Toward a platform to support vocational training of people with disabilities

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Vocational training can bring significant benefits for people with disabilities (PwD), particularly in terms of self-esteem and autonomy. Nevertheless, only a small fraction of Brazilians with disabilities actually work, due to lack of job qualifications. In this paper, we report on the early progress of an ongoing research agenda that investigates new educational and social engagement technologies to facilitate the qualification and inclusion of PwD in the Brazilian labor market. Based on our experiences working with multiple disability populations in a series of exploratory studies, we discuss relevant aspects to be considered in the design and implementation of a vocational training platform targeted at PwD.

Introduction

Educational technology has long been recognized as a powerful and effective enterprise for teaching and learning. Recently, the convergence of new technologies supporting social media [1], Linked Open Data (LOD) [2, 3], and Big Data Analytics [4]—along with current research in distributed learning theories (e.g., behaviorism, cognitivism, constructivism [5, 6], and the flipped classroom [7])—promises to fundamentally reshape the next generation of educational solutions [8]. The increasing interest in Massive Open Online Courses (MOOCs)—sometimes described as a "tsunami in education"—has also fostered valuable discussions regarding the role of technology in education [9].

In this paper, we acknowledge these previous efforts and use them to motivate our own research. However, we focus on the use of educational technology applied to a particular context: *vocational training for people with disabilities (PwD)*. This scenario involves a wide range of barriers that are not just restricted to the school or work environment. PwD struggle every day to be integrated into society. They face many challenges that affect how they live, from access to proper education, to urban mobility, to missing skills, and lack of job opportunities, to name a few. We recognize that there is a large body of contributions regarding technology applied to PwD (e.g., [10, 11]) and, to a lesser extent, to vocational training [12]. However, there is still a need for more investigations and studies in this field [13, 14].

This work is part of a long-term project that has been partially funded by the Brazilian Funding Authority for Studies and Projects (MCTI/FINEP/FNDCT, *i.e., Ministério da Ciência, Tecnologia e Inovação/ Financiadora de Estudos e Projetos/Fundo Nacional de Desenvolvimento Científico e Tecnológico*). As mentioned, the goal of this project is to understand the role that technology can play in improving vocational training for PwD. In particular, our research aims at designing and developing new educational and social engagement technologies to facilitate the qualification and inclusion of PwD in the labor market. Our methodology includes the use of iterative user-centered design (e.g., for requirements gathering, iterative prototyping, and user evaluation) and a hands-on approach to develop mobile educational solutions. We started with community studies to investigate the needs and limitations of particular groups of PwD. The results we obtained from this process and, more recently, from a qualitative study using a popular MOOC platform, led to a better understanding of some demands and challenges faced by PwD. In the long run, we expect that the lessons learned throughout this process can be realized in a vocational training platform, bringing increased usability and accessibility for everyone and not only for PwD (e.g., universal design principles [15]).

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This paper is organized as follows. In the next section, we overview the theoretical foundations and the related work we used to motivate and frame our research. Following this, we present the supporting technologies we designed and developed to explore the problem space. We also present field experiments we conducted with these tools. Next, we report on a study involving students with intellectual disability using a traditional online learning platform to develop a set of job skills. Finally, we indicate opportunities for future research and development in this area, and then, we present our closing remarks.

Background

In this section, we briefly explain how vocational training differs from traditional learning and how it is being applied in the context of accessibility. We also introduce the concepts of Supported Employment (SE) and discuss related work on technology-mediated education for PwD.

Vocational training

According to the Adaptive Control of Thought—Rational (ACT-R) theory of learning [16], human knowledge is divided into two groups of representation: *declarative*, which refers to knowledge acquired through verbal and visual interaction; and *procedural*, which is associated with practical experiences—i.e., one acquires procedural knowledge by *doing* something [17]. This classification allows us to identify key conceptual differences between *traditional learning* and *vocational training*. Historically, traditional education is associated with more general concepts and skills, which tend to consist of teaching of declarative knowledge. Conversely, vocational training is concerned with the ability to perform sequences of concrete tasks, which tend to be more procedural.

The conceptual differences between declarative and procedural knowledge suggest that vocational training relies on certain features that are not so well explored in typical educational technology solutions. These differences are reflected even in simple things, such as the content delivery channels. For example, whereas traditional digital education technologies are suitable both for desktops and mobile devices, vocational training may involve activities in the field; therefore, they can demand mobility capabilities that only portable devices are able to provide.

Finally, it is possible to identify work in the literature (mostly government documents) where vocational training of PwD is addressed [15, 18]. However, references about the application of technologies in these scenarios are rare. Thus, there is still a need for more research in this area.

Supported employment

In the context of vocational training for PwD, SE [2] is a person-centered approach in which vocational profile assessment, identification of job competencies, and post-placement coaching are performed on an individual basis. This methodology proposes an inversion of the traditional vocational training logic: from "train first, then place" to "place first, then train" [19]. No minimum ability level is required to include an individual regardless of the degree of his/her disability [20]. Presumably, anyone can work as long as proper Employment Supports (or assistance) are provided (e.g., modify the tasks performed at the job, add accommodations or assistive technology, and/or enhance on-the-job site training [21]).

In addition to the fact that SE initiatives may vary from one country to another [22], research on technological supports to assist PwD in vocational training scenarios is rarely encountered.

Related work

Several research efforts have focused on formal educational tools for people with multiple types of impairments. Some research addresses the improvement of traditional learning sessions; for instance, Federico and Furini [23] focus on the problem of taking notes for deaf and dyslexic students, whereas Hayden et al. [24] present a solution for people with low vision. Alternatively, we see an increasing exploration of the e-learning concept, which minimizes traveling and investment [25]. Baker et al. [26] suggest that computer-based learning environments can be enhanced by pedagogical interventions that prevent students from entering boredom cycles. However, there are still barriers to the access of electronic knowledge. The main causes of these obstacles are social and economic, rather than technological [27].

In the e-learning scenario applied to PwD, Buschmann et al. [28] implement a method to provide lessons of basic skills to individuals with developmental disabilities through a web application on an iPad**. Recently, Fernandez-Lopez et al. [29] reported on a comprehensive work addressing the use of tablets for the education of people with cognitive disabilities. They note the importance of simple interfaces that display content in various media types, exercises that promote association of ideas, and means to achieve student focus, organization, and encouragement. In addition, they state that content personalization is fundamental because of the large range of cognitive disabilities that lead to different learning profiles. The IMS Global Learning Consortium's Accessibility Initiative reinforces that personalization is also important to people without disabilities or with situational disabilities [30]. (IMS originally stood for Instructional Management Systems.) The consortium works toward a standard for presenting a resource in an alternative or augmented modality.

Personalization is also the key aspect defended by the Floe (Flexible Learning for Open Education) Project [31], an initiative that uses Open Education Resources (free

public materials available in different media formats) to promote accessible education. Content can be reused and personalized by changing the text style, adding captions to videos, etc., in order to comply with fundamental guidelines for the determined audience. According to Bevan and Spinhof [32], there is no perfect set of web guidelines that encompass all audiences, and important efforts have been made toward the specification of accessible navigational practices by the W3C Web Accessibility Initiative (WAI) [33].

Despite the advantages of e-learning, it is very important that the social benefits from group lessons are retained; thus, complementary strategies to use electronic tools in-class should be encouraged. The aforementioned studies suggest that personalization is fundamental when dealing with multiple disabilities. However, most articles address problems that are very unique and difficult to extend to other scenarios, such as vocational training for PwD. Moreover, solutions such as MOOCs are not so practical for instructors who wish to create new courses and exercises and to adapt previously created content. Unlike previous work, we report on directives for an educational platform based on several field experiments, taking into account particularities of vocational training.

In search of qualification and inclusion of PwD

At the beginning of this work, we performed a number of community studies involving PwD in order to better understand their reality and the way they interact with technology. For this, we developed and evaluated solutions for social communication [34], user engagement [35], and personal empowerment [36] that integrate the UNESCO (United Nations Educational, Scientific, and Cultural Organization) four pillars of learning (learning to know, learning to do, learning to live together, and learning to be) [37, 38]. Later, we performed an exploratory experiment with a popular MOOC platform. In the remainder of this section, we present the initiatives that allowed us to gather insights and identify relevant requirements for vocational training platforms targeted to PwD.

Exploratory studies in accessibility

We present in this section a set of technologies that were used in experiments we conducted with different communities of PwD to improve our awareness and understanding about challenges typically addressed in accessibility research.

Smart board

Based on the Community Resource Messenger [39], we developed Smart Board, a Short Message Service (SMS)-based communication tool that fosters information sharing within geographically restricted groups. Users can send text messages to a specific phone number and have them displayed in a *shared message board*, which is a screen positioned in a public space. Smart Board explores the widespread use of entry-level mobile phones and the demand for specialized social networking solutions, containing mainly information that is relevant for individuals circulating in a specific location. For more details, see [34, 40, 41].

Accessible way

Based on the concept of participatory sensing or citizen sensing, we developed Accessible Way, a crowdsourcing application that allows citizens to report accessibility issues affecting urban mobility of PwD (e.g., obstacles on sidewalks and defective tactile paving). For every report, the user collects a minimum set of data describing the issue, together with a picture taken with the mobile device. The report is then submitted to the server with its geographical location, captured by the device's embedded GPS (Global Positioning System), enabling its visualization into a map. For more details, see [35, 42–44].

Marker-based image recognition

This technology consists of a smartphone application that recognizes dynamic content presented in panels or boards with fixed layouts displayed in public environments, such as vending machines, split-flap displays (used in railway stations and airports), and electronic panels (e.g., from subway, tram, and bus stops). First, unique sets of four fiducial markers are placed on the corners of the registered panels. Then, users take pictures using the application, which are given as input for image recognition algorithms. If one or more markers are not identified, users are instructed to move their devices in the correct direction; otherwise, the content is recognized and read out loud by the application. Location and classification are big challenges for object recognition in public environments, and our results suggest that the use of markers can improve recognition accuracy. For more details, see [36, 45].

Field studies and experiments

Smart Board was evaluated during ReaTech 2013, one of the largest fairs in Latin America addressing accessibility challenges, to assist PwD in the task of getting a job. In this experiment, companies and individuals had the opportunity to post messages in order to broadcast job offers and to apply for these positions, respectively. This experiment allowed us to interact with the deaf and visually impaired communities.

In conjunction with several well-known local institutions specialized in the support of PwD, an experiment with volunteers was conducted with Accessible Way in a region of São Paulo City. The experiment resulted in the collection of approximately 1,000 reports over a period of 3 hours, thus showing that Accessible Way may be

effectively used for crowdsourcing initiatives and that communities of PwD are willing to participate [35].

The image recognition tool was not tested with blind individuals, but technical experiments with vending machines showed that the accuracy of the application was considerable (approximately 90% of the products were identified correctly). Discussions with accessibility researchers and with communities of PwD suggest that these individuals are able to use smartphones on an everyday life basis, so this type of technology is likely to be adopted.

Vocational training of people with intellectual disabilities

Supporting vocational training of people with different types of disabilities is a big challenge, and for us, it was essential to identify partners who could help us to address it adequately. Therefore, we decided to establish a partnership with APAE DE SÃO PAULO (Association of Parents and Friends of People with Intellectual Disabilities), a Brazilian non-governmental organization. Within one year of collaboration, we performed several focus groups sessions and interviews to discuss the qualification and inclusion of people with intellectual deficiency in the labor market.

In this process, we observed a session of their SE service, which assists people with intellectual disability in obtaining and maintaining regular jobs. Ultimately, we performed a qualitative study of a simple educational technology intervention in an SE training session, conducted with our local partner. We used Khan Academy, a popular MOOC platform, for this activity, mainly because it offered exercises in Brazilian Portuguese that were interesting to a particular group of students with intellectual disability [46]. These exercises involved quizzes (or multiple-choice questions) in the area of basic mathematics and clock reading. This study was organized and planned based on the results of an interview with two instructors from APAE. Five individuals were recruited to participate: one instructor and four students.

During the activity, the instructor and the students used tablets (one per person), and the research team provided individual teaching assistance for the students, whenever needed. The overall experience was considered very positive, and the students with intellectual disability felt highly motivated by the use of tablets. With little training, even those who had no previous experience with such devices performed remarkably well. Further details about this process can be found elsewhere [47].

This experiment showed that mobile devices can be used satisfactorily for content delivery. Nevertheless, MOOC solutions such as Khan Academy lack features for creation of courses and does not explore previous knowledge of instructors about their students.

Discussion and future directions

The ultimate goal of our project is to develop a platform that supports vocational training of PwD. This platform should cover the creation of learning material and the delivery of suitable content to students. We envision a platform composed of two main components: a *web portal*, in which instructors can create courses and enroll students, and a *mobile application*, through which students execute courses.

Our interactions with APAE indicate that repetition is an important element for the construction of procedural knowledge for people with intellectual disability, so the possibility to represent nonlinear execution flows is necessary. Therefore, in our design, a course is a sequence of steps. A step can be either a presentation step, used to display some content (and with a single successor) step, or an evaluation step, in which a multiple-choice question is presented to the student, and each choice leads to a (potentially different) successor step.

Note that nonlinearity is accomplished with the support of evaluations steps. Thus, course structures can be seen as Directed Acyclic Graphs, where nodes are steps and arcs represent transitions between steps.

Another important finding from our study with APAE is the need for *handcrafted personalization* (or *micro-personalization*) of courses. Personalization is a desirable feature for technologies supporting content delivery, but there are significant challenges for its realization in the context of vocational training for PwD. Technically, personalization relies on two tasks: identification of groups of individuals with similar profiles and delivery of content tailored for each of these groups. Ideally, student classification and assignment of content can be accomplished, respectively, by unsupervised learning and matching algorithms. However, the quality of the results produced by these algorithms depends on the amount of available training data, which is scarce in the scenario we are considering.

With respect to student classification, the variety of profiles in communities of PwD is large, and data describing their interaction with vocational training material is virtually nonexistent. Recall that, according to the ACT-R framework, traditional learning is mainly declarative, whereas vocational training is procedural, and thus features used by the former are not necessarily useful or significant for the latter. For these reasons, algorithm-based student classification approaches are not likely to yield satisfactory results in this context. Similar challenges are involved in the assignment of content to groups of PwD. These facts suggest that personalization in vocational training for PwD can only be satisfactorily accomplished with the active support of instructors; i.e., there is still a need for human participation in the construction of courses, in the

classification of students, and in the assignment of material to groups of individuals.

We intend to address the challenges of the personalization process by incorporating *multiple content representations* to our platform. More precisely, instructors should be able to represent each presentation step (or learning object) in a variety of ways. We refer to each individual representation as a *composition*, so one presentation step may be associated with several compositions. For instance, an explanation about the mathematical operator of addition could be represented through a video or plain text (distinct compositions for the same step).

In order to facilitate personalized content delivery, students and compositions can be associated with *tags*. Namely, students associated with a tag X will receive compositions also associated with tag X whenever possible. It can also include special modules associated with a certain tag, e.g., students with visual impairment can execute tasks supported by computer vision algorithms. Tags can also facilitate the incorporation of *crowdsourcing features* into the platform by allowing volunteers to identify how they can contribute. Our experiments with Accessible Way showed that communities of PwD are willing to participate in such initiatives. Moreover, unlike in traditional education, there is still a lack of digitalized content associated with vocational training. Therefore, enabling volunteer contributions could significantly enrich the repository provided by the platform as well as foster technology adoption.

Finally, there is a large potential for the use of students' interaction data in such a platform. This information may bring valuable insights for instructors about the performance of their students and about the efficiency of their course. Since collection of personal data is a sensitive issue, appropriate measures need to be considered when handling this type of information.

Conclusion

In this paper, we presented the early results of our efforts in a long-term project toward the construction of a platform supporting vocational training for PwD. Previous work on this topic is relatively scarce, especially for developing countries, so a requirements engineering process based on exploratory experiments was essential. We conducted experiments with proprietary technologies and an open educational platform to explore the interaction of people with different disabilities with technological tools. These field works allowed us to better understand the reality of PwD in the learning context and to identify several features that we intend to incorporate in a platform supporting vocational training for them.

Our results reiterate directives presented in the literature regarding content personalization for scholar education, but alternatively, we suggest that because of the lack of existing data, the role that instructors currently play in this task is still indispensable and should be emphasized. Therefore, we propose the use of features such as tags and nonlinear course structures that can be reused and adapted. Scalability can be reached by crowdsourcing, which has proven to be effective in our experiments. So far, we believe that both features are suitable for displaying proper content in a semi-automatic manner; however, the same features can also be used in a fully automatic way when enough data is available.

Since we focus on vocational training, which mainly involves procedural tasks, we also believe that evaluation steps are fundamental. If the platform is able to respond differently according to the student's input at a given assignment, it can properly be used as a technological support during vocational training sessions, which is our main goal. Moreover, we reemphasize that sending execution data to the instructors can represent valuable information to adapt the courses that will be created next.

In future work, we intend to report on the implementation and on the practical application of the platform outlined in this paper. Further implementation and usability issues are likely to emerge from real-world experiments involving people with other types of disabilities, so we believe that our list of features is very likely to be extended from the upcoming experiments.

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