Start button. (High priority) |
| The user cannot exit the process of saving the video. | User should be able to stop the process of saving the video if it takes too long. (High priority) |
| When the screen reader user navigates by using tabulator, it only reads the names of the instruments at the top of the page and then continues to the selected video device's dropdown menu. The user cannot return to the instructions. | The user should be able to view the instructions if needed. Enable accessing them. (High priority) |
| The (meta) information of the web camera's user interface cannot be read properly. This may be caused by several nested div or button elements. | Check and remove the nested elements to allow the user to access the meta information. (High priority) |
| The screen reader does not identify the Start button. Users of screen readers cannot complete the face recognition enrolment. | Meta-information must be added to the Start button. (High priority) |
| Face recognition works differently with different versions of Chrome.<br>- Web camera loops. Version 67.0.3396.87 (Official Build) (64-bit)<br>- Start button returns the user to the start of the page. Version 66.0.3359.181 (Official Build) (64-bit) | The web camera should work properly. It should not loop. The Start button should start the camera. (High priority) |

**Table 6.** Comments and recommendation for voice recognition enrolment

| Tester's comment | Tester's recommendation |
|---|---|
| When navigating by tabbing the Start button does not indicate that it is active. | Start button should indicate clearly that it is active. (High priority) |
| The screen reader does not identify the status voice model information. How does the user of a screen reader know the progress? | Meta-information must be added to the status voice model. (High priority) |
| Voice recognition works differently with different versions of Chrome.<br>- User can save the sample but not stop. The system loops trying to get the voice sample but does not inform the user of the loop or any notifications, such as, 'Sample has too long a period of silence preceding it'. Version 67.0.3396.87 (Official Build) (64-bit)<br>- It is not possible to save the sample. Returns to the start of the page. Version 66.0.3359.181 (Official Build) (64-bit) | User should be able to save the sample and stop recording when needed. (High priority) |

**Table 7.** Comments and recommendations for keystroke enrolment

| Feedback provided by WAVE | Recommendation by WAVE |
|---|---|
| A form control does not have a corresponding label. If a form control does not have a properly associated text label, the function or purpose of that form control may not be presented to screen reader users. Now the screen reader does not identify the form and user only finds it if he navigates the keystroke dynamics enrolment page by tabbing. | Use the element to associate it with its respective form control. (High priority) |
| **Tester's comment** | **Tester's recommendation** |
| Once screen reader user starts typing in the form, the system does not inform him about the progress (increasing percentages) or instructions. | The instructions and status keystroke model should be available when typing in the form. (High priority) |

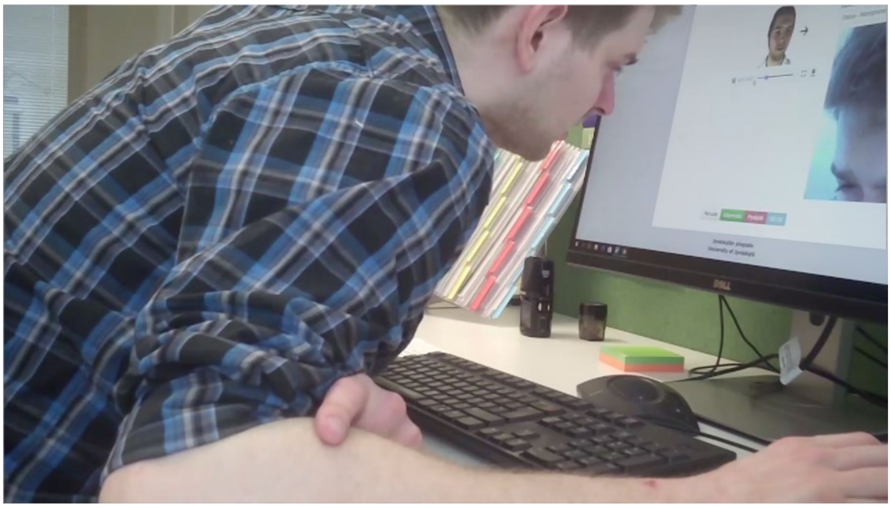
**Table 8.** Comments and recommendations for forensic analysis enrolment

| Feedback provided by WAVE | Recommendation by WAVE |
|---|---|
| A form control does not have a corresponding label. If a form control does not have a properly associated text label, the function or purpose of that form control may not be presented to screen reader users. Now, the screen reader does not identify the form and user only finds it if he navigates the forensic analysis enrolment page by tabbing. | Use the element to associate it with its respective form control. (High priority) |
| **Tester's comment** | **Tester's recommendation** |
| The Start button appears under the form when the user has inserted enough text into the form. The system does not inform screen reader users when the Start button appears on the screen. How does the user know there is a sufficient number of words? | The Start button should inform the user when it appears on the user interface. (High priority) |
| The user can navigate the entire page using tabs. During the process, the number of words is read aloud, but this may take several minutes. | The number of words should be available all the time on the user interface. (High priority) |

These test results are presented with all the details to demonstrate how the accessibility can be tested by a specialist and what types of information these test methods offer. After this kind of feedback, how the recommendations are met will be in the hands of the technical developers.

## 12. Observing and recording students' test situations

Using automatic testing systems or consulting a usability/accessibility specialist is not enough to guarantee the best outcome. It was important to have some end users not only using the TeSLA system independently but also testing it under the recorded test and research design conditions. Fifteen students from one pilot university participated in such research. The group of students was highly heterogeneous, including 4 male and 11 female students with a variety of special educational needs, for example, because of limited vision, chronic illness, dyslexia or panic disorder. Two of them used sign language. They were volunteers and tested the system out of the pilot courses, meaning that the test situation was not the real assessment situation with exam stress. Several data collection methods were used for ensuring rich data. The whole test situation was video recorded; the screen was also recorded. Two researchers observed the test and supported the students in case of technological challenges. Observing the test situation made it possible to provide accurate feedback for technical developers. (See Fig. 3 for an example of the test situation.)



**[Insert Figure3.jpg** - A student with limited vision is testing the TeSLA system **here]**

**Fig. 3.** Student with limited vision testing the TeSLA system.

As the following examples show, many issues emerged in the testing that were not recognised earlier:

- A student with limited vision was not recognised by the web camera because the student's face was too near to the screen;
- Against the former assumptions, some students using sign language sometimes preferred to use the voice recognition instrument as well;
- It took too many recordings and too much time to complete the enrolment activity, especially among students with slow speech or many breaks in their speech;
- It took a relatively long time to complete the keystroke enrolment if a student was a slow writer or had dyslexia; and
- The TeSLA system seemed to be robust. One student was too 'busy' to read the instructions; pushing many buttons almost at the same time did not break the system.

The main focus of the test situations was collecting user experiences and giving feedback for technical developers of the TeSLA system. In addition to this, the recordings offered rich, interesting data about how students used the keyboards, how they acted in the Moodle environment during the enrolment and follow-up activities and what types of choices they made. All this information will help higher education institution staff generate better solutions while building new online courses with new technology.

## 13. Conclusions

Accessible online education is a salient topic for at least two reasons, namely, the new European legislation and the growth of online education programmes and courses offered by universities. The TeSLA e-assessment system has an important role, creating new possibilities and flexible ways for diverse students to study. By organising accessibility tests and implementing the recommendations in the development of the TeSLA system, it is possible to ensure that the TeSLA system is accessible for diversity of students.

The best result in improving accessibility is reached when using all three methods of end user testing, automated testing tools and tests by accessibility specialists. All these methods were employed during the TeSLA project. Accessibility testing requires time but not necessarily financial investments; for example, using automated testing tools is fast, easy, free of cost and does not require special training. One does not have to be an accessibility specialist to interpret the outcome. The tools also provide clear instructions, with concrete examples of how to fix accessibility issues.

Software, devices and platforms are in constant development. Accessibility issues have become part of technical development and solutions. For example, some programs (e.g. PowerPoint, Word) contain built-in accessibility checks for the end user. Checks are easy to use and advise the user on how to fix accessibility issues. Even mobile devices already have features (e.g. dictation, text to speech) that improve accessibility, and thus, reduce the need for separate accessibility devices.

Considering that even WCAG level AAA does not guarantee accessibility to all, it is important to be vigilant to ensure that the TeSLA system does not become a barrier in itself. As described in this chapter, universities have variety of practises in terms of accessibility, individual arrangements and support for their students. This means that universities must carefully plan their e-assessment modes, choose and use appropriate TeSLA instruments and allow different user profiles for their students. Finally, they should continue to implement accessibility tests and collect user experiences, and if needed, offer alternative and traditional modes of study and assessment.

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## Glossary

Accessibility means that people with disabilities have access, on an equal basis with others, to the physical environment, transportation, information and communications technologies and systems (ICT) and other facilities and services. ............ 1

Assistive technology comprises assistive, adaptive and rehabilitative devices or software for people with disabilities or elderly population. .............................. 8

Learning Tools Interoperability (LTI) is a standard that links content and resources to learning platforms.......................................................................................17

Screen reader is a form of assistive technology. It is a software application that produces text to speech. Screen readers are useful especially for people who are blind or visually impaired. .......................................................................................17

Universal design for learning provides the framework for creating more robust learning opportunities for all students. It is an inclusive approach to course development and instruction that underlines the access and participation of all students. ...........................................................................................................12

Usability is the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. ................................................................................. 4

User experience means the perceptions and responses that result from the use and/or anticipated use of a product, service or system. The concept refers to experience in a broad sense, including all the persons' emotions, beliefs, perceptions, preferences, physical and psychological responses, behaviours and accomplishments that occur before, during and after use. ............................................................ 5

Web Accessibility Initiative (WAI) is an initiative developed to help make the internet more accessible to people with disabilities. ...........................................17

Web content accessibility guidelines (WCAG) are widely used as design principles for making web content more accessible. .......................................................15

## Index of terms

## Acronyms/Abbreviations

ADHD. Attention Deficit Hyperactivity Disorder
AU. Anadolu University
ICT. Information and Communications Technologies
ISO. International Organization for Standardization
JYU. University of Jyväskylä
LTI. See Learning Tools Interoperability
OUNL. Open University of the Netherlands
OUUK. Open University United Kingdom
SEND Special Educational Needs or Disabilities
SU. Sofia University
TUS. Technical University of Sofia
UDL. Universal Design for Learning
UOC. Open University of Catalonia
VLE. Virtual Learning Environment
WAI. See Web Accessibility Initiative
WCAG. See Web Content Accessibility Guidelines