Collaborative Robots Can Support Young Adults with Disabilities in Vocational Education and Training

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ABSTRACT

To explore the opportunities of collaborative robots (cobots) to assist young adults with disabilities, we accompanied the deployment of a cobot in a vocational training workshop. The study with eleven participants investigated how trainees with intellectual disabilities react to a cobot, which tasks can be supported, and which challenges and opportunities arise. The study includes two surveys on negative attitudes toward robots, two workshops followed by interviews, a group interview, and an email survey with supervisors. The surveys were analyzed using descriptive statistics and qualitative methods. The results indicate a low negative attitude towards robots before and after working with the cobot. The cobot can be used for assembly, handling, and quality control. However, challenges such as the cost and the identification of suitable users and applications must be overcome to fully use the opportunities like improving workplace ergonomics, expanding users' skills, and preparing employees for the primary job market.

CCS CONCEPTS

• **Social and professional topics** → **People with disabilities**; • **Human-centered computing** → *Empirical studies in interaction design*; • **Applied computing** → Interactive learning environments.

KEYWORDS

Cobots; Vocational Training; Human-Robot Interaction; Inclusion

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1 INTRODUCTION

Since 2021 the Social Committee of the European Union has been actively contributing to the "establishment of a general framework for the realization of equal treatment in employment and occupation, taking into account the UN-CRPD (Convention on the Rights of Persons with Disabilities), effectively moving toward a long-term transformation of workshops for people with disabilities in their current form [9].

The use of assistive tools can be a first step towards renewal, especially when worker assistance systems and collaborative robots (cobots) are used for individual support. This means that the individually assisted workplace could also be located in a production hall in the mainstream job market and that current workshops could serve as integration supporters, assisting people at these workplaces according to their individual needs [5, 11].

Furthermore, several immediate benefits for the workshops arise. Digitization and technologization open up new possibilities as orders can be placed in ways that might pose challenges when incorporating them into the conventional workflows of a workshop designed for individuals with disabilities. In addition, they can offer more attractive working conditions for employees with disabilities through digital assistance systems, allowing them to be more free in their decision where they want to work. Simultaneously, in the face of a prevailing shortage of skilled workers, workshops become more attractive for employees who want to include people with disabilities. This provides them with a more interesting and diverse working environment [11].

In a similar setting to this project, the authors of [6] conducted a group discussion between all participants and facilitators before and after interacting with a cobot. During their tests, all four participants without any prior wiring experience successfully connected the cables in the cabinet sequentially and correctly, following the stepwise robot guidance instructions. The authors of [2], who did a similar study in a workshop for workers with disabilities in Germany, recommend a familiarization phase that should last for about 20 min. In their study, the robot was well accepted and did not cause fear or discomfort among the participants, based on observations. This study expands their promising results and adds standardized survey data.

Our study was conducted at an institution for vocational education and training for young adults with intellectual disabilities. The focus was on the use of cobots for the inclusion of people with intellectual disabilities, using a Franka Robotics arm. The deployment of cobots as support presents various opportunities: e.g., inclusion potential, reduced workload, attractiveness for employers and applicants, expansion of skill and task spectrum, but also challenges (e.g., lack of acceptance, potential risks to occupational safety) [1]. Similar projects like the AQUIAS project at the Fraunhofer Institute for

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Industrial Engineering and Organization in Germany have already used cobots to assist production workers with severe disabilities [8]. The Iserlohner workshops (Germany) have also worked with the cobot "Sawyer" by Rethink Robotics [4], exploring the assistance provided by cobots in various tasks, such as quality control [11].

The objective of this joint project is twofold: first, to determine the level of acceptance of cobots among people with intellectual disabilities, and second, to gain a better understanding of the interaction between people with intellectual disabilities and cobots to investigate how people with disabilities can be supported in their integration and participation in the workforce. The project specifically addresses the following research questions:

- Is the cobot accepted among the workers?
- Which reactions does it elicit?
- Which tasks can a cobot take on in this field?
- What added value does the cobot offer?

2 METHOD

2.1 Ethics Statement

This study was conducted in accordance with the principles embodied in the Declaration of Helsinki and in accordance with local statutory requirements. All participants and their legal representatives (if applicable) gave their informed written consent to participate in the study. The local Ethics Committee for Human Participant Investigations was consulted, and the study design and materials were reviewed. No objections were raised and the study was approved by the review board under reference number 2022-571-S-KH.

2.2 Procedure

To address the research questions, a single arm robot from Franka Robotics GmbH [3] was placed in a vocational education workshop for a period of three months. The basic setup is shown in Figure 1. The following sequence of surveys and workshops was conducted at the workshop for vocational training and education for people with disabilities:

(1) Negative Attitude towards Robots Scale (NARS, [10]) transferred to Simple Language (transferred in collaboration with the vocational training institute and the Office for Simple Language)
(2) Workshop 1 and Interview 1: Familiarization
(3) Group Discussion
  - Topic: Possible Areas of Application for Collaborative Robots in Vocational Education
  - Goal: Idea generation + Capture reactions and evaluations of the new situation
(4) Workshop 2 and Interview 2: Practical Tasks
  - Workshop Topic: Recap of Workshop 1 and Practical Tasks (grinding / attaching valve / packing hose)
  - Interview: Experience with and acceptance of cobots
(5) Closing Survey (NARS)

The NARS questionnaire [10] was transferred to Simple Language in collaboration with the vocational training institute and the Office for Simple Language. Following the vocational training facilitators' recommendation, the Likert scale grades were reduced to four (no, rather no, rather yes, yes).

Figure 1: Setup of the robot workplace (left) in the workshop and study participants with cobot (right). (Photo: Own)

Both workshops were divided into four parts, each lasting one hour and spread over four days in order not to overwhelm the participants. In the first workshop, participants were able to familiarize themselves with the cobot. It also served to improve their understanding of how the robot functions. Following the workshop, participants were interviewed about their experiences. Finally, in a group discussion, their experiences and expectations regarding working with the cobot were identified.

On the first day of the first workshop, the area of application of cobots in general, as well as the basic structure and functionality of the present robot, were explained. On the second day, the commissioning and safety concept, as well as the behaviors during robot handling, were explained. Safety functions of the robot (e.g., collision detection or force limitation) were explained and demonstrated prior to direct interaction. In addition, hazards associated with working with the cobot and measures to reduce these risks were discussed. The available applications and programming possibilities were explained before the practical exercises on the third day. The collaborative robot Panda by Franka Robotics served as a visual aid for the individual thematic focuses on all days. Finally, on the fourth day, the participants independently and, if necessary, with the assistance of the study leader, programmed two positioning tasks. The goal of the workshop was to provide participants with an initial insight into the topic of "collaborative robots" and, if necessary, to overcome any apprehensions.

In the second workshop, three practical exercises were conducted using the cobot after they programmed it themselves using a drag-and-drop interface. The tasks were: 1) Grinding 2) Attaching a Valve and 3) Packing a Hose. After the workshop, the participants were interviewed and completed the NARS again.

The questionnaires were analyzed using descriptive statistics. The workshops, interviews, and group discussion data were transcribed and qualitatively analyzed using MAXQDA [12]. The category system for this analysis was developed both deductively (from the research questions) and inductively (from the material). The formation of the main deductive categories resulted from the interview guidelines, the group discussion guide, and the workshop structure. The categories are experience, future, perception/features, and area of application.

2.3 Subject Sample

Eleven out of 22 members of the vocational training sector at the selected workshop participated. Due to illness or the decision not to participate in a specific survey, the number of participants ranged between five and eleven for each assessment. The data collected were pseudonymized, so data points from the surveys could be matched.

All evaluations were conducted on-site and in person, complying with health and hygiene regulations. Participants did not receive any compensation for participating in the study. Five participants identify as male and six as female. The mean age was 19.55 years (*SD* = 1.04 years, *range*=18-21 years).

Participants have varying degrees of disability, ranging from single diagnoses to double and multiple diagnoses, including mild intellectual disability, autism, and Down syndrome. The spectrum of the participants' disabilities is broad and includes different manifestations. In some cases, in addition to intellectual disability, a physical impairment affects fine motor skills, arm movement, communication, hand and finger coordination, or vision.

The 11 participants perform various tasks according to their competencies in the regular operation of the workshop. They engage in tasks such as assembling exhaust insulation hoses, interim stands, or condensate containers. Other tasks include crafting storefront decorations or practicing specific skills for assembling components using learning kits.

The participants have intellectual disabilities that partially hinder them from reading and understanding texts. For this reason, the workshops were conducted in three groups, divided based on their reading ability, with each group consisting of two to four individuals to provide better conditions for understanding. It was done in close consultation with the facilitators, who have profound knowledge of the participants and their abilities. The reading ability was determined by the supervisors as part of the competence analysis in the area of cognitive characteristics. Participants are categorized into A=Other, B=Cannot read, C=Can read simple words, D=Can comprehend simple sentences, E=Can confidently read simple texts, F=Can confidently read complex texts.

3 RESULTS

The results demonstrate that the young adults with intellectual disabilities in this sample accept the collaborative robot at their workplace. They respond primarily positively to the robot, expressing joy, interest, and enthusiasm during collaboration. They actively participated in the introduction of the robot, asked questions, and participated in its setup. They show no hesitation in performing practical tasks with the collaborative robot. In the surveys participants reported a low negative attitude toward collaborative robots before and after working with the robot. Table 1 shows the results of the NARS evaluations.

The comparison of the results of the pre- and post-survey shows that the mean score for the negative attitude towards interacting with the robot decreased by 0.21 points compared to before the study was conducted. Similarly, the mean score for the negative attitude towards the social influence of robots has decreased by 0.28 points. In contrast, the mean score for the negative attitude towards emotions in the interaction with robots has increased by 0.22 points. However, the mean scores in both surveys (before and after direct collaboration with the robot) are in the lower range and thus closer to the minimum of the scale. The overall scores

Table 1: Results of NARS sub-scales before (pre) and after (post) interacting with the cobot. Scores range from 1 (no negative attitude) to 4 (negative attitude).

	Negative attitude towards..	Mean	SD
Pre	S1 ..interacting with robots.	2.19	0.99
	S2 ..the social influence of robots.	2.38	0.80
	S3 ..emotions in the interaction with robots.	1.70	0.83
Post	S1 ..interacting with robots.	1.98	0.88
	S2 ..the social influence of robots.	2.10	0.78
	S3 ..emotions in the interaction with robots.	1.92	0.86

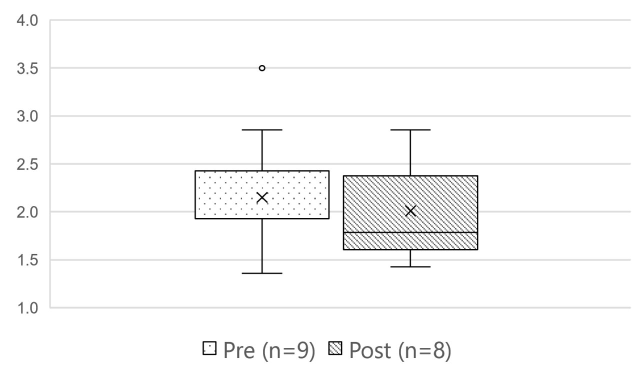

Figure 2: Boxplots of negative attitude towards robots. Overall NARS scores before (pre) and after (post) interacting with the cobot.

are depicted in Figure 2: the mean score decreased by 0.15 points, but did not differ significantly. One participant dropped out for the second survey, leading to mismatching samples. However, the drop-out was not the outlier in the pretest (see Figure 2).

In the group conversation, the participants imagined the perfect collaborative robot for the workshop with multiple arms and hands, legs, an upper body, reduced speed and automatic programming. Participants generally perceived the robot as a helpful and positive addition to their activities, functioning as a collaborative team member. Furthermore, the participants envisioned potential areas of application for the robot (verbatim impressions translated from German):

- "Oh, and it can also check if it's correct." (quality control)
- "[...] the robot takes the hose, puts it in, and the other one holds the hose tight." (collaboration)
- "Teamwork." (collaboration)
- "Or, if something is too far away, it can hand it over." (collaboration)
- "Like baking, for example." (leisure use case)
- "Robots can also be friends." (leisure use case)
- "Can it do crafts? Like corner to corner?" (leisure use case)
- "Hmm, picking something up." (physical assistance)

Interview responses revealed that some participants believed their attitudes towards the robot improved, attributing this to a better understanding of the robot's functions. They expressed anticipation for future collaboration with the robot, indicating a desire to continue working with it. The robot's appearance, movements, and functionalities were frequently compared to everyday objects.

The interviewed supervisors acknowledged concerns about potential fears and stigmatization among users but recognized the robot's potential to aid individuals with intellectual disabilities by providing support and enhancing daily activities. They also reported the fear that the robot support might be perceived as a weakness by participants who do not use the robot. Another hurdle they see is the cost associated with the collaborative robot. The supervisors were also asked about their perception of the perfect collaborative robot for the given setting. User-friendliness and accessibility were their top priorities. They emphasized that the robot arm should be self-explanatory, safe, mobile, and robust. Additionally, the supervisors highlighted the importance of the robot being able to recognize problems and intervene proactively. Additionally, the robot could provide support for people with intellectual disabilities and, for example, compensate for motor limitations by providing assistance. The use of the robot arm could make the daily life more diverse. Supervisors also see an opportunity to expand the users' technical understanding.

4 DISCUSSION

The study was conducted under controlled experimental conditions in the training room. This does not represent a natural work environment for the participants. However, tasks from actual workshop assignments were selected for the experiments. Additionally, these tasks were carried out within the workshop premises.

Only people who actively agreed to participate in the study and work with the cobot were included in the data collection, which was only half of the employees in the vocational training sector. This may have led to a potential positive bias in acceptance and resonance. Participating in the study creates an unfamiliar situation for the employees. This means that the study may not necessarily trigger reactions solely related to the influence of cobots but also novelty effect reactions to the new situation in general. To counteract this, the first workshop was conducted to familiarize participants with the robot. Only after that tasks were performed together with the robot in the second workshop. Moreover, all surveys were conducted at the workshop to avoid exposing participants to a new environment and circumstances that could distort the results. The frequent comparison of the cobot to everyday objects indicates that the robot does not feel strange or awkward to the participants. Potential fears and stigmatizations might occur over a longer period of use.

It must be emphasized that the results are based on a small and — due to different diagnoses and manifestations of disability — heterogeneous sample. Therefore, the transferability of conclusions to other people with intellectual disabilities and other studies with a similar design is limited. Despite the small number of participants, the survey provides an initial insight into the impressions of people with intellectual disabilities about cobots.

Since only one specific robot and specific interactions were tested with participants from a specific group the results are limited in transferability to interactions with a robot of similar appearance and complexity, and a comparable group of participants. The results of this study cannot be extrapolated to the general population.

Furthermore, the survey only allows for a prospective assessment of the participants' subjective attitudes. NARS statements were transferred to Simple Language. This could lead to the distortion of the initially standardized assessment, and essential aspects might be lost. However, since an assessment without this translation would not have been possible due to the limitations of the participants, it is justifiable to ensure understanding.

It is important to note that all assessments can only reflect a snapshot. Contradictory statements and actions occurred during the workshops or interviews. For instance, one person stated in the interview that collaboration was not enjoyable while actively and joyfully working with the robot during the workshop. Another person wanted to participate only on one day of the first workshop and then assessed the robot and the workshop as very good in the interview. The caregivers of the participants confirmed that the individuals' attitudes also depend on their daily form. In this regard involving family members and caregivers more would likely be beneficial.

We propose a long-term study with a cobot to identify a specific application and analyze its long-term benefits. Referring to [7, p. 280] "only in the concrete implementation and application in a specific context the different facets of new technologies and the associated challenges become visible". Additionally, this would mitigate the novelty effect.

5 CONCLUSION

Our results from a series of two workshops, interviews, and surveys in a vocational training workshop for people with disabilities indicate that young adults with intellectual disabilities in this sample accept a cobot at their workplace. They respond mainly positively to the robot, expressing joy, interest, and enthusiasm during collaboration. They show no hesitation in performing practical tasks with the collaborative robot. The results indicate that participants have a low negative attitude toward collaborative robots both before and after working with the robot. The cobot can be used in vocational education for assembly, handling, and quality control. However, the use of a cobot comes with challenges, such as the cost, fears, and the identification of suitable users and applications. It is crucial to mitigate these to exhaust the potential of using cobots in workshops for individuals with disabilities. Nonetheless, the benefits are promising: fostering renewal in workshops in alignment with the UN-CRPD, improving workplace ergonomics, expanding employee skill spectra, and adequately preparing employees for the mainstream labor market.

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