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# ASSESSING THE ACCESSIBILITY OF E-LEARNING

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## **ABSTRACT**

*Equal participation for people with special needs is an important objective in education politics. Governments have a strong emphasis on enabling education for all citizens. The trend of using e-learning both for on campus and remote delivery of students has the potential of enabling new opportunities for people who previously faced challenges following education. On the other hand, providing online education bears the risk of creating new barriers.*

*This paper examines different stages of providing educational content and delivering teaching material online. This is based on practical experiences from Noroff University College providing a bachelor degree in a security related area. Based on both practical experiences and state of the art literature review, we analyze potential accessibility barriers, and investigate how the barriers can be identified and removed based on state of the art accessibility measurement techniques.*

*Consequently, this paper is a first step towards a methodology on assessing e-learning content based on accessibility. This methodology would assist others in obtaining an overview concerning the degree of accessibility of their own learning materials.*

# 1. INTRODUCTION

Accessibility for people with special needs, such as people with hearing, visual, motor and reading impairments, is a politically prioritized area in most levels of government (Cappemini, 2011), (Nietzio, Goodwin, Brynn, Snaprud, 2009) (Goodwin, Susar, Nietzio, Jensen, Snaprud 2011). An essential part of the political agenda is on inclusive educational opportunities.

Online content has some clear positive effect, including: Flexible hours of studying, individually adapted teaching, possibility to use your own assistive technologies. However, online education may impose itself as a potential barrier for many students. The authors have experience of specific needs in terms of the delivery of educational material. In most higher education institutions accessible content is often created when needed, tailored for particular students. Typically, students with special needs receive the content formatted in a way which can be accessed with assistive technologies, such as text to speech or image magnification tools. This is despite the common acceptance of making content accessible from the start is both more cost effective and ensures material is appropriate for all students. (Guenaga, Burger, Oliver, 2004).

However, the challenges in accessible e-learning are mostly not relating to general content, but arise when students engage in practical work.

## 2.1 The Technological Environment

Technology has for a long time been seen as an essential method for enabling educational opportunities for people with special needs (Hawkridge, Hales, 1985). In recent years the focus has been around e-learning and online environments (Seale J., 2006). This includes social aspects of the Bologna process to include equal access for all students (Iglesias, 2010), which is widely accepted in European higher education.

Similarly, much research exists on web accessibility in recent year. Web accessibility has received increased attention with the launch of the web content accessibility guidelines in 1999 (World Wide Web Consortium, 1999) by the web accessibility initiative (WAI), and became the de facto standard for ensuring web accessibility. WCAG 2.0 superseded WCAG 1.0 in 2008 (World Wide Web Consortium, 2008).

It is noteworthy that providing learning material online is by itself a step towards more accessible content. Following Tim Berners-Lee's Five stars in open linked data (Berners-Lee 2010), making data available online in any format is better than all data being offline. The same goes for teaching material. Making the content online is by itself a step towards making content accessible.

The remaining paper is outlined as following. Section 3 presents experiences from Noroff University College (NUC). Section 4 presents a state of the art review of how e-learning is made accessible. Section 5 draws upon the findings from section 3 and 4 to present a methodology for assessing and measuring accessible learning environments. Section 6 extends the methodology by proposing a quantifiable scoring method. Finally, section 7 and 8 concludes the work and presents further steps.

## 2. EXPERIENCE

This section presents practical experiences acquired at Noroff University College (NUC) specifically towards teaching a security degree.

### *Instant messaging without sound*

Noroff University College includes a mix between online and on-campus students. The initial setup was to use the learning management system Moodle for chat both between students, and between the students and the teacher. The aim was for students to ask questions, provide comments etc. This approach proved problematic for the following reasons:

(1) Moodle does not provide an audible indication when messages were received. This meant that the teacher, who was busy lecturing to the class, had to actively poll the Moodle system for any new messages. This was not practical.

(2) The video streamed out to online students had a delay of between 20 and 40 seconds. This means that when the teacher asked a question s/he had to wait 40 seconds before s/he could expect a reply to the question.

The solution was to switch from Moodle to the more commonly used instant messaging system Skype. We saw an immediate switch from close to no communication from students to a massive response from students both in class and online.

This further has an advantage for teachers and students with special needs. Since Skype has the possibility to communicate both visually and by sound that messages have arrived, people who have challenges with hearing or seeing are not excluded.

### *Difficulty in watching lectures*

The authors have encountered a number of students with a degree of visual impairment. In most previous cases a dedicated assistant is provided in the lecture and tutorial sessions. In the case where the teaching material is produced electronically in slides or text format (for example PowerPoint or Word) these are provided to the student to enable them to be re-read later on an appropriate device for the visually impaired. To some extent this reduces the need for dedicated assistants.

### *Difficulty in hearing lectures*

Most people assume hearing loss is merely a loss of volume and that this can be fully corrected by a hearing device that boosts volume. This is not the case, while hearing loss is a loss of volume; the loss of clarity is tends to be the main problem. A hearing aid user loses the ability to distinguish specific sound (usually speech from background noise).

A way around this problem is to use radio microphone to enable the hearing impaired student to receive a clearer signal from the lecturer. The presentation may also be recorded (possibly using a hand held digital recorder) to enable the student to review the presentation again at a later date.

The authors have had a number of experiences with students successfully using the above techniques. It should be noted that online these features are present in most online deliveries as material is recorded for later viewing and to ensure an acceptable level of sound quality, a wearable or directional microphone is used to capture the speaker voice.

### *Difficulty in using a keyboard and mouse*

There are varying degrees of motor impairment that can affect how a student is able to interact with degree material. Depending on the type of degree being studied the impairment can pose varying challenges.

If the course requires extensive practical work (such as chemistry) then this can prove problematic. Other degrees can also contain elements of practical work that can pose a challenge.

The authors have experience of students with varying degrees of mobility problems while teaching on a security course. One individual with upper limb mobility problems had developed his own techniques to deal with practical issues and required no specific provisions. Another student with more significant mobility issues required an assistant to handle and process hard disk drives.

It should be noted that both of these students were able to use a mouse and keyboard. There have been various ideas concerning ways in which laboratory systems can be simulated online (Ott, Sethmann, 2012). In this case both of these students would have been able to access an online system. The authors have only encountered one student whose disability was so severe that they were unable to use a modified keyboard and mouse and so needed an assistant to perform all computer related activity.

### *Difficulty of reading the lecture material*

The authors have encountered a high number of students with reading difficulties such as dyslexia. These students tend to have less of an issue with lectures, but more difficulty with written material or in examination situations.

In the case where the teaching material is produced electronically in slide or text format these are provided to the student to enable them to be accessed on an appropriate device to enable the student to adjust color / fonts for easier access to the material. Even though there has been some changes to PDF accessibility recently (World Wide Web Consortium, 2010), our experience is that it is easier for students to adjust colours and fonts in editable documents. This tends to be a popular approach as suggested by the uptake of specialized fonts (BBC 2012).

## **3. ACCESSIBLE LEARNING MATERIAL.**

This section presents a state of the art review of how accessibility is made part of e-learning.

From the point of view of a lecturer, teaching can be defined as a method of transmitting information (Shank, Sitze, 2004). The traditional method would be a lecturer in an auditorium – transmitting his or her knowledge to the students present at that location.

From the student point of view, learning is a way of constructing and understanding (Shank et al, 2004). In this situation the student finds himself/herself in the middle, struggling to make new information fit into what is already known and how to apply the acquired knowledge in new situations. When we construct knowledge we are working to gain experience in context, not just remembering isolated facts.

An electronic learning environment needs to consider the student, the teacher and the interaction between them. The technical components aimed at creating the environment may actually result in an accessibility

barrier if not carefully implemented. The general aim is to have a flexible design and configurable environment (Krug, 2000).

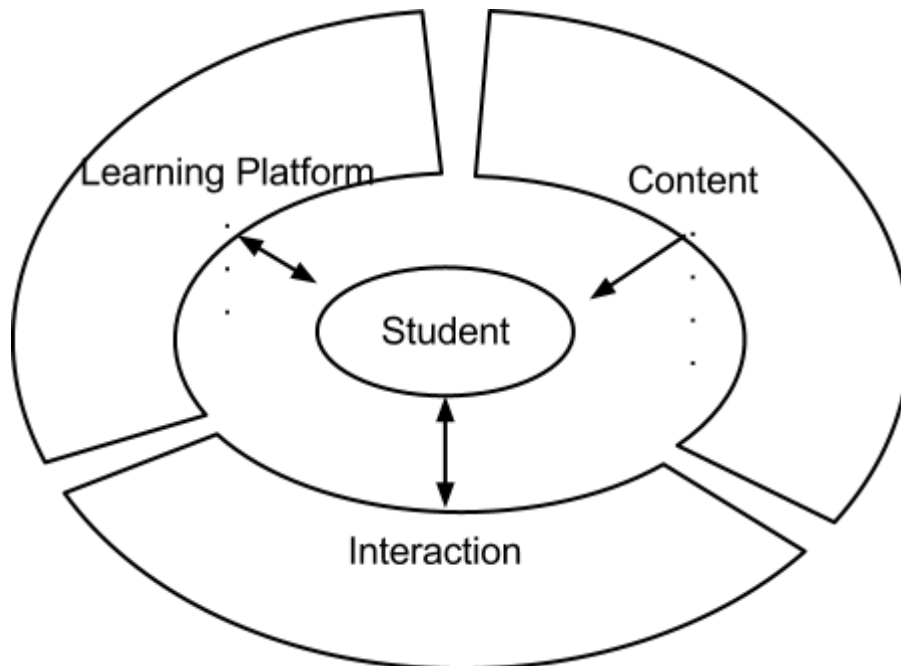


Figure 1: Student interaction with the learning environment

As shown in figure 1, e-learning consists of three main parts playing an important role in a student's daily life: The learning platform, the course content and the interaction both between students in the class cohort and the interaction between the student(s) and the teacher.

### *Content*

There has been considerable work in relation to moving pedagogical content online. There has also been effort in developing material for delivery online in an accessible way. In particular the Open University in the UK which specializes in distance delivery, providing postgraduate courses among other security related areas (Open University, 2012).

The de facto standard for web content is Web Content Accessibility Guidelines (WCAG) 1.0 and 2.0 (World Wide Web Consortium, 1999, 2008). This contains guidelines on how to make HTML and, recently, PDF content available in a way that it is accessible to all. Kelly, Phipps and Swift (2004) instead of using the WCAG 1.0 guidelines, aimed at a more holistic pedagogical approach. There is also the suggestion that following WCAG for learning material is actually counterproductive because it encourages developers to focus on areas that can easily be reported and not necessarily those areas in the greatest need of improvement. Kelly, Phipps and Swift (2004) focused only on the content rather and included an additional quality assurance framework.

The first step to making the content accessible is to make it available online in a digital open format (Berners-Lee 2010). Although this can be achieved by simply scanning documents, this is not best practice as scanned documents can propose major challenges to some user groups. Experience gained at NUC has limited the use of scanned material to coursework submission as students studying animation / art subjects may choose to submit scanned documents of a paper drawing.

The accessibility of online content can be partly ensured through the use of automatic checker tools. An example being PDF documents (World Wide Web Consortium, 2010), (Goodwin, 2011).

### *Learning platform*

E-learning students conduct their main learning activities on a learning platform. Students need to submit content to the learning environment in a way that the teacher can receive it. Further, the teacher needs to be able to read the content and submit a response that the student(s) can receive. Hence, a learning platform is a form of web authoring tool. There has been considerable research in authoring tools accessibility, perhaps most specifically the Authoring Tool Accessibility Guidelines (ATAG), which is, as of June 2012, a working draft W3C standard (World Wide Web Consortium 2012) ATAG 2.0 is closely related to the W3C recommendation Web Content Accessibility Guidelines 2.0 (World Wide Web Consortium, 2008).

Many learning platforms exist and there have been several attempts to assess the accessibility of learning platforms. Moreno, Iglesias, Calvo, Delgado, Zaragoza, (2012) showing in particular that learning platforms tend to be accessible for students not for teachers.

Moodle is one of the most commonly used learning platforms and is the platform currently used in NUC. Even though it is claimed to be accessible (Moodle, 2012), it has been conclusively shown that this is not the case (Calvo Iglesias and Moreno, 2012), (Moreno et al, 2012), especially for visually impaired people using the Non-Visual Desktop Access (NVDA) tool.

### *Interaction*

The student/teacher interaction, and the interaction between students, occurs both on campus and remotely. This means that the teacher typically provides a lecture in front of a camera with a projector and white board or smart board that is filmed and streamed for students to watch. Additionally students interact with other students during group work exercises.

From any of the campus locations (remotely or locally), the students can raise questions as if they were in the classroom with the teacher and the teacher will observe it on a screen. Further, the remote students watching from their laptop or any other device will be able to communicate with the teacher and other students through instant messaging systems. Thus, interaction comes down to making lecture videos and the interaction accessible.

There are several attempts at making videos accessible for all users (Moreno, Martínez, Iglesias Gonzalez, 2011), (González, Moreno, Martínez, Iglesias, 2011), (Moreno, Gonzales, Martinez, Iglesias, 2011). These attempts have not been completely successful. Video streams pose challenges for some groups with special needs, such as visually and hearing impaired. To ensure accessibility via the use of state of the art video conferencing facilities, a real time high definition video feed is important for some hearing impaired individuals as a synchronized audio and video feed will aid lip-reading techniques. However as the video streams are live, there are no sufficient techniques available for sub texting live broadcasts without substantial cost. The most adequate technique for the students with special needs is to use a corresponding mini lecture (a written summary of the lecture contents) as text, and follow the video / audio live. The use of ambient noise canceling microphones will help individuals who are hearing impaired by providing high quality sound, with the addition of appropriate equipment at the users location to ensure background noise is canceled out making it easier to discern the lecturer's voice.

## 4. PROPOSED METHODOLOGY

This section presents an evaluation methodology originally meant for Noroff University College as a method for self-evaluation in the process of creating a new study program. During the content development and procurement process, the methodology could be used as a quantitative method for making sure that we follow the correct accessibility guidelines. However, realizing that the methods of evaluation are not specific to one institution, the methods are rather general for any learning institution that focuses on e-learning, a general methodology is extracted.

Based on the state-of-the-art review and hands on experience, we have identified three main stages involved in e-learning as shown in figure 1: The content, the learning platform and the interaction between the student and the teacher and within the student group. Consequently, these all need to be made accessible. This includes three main accessibility areas, namely: document accessibility, web accessibility and accessibility of the interactive media.

### Content

Typically, teachers use a standard format which has been developed based on a number of years' experience in delivering material. It is believed that both making the template accessible and following up with a strict process on the content will fuel more accessible content (Lazar, 2004). From this PDF documents (or similar) are generated.

It is noteworthy that the teaching materials typically only have minor updates from year to year in some subject areas. If this is the case the degree of effort required to make the content accessible would not need to be reinvested each year. In some courses, notably the security and forensics courses, there is often a need for the material to be updated frequently due to the rapidly changing subject area (Sutherland 2004).

Since the teaching material is pure text and images in English (no forms or interaction), the following WCAG 2.0 PDF techniques (World Wide Web Consortium, 2012) are applicable:

- PDF1: Applying text alternatives to images with the Alt entry in PDF documents
- PDF2: Creating bookmarks in PDF documents
- PDF3: Ensuring correct tab and reading order in PDF documents
- PDF4: Hiding decorative images with the Artifact tag in PDF documents
- PDF6: Making tables accessible in PDF documents by using table elements
- PDF8: Providing definitions for abbreviations via an E entry for a structured element
- PDF9: Providing headings by marking content with heading tags in PDF documents
- PDF11: Providing links and link text using the /Link structure element in PDF documents
- PDF13: Providing replacement text using the /Alt entry for links in PDF documents
- PDF14: Providing running headers and footers in PDF documents
- PDF16: Setting the default language using the /Lang entry in the document catalog of a PDF document
- PDF17: Specifying consistent page numbering for PDF documents
- PDF18: Specifying the document title using the Title entry in the document information dictionary of a PDF document
- PDF21: Using List tags for lists in PDF documents



Additionally, further manual accessibility analysis could be carried out (Wab Cluster, 2008) including user testing.

### *Learning platform*

The learning platform is typically out of the box technical software that is made accessible from the vendor. As shown in section 3, this is similar to an authoring tool. Because of this, we draw accessibility techniques from the Authoring Tools Accessibility Guidelines Draft (ATAG) 2.0 (World Wide Web Consortium, 2012).

Following are the authoring ATAG 2.0 Draft Guidelines, which are applicable to learning platforms:

- A.1.1. (For the authoring tool user interface) Ensure that web-based functionality is accessible
- A.2.1. (For the authoring tool user interface) Make alternative content available to authors
- A.2.2. (For the authoring tool user interface) Editing-view presentation can be programmatically determined
- A.3.1. (For the authoring tool user interface) Provide keyboard access to authoring features
- A.3.2. (For the authoring tool user interface) Provide authors with enough time
- A.3.3. (For the authoring tool user interface) Help authors avoid flashing that could cause seizures
- A.3.4. (For the authoring tool user interface) Enhance navigation and editing via content structure
- A.3.5. (For the authoring tool user interface) Provide text search of the content
- A.3.6. (For the authoring tool user interface) Manage preference settings
- A.3.7. (For the authoring tool user interface) Ensure that previews are at least as accessible as in-market user agents
- A.4.1. (For the authoring tool user interface) Help authors avoid and correct mistakes
- A.4.2. (For the authoring tool user interface) Document the user interface including all accessibility features

Note that this does not consider the accessibility of the tool itself from a teacher's point of view, which is part of ATAG 2.0. Even though it is a growing problem (Moreno et al, 2012), accessibility support for teachers is out of the scope of this paper.

### *Interaction*

The interaction is limited to online videos the student watch, and messaging systems for the student and teacher to speak with each other.

Following are the WCAG 2.0 techniques (World Wide Web Consortium, 2008) related to interaction.

- G54: Including a sign language interpreter in the video stream.
  - Not included at this stage as there are no students currently requiring this facility and also for financial reasons
- G68: Providing a descriptive label short text alternative that describes the purpose of live audio-only and live video-only content.
  - This is handled in the learning platform. The teachers are required to provide a meaningful and descriptive link to the video stream.
- G69: Providing an alternative for time based media
  - All lectures are supplemented by a mini lecture, a written document. Reading and understanding the mini lecture is an alternative to watching the video.
- G81: Providing a synchronized video of the sign language interpreter that can be displayed in a different viewport or overlaid on the image by the player
  - Not included at this stage for financial reasons (as G54 above).

- G166: Providing audio that describes the important video content and describing it as such
  - The teachers are encouraged to be as descriptive as possible in their presentation. Thus, for people who are only able to listen to the videos

Note that this does not include techniques for providing text for videos. Videos with text are more accessible for people with, among others, hearing impairments. However, at this point it is impractical for most institutions to text lecture videos for two main reasons: (1) It is too costly, and (2) since the videos are live it is not possible to provide text instantly. Techniques to provide text for online video content may be put in place at a later stage if appropriate techniques emerge.

## **5. SCORING AND RANKING OF ACCESSIBLE E-LEARNING**

This section takes the methodology a step forward summarizing it as a quantifiable ranking system. This is needed for an accessibility measurement methodology to work in practice and communicate effectively (Goodwin, 2011).

Material cannot be judged to be accessible by passing some form of ‘accessibility threshold’; rather there may be degrees of accessibility that can be dependent on disability (Savi, Savenye, Rowland, 2008). Content can be accessible to some, but inaccessible to others depending on the disability, tools available and the form and nature of the teaching material (Rømen, Svanæs, 2008). It should be noted that making content available in a highly accessible format is obviously better than a format with limited accessibility. Also providing accessible content should be recognized by the methodology even if the interaction with the teacher permits only limited access. The methodology scoring system should be such that any improvement is recognized, even if some parts are inaccessible. The intention is that staff should be encouraged to improve accessibility as far as feasibly or practically possible, even though this may leave some parts of the system with limited accessibility.

### *Criteria for an evaluation methodology*

This section presents criteria needed for a successful evaluation methodology. The main criteria are:

1. Should provide a semi-quantitative measure of the level of accessibility a student with special needs perceives.
2. Should be usable in a continuous online environment allowing teachers to get feedback on the level of accessibility during content development.
3. All three stages (content, learning platform and interaction) should be addressed.
4. Efforts on making some parts of the stages accessible should be rewarded. This means that if for example the teacher makes an effort in making mini lectures accessible (i.e. improving content), this should result in an improved scoring even though the other the area (learning platform and interaction) may still have limited accessibility.

### *Proposed scoring system*

Based on the defined criteria, this section proposes a methodology for evaluation. The suggested evaluation stems from the W3C Web Accessibility Metrics (World Wide Web Consortium, 2012) and particularly the WCAG 2.0 scoring system suggested by state of the art developed by Nietzio (2012).

The methodology proposes a score based on the individual success criteria of each component (content, platform and interaction) involved in the delivery of the individual component courses of a degree.

Courses level is considered sufficient to distinguish those areas of a degree with different accessibility requirements. This means for each subject and each state a score can be calculated as failed success criteria over the number of instances. For example the score for the teaching material in course '1' could be calculated as follows:

$$Score(Teaching\ Material, Course\ 1) = 1 - \frac{Number\ of\ barriers}{Number\ of\ instances\ a\ test\ can\ fail}$$

This is in line with criteria 1 and 2 as listed above.

To further include all three stages, the methodology weights all three stages equally which consequently gives an equal priority to course work, learning environment and interactivity.

$$Score(Course\ 1) = \frac{1}{3}Score(Teaching\ Material, Course\ 1) + \frac{1}{3}Score(Learning\ Platform, Course\ 1) + \frac{1}{3}Score(Interaction, Course\ 1)$$

This is in line with criteria 3 and 4 as listed above.

It is noteworthy that even though the scoring system is on an individual course, some improvements may affect more than one course and consequently improve the entire learning system. For example, if the accessibility of the learning platform is increased, this will have an impact on all of the courses, with the score for all courses, and subsequently the accessibility score of the degree as a whole will be increased. This does not conflict with any of the proposed criteria.

In conclusion the score of a course will be a number between 0 and 1, where 1 would be completely accessible and 0 would be completely inaccessible. To provide a finer scoring this can further be discretized into a A-F scheme.

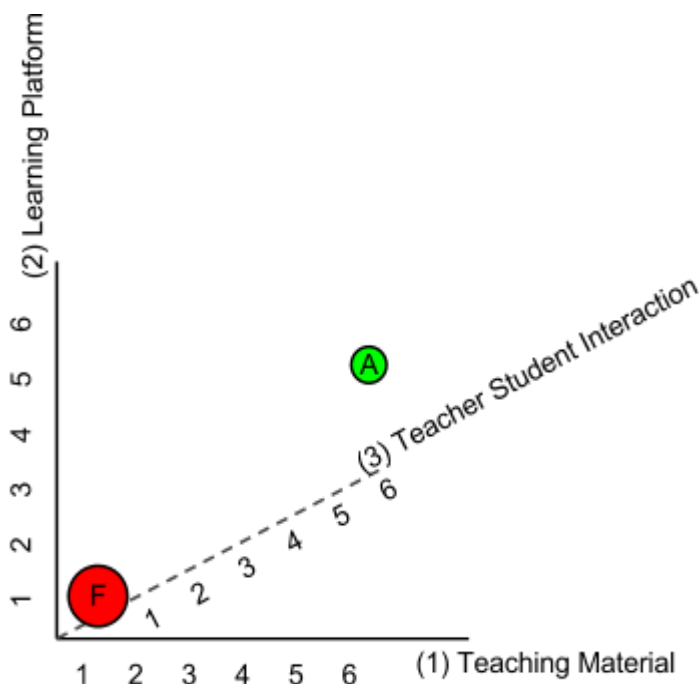


Figure 2: Example of graphical representation of the scoring system

Figure 2 shows an example of a graphical representation of the proposed scoring scheme. Each dimension represents the three stages in making learning content available. As outlined above, the score is a weighted scheme where each dimension contributes equally and discretized into a A-F scoring scheme. A learning environment that scores poorly in teaching material, learning platform and interactivity will consequently get an F. On the other hand, a learning environment that scores highly in all three areas will achieve an A grading. This methodology will subsequently be tested with empirical data from NUC courses.

## **6. CONCLUSION**

This paper presents both practical experience and knowledge based on current state-of-the-art deliveries on how to make e-learning accessible. This includes making content available online, enabling the students to interact with the teacher and other students and with a possibility to publish content online. Our study shows that it should be possible with little effort to make degrees accessible for all people including students with special needs.

Based on our experience, the paper concludes with initial steps towards a methodology for assessing the accessibility of learning environments that can be used for other institutions aiming at increasing the accessibility of their online learning environments.

## **7. FURTHER WORK**

This paper shows the essential first steps towards measuring learning material at Noroff University College. Our further steps are to first empirically verify our proposed methodology and to determine the effectiveness both during content production and lecturing. This includes testing the methodology with real users with specific accessibility requirements.

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