Cognitive Support Technology: Enhancing Self-Efficacy in Workers with Impairments

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Abstract

This study investigates the impact of Cognitive Support Technology (CST) on self-efficacy and employability among workers with impairments in a sheltered work environment. Fourteen participants completed a pilot involving a pick-and-place task for dental care kits, supported by the Arkite system. The pilot assessed the feasibility of these workers performing tasks at a regular company. Initial and final questionnaires measured personal details, experience with technology, self-efficacy, and user experience. Observations focused on work pace, quality, and guidance time. Results showed that CST improved task performance, with 79% achieving a good pace and 93% high-quality work. Technology acceptance was high, with 11 out of 14 participants wanting to continue using CST. Seven participants were identified as having high potential for regular employment, showing significant self-efficacy improvements. The study concludes that CST can enhance work accessibility, support cognitive skills, and foster personal development, potentially increasing employability in both sheltered and regular workplaces.

CCS Concepts

• **Information technologies**; • **Accessibility technologies**; • **People with disabilities**;

Keywords

Cognitive Support Technologies, Self-efficacy, Employability

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1 INTRODUCTION

There are personnel shortages on the European labor market, yet many people who would like to work struggle to find or keep a job. Many people with some type of impairment have no job and are struggling to find one. In the Netherlands, with a labor force of 9.9 million, the number of people who are willing to work but are without a job exceeds 1 million 1. The underlying reasons are diverse, but include, among others, low education, low IQ, low literacy, cognitive impairments, or psychosocial problems. The longer people remain unemployed, the more difficult it is to find a job. For those who manage to find a job it can be difficult to hold on the this job 2. Current advancements in technology and AI means there are more user friendly cost effective ways of assisting people with performing their tasks on the job e.g. the amount of translation apps and tools make it possible for somebody to work while not speaking the native language. Another example is Cognitive Support Technology (CST) that can assist individuals, particularly those with cognitive and psychosocial limitations, in performing tasks. This form of inclusive assistive technology is designed to help people by providing visual step-by-step digital work instructions. CST can compensate impairments in memory, recall, information processing, decision making, or the ability to focus 3. Digital work instructions may concern step-by-step pictures, videos text and symbolic instructions that can be presented to workers through the means of monitors, tablets, smart phones, or near-eye displays (2D or 3D smart glasses) or beamer projections (Figure 1). This presentation could be in the form of an overlay to the real world augmented reality either by beamer projections (in situ) or smart glasses or not i.e. instructional reality. CST may also concern more general information provided through an app or another platform, to give support in the performance of tasks.

Cognitive Support Technologies (CST) have been integrated into the regular assembly and manufacturing industry to enhance productivity and maintain high quality standards, as reviewed by Egger and Masood 4. While some studies have reported positive outcomes, others found no significant differences in efficiency when comparing CST to traditional paper-based instructions. Büttner et al. 5 found that CST helps prevent incorrect learning of assembly steps. Research has also explored the impact of CST on individuals with intellectual disabilities. Funk et al. 6 demonstrated that such workers could assemble products up to three times faster and with 50% fewer errors using projected instructions compared to electronic

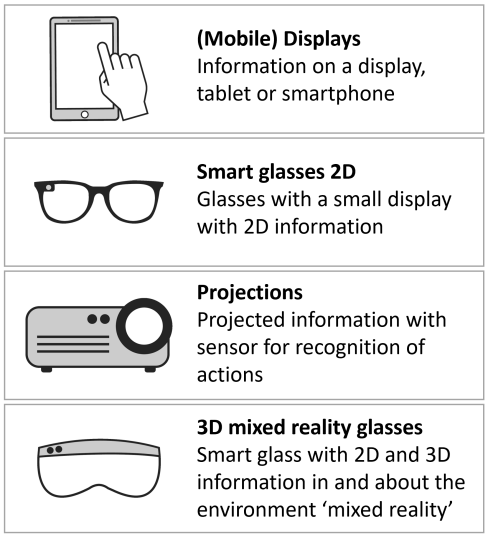

Figure 1: Examples of cognitive support technologies with digital work instructions

displays. Korn et al. 7also observed increased productivity with projected instructions, noting a reduction in errors for most workers but an increase for some, likely due to the cognitive load of processing digital instructions. Individual work capacity may have influenced these results. However, a follow-up study by Korn et al. 8 did not replicate the positive effects on productivity. Heinz et al. 9 reported benefits such as increased worker satisfaction and independence, along with higher productivity, after implementing CST in an assembly line. Bosch et al. 10described five CST implementation cases in industrial practice, including two in sheltered workplaces for workers with intellectual disabilities, which showed mixed results. It appears that factors beyond the technology itself, such as task characteristics and worker capacities, as well as the technology development and implementation process, influence the outcomes. In a recent study 11 also theses mixed results were found but the majority of the people indicated that they preferred to work with the technology compared to working without the technology. In some of the interviews it was stated by team leader or job coach that they had noticed a considerable change in the attitude towards new work and the confidence of people participating in the study, although this could not supported by the data from the questionnaires. This led to the research question whether working with the CST had an effect on the participants themselves. Does the technology, for example, make the employee stronger, more resilient, or more motivated? In what way does the use of technology contribute to increasing chances for sustainable work or outplacement at a regular employer?

Self-efficacy (SE) is a crucial predictor of motivation, reflecting an individual's belief in their ability to successfully perform specific actions 12. It significantly influences job performance, with employees who have higher SE levels more likely to set ambitious goals, persist through challenges, and achieve superior outcomes. This confidence drives them to engage deeply with their tasks and responsibilities 13. At work, SE is strongly linked to good performance and motivation 14.

In the context of return-to-work (RTW), individuals with low SE often believe they will fail to meet work demands or fulfill their roles. These efficacy cognitions are particularly prevalent among those with mental health issues, as such disorders can erode a positive self-concept 15. Lageveld's study 16 demonstrated that SE is a crucial indicator of how quickly individuals with mental health problems can return to work after illness. The research found that higher SE levels significantly predicted a faster RTW process for these employees

It is very likely that confidence in one's own abilities, or self-efficacy, will increase among people with disabilities when they experience they can learn new tasks, do more complex work while being continuously supported by CST. A challenge is to design an experiment and instrument to in capture the long-term effects of CST on work among people with cognitive disabilities. Previous case studies were limited either in their exposure to the technology or the duration of the study, preventing the examination of these effects. Learning to use new technology and performing different tasks often takes longer for this group, necessitating longer measurement periods to study the impact of CST on self-efficacy. This presents a challenge for research design and the practical execution of the research within the context of the sheltered workplace. Additionally, developing a questionnaire that is easy to understand for individuals with varying levels of literacy and conceptual thinking skills is not without challenge, given the wide range of abilities among participants.

For this case study we looked at the organization MondzorgPlus who provides mobile dental care services to dependent individuals throughout the Netherlands. They focus on delivering dental care to people who are unable to visit traditional dental clinics due to their care needs. For this they have to unpack disinfect and restock dental care kids for dentist that work remotely. This work is done by six dental assistants that were experiencing increased workload by the increased volume of dental kits needed and lack of available qualified personnel. The organization aimed to outsource part of the packing of dental care kits to people with a distance to the labor market to a sheltered workplace social work and development company MidZuid. The aim was to see if people that worked at the packaging department (typically placing 2-5 products in a packaging) were able to restock dental care kits which is a more complex and taxing job i.e. more objects to place and count and the placement is more critical. We looked at productivity and quality of the work and the amount of guidance that was needed from the team leader next to the support of the CST. We also looked at technology acceptance and attractivity. Furthermore we asked their job coach several questions regarding skills and employability of the participant. A job coach is a professional who helps individuals prepare for and succeed in employment within or outside the sheltered workplace. Our hypothesis were 1) with CST people can learn and perform new tasks and experience an increase in self-efficacy (SE) 2) people with a higher employability that are more suited to work at a regular employer have a higher SE.

Figure 2: Example of the product, a dental care kit (left)

Figure 3: Projection work cel. A projector and time of flight sensor are positioned above the work bench. Information is projected in de green dashed area with additional information on the screen (blue dashed line).

2 METHOD

The participants were recruited by the job coaches of the sheltered work organization. All employees working at the sheltered work organization have a distance from the regular labor market. The goal was to have a diverse group of employees representing the sheltered work population. Twenty-one participants started the training with the technology. One participant dropped out of the pilot after the first day due to anxiety from the technology. During the pilot, which lasted several weeks, six participants dropped out due to absence or another job opportunity. None of them dropped out due to performance on the task. Fourteen participants finished the pilot. Their average age was 40 years (SD = 13), and they had, on average, 20 years of work experience (SD = 24).

Participants performed a pick-and-place task. The product was an organizer box with articles for dental care treatment by a dentist (Figure 2). A precise number of articles had to be placed in specific bins of the organizer box. The task was supported with projection technology. The Arkite system, which included a projector and a time-of-flight (ToF) sensor, was used (Figure 3). The Arkite software was programmed to present the instructions step-by-step. A pick step was supported with projected light in the bin with the specific article. The ToF sensor detected when the hand of the participant was in that specific bin, which automatically proceeded the instruction to the next step. The placing step was again supported with projected light in the correct bin of the organizer box. The ToF sensor detected the article in the bin of the organizer, and the participant could validate the placing step, by placing the hand on a projection of a green check mark icon on the workbench. These steps were repeated until all the articles for this box were placed, and the task could be finished by sealing the box with a sticker. There were three types of organizer boxes with different article compositions.

The pilot was performed at the location of the sheltered work organization. At the start of the pilot, the job coach administered the initial questionnaire to the participants. The initial questionnaire consisted of personal details (age, work experience, and gender), experience with technology, self-efficacy, and self-assessment of their ability to produce the product with and without the help of technology. Just before the self-assessment question of performance with technology, participants were introduced to the projection work cell. After the introduction, participants worked with the technology at least twice a week for a total of 4 hours. During each session, a supervisor was present to help the participants with starting up the system and to provide support during the work if necessary. The supervisor also filled out an observation questionnaire for each session. The observation questionnaire focused on the work pace and work quality, the additional guidance time by the supervisor, and the number of finished products. After about 8-10 weeks, participants finished the pilot with a session filling the boxes without the technology. The job coach administered the final questionnaire to the participants. The final questionnaire consisted of self-efficacy, user experience, and open interview questions about the pros and cons of the technology. All texts in the instructions and questionnaire were written at the B1 level of participant's native language (Dutch; 17) to ensure better understanding of the information and concepts by the participants.

In consultation, the job coach and supervisor assessed the feasibility of the participant performing this work at a regular employer. This expert assessment was based on observations of performance and more general employee skills. The participants were grouped as having low potential or high potential for placement with a regular employer.

The collected data were analyzed using a standard T-test to determine the statistical significance of the differences between the two groups, respectively low and high potential for placement with a regular employer. The statistical tests were focused on effects of working with technology on self-efficacy. The T-test was conducted at a 95% confidence level, with a p-value of less than 0.05 considered statistically significant. All statistical analyses were performed using SPSS 28.

3 RESULTS

After couple of weeks with multiple training session, the majority of the employees were able to perform the tasks at a good pace (79%) and with high quality (93%) using the technology (Figure 4). Over the course of the pilot, the need for supervision decreased, with most employees requiring little guidance of the supervisor (71%). However, some employees (29%) still needed additional support regularly alongside the support of the technology. At the end of the pilot, more than half of employees (64%) were able to, for a short time, work without the technology, indicating they had learned to

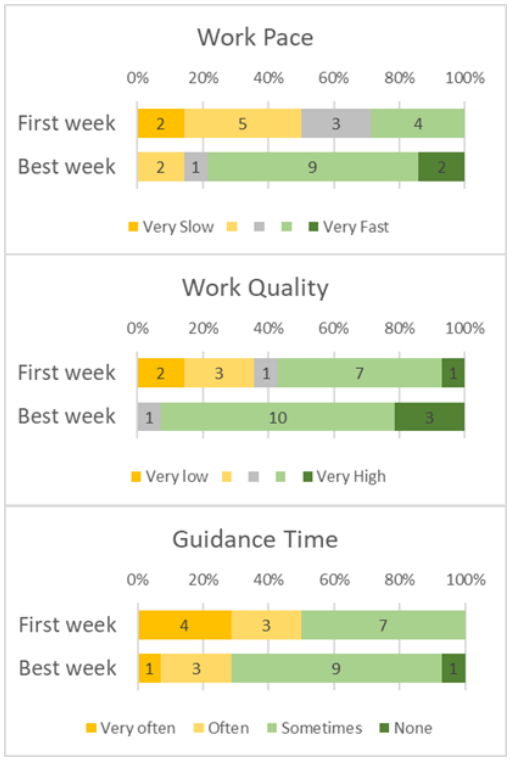

Figure 4: Work pace, work quality and guidance time observed by the supervisor. Results for the first and best week of the pilot. The number of participants is given in each color bar.

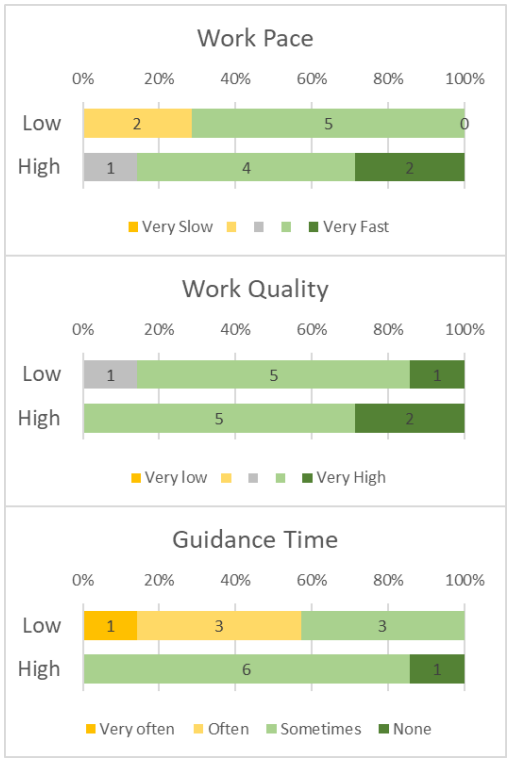

Figure 5: Work pace, work quality and guidance time observed by the supervisor. Results for the best week for the low and high potential group, for placement with a regular employer. The number of participants is given in each color bar

perform the tasks independently. Number of boxes filled per hour varied between participants with a mean of 11,6 (S.D.> 5,9) for the first day and a mean of 14,6 (S.D.=5.5) on their best day.

The acceptance of the technology was high, with 11 out of 14 employees wanting to continue using it and learning new tasks with the technology. Employees responded positively to the attractiveness and user-friendliness of the technology, giving the workplace a score of 8 out of 10.

Based on their performance in the pilot, 7 employees were assessed to have high potential for placement with a regular employer. On observed work pace and quality, there was no difference between the high and low potential group (Figure 5). However, in terms of guidance, the high potential group scored better, requiring less supervision time. At the start of the pilot both groups had an equal score on the self-efficacy construct. At the end of the pilot the higher potential employees scored significantly higher on the self-efficacy construct compared to the group with low potential (Figure 6). It was noted that these individuals, in particular, had shown growth in item scoring their "belief in their own abilities" (Figure 7).

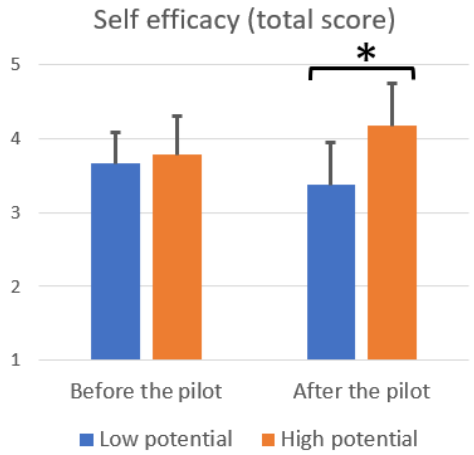

Figure 6: Self-efficacy score for the low and high potential group, before and after the pilot.

4 DISCUSSION

CST has shown it's potential to increase the work participation of people with cognitive impairments within the labor market. It

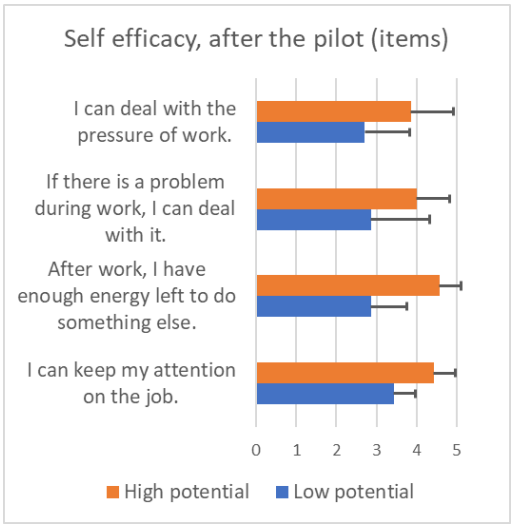

Figure 7: Self-efficacy items with significant difference between the low and high potential groups.

can support task complexity and learning and thereby removing a barrier to work on new tasks or jobs. Moreover, it may empower people and encourage personal autonomy becoming less dependent on a job coach or supervisor. CST made work more accessible by supporting cognitive skills, enabling more complex tasks such as remembering, counting, and correctly placing materials.

These results highlight the importance of taking self-efficacy into account, when studying the effect of technological support. Self-efficacy should be measured alongside changes in speed and quality and the amount of guidance. This study showed that measuring self-efficacy can help understand the personal development that people go through while working on a new tasks while being supported by CST. This has been previously noticed in other pilot studies studying the effect of CST by job coaches or team leaders [10, 11]. They spoke about an increased self confidence in people or the changes in independence or the willingness to try something new. Quote of the team leader (translated from Dutch): *"Participating in the study gives so much self-esteem to the participants. They normally no longer dare to say that they want to do other work. They no longer know how to express their own opinion. They are never allowed to participate and now suddenly they are allowed to do new things and challenges. You can see in their behavior that they are going to do something very special when they come to the study area. They are proud to be in the space with technology and to take on more responsibilities."* This was never supported by data, with the SE questionnaire we have developed a measure that showed that the development of personal competence can help to achieve their full potential in a (sheltered) workplace.

4.1 Limitations

CST is not a one-size-fits-all solution, as some individuals were unable to work with the technology. It remains unclear for whom CST is most supportive and for whom it is not. Future research should focus on identifying the characteristics of individuals who benefit most from CST and developing strategies to support those who may struggle with the technology. Also with current AI developments technology will become more adaptive to the user and more user friendly in the near future which could benefit people with cognitive impairments. Although AI comes with its own challenges regarding privacy ethics bias accountability and other. Clear however is that it mainly supports cognitive functioning by giving step by step instructions and visual aids.

Due to the small sample size, heterogeneity of the participants and the uncontrolled conditions on the work floor it was difficult to not lose the actual results in the data. Calculating group averages or removing outliers should be done with consideration – is it an outlier or is it the actual data? And where possible including as many participants as possible is recommendable for future studies although this often limited because of availability, amount of guidance or logistics of the work place.

4.2 Future implications

CST can foster growth and development in employees' work, which has a positive impact on their progression to meaningful employment. As a result of this study, two high potential participants were successfully placed in secondment at the regular employer MondzorgPlus. They continued their work activities i.e. packing part of the medical kit and also got additional work that could be reassigned from the dental assistants.

The expansion of inclusive technology in both social and regular businesses is important for achieving higher participation rates of people with impairments in the labor market. The technology is available but requires adaptations for successful implementation. Key conditions for this include involving end-users in the design process, securing funding, and collaborating with companies that have an innovative approach to social entrepreneurship. Embracing technology such as CST helps the digital transformation of sheltered workshops and creates opportunities for more economically valuable work as well as more opportunity for the supervisor to focus on personal development and growth of the employee.

5 CONCLUSION

In conclusion, technology like CST can play a significant role in making work more accessible and can contribute to a development in self-efficacy. By supporting some of the impairments of people, technology can enhance employability both within and outside their own workplace.

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