Advanced and Emerging Solutions: ICT and AT in Education of Low Vision and Blind Students

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ABSTRACT

This keynote gives an overview to emerging Information and Communication Technology (ICT) and its impact on low vision and blind people (LVBP). The transition into the information society makes established structures more fluent what supports inclusion in almost any domain. We will reflect selected aspects of these developments, in particular for education of LVBP. Education plays a key role both as a domain where ICT gets intensively used and as the field which is in charge of forming the skills needed, both technical and social, for advancement.

Expectations but also fears in this process of change are high asking for careful reflection. Therefore, besides offering a structure for discussing the wide range of emerging technologies, we will argue that a) emerging technologies, to beneficial, have to seamlessly integrate into proven ICT and Assistive Technology (AT) interaction standards, b) skills in using AT/ICT have to become part of all levels of education, both for learners and teachers, and c) elaborated methods, techniques and competences of LVBP in interacting with content must not get lost but adapted for advanced ICT solutions.

1. WHAT IS ADVANCEMENT?

LVBP, as people with disabilities in general, are amongst those groups in society who could benefit most from the ongoing ICT revolution. What is often more a fancy alternative in general opens first time access points and supports independent and self-determent living for these groups. This holds true wherever ICT gets used (and where not?) and becomes a strong motivation and driver making people with disabilities early adopters of ICT.

But we also learned our lessons over the last decades that having this huge potential at hand does not yet guarantee advanced solutions. Hindering factors can be found both inside the sector and in mainstream. Making AT/ICT operational and advancing asks for a lot of re-organizing and changing of established processes and structures what turns out to be often the much more challenging task compared to pure technical innovation. Social meanings and roles become fluent what is for sure positive in respect to overcoming traditional exclusion. But this also provokes fears, resistances and risks. Tempting technical promises initiate transformation processes in domains, which are not yet prepared for it leading to abolishing traditional structures before having set up and reflected new ones. Therefore faster and faster technical developments often meet with only gradual and slow uptake, in particular in formal education. [1]

Inclusion does not automatically lead to more participation, less stigmatization and better quality of life for LVBP in a more and more visually focused information society. This is the same in teaching and learning environments. Giving up established structures without transferring the specialized and user-centered techniques and competences into new settings, is neither innovative nor advanced but negligent. This tends to lead to loosely prepared teachers and students facing very complex socio-emotional processes [e.g. 2, 3, 4]. Inclusion needs a solid basis of methodologies, techniques and skills for mastering AT/ICT supported inclusion. Such a valuable and proven body of knowledge has been developed over the last centuries in education and service provision for LVBP what merits attention for adaptation and use for further advancing emerging technologies and developing efficient AT/ICT based methods and techniques. [4]

Also towards mainstream AT/ICT based inclusion demands for accessibility to allow participation. We are aware that this demand, which became legally accepted in many countries, is not really taken up. Compared to the exponential growth of digital information, there is only gradual growth of eAccessibility. Although measures for awareness raising, legislation, economic facts, recommendations, guidelines, examples and tools are in place, real advancement is still lacking very much behind. [5]

Therefore, to avoid misunderstandings, it is important to state at the beginning, that we do not understand emerging technologies as “advancements” by themselves. Whatever the new potentials might be, it can only be part of an advancing solution. Disability and inclusion always have been socio-psychological phenomena. [6,7] They are established and formed in complex social situations and advancement can only be measured in this holistic social, psychological, economic, and organizational context. This is again in particular true for education playing also here a major initiating and forming role for the formation of the social meaning of disability [5,8].

AT/ICT with no doubt has a huge potential and not using it would be negligent. In the same way as giving up proven techniques and competences and underestimating the complexity of the social process of inclusion is negligent. Respecting and reflecting both should help avoiding a purely agitating jumping on each new wave of AT/ICT. Technical “agitating” often seems to be more an excuses to avoid developing demanding skills and competences at the side of learners and teachers.

Evidence shows that unprepared inclusive settings, driven by tempting technological opportunities, risk losing proven techniques and competences, what can't be seen as advancement. [9]

Statements about "advanced" technologies in a technical research context by nature tend to measure only a restricted set of technically functional criteria. This might lead to overestimation and fears regarding the actual potential. The often-stressed need for interdisciplinary reflection becomes crucially important here.

2. CHANGING, BUT RELYING ON A STABLE BASIS

Therefore I am convinced that it is one of the key requirements and principles for any advancement in the mentioned holistic sense that technical innovations integrate into known standards of AT/ICT which themselves rely on and support proven competences both at learners and teachers site. [10] This should help overcoming unrealistic expectations, fears and resistances and establishing the needed motivation and creativity for advancement.

Therefore we analyze first the existing standard to group the overwhelming flow of technologies and gadgets and integrating them into a reasonable discussion how they could advance inclusion. Here the first good news is, that we have long-lasting educational methodologies and techniques, which proved to be successful over centuries. The second good news is that, after not much more than three decades, we already can rely on a solid and stable basis of AT/ICT technology providing access to LVBP.

Looking into the ICT history we learn that, despite all overflow with new gadgets, at the point of access, at the Human-Computer Interface (HCI) we find some very stable principles. It was already in the early 60ies of last century that groups at Stanford University and XEROX Labs [11] introduced new interaction concepts and elements which became known as window, icon, Menu and Pointer (WIMP) represented on a virtual "desktop" using a refreshable screen and handled with actions like Point&Klick and Trag&Drop with so called pointing devices, first of all the mouse. These concepts complemented with the existing HCI using keyboard commands and command line. Soon they proved to be better usable in particular also for "non-techy" users what made them soon the standard for any system running on computers, in particular on the emerging Personal Computer (PC).

And still today these principles are used everywhere for interacting with ICT including mobile, personal and embedded devices. Of course these concepts have been expanded and enriched, e.g. by what is summarized with the term SILK (speech, image, language, knowledge) and today with gestures and other sensor based interaction possibilities. But the fundamental elements and actions are still there and change only very slowly and gradually by adding new alternative options and not replacing what people already know. The multiple variations and adaptations get integrated without major learning and training efforts. So HCI became an independent instance, which is applicable to any ICT processes allowing us to rely on three major qualities for all AT/HCI/ICT interaction [12]:

- **Flexible and adaptive**: WIMP, SILK and all gesture/sensor interactions use virtual representation of objects in abstract computable notations. This allows and supports multi-media representation of any element and content. Only when accessed with a particular device and profiles (preferences) the media specific qualities (e.g. visual, audio, haptic) are put in place. The same is the case for the modality of interaction: We can perform the restricted number of commands on abstract objects with a broad variety of devices and activities as mouse, keyboard, touch screen, gestures detection, spoken commands, switches, brain-computer interfaces (BCI).
- **Standardized and stable**: Once, established, learned and accepted the HCI tends to be stable as it allows us to use the same principles and techniques on any "e-system and e-service". Users expect that new applications seamlessly integrate into these standards; otherwise they don't follow. Content, devices, contexts, users and situations might vary; the principles of interaction are stable.
- **Ubiquitous and universal**: All ICT systems and services we develop use and support these interaction principles. They have to support the established interaction modes and modalities; otherwise they do not meet with acceptance by users what makes these principles universally applied around the globe. Once learned, the intuitive interface becomes a new "cultural skill" (like using pencil and paper) and can be applied everywhere.

These qualities are main drivers of the ICT revolution and thereby make AT/HCI a universal tool for inclusion. eAccessibility of the restricted number of HCI elements and actions allows ATs "interfacing the interface" [14]: More individually adapted access to the same HCI elements and actions and via them to the same content, system and services facilitates inclusion and participation. Developing competences in handling this stable standard and respecting eAccessibility allow real advancement.

We can already rely on a proven and stable standard of ATs for blind people including screen-reader, Braille display and speech output. We can rely on a proven and stable standard of ATs for low vision users including adapted visual display and screen reader based speech output. There is no need to explain them here. Once learned they can be used to work with any system and service where ICT is used and accessibility respected.

Even new revolutionary HCI trends as gesture interaction [e.g.14] proved to be accessible, applicable and usable by LVBP. Emerging interface technologies, due to the flexibility of HCI no longer tend to become major barriers, as HCI supports many different interaction variations and adaptations. Keeping the flexibility is a key requirement in any accessibility but also usability standard. It is important for mainstream systems and services that they can rely on a standardized set of recommendation, guidelines, techniques and tools to support accessibility. [e.g. 15, 16] With emerging technologies these standards get expanded and adapted but remain a stable basis. [e.g. 17]

Therefore today, already after few decades of the ICT revolution, people with disabilities in the same way as anybody else can expect that the interface adapts to her/his accessibility requirements and individual preferences. They can claim it even more as their fundamental right. With no doubt the inclusion movement is first of all a civil right and democratic movement. But this movement would not have advanced as it did without the facilitating role of AT/HCI/ICT. The UN-Convention on the Rights of Persons with Disabilities [18] as the most important expression of this societal and democratic change could not have been written and implemented without AT/HCI/ICT as its major tool and facilitator for inclusion and participation. Inclusion in many aspects would still be recognized as being part of utopia. Implementation would be much further away without having practical tools at hand, which allow us shaping inclusion as an integral part of the societal change into the information society. AT/HCI/ICT has become a universal tool for inclusion and makes participation practical.

3. EMERGING AND ADVANCING TECHNOLOGIES

For our discussion of emerging technologies the above allows us to formulate three key questions to reflect how emerging technologies could lead to real advancements:

a) No advancement without profound AT/HCI/ICT skills and competences, both at learners and teachers site. Are these skills part in education of learners/teachers? [10]

b) AT/HCI/ICT advances best if proven techniques and competences of LVBP get supported. Do we support, adapt and enhance these specialized competences and are they part of emerging technologies?

c) Seamless integration into accepted interaction standards supports uptake and usability. Is this reflected and at focus in emerging AT/HCI/ICT?

We should have these questions in mind and we will revisit them when we analyze emerging technologies along the line of the AT/HCI/ICT interaction.

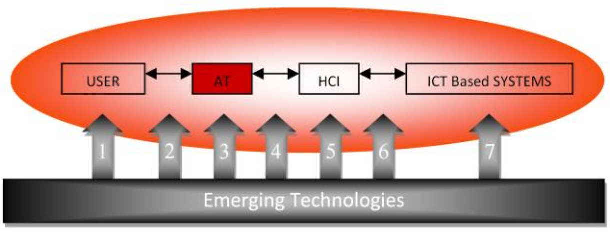

Figure 1. AT/HCI/ICT interplays with seven domains for technical innovation and advancement [see 24]

Figure 1 proposes seven domains for discussing advancements in the overwhelming flow of emerging technologies and their dependencies of technological and environmental factors: [19]

3.1 User and Skills

Starting from the user the first domain for potential advancement is related to understanding, developing, exploring and integrating existing and new skills, competences and preferences of the user.

This relates first to how developing skills to better and more efficiently interact with AT and HCI; this includes better working with standard AT/HCI as outlined but also includes new aspects like using gestures for interaction, working with 3D spatial sound or working with tactile interactive graphics. There are many unemployed potentials and advanced use of technologies supporting them is subject to developing skills in using and integrating them into already existing competences. The flow of new technology asks for development of methods and techniques of how to use them in an efficient manner.

This relates second to the mentioned support and integration of traditional elaborated techniques and skills into the AT supported interaction as e.g. short hand Braille, math/chemistry/music and other notations, know-how in producing and working with graphics and audio. [20] Such specialized competences, which have been developed and taught by experts in specialized centers over centuries, as already outlined, must not get lost. Any emerging technology will greatly benefit if they can rely on such extended competences. Coping with the growing amount of information needs high competences in traditional and adapted or new methods and techniques.

In inclusive settings the forming and professionalizing these specific skills, when not accompanied by e.g. resource centers, are often no longer part of curricula, both for learners and teachers. [4] In any case the adaptation of such traditional methodologies and techniques for AT/HCI/ICT or developing new ones seems to be everything else than in focus in the uncertainties of the transformation towards inclusion. This might vary amongst different regions and language areas, but studies underline such a trend. [9]. It is sometimes even argued loosing these techniques to be a positive trend for “normalization” as they are seen as stigmatizing. [9]

Whatever new technical systems might emerge, better handling and using them will benefit from efficient interaction methods and techniques. The proven traditional body of knowledge, of course subject to adaption, is for sure a powerful and unique source for working with AT/HCI/ICT more efficiently. It is therefore an antagonism to see that such basic skills are given up using digital tools as an argument that such skills would no longer be needed. What ever, to make an example, advanced reading systems might bring, blind people will always be faster, more efficient and effective, when they can rely on elaborated sets of short hand Braille. [e.g. 20] In the same way, what ever a new system for accessing mathematics or other non-linear notations of visual concepts might be, being able to use elaborated and proven context sensitive notations as Nemeth or Marburg notation [21] will always allow better coping with such subjects. Elaborated techniques in producing and accessing graphics [e.g. 22] will help any technology enhancing the production and use of graphics or refreshable presentation on emerging 2D displays. Any emerging technology needs these techniques and must rely on that the competences are in place, otherwise their potential for advancement is lost.

Real advancement in this context is seen when such traditional, proven user centered techniques get adapted and better supported in education. Basic functionalities to support these traditional techniques are in place as e.g. in screen readers, but lacking skills development at teachers and learners site and decreasing demand do not support elaborating them further [5]. This looses priority.

There are of course many factors influencing participation in science, technology, engineering and mathematics (STEM) education and related jobs, but the decreasing numbers of LVBP in these domains are an indicator that such basic competences are decreasing and that technology alone does not advance the situation. [9]

In a similar way skills in orientation and mobility (O&M) for using navigation support tools, daily living skills for interacting with consumer electronic, music, chemistry and other notations for education and job could be discussed as indispensable facilitators for user centered design and advanced practice. In this vicious circle of decreasing competences leading to decreasing demand for functionalities, leading to missing support by AT/HCI/ICT the potential for advancement gets lost.

This let us summarize that advancement needs organizational and educational settings which develop, integrate, adapt and enhance proven competences for the AT/HCI/ICT interplay. Considerable research is going on in this domain [19] but real demand as a driver for up-take in practice seems to be missing and decreasing.

3.2 Matching Persons and Technology

Moving further right in our scheme brings us to "matching of person and technology". [23] Assessment of skills and preferences of users play a key role for advanced systems and services in the same way as assessing technology how it can support and enhance these skills. Emerging sensor technology [24] allows us to better measure conditions, status and activities of the body and the environment to provide more objective data and means for the selection and adaptation of AT in diverse situations (e.g. home, workplace, school, materials). This allows AT/HCI/ICT to be self-adaptive. Systems and tools can only adapt when data about a) the skills (e.g. cognitive, visual, audio, haptic), behavior and preferences of a person are measured, quantified and analyzed and b) translated and integrated into computable profiles. Emerging responsive technologies for LVBP [25] use ICT coming from medical applications as e.g. ophthalmology for better diagnosis over sensors in mobile devices and embedded systems to measure the data needed about the user and the context (e.g. user, location, time, activities, emotions, objects) for better adaptation and support. Examples for such adaptive systems are:

- Probably best known are mobility support systems providing location-based guidance [26] and other information systems (e.g. tourism, museums); the more accurate systems know the location the better they can select the information relevant; this is an assistive functionality of particular importance when visual orientation "at a glance" is difficult of missing.
- Supporting perception when the system knows where the finger or the eye (gaze contingent displays) [27] is reading by providing e.g. audio cues (e.g. this is bold, this is a link) to enhance reading by allowing parallel information display. This is in particular helpful for working with complex notations like math or music to present important information in parallel. [21]
- Tracking of non-verbal communication (e.g. deictic gestures, facial expressions, movements) [28] and emotions [29] allows better support of interaction by employing alternative skills.

Looking at mobile devices and what sensor technology they already include at almost no cost (e.g. gyro, gravitation, temperature, video sensors) allowing to collect and analyze valuable "big data" out of what we "trop" when simply having and using ICT, let us estimate the huge potential at hand to support everyday activities and independent living, as the Ambient Assisted Living Sector [30] outlines. Of course this matching process based on data collection raises, as for anybody else, ethical, security and privacy questions, which have to be carefully respected. Information and competence are again important to make educated decisions how far one wants to go.

3.3 Emerging AT

AT for accessing HCI/ICT has become an own research field over the last decades. The scheme proposes two kind of AT to help structuring this growing domain:

- *Towards the user*: AT using, integrating and enhancing skills of the user to access HCI/ICT.
- *Towards the environment*: AT integrating (by "digitizing") more parts of the environment into AT/HCI/ICT.

3.3.1 AT towards the User

The already mentioned and well-known standard AT for our target group has proven to be a profound and stable basis, both for input and output. As mentioned it can be expected that the uptake of emerging technologies will depend on how well they integrate into, support and enhance these basic cultural techniques.

This is seen when we look at ATs to support and enhance **input** by LVBP: Available alternatives as speech input meet with the same psycho-cognitive and environmental barriers as for the general population. The keyboard and a hopefully accessible keyboard interface to systems is still seem to be preferred although speech recognition is a promising technology since decades allowing LVBP to keep their fingers more free for reading as they use them for both in- and output. Speech input has a high accuracy and becomes user-friendlier [31] but up-take is rather limited. It is most probably not a technical issue but more awareness, development of techniques and training also here. [32, 33]

A real advancement meeting with broad acceptance has been the touch/gesture interface on portable devices. Expected first to become a big barrier, it turned out to be very beneficial for LVBP on mobile devices. [34] One of the key success factors: It is based on known skills of navigating and commanding in a hierarchical/tree structure known from keyboard input and speech/Braille output and integrating easy to use gestures as an alternative.

Emerging functionalities as the mentioned sensing of the finger position on the Braille display, using gestures both on the display or even above in 3D, including other parts of the body [28] will have to proof how they integrate and enhance the state of the art. The same holds true for Brain Computer Interfaces (BCI).

One issue to be mentioned is also the still existing focus on "access" in terms of getting hold of the information. Questions like e.g. a) more efficient and enhanced navigation through enriching content with structural information by developing skills for "browsing", b) supporting "doing" things with ICT as e.g. efficient producing and layout text, solving mathematical, chemical, musical, tasks are still to be addressed. The focus on accessibility in terms of simply getting hold of information seems to keep us away from such important methodological questions. Inclusive settings, as mentioned, risk even loosing proven approaches instead of making them ready for advanced AT/HCI/ICT. It is once more to be underlined that real technical innovation and AT advancement is subject to focused development of user-centered methodologies and techniques for input.

The situation is similar when looking at the **output** or display site of AT/HCI. It is basically sequential text including structure, links ("Hyper-Text") and semantics what has been and most probably will be best for the reading finger, adapted display and audio. There have been many promising research activities including 2D Braille and graphic displays [e.g. 35] and haptic 3D forced feedback [36]. The core arguments for the lacking uptake has been the high price. In my opinion there is also an overestimation of these technologies due to the simple reason that the physical, psycho-cognitive parameters of haptic perception do not change. The quantity and dynamics of graphics might allow enhancements, but what was learned already with traditional handmade or PC supported tactile graphics or 3D models, including touch sensitive "talking" graphics [22] is most probably also applicable here: 2D or 3D haptic access does not make people percept visually at a glance. First the user tends to get disoriented when the finger leaves a well-defined and guiding spatial, sequentially and hierarchically arranged, linked and navigable environment. Of course methods and techniques for designing and using graphics [e.g. 22, 37] have been developed. They are applicable for such dynamic 2D/3D technologies, their use seems to be rather restricted and decreasing due to mentioned reasons. Although efficient and cheaper methods of producing them became at hand the last 30 years a more intense use is not seen. [9] When cheap and affordable refreshable, dynamic and forced feedback 2D and 3D haptic displays become available advancement will again depend on a) developing graphics based on elaborated guidelines, b) sharing and teaching how to use them and c) integrating them in well elaborated accompanying textual description. A lot has been at hand and is subject to rediscover and adapt for advanced solutions.

Potential for advancement is seen in emerging technologies for automatic or supported semantic interpretation and contextual annotation of graphics and non-linear elements to allow an easier and more efficient production of equivalent descriptive alternatives. Concepts like descriptive and dialog-based access to images [e.g. 38] are promising as they integrate into the existing standards.

Another domain which still lacks broad uptake is enhanced audio display including 3D audio and use of cues as pitch, prosody, melody and non-speech sounds for augmented and parallel presentation of information for e.g. mobility support [e.g. 26, 39] or games, game like interfaces or game based learning [e.g. 40]. There are many other emerging technologies as tangible interfaces [e.g. 41] providing information (visual, audio, haptic or olfactory) when touching (or even looking or thinking about them) in an adapted and parallel manner. Body near interface, technologies stimulating parts of the body also intend to allow parallel presentation of information to compensate for reduced or no vision [e.g. 42] which all seem to meet with the same restrictions when moving away from the known standards without according development of methods and techniques for production and use and training on the interaction elements. Advancement stays restricted when they are not developed in parallel.

Many of the above is also applicable for low vision people, as they often use haptic or audio in parallel. The analysis holds also true for emerging see-through technologies, head mounted displays, 3D virtual and augmented environments, and retina displays [43] for low vision: They promise technical progress but it is unclear how they integrate into the existing standards of interaction and the expected user experience. We lack in concepts, trainings, know-how and competences to prepare and use such information spaces in education (e.g. game like learning) and everyday life. Expecting this to happen from scratch in inclusive settings without professional development and training of specialized techniques might risk both technical advancement and inclusion.

3.3.2 AT towards the Environment

When looking from AT towards the environment there is also a long lasting tradition of providing access first related to transcribing and since ICT is available digitizing documents. Emerging technologies allow better analysis of document structures and, as already mentioned, graphical information in the digitization and optical character recognition (OCR) process. [44] These information layers can be accessed using the standard interfaces and tools for consuming and producing documents with AT/HCI/ICT. Support of standards as ePub3 [45] and Daisy [46] for rich document formats meets with interests of the publishing industry. They are referenced in legal and administrative procedures as the National Instructional Materials Accessibility Standard (NIMAS) in the USA. [47]. In the same way PDF/UA

[48] may advance better accessibility. Better tools for integrating accessibility into the production (check & repair) become available. The uptake, also in inclusive education (!) [9], is often very much lacking behind.

In a similar way automatic video analysis tools, following similar paths as single static image analysis and video based tracking, will become available, supporting or even automating domains as video description for LVBP into synchronized subtitling. The mentioned tools for accessing non-verbal communication by tracking gestures, facial expression and other cues, semantic reasoning to gain information what they mean in the context and presenting them to the user the known interaction context [28] is an example of such emerging technologies.

The demand of AT to digitize for access converges with the general need of ICT to get data. Emerging sensor technology, as discussed before for tracking the user, also tracks and “digitizes” the environment. This kind of sensor technology forms one of the fastest growing ICT domains, referred to as “Internet of Things” [24,49]. Almost any detail of the environment can be tracked and handled with ICT. If a pullover in a shop exposes otherwise visually bounded information (or a mobile app allows tracking it) what it is, what characteristics it has (e.g. color, size, seasonal aptitude), to what preferred style and fashion and other clothes in the users’ wardrobe and occasions of wearing it fits, and even to what styles of other persons (known from and exchange in social media) one likes, it fits, what a helpful gadget for many, but in particular what a cool AT enhancing independence for LVBP (or e.g. people with cognitive problems, people in different cultural contexts).

Using such a trivial example should underline how low level and affordable the implementation of such assistive functionalities has become. All “things” get a digital and computable representation and become subject to the inclusive potential of the AT/HCI/ICT interplay. We can trust on the creative mind of readers to imagine the potential in all domains including education.

What is to be repeated again: Advancement of these ATs depends on how the growing amount of information and applications integrates into the proven and enhanced skills of users. It depends on developing and teaching technique to use these technologies for making the environment accessible. This will not happen by itself but nets a highly competent sector. And it also depends on how far these tools can rely on eAccessibility, what brings us to the next item in our journey

3.4 eAccessibility

Users with disabilities and AT demand for supporting accessibility requirements at the HCI from mainstream what is known today as eAccessibility. As mentioned, elaborated recommendations, guidelines, techniques, tools and examples do exist [e.g. 15, 16, 45-49] and are permanently updated for usability and covering emerging technologies as e.g. the mentioned Internet of Things, mobile system, Virtual or Augmented Reality [e.g. 17, 19]. Legislation in favor of eAccessibility [e.g. 18, 47] is in place around the globe. With no doubt there is still much to do to provide better, more usable and automated tools for implementing eAccessibility and we can expect advancement here. The body of know-how in accessibility is already remarkable, but implementation advances only gradually. We mentioned the low ratio of web accessibility. It is the same when looking at printed materials and the publishing sector, consumer electronics, ATMs and all kind of devices in the environment, which do work with HCI but do not support accessibility.

Even more crucial, we can identify many accessibility problems in the service provision sector for people with disability. Education, inclusive or not, lacks in making learning and training materials accessible. [5] And accessibility is still not part of curricula and education of teachers both for special/inclusive and mainstream education [4]. This makes accessibility at the moment much more a question of awareness, changing minds, education and day-to-day practice than technical innovation.

With no question we should expect mainstream to take accessibility on board. But professional support, guidance and consulting is needed what again raises the question, if our sector itself is able to provide it. It is a new and challenging responsibility for our sector to take responsibility for the implementation of eAccessibility: from the bus stop nearby over ATMs, banks, municipality services, churches, cinemas, theaters towards the private space/home. This might read overwhelming but it clearly shows that the competences and skills developed do not get obsolete. They are needed even more in inclusive settings. The fears of becoming redundant are unfounded; the contrary is the fact: Specialized know-how is needed for any advanced solution and the traditional specialized institutions should transfer into these competence centers advocating, consulting and helping implementing eAccessibility far beyond traditional institutional borders.

3.5 Emerging HCI

Emerging HCI technologies provide many “non-traditional interfaces” which go beyond established desktop interaction. Sensor/gesture based input, from touch displays towards 3D recognition using high resolution cameras, Microsoft Kinect (http://en.wikipedia.org/ wiki/Kinect), Leap Motion (https://www.leapmotion. com/), gyro /acceleration/ gravity, EMG, EEG or any sensors [24] become integrated for tracking activities of the user and employ them for handling the HCI. We already mentioned them for AT where they provide an even bigger potential as the help reestablishing functionalities, which a user could not or only in part realize in an independent manner. A more flexible HCI by nature includes more assistive features.

On the output/display side we find again many technologies already mentioned as AT: VR/AR, see through, head mounted and retinal display technology. Most is still in laboratory or used for specific domains like gaming and game based learning. But we can expect growing importance what asks for pro-active accessibility and AT research for identifying the user centered potential, accessibility barriers as well as again developing the methodologies and techniques needed for advancing interaction.

First research results [e.g. 17, 28] show and underline that also these advanced technologies first of all ask for integrating new tracked information cues into the standard interface of LVBP. On this solid and semantic rich base we can expect gradual steps towards new user experiences using 2D and 3D haptic and VR/AR or audio display allowing perhaps comparable immersive experiences and feelings for LVBP. But still it is to be asked if a good story (text) and the imaginative and creative mind of the user do a similar job. How much this will advance our interaction, communication and activity or more distract our mind from focused work, is still not seen.

What role this could play in education to better establish mental concepts and competences, is to be researched but for sure will need again solid methods, techniques and training, where we can learn a lot from history. Accessibility of these emerging technologies asks first of all for exposing all the important information cues in standard text following the elaborated and up-dated guidelines. Based on this solid base we can reach out to new sensory experiences and interactive actions.

3.6 Interoperability

At the HCI we are at the door to reach out to an endless and exploding number of systems and services. To keep up the flexibility of HCI, to allow exchange of data and a seamless integration of a broad variety of applications interoperability and standards play a key role. [e.g. 50] This is first of all a technical and standardization issue but includes, when moving from the personal AT/HCI into systems and services connected in a "cloud" full of divers interests, questions like privacy, security, digital vulnerability and ethics, which have to be part of reasonable and advancing application.

3.7 ICT Based Systems and Services

From here we reach out to, what should be advanced solutions in terms of accessibility, lernability, efficiency, effectiveness, memorability, error prevention and recovery, trust, satisfaction and finally quality of life, as the domain usability outlines and defines also for AT. [51]

The fundamental impact and role of AT/HCI makes clear that we can't discuss all the domains with their specific potential for better inclusion as well as the risks in eAccessibility. We trust again that the reflective creativity of the reader will allow independent analysis in divers domains. We learn from our tour that very few principles are the foundation on the vast fields of embedded and cloud connected systems and services. They are at reach, when accessibility and advanced skills in interacting with AT/HCI/ICT are in place. This let us move on to a final discussion of advancements in education.

4. E-LEARNING

Following the above, eLearning by nature has a huge impact on education. First the focus was on the use of all the electronic learning and instructional technologies for enriching and enhancing the existing educational settings. Buzzwords like Computer-based Training/Instruction (CBT/CBI), Technology Enhanced Instruction and Learning (TEI/TEL) [52] outlined the wish to use the above mentioned multi-media and modality flexibility for advancing education including accessibility.

It is the more fundamental aspect that ICT provokes changes of organizational structures in terms of time and location. Distance/Asynchronous Learning, Internet/Web/Networked Learning, Virtual Learning Environments (VLE) and today Mobile Learning (mLearning) [52] considerably impact on the reorganization of traditionally rigid settings, also opening doors for inclusion.

It is with interest that after a first hype of technology driven innovations in education very soon the social aspect of learning re-entered the discussion and lead to new concepts as e.g. Blended Learning [52]. It recognizes the need of reflecting and balancing the use of ICT in practice in terms of the positive benefits for more flexibility of producing and using media but also the negative impact in terms of e.g. overestimation of the potential, focusing more on technology than on content, bringing in pseudo-objectivity, overstimulation [53, 54] and change of learning and teaching culture [55, pp. 1-39].

In the same way this allows to analyze eLearning for inclusive education. We did this in our scheme for the more flexible and adaptable media presentation and interaction and highlighted some consequences for inclusive education. We highlighted also the importance of transferring established skills into AT/ICT/HCI based learning and developing new methods and techniques for efficient and successful use of emerging technologies. And we will finish with discussing organizational changes.

First of all eLearning systems are a storage and distribution system for content. The accessibility of such systems is under discussion since many years as discussed in 3.4 and there are still many accessibility and usability issues for LVBP. Many concepts are in place but the day-to-day uptake is missing. [44, 56] Solutions have been analyzed and adapted, as e.g. by the EU4All project (http://www.eu4all-project.eu/) for better and efficient management of accessibility requirements and material provision in eLearning. Such management systems allow specifying the needs of people with disabilities, embedded in adapted ePortfolios, and to manage the required actions in education. [44, 56] But when it comes down to the provision of the actual content it most often turns out that the requested alternatives do not exist.

eLearning tends to be a barely accessible distribution platform for non-accessible learning content. [44[In view of the high expectations it might be named one of the biggest disappointments for inclusive education. And again we miss specific competences in making a) eLearning platforms and b) the distributed content accessible. Any inclusive educational setting needs this professional support and expertise, what in my opinion is the outlined new enlarged role of the former special education sector.

Second eLearning provides more time and location flexibility. Individual learning paths are for sure beneficial and also the possibility to bring the content to the learner. But there is still a lot of misunderstanding that bringing the content to the disabled learner could be valued as inclusion by itself. If the core aspect of inclusion is the participation in the social process of learning, using the time and location independence provided by ICT for an excuse to not opening the social learning process, we actually reach to contrary of what was intended. [57] More than in general education, inclusive settings ask for participation, as disability is a social phenomenon, which in many aspects is formed due to exclusion.

Of course eLearning provides social meeting places/networks for communication and discussion, what is beneficial when accessible. But by no means they can replace direct social interaction. Participation in social media must not become an excuse for full participation.

5. CONCLUSION

This let us conclude for eLearning and in general for emerging technologies that a) the potential is enormous but advancement needs b) high competences in handling AT/HCI/ICT, c) new methodologies and techniques for teaching and learning, most probably based on historically proven approaches which must not be given up but are to be integrated and adapted and d) reflected and rearranged social learning environments which use the gained flexibility at all levels for advancement and not as an excuse. This might help to learn driving inclusion towards advancement and not being driven by tempting trends coming up with emerging technologies.

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