Accessibility in Multimodal Digital Learning Materials

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Abstract. This review is based on research-based guidelines and principles for accessibility in multimodal digital learning materials and educational texts. It also includes research on the use of the body and interaction as a kind of modality. In the context of the review a number of recommendations is themed, based on findings in the literature, from a didactic-pedagogical perspective. These themes relate to: the structure and content of learning materials; software and formats; the correlation between modalities; and kinesthetics. We conclude with a presentation of general principles for the idea of broad accessibility.

Keywords: Accessibility, Multimodality, Digitalisation, Learning materials, Reading.

1 Introduction

Accessibility is a continuously changing concept, which depends on the context, in which the concept is discussed. It is often presented in the form of a statement of intent, backed up in varying degrees by concise requirements for the form and content in a particular context. In The United Nations Convention on the Rights of Persons with Disabilities accessibility is defined as follows: "Recognizing the importance of accessibility to the physical, social, economic and cultural environment, to health and education and to information and communication, in enabling persons with disabilities to fully enjoy all human rights and fundamental freedoms".[1]

More specifically this article examines new conditions surrounding accessibility, which are relevant vis à vis the fact that materials are increasingly digitised, which enables them to express themselves in multiple modalities. Accessibility relates to: access, readability, correlation, motivation, recognition and interaction (Carlsen et al. 2009, Hansen 2012, Hansen and Bundsgaard 2013).[2]

Multimodality is also a concept on the move and can contain different meanings. In this article we define modality as "a culturally and socially fashioned resource for representation and communication" (Kress 2003:45). That is to say, modality refers to

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[1] http://www.un.org/disabilities/convention/conventionfull.shtml, retrieved 22.01.2014.

[2] http://www.laeremiddeltjek.dk/, retrieved 01.02.2014.

the way, in which a representation (a picture or a text, for example) relates to the content it represents (Hansen 2010:1). The use of multiple modalities is thus a combination of forms of representation (ibid:2). For example, a combination of modalities can be used to assist the understanding and creation of meaning in relation to a material. Løvland, D.A., underlines: "Multimodal texts combine units, which create meaning in a variety of ways. This might involve the combination of words, which we understand, because we know the verbal language system; and photography, which we understand, because we think it resembles something real." (Løvland 2010:1). This article looks at the combination of text, sound and visual forms and the significance of kinesthetics and interaction.

Nota is The Danish National Library for People with Reading Difficulties. Nota has approximately 58,000 members, most of whom are young dyslexics in education. In addition, the library has a large group of older blind or visually impaired members and people with other disabilities. However, Nota's membership represents only a section of the Danes, who have a great need for accessibility in texts. PISA (Programme for International Student Assessment) 2012 shows that 15% of Danish pupils in lower secondary education do not possess functional reading skills (Egelund 2013:7), so a lack of literacy can be considered as an obstacle to further education for a very large group of students in society as a whole.

The research in this article is not directed at specific disabilities, but at a broader approach to the concept of accessibility as a tool to enable as many people as possible to understand and make use of texts. Thus, while the motivation for investigating the concept of accessibility is of particular relevance for Nota, the findings of this article concern anyone involved in the design and accessibility of digital materials.

Within the area of research on the subject of accessibility and multimodal digital books, there is a tendency to concentrate on learning materials, perhaps due to the fact that textbook systems are particularly representative of the use of multimodal devices (Hansen 2010:5). It may also relate to a growing political focus on reading difficulties as a serious barrier to the ambition of getting more people through the education system.[3] On the basis of the issues mentioned, the article concentrates specifically on accessibility in books for school and study.

2 Review of the Literature

In what follows, the way in which the literature is methodically selected is outlined. The review is illustrated in a summary, before expanding upon relevant aspects of accessibility in multimodal learning materials.

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[3] Research has shown a direct correlation between poor literacy skills and lack of education (Andersen 2005). The current Danish government have set an objective that 95% of young people should complete a secondary education, 60% higher education and 25% a further education (Woller 2013).

2.1   Method

The literature for this review was not found via specific databases, but from search/inclusion criteria: that the literature is in English, Danish, Norwegian or Swedish; and that the research is less than 10 years old. The review is based on articles, reports, books and a single website.

2.2   Structured Review Summary

Table 1. Summary of the literature used for the review

Author	Pub-lished	Chosen purpose	Selected findings
Arnbak	2005	To give teachers the tools to assess whether academic texts are accessible and readable for the students on vocational education.	Use of language, correlation between text elements, and layout and organisation of content are vital for accessibility.
Carlsen and Krog	2012	Presentation of an e-learning concept, which focuses on multimodal forms of expression.	Design framework which connects various didactic spaces with the use of mobile phones, QR-codes, videos, and the body.
Carlsen et al.	2009	User manuals for teachers and for publishers. How a learning material should be organised and used in order to be accessible to pupils.	There should be meta text; the learning material should include tasks, which support access to, and the learning of content; technical terms should be explained; and the link between modalities should be explicit.
Hansen	2010	Development of structure for analysis of learning materials and planning of multimodal teaching	Forms of representation, whether in terms of body, object, picture, diagram, language and symbol, are important parameters in relation to making knowledge accessible. Multimodality can be divided into: conventional and unambiguous; and creative and ambiguous. Learning materials do not make a particularly conscious use of multimodality
Hansen	2012	Create a summary of important didactic and usability parameters in relation to evaluations of accessibility of digital educational material	Didactics and usability in learning materials should be evaluated from a macro, medium and micro perspective, where micro involves didactic elements: accessibility and flexibility

Table 1. *(continued.)*

Hansen and Bundsgaard	2013	Recommendations, benchmarks and criteria in relation to digital learning materials and pedagogical practices using them	A typology of digital learning materials. The selection criterion involves open standards. Design principles relating to the learning material is focused, supports and challenges
Kirkeby et al.	2009	Create knowledge of how schools' physical contexts and IT can support teaching and work processes	Teaching and teaching environment should have a clarified structure of expectations. Examples of these include: the instructive, the dialogue-based, the nomadic, the physically active and the multifaceted environment
Kress	2003	Discussion of what literacy and multimodality is in an age with many new types of media	A modality is a socially and culturally contingent resource for representation and communication. Multimodality can support understanding and learning The importance of a clear reading path
Læremiddeltjek.dk		Didactic guidelines and criteria for analysing readability in multimodal digital learning materials (web-based)	Development of the Læremiddeltjek.dk model, which is based on expression, content, and activities in relation to the following parameters: accessibility, progression, differentiation, teacher support, correlation and legitimacy
Løvland	2010	Define multimodality on the basis of social semiotics and multimodal theory	A multimodal text creates meaning by combining different modalities. Taking into account the interaction between culture, situation and multimodal expression

2.3   The Architectural Structure of the Learning Material

Although the design and structure of multimodal digital learning materials vary, the layout, organisation and outline of materials are all important, if the reader is to know exactly where s/he is and create an overview (Arnbak 2005:57,64).

Specifically, elements such as typography, layout and logical structure play a vital role in the actual accessibility of the content of learning material (ibid.:53). We will now briefly consider these three elements.

Typography. Fonts with serifs and a point size of minimum 12 is appropriate to support the visual accessibility of a text (ibid.:53).

It is therefore recommended to use upper case letters and clear typography, such as fonts, that are specially designed for reading on a screen, including Verdana Font, Georgia Font, Font Tahoma and Trebuchet MS (cf. Rainger 2003:6). It is also recommended that the user should be able to change the style of lettering and size as required.

Fig. 1. 'Dyslexia', which the Dutch graphic designer Christian Boer has developed for people with reading difficulties, concentrates on the distinction between letters and comes across clearly on a screen.[4]

Layout. Layout contributes to clarity and directs the reader's attention to the relevant elements in the correct order.

It is useful to have a minimalist design (Hansen 2012:2), which cuts out superfluous information, so that the reader's attention is drawn towards relevant factors (Hansen and Bundsgaard 2013:30).[5] "Layout in an item of digital learning material helps to guide both the direction and way of reading" (Hansen 2010:3).

Associate professor in audiologopedics Arnbak denotes texts with many modalities as mixed-mode texts (Arnbak 2005:48-49). In contrast to highly text-heavy, classic "black-and-white" books, the challenges of recent tests are: "There are far too many different text elements, models, illustrations, colours and fonts on the same page. All these sources of information compete for the reader's attention." (ibid.:53).

The lack of a clear reading order of the elements in the learning material hampers the reader's assimilation of the content, thus reducing accessibility, because the reader has to work cognitively to find a meaningful reading path (cf. Kress 2003). So, even though multimodal learning materials may contain substantial learning potential, given that the many modalities provide more opportunities for understanding and making use of the content (Carlsen and Krog 2012), research also indicates that it may be an advantage, in terms of layout, to limit the amount of different expressions and forms.
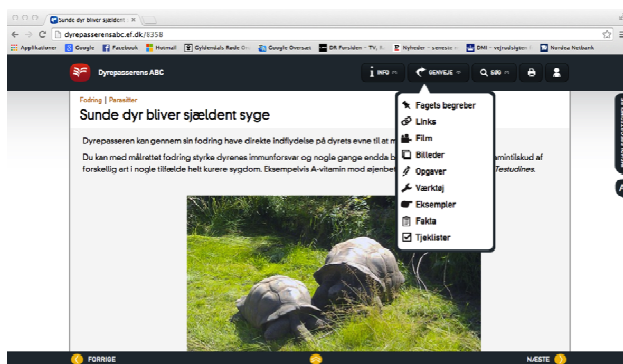

Fig. 2. Example from the publisher EF Digital's iBooks, which acts as a web page, and which has shortcut headlines for expressions, links, tasks, checklists etc. in the book.

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4   http://www.studiostudio.nl/en/the-designer/, retrieved 01.02.2014.
5   Neurological research substantiates this point. As neurobiologist Mikkelsen, MD and From-Poulsen MA (Literature) say: "One recalls simply better by only reading the text than by reading it in conjunction with other audio-visual information, whether they are related to the text or not."(Mikkelsen and From-Poulsen 2011:3).

Navigation. Navigation options also constitute an important parameter, when it comes to accessibility. In this context, Hansen presents some important options: "Does it [the learning material] have a good navigation structure? Do you know where you are and where you can go?" (Hansen 2012).

It is essential that the learning material has a clear navigation structure, so that the reader is always aware of his/her place in the book. Therefore, it is recommended that the text be laid out with a thorough overview of content, and that navigation in the text be organised flexibly with good keyboard shortcuts.

Repetition. Another important parameter is familiarity, which can be used to create coherence in a text (Løvland 2010:4). Hansen and Bundsgaard use the word repetition in the sense that a learning material should both include something of the same, thus creating recognition, and expand with something different, thus creating awareness (Hansen and Bundsgaard 2013:30). Hansen uses the web service Dropbox as a good example of a system which, by reason of a recognisable construction with folders as an archive system, in conjunction with the functionality, which the system provides, is often used in the context of teaching and digital learning materials (Hansen 2012).
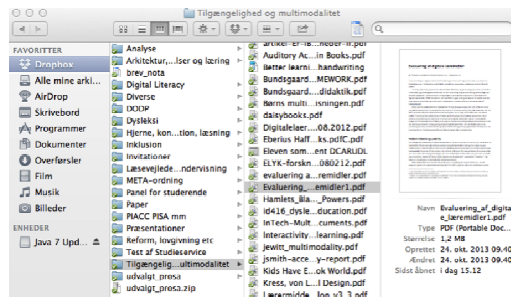

Fig. 3. Photo of Dropbox, which integrates functionality into the PC's existing filing system

It is recommended, therefore, that learning materials should be constructed on the basis of well-known principles for layout and outline to support accessibility.

Thus, it can be said that architectural structure guides the reader through the content of the digital learning material. However, researchers point to a tendency for an unconsidered use of many different modalities at the same time, which can sometimes make learning materials unclear.

2.4   Content

The extent to which the content of a book is actually accessible for the reader is closely related to its linguistic composition and complexity. The readability index LIX, introduced by the educationalist Björnsson, aims to measure a text's readability. Despite its extensive use, it is far from sufficient to assess linguistic accessibility, since it only evaluates the complexity of a text's content (cf. Arnbak 2005:51).

Textual Content. Arnbak focuses specifically on the text, including the complexity of the subjects, the text's organisation of the information, and the outline of the subjects and calls this "The text's linguistic accessibility" (ibid.: 50-52,54). In relation to this, she mentions partly the outline of text in headlines and clear paragraphs, and partly support for difficult words and concepts in relation to the placement of figures, tables and illustrations (ibid.:52). The text should be readable without excessive effort.

Scaffolding and Personalisation. Hansen introduces the concept of "scaffolding", which suggests that the text's content should be flexible, so that it can constantly be adapted to the development of the pupil (cf. Hansen 2012). In this context, scaffolding should also be understood as processual assistance and support, the building up of a ladder over time, via technology. For example, this can be done by applying some options, which the printed book does not have, such as making the book clickable, so the reader can use links for quick and easy access to glossaries etc.

Digitisation facilitates the processing of content and differentiation in relation to the individual's need for support. Hansen and Bundgaard go on to discuss "the personalisation principle" (Hansen and Bundsgaard 2013:32): "The form of inquiry and user interface of the digital learning material should be personalised or personalisable in relation to the target group." (ibid.). In addition to customising learning materials to suit the level and needs of the reader, a personalisation can motivate and create attention via the interaction between material and user. Examples of this could be: options for creating bookmarks or jotting down notes in a text.

Readability, organisation, scaffolding and personalisation are all factors to be taken into consideration and incorporated into multimodal digital learning materials in order to increase accessibility.

2.5   Software and Formats

According to research, when dealing with digital learning materials, it is essential that they can be implemented in many different browsers, operating systems and formats, which meet certain standard requirements, such as those defined by W3C.[6]

Standards and Text-To-Speech Programmes. Hansen and Bundsgaard emphasise "openness" as a key word (Hansen and Bundsgaard 2013: 28-29). Software and formats must also be open, in terms of time. This means that the latest knowledge within a given topic should be available in the digital learning material via constant updating. This is hampered, if programmes are not open to information updates.

In this context, Hansen and Bundsgaard make use of the concept of "universal text-to-speech programmes" and emphasise how important it is that material should be made compatible with these so-called universal programmes (ibid: 18.30). Here, "universal" means that programmes can read any text out loud from the user interface, regardless of the software, which is displaying it. However, there is no

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[6] Word Wide Web Consortium, `http://www.w3.org/Translations/WCAG20-da/`, retrieved 03.02.2014.

universal standard for how this goal can be achieved. Researchers are careful about providing specific criteria or guidelines in this area, since text-processing and text-to-speech programmes are constantly developing, thus changing the premise for decent accessibility. An important principle is, however, that the software used to implement a learning material should work, regardless of which platform one uses, and that it should be compatible with the text-to-speech software used by the user.

Intuitive Software. In line with the recommendation for a single minimalist design (cf. Hansen 2012), this is significant for accessibility, to the extent that the reader will intuitively find out how to use of the digital multimodal learning material (ibid.). According to Hansen, everything, which appears intuitive, is based on tradition, thus one can instead speak of familiarity with the technology (Raskin in Hansen 2012). Therefore, for the purpose of accessibility, it is an advantage, when software is based on widely familiar icons, design and interaction structure.
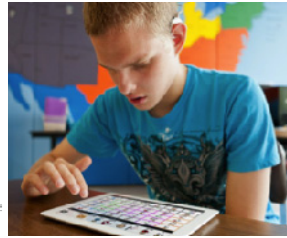

Fig. 4. On their website Apple refer to "Accessible to the core" and stress that their accessibility functions work in the same way across Apple's products and apps.[7] However, Apple is also well known for not being compatible with non-Apple products. For example, their screen reader, VoiceOver, can only be used on Apple products, and thus does not comply with Hansen and Bundsgaard's principle of universal programmes (Hansen & Bundsgaard 2013:30).

So far the article has looked at the fact that accessibility is to do with the form and organisation of the learning material, and with how the outline and support of the content increase not only access to learning, but also accessibility. Independent software also has an important role to play. In what follows the article looks at how the correlation between various modalities is important for access and assimilation of the content in a learning material. It also considers the body as a resource for learning.

2.6   Correlation between Modalities in Context

Correlation in the use of different modalities is related to accessibility (Løvland 2010:4). It is important, therefore, that the modalities such as text, graphics and sound is linked, and that the combination makes sense in relation to both purpose and user.

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[7]   https://www.apple.com/accessibility/, retrieved 01.02.2014.

Interaction. Different modalities have different potentials of meaning. For example, writing is a good modality for conveying a person's name or a road sign, whereas a piece of music is a modality, which works well, when expressing a mood or emotion. Therefore, the use of multiple modalities can increase the understanding and anchoring of the content of a learning material, thus improving accessibility. "A good multimodal text combines modalities in a way, which makes the text function optimally in relation to the various objectives, which the creator of the text may intend for the text in different contexts" (ibid.:3).

When different forms of representation, for example, image and text, are combined in a way, in which they both embody something of the same, but also elaborate upon each other and create variety, there is positive redundancy (Hansen and Bundsgaard: 30-31). Such redundancy makes pupils perform more successfully, which suggests that accessibility to the content is increased.
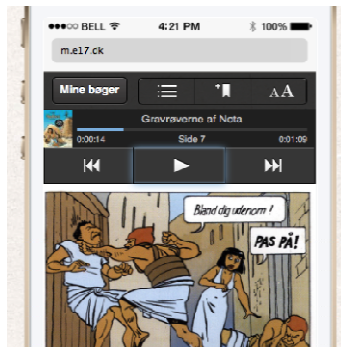

Fig. 5. Nota's comic strips combine sound, images and text, in an attempt to provide the reader with a coherent multimodal experience

As Løvland also stresses, it is important that one gives very careful consideration to the use of different modalities and develops a certain sensitivity in relation to the many idioms (Løvland 2010:5).

The Reader's Context. Accessibility is not just about how the modalities are combined, but also about being able to understand and interpret the use of different modalities (ibid.:5). The reader's prerequisites for identifying or assessing, when and how something is a modality depend on culture and tradition (ibid.:2-3) : "A mode of expression, which creates meaning in one context might not in another. Deliberate use of a religious colour will for example not be meaningful in a culture that does not know or take into account the conventions of this use of colour" (ibid.:1). It is precisely for this reason that Kress describes a modality as socially and culturally shaped (Kress 2003). As Hansen argues, the accessibility of the expression and content of a learning material also depends on the extent, to which the structure and complexity reflect the reader's social, cognitive and emotional skills (Hansen 2012).

When modalities are put together, it is important to reflect on how the interaction strengthens the reader's access to content. In addition, the reader's reception of the modalities depends on culture and tradition as well as on personal skills.

2.7   Kinaesthetic Dimension

Digitisation has given rise to new opportunities for linking physical activity to learning. As Hansen says, this means that the pupil's "body acts as a medium for an academic representation." (ibid.:3). This dimension can refer to both small and large physical forms of interaction, as well as the possibility of co-creating and designing a learning material by adding content oneself.

Physical Kinaesthetic Dimension. Physical kinaesthetic dimension refers to the sensation of physical movement. Such a sensation and consciousness can be important in the assimilation of new knowledge. Architect and D.Tech Kirkeby et al. use the so-called physically active playing space as an example, where an interactive IT-based glass plate on the floor connects bodily activity to concept formation, thus leading to learning (Kirkeby et al. 2009:14,52).

Fig. 6. Photo of the Vidensbrønden (Eng. "knowledge well") interactive floor[8]

Thus, in order to increase the accessibility of, and learning from the content of a digital learning material, one can benefit from connecting the learning material to physical activity.

Elements from here can be usefully incorporated in digital learning materials, where one could, for example, imagine the learning material encouraging users to move their bodies in a figure eight, in order to learn how to tie a reef knot; or otherwise connecting sensors to the subject and content of the learning material. Thus the context (also) of what is traditionally understood as a book is broken down.

Co-creative Dimension. The physical form of learning is used by getting pupils to produce videos with content relevant to their education[9], which provide them with

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[8]   The picture is from Kirkeby et al. 2009:52.

[9]   You can see one example of such a video here
http://www.youtube.com/watch?v=Zu5SmcZuepw, retrieved 02.02.2014.

"the opportunity to anchor their understanding in a bodily sensation. One could say that pupils are offered a wider repertoire of possibilities for learning" (Carlsen and Krog 2012:62). As Carlsen and Krog say, "The students should have access to knowledge through various channels" (ibid.:52). In this case the pupil becomes a manufacturer (ibid. 2012), in the same way that a digital book can have an interactive design, for which the reader can personally create content.

Hansen and Bundsgaard talk about the interactivity principle in their recommendations for the design of digital learning materials (Hansen and Bundsgaard 2013:32). The options generated by interactivity, such as giving response to tasks, can thus be described as means of anchoring the understanding of content.

3   Conclusion

This article has presented research perspectives on accessibility to provide an insight into a new and broader concept of accessibility, related to multimodal digital learning materials. It could lead to some general principles for accessibility applicable to everyone, regardless of age and stage of education. These principles are summarised below.

- The architectural structure must be included in the digital book's content.
- There should be the option of adapting form to suit the needs of the reader.
- The interaction between modalities should be considered in relation to the purpose and the reader's skills and socio-cultural framework for understanding.
- Software should be open and independent.
- It should be possible to anchor assimilation and understanding of content in a kinaesthetic way, with the benefit of involving the pupil as a manufacturer.

Thus in many ways there is a difference between the concept of accessibility in the printed learning material and that in the multimodal learning material. Options to customise the content and structure to the reader's context and capacity in crucial ways can lead to more people gaining access to the content and relevance of the learning material. But it is crucial constantly to explore, debate, and examine for evidence the principles of accessibility in multimodal digital learning materials.

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