Using Inclusive Design for People with Cognitive Limitations to Develop Online Training in the Workplace

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Abstract: Whether it's downloading applications, doing research, using communication tools, shopping online, filling out a form or finding directions, having good digital competencies is essential in our contemporary society. But what about people with cognitive limitations (PCLs)? It appears that more than 31% of PCLs do not have the basic competencies to face this new digital reality and thus function harmoniously in society. To enable them to become autonomous in activities requiring the use of the Internet via a tablet, a research and development project is underway to create TAQ-TIC, an online digital literacy learning environment adapted to their needs. Using an inclusive design approach that puts the learner at the heart of the creation process, we validated the design, usability, and pedagogical readability of TAQ-TIC with PCLs. Findings emerged that allowed us to make recommendations for online training intended for PCLs, notably the addition of navigation indicators and contextual aids, the cleaning up of screen pages both graphically and textually, and the predominant use of video-based content.

1 INTRODUCTION

Digital competencies are increasingly sought after by employers around the world. This workplace trend to increasingly use digital tools can, at first glance, pose challenges for those who have not been able to develop their competencies in this area, either due to lack of interest or limiting factors. Yet "these skills are paramount in the current context, marked by technological innovations that are transforming the job market and influencing the skills sought by employers" (MESS, 2019).

In this context, questions emerge. What about the competencies of workers living with cognitive limitations? Are these people excluded, for the most part, from the opportunities offered by the digital world? How can the development of digital competencies be made accessible to this part of the population? According to the few firms in Quebec that hire the majority of people with cognitive limitations (PCLs) who are in the workforce, it appears that they do need particular assistance to face this new digital reality, which is now an inescapable part of functioning harmoniously at work and in society (Bourget, Boucher, & Couturier, 2020).

Moreover, it seems obvious to us that society has a civic responsibility to ensure the social inclusion of those with cognitive limitations, in the face of the transformations brought about by digital technology, by offering them tools and resources to manage as independently as possible.

With these larger goals in mind, we are undertaking research and development that aims to

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create an engaging, incremental learning environment for people living with cognitive limitations who want to be integrated into the labour market and society. The environment, called TAQ-TIC, includes mini-training modules (short video vignettes), grouped into lessons, that promote specific learning achievements related to the use of technology in daily life. These are supported by a game to encourage learners to playfully review and consolidate their learning.

This learning environment is to be used to develop digital skills that PCLs need to function normally as independent individuals in society, on par with everyone else (Ruel et al., 2019). Using communication tools; buying entertainment online; finding a bus route; creating, storing and filing documents; downloading applications; doing online research; and other digital competencies are essential to integration into society. Consequently, the development of digital literacy competencies should increase PCLs' level of employability and integration in the workplace, making them more autonomous as citizens.

In this paper, we first describe the inclusive design approach used in our research and development to ensure that the online learning environment meets design, usability, pedagogical, and readability criteria specifically for PCLs. According to Tanis et al., (2012) and Lussier-Desrochers et al. (2016), it is necessary to constantly revaluate these aspects when introducing new devices to PCLs. We then describe how we adapted our data collection practices with this clientele to ensure that they were comfortable with the process and were able to provide us with useful feedback on the environment's initial design. Finally, we present the results obtained during validation of animated mock-ups that were used to design the training vignettes and review game, followed by recommendations for inclusive design for the PCL population.

2 INCLUSIVE DESIGN

According to Bourget et al. (2020), 42% of Quebec adults with learning disabilities want more accessible websites, and these concerns go beyond web accessibility guidelines. To ensure effective accessibility and the appropriateness of our design for PCLs' learning needs, our methodology relies on an inclusive design approach commonly used in the context of digital design. This is a continuous process of pedagogical and multimedia creation that considers PCLs' points of view, experiences, and situations, realizing that these have often not been taken into account. The approach, like digital ergonomics, places the user at the centre of the creation process and requires a collaborative approach with practitioner experts in the field (Hoppestad, 2013; Lallemand & Gronier, 2015) as well as with the people one wishes to serve. Studies in the innovation sector show that it is essential to place the user in the centre of both the design and development phases for technological solutions (Boucher, 2015; Quiguer, 2013).

Validation of the animated mock-ups is the first of three validation steps to be carried out with PCLs. When the learning environment is programmed, we plan to test it with a small group in order to confirm the appropriateness of the ergonomic adaptations identified during the first validation. Finally we will carry out real-time testing with a larger group of PCLs.

Before creating the mock-ups, the project team met regularly with experts (company personnel and teachers of PCLs) to identify appropriate digital skills to be taught, the choice of learning scenarios, and how best to adapt the learning content for this audience. After the mock-ups were created, the team met with PCLs to directly validate the animated mock-ups, as reported in the rest of this paper.

3 VALIDATION CRITERIA

When validating the TAQ-TIC mock-ups, we focused on the following dimensions: design adaptability, usability, and readability (Blanck, 2014; Dagenais, Poirier, & Quidot, 2012; Langevin et al., 2012; Williams & Hennig, 2015).

3.1 Design Adaptability

The design of the learning environment's components (the user interface, mini-training modules, review exercises, and review game) must be adapted to the characteristics of its users (PCLs) (Williams & Hennig, 2015). Here we are concerned with the type of screen display, the visual organization of the screen pages, the choice of colours and contrasts, etc. (Nogier, Bouillot, & Leclerc, 2013). The role of the graphical interface is to help PCLs to focus on what is important. For example, icons should be used consistently (i.e., a particular icon should be used for the same function and in the same format throughout the environment). All pages of a given website must have the same structure. Consistent formats should be used for titles, alignment, image layouts, etc. It is

strongly recommended that a web page template be developed at the start of the process and used for the design of all pages. Also, an action sequence should have the same effect throughout the environment. The terms used in the environment must be consistent: the same word must always have the same meaning. The location of menus, buttons, and texts must be the same for all pages on the site. Finally, the visual interface must clearly highlight the essential elements that need the user's attention (Boucher, 2015; Kellner, 2008).

3.2 Usability

Usability refers to the quality of navigation in the learning environment and the degree of its accessibility (Lussier-Desrochers et al., 2016). In other words, PCLs using the environment must be able to perform their actions quickly and intuitively with as few errors as possible and with easy error correction. The environment must be clear and enjoyable to use and understand, even by someone with little computer knowledge (Fraser, 2018). Studies find that the problems in technology reported by PCLs are most commonly associated with usability and can be solved by appropriate design of the learning environment (Blanck, 2014; Chevalier, 2013; Noël, 2017). Wong et al. (2009) point out that the more steps required to complete an action with the technology, the greater the difficulties encountered for PCLs. These issues can be addressed and by inserting navigation indicators, contextual aids, etc. and by validating the design during implementation (Lussier-Desrochers et al. 2016).

3.3 Readability

By readability, we refer to how text, illustration, and video are formatted to make them easier for users to read and understand. A readable interface is an indispensable element of any digital product (Ergolab, 2003), especially for a learning product for PCLs (Lussier-Desrochers et al., 2016). The learning environment must meet certain minimum requirements with respect to text, video, graphics, and illustrations. Simplifying the interface, avoiding distracting elements, and reducing the density of text are all techniques to make content accessible to PCLs. For example, the length of video vignettes in relation to the user's ability to retain information, the type of illustrations (realistic or more or less abstract), the font, and other elements may need to be adjusted. For reading, how text is presented on the screen in terms of brightness, text/background contrast, space between lines, length of lines, etc. must also be considered.

4 THE TAQ-TIC LEARNING ENVIRONMENT

The TAQ-TIC learning environment, which is designed to be fun and to be personalized for individual users, includes five courses. Each course consists of mini-training modules grouped into lessons. Each of the modules has a specific learning objective.

As an example, in the "Working with a Tablet" training course, 18 lessons are offered. In the "Take the first steps to use a tablet" lesson, eight video vignettes (the mini-training modules) must be viewed to complete the lesson, as shown in Figure 1.

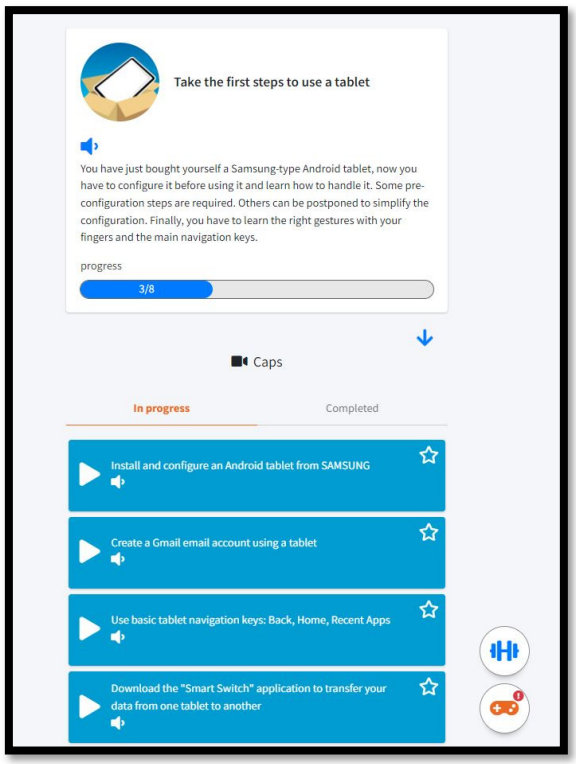

Figure 1: The web page of the lesson "Take the first steps to use a tablet.

Each lesson provides review exercises and the option to review using a game once the PCL learner has completed the lesson (Figure 2).

Figure 2: Reviewing a lesson through play.

Finally, each PCL has a personalized learning path, showing lessons and their progress, that they can access at any time. (Figure 3).

Figure 3: An example of a personalized learning path.

5 INITIAL CONTENT AND DESIGN VALIDATION WITH EXPERTS

Zoom group meetings with expert resource people allowed us to prioritize five themes for the development of digital competencies for people with cognitive limitations:

- the effective use of a tablet (a device that is increasingly used in corporate work);
- the financial management of their online bank account;
- getting around town for work and leisure by bus, paratransit, and taxi;
- the use of web communication technologies (Messenger, Duo, Zoom); and
- access to cultural activities such as virtual libraries and video streaming.

Before PCLs were asked to choose an appealing game to be integrated into TAQ-TIC for learning review, the experts recommended that the PCLs be presented with a limited number of games to avoid the confusion and stress that can result from too many choices. The experts then chose an initial set of possible games, picking six games (two card games, two action/reaction games, one shooting game, and one puzzle) from an initial group of 20.

Later, the resource experts commented on the visual, textual, and audio aspects of the learning environment mock-ups, suggesting some changes that we then validated with PCLs.

6 VALIDATION OF THE LEARNING ENVIRONMENT WITH PCLs

When we reviewed the research on methods of collecting data from this clientele, it became clear that there was little written material on the methodology to be used, in particular on how to approach these users to gather as much useful data as possible while respecting their abilities.

Starting with the expectation that our meetings should be simple and small, we began with a protocol of 30-to-45-minute meetings, each with four to six PCL participants and extra observers. However, we found that one-on-one, shorter (15 minute) meetings were more successful due to PCLs' difficulty maintaining longer-term concentration. These individual meetings also avoided the risk of participants influencing each other. The elements to be validated were set in advance for each meeting, and the questions asked of participants were simple and precise. This approach allowed us to reduce the PCLs' anxiety, encourage them to be more talkative, obtain clear answers to more of our questions, and, above all, to accurately adjust our design specifications to the PCLs' needs.

We conducted five series of individual interviews, with six participants per series. (Note that Nielsen (2000) reports that five users typically detect over 80% of ergonomic errors.) In the interviews we collected the PCLs' preferences regarding the choice and mechanisms of the mini-training modules and the review game.

In order to better target participants, we asked teachers about the types of cognitive limitations of their students. They told us that participants had significant limitations in intellectual functioning, including reasoning, planning, problem solving, abstract thinking, understanding complex ideas, learning from experiences, memorization, and attention. They had problems with oral language (receptive and expressive aspects), written language (spelling and written production), and reading (comprehension and word identification). They showed a general delay in development of fine motor skills, communication, and comprehension, as well as a lack of cognitive strategies for problem solving. They experienced difficulties in perceiving, discriminating and encoding relevant stimuli, in quickly understanding numerous or complex information, and in making connections between memorized elements.

When recruiting PLCs for our study, the teachers paid special attention to selecting people with different limitations in order to obtain the broadest possible feedback from them.

6.1 Validation of the Game

Participants' comments provided us with valuable feedback about the game components. PCLs are looking for both specific benefits and general entertainment – in short, they play games that they find fun and engaging. PCLs abandon games for a variety of reasons as, for example, when the games are boring, require movement that is too fast for them to remember or react, or leave them confused about what to do.

To ensure that we chose a game that PCLs find appealing, we conducted an initial series of interviews to find out about their preferences. The card game *Solitaire*, as well as the animated game *Save the Girl* (which invites them to choose between two actions), were found to be the most popular. Shooting games such as *Angry Bunnies* were not chosen, despite their general popularity, because destroying living beings was stressful to the PCLs.

We understood from these discussions that the game PCLs would prefer should be familiar and playable within five minutes and should have a very visual and bright interface. The card game *Solitaire* was the first choice of all respondents because they did not have to learn the rules or how the game works, reducing the frustration and anxiety that they feel when learning to play a new game. In addition, they felt that the game should offer contextual aids to explain each action that they have to do in the game. These aids must be accessible in real time, at the time an action is to be performed.

Following this choice, we adapted our tablet-based *Solitaire Quiz* game for the new learning environment by integrating review questions about the digital skills training topics. When the player answers a question, they can earn extra points if they give the right answer, which increases their game score. The more effective their learning has been in the mini-training modules, the higher their game score will be and the higher they will rank among the players.

We then conducted a second series of individual interviews with an animated model of the *Solitaire Quiz* game. These provided the following findings:

- With respect to the balance between answering questions and moving cards, respondents felt that displaying a question with each card movement breaks the rhythm of the game. Instead, to maintain interest they recommended posing one question for every three to five card moves.
- The review questions offered in each game should be directly related to the training content. Respondents felt that questions should be short, not exceeding 15 words. They suggested using an illustration with each question to facilitate understanding. They also recommended including a digital voice to read each question, as they read slowly and may lose interest in the game if questions take too long to read.
- There should be no more than three items to choose from in answering a question. Most respondents are confused about what to answer when they have four or more choices. Their preference would be to choose between two answers (Yes/No, True/False, or any two statements). In addition, they preferred to have visual rather than textual responses (Figure 4).

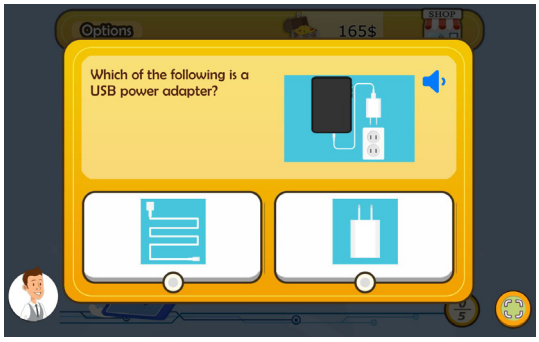

Figure 4: Answer choices in the game.

- They very much appreciated the use of feedback to comment on their answer, whether right or wrong. This feedback allows them to understand their mistakes. Respondents indicated that the feedback should be short.

Figure 5: Score at the end of the game.

- Most respondents were surprised by a display leading them to a mini-training module to be reviewed in case of a wrong answer. They thought that this was a good idea, especially since they could use their personalized path screen to click on the training module to be reviewed.
- The display of the game score, their best score, and the best player score (Figure 5) motivated respondents to replay to improve their scores.

6.2 Content Validation

The meetings also identified design modifications to make the content more accessible for PCLs. In the mini-training modules, the content should be brief (between two and three minutes), preferably animated (in the form of a short video), with a few review questions added to check whether they have understood it correctly. In addition, it is important to integrate hyperlinks to quickly find an excerpt from the module that they wish to review. Finally, reviewing three types of image organization for the videos, respondents opted for images that draw their eyes to the essential elements to be observed in the video; for example, by focusing the action with a pointer or highlight to help them concentrate (Figure 6).

For textual content that introduces training modules and lessons, respondents are most comfortable with short sentences and simple words. Once the number of characters exceeds 350, respondents become distracted. They also appreciate that all texts can be listened to. They find that action verbs in module and lesson titles motivate them to use the materials for learning and review.

In terms of graphics, they feel that using different colours to distinguish the five themes covered in their digital literacy training make it easier for them to navigate the learning environment. For each theme, they prefer illustrations with a consistent graphic style and colour palette, noting that this treatment prevents them from getting lost. They also prefer less realistic and less detailed illustrations: participants indicated that overly realistic imaging makes them feel less engaged. It is also important that there are as many men as women in the images.

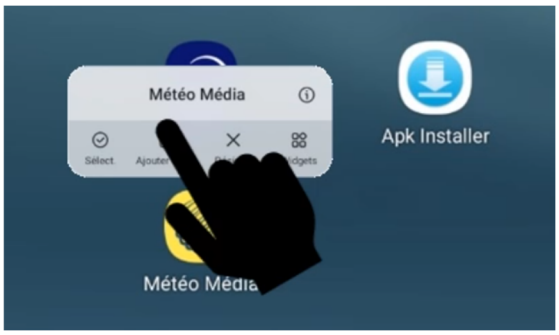

Figure 6: Use of a pointer.

The use of a digital voice wherever there is textual content is essential for PCLs and makes it easier for them to read and understand the content (Figure 1). Similarly, they find it important to be able to choose whether the voice will be female or male by opting for a female or male avatar (Figure 7). When asked about the speed of the digital voice, they prefer a slow voice.

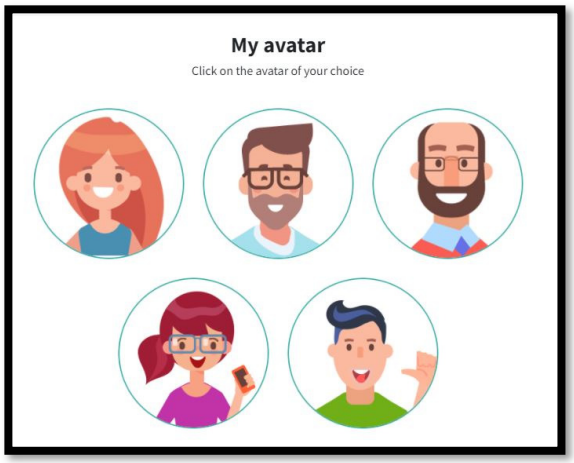

Figure 7: Example of avatar.

In terms of their learning, they appreciate graphics that allow them to visualize their progress through each topic, lesson, and mini- training module; for example, Figure 1 indicates that the person has completed three of the four mini-training modules offered in the lesson "Take the first steps to use a tablet."

Regarding the review exercises, PCLs prefer that when they are not presented within a game, they

should be shown using one question per page rather than with several questions on one page; they find a single-question page to be more motivating.

Participants also indicated that showing the number of questions they would have to answer in advance allows them to plan their learning time. In addition, giving real-time feedback on their answers seems more effective than waiting until the end of the exercise to do so, when it comes too late to help them correct their mistake (Figure 8).

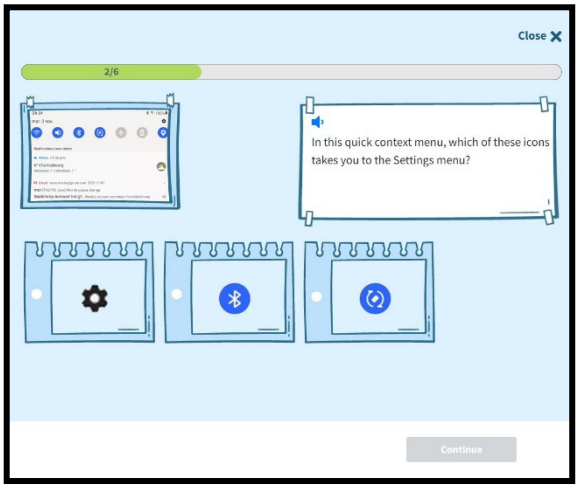

Figure 8: Review exercises.

Finally, in terms of navigation, respondents find it easiest to use the navigation bar that appears on all pages, along with visual or textual cues showing their

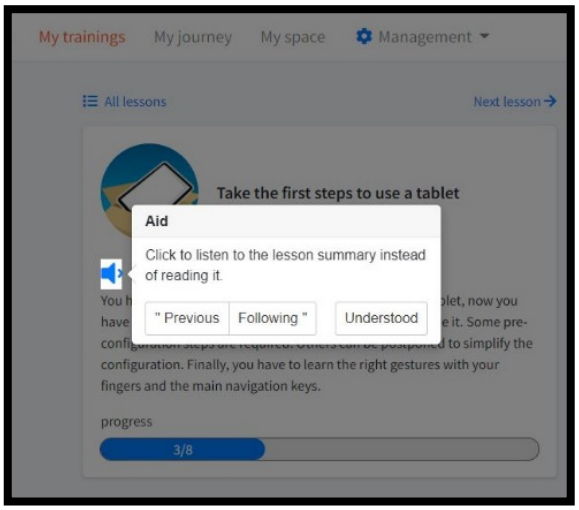

Figure 9: Example of contextual help.

position in the course and on the page. This can be achieved, for example, by arrows positioned in the same place on each page. The PCLs find that contextual aids make it easier for them to understand how each web page on the site works (Figure 9).

7 RECOMMENDATIONS

A number of recommendations emerged from these interviews to support inclusive design with PCLs:

7.1 Adapting the Interview Protocol

To maximize PCLs' comfort and ability to provide useful feedback, it is preferable to use short, one-on-one interviews rather than longer group sessions that could lead to greater distraction and anxiety for PCLs who find it difficult to concentrate for longer periods. Set a detailed list of simple, precise questions for each interview to maintain focus and help to ensure that validation questions are answered clearly.

7.2 Adapting Games Used to Validate Learning

When adapting a game for PCL use, it is important that:

- the game is short and easy to play, with few rules and actions;
- to sustain player motivation, a balance is maintained between time for play and time for answering questions;
- review questions use as few words as possible and words that are simple to understand;
- a digital voice supports the reading of questions;
- answers are in pictorial form rather than text;
- for each question, short feedback gives the correct answer and explains why other answers are not correct;
- visual or auditory feedback is used to reinforce answers to questions. For example, the face (smiling or sad) that accompanies each piece of feedback, as well as the sound that highlights a correct answer, allow players to quickly know whether their answer is correct.

7.3 Adapting Learning Content and Presentation

The treatment of learning content must consider PCLs' cognitive limitations. Our research shows that it is important to:

- clean up the interface so that it avoids distracting elements;

- use a consistent layout to make the text easier to read and view;
- incorporate a step-by-step learning progression;
- break down the content into small learning units;
- reduce text density to less than 350 characters;
- use short sentences and simple words;
- include narrative text so that PCLs have the option of listening rather than reading;
- present the same content in multiple formats (audio, visual, and text);
- provide different ways for learners to check their knowledge;
- in review exercises, use closed-ended questions limited to two or three responses (e.g., true/false or multiple choice with just two or three responses);
- use action verbs in the titles of content segments.

7.4 Adapting Online Navigation

Usability criteria remain the same for PCLs as for other users of online learning environments:

- Insert a navigation bar on all pages;
- Standardize visual and textual navigation cues on all pages of the learning environment with navigation bars, navigation indicators, etc.;
- Integrate just-in-time contextual help.

8 CONCLUSIONS

As the first phase of a research and development project to train PCLs in digital literacy competencies, we used inclusive design principles to design and validate animated mock-ups of the proposed learning environment. Re-evaluating usability criteria with PCLs allowed us to confirm certain principles identified by Lussier-Desrochers et al. (2016) in a digital literacy training context and to reiterate that learning environments intended for the general public need to be reviewed and adapted to ensure that PCLs learn effectively.

In the next step of our validation process, we will examine with our participants the usefulness of the Web environment in the sense of measuring its capacity to meet defined learning objectives, in specific contexts of use and for specific clientele groups.

Further investigations must be conducted to gain additional feedback from this population as development of the learning environment progresses. This will lead us to adjust and adapt the learning content and presentation in the best possible way for the PCL audience. Thus, these initial findings will be evaluated again with small-group testing of the online learning environment and through real-time experimentation with a larger group.

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