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Job Crafting to improve Low-Usability Automation: Sustainability through Human Work Interaction Designs

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Abstract. In industry 4.0 manufacturing, workers experience a variety of old and new automation and adopt and adapt to this automation to the best of their ability. This paper contributes a design case in which we aimed to support workers' job crafting with a four-week, peer-tutoring training program to create sustainable human work interaction designs. The peer-tutoring program facilitated job crafting by training the workers in identifying problems in their work and proposing solutions to these problems. We find that the peer-tutoring program enabled conversations among the workers about recurrent work problems and their solutions. This finding was achieved despite the low experienced usability of the automation in the case company. In terms of job crafting, the workers focused on their enjoyable tasks and invested in their relationships with their favorite colleagues but did not put a lot of effort into seeing their tasks as important and meaningful. We also encountered a tension between job crafting and management's view of the peer-tutoring program as a means of supporting standardization.

Keywords: Job crafting, Digital peer tutoring, Manufacturing, User experience.

1 Introduction

A worker-centric approach to automation is important to the wellbeing of the workforce [1] and hence to socially, economically, and environmentally sustainable work practices [2]. Job crafting promises to deliver *sustainability through design*, that is, to influence workers' (users') decision-making and attitudes to work. Thereby, it will foster more sustainable work-lifestyles [3, 4] and create sustainable human work interaction designs. In the context of this paper, a human work interaction design is an automation situation in manufacturing with a human worker performing work processes using interactive systems. Job crafting supports workers in the bottom-up design of their own work to achieve work engagement [5, 6] and wellbeing [7–9]. By prototyping possible changes in work practices and worker-technology relations, job crafting can be a strategy for empowering the individual worker [10]. In contrast to top-down job design by management, job crafting is often union-supported [7]. It emphasizes workplace innovation over standardization [7] and has received increasing attention in small and medium-sized enterprises (SMEs) challenged by robotics and automation [11]. Job crafting shares some resemblance with notions like job design, job enrichment, and work

customization that all aim to create wellbeing at work [7]. In this study, we report from a manufacturing company with low-usability automation (legacy, non-interoperable stamping machines), in which we aim to foster job crafting with a digital peer-tutoring training program [12]. The low-usability automation, combined with a high demand for digitally skilled workers [13], makes job crafting difficult in this situation. However, such a situation is not unusual because many companies have not designed their automation as a resource that facilitates job crafting [14]. Instead, many manufacturing SMEs use legacy and non-interoperable automation in their factories [11]. The usability of these systems may be quite ordinary [15, 16], though with variations depending on the task, the work shift, the people with whom the task is done, and other situational factors [15]. We ask the research question: *Is job crafting possible in a situation with low-usability manufacturing automation?* Furthermore, we discuss whether the value produced by job crafting in a low-usability manufacturing situation led to sustainability improvements such as a sustainable work life, worker wellbeing, or job engagement.

2 Job crafting

Job crafting can be about self-initiated changes in one's tasks (task crafting), social relationships (relational crafting), perception of one's own job (cognitive crafting), and the time and place of one's work (time-spatial crafting) [7, 8, 17, 18]. A longitudinal meta-analysis of job crafting found that it is, in general, associated with an increase in work engagement [19]. Another meta-analysis confirmed this finding and also found that job crafting had a positive effect on wellbeing [5]. Furthermore, it appears that job crafting is positively related to work performance [20]. The job-crafting literature tends to agree that job crafting is, by definition, a bottom-up activity that happens on the worker's initiative. Thus, job crafting can neither be driven by management, nor can it be imposed as a job requirement [19]. However, job crafting can be encouraged, and it can be facilitated with training.

A meta-analysis has shown that interventions are moderately effective at increasing job crafting, work engagement, and task performance [21]. The interventions tend to take the form of exercises that involve real-life examples, group discussion, and an invitation for participants to formulate their own job-crafting plan [22]. As an example, the Job Crafting Exercise challenges participants to take a step back and think creatively about their jobs in a visual way supported by a booklet [23]. Relatedly, the Job Crafting Intervention is a one-day training session followed by a four-week job-crafting period, during which the job-crafting plans should be put into practice [24]. At the end of the four-week period, the participants attend a reflection session to discuss the outcomes and the implications for their work. The literature appears to suggest that job crafting is related to the workers' personality so that it is mostly proactive workers who engage in job crafting [19, 25]. This finding indicates that job-crafting interventions will benefit proactive workers.

3 Case and approach

This study was part of a regional development project, which aimed to improve the digital capabilities of SMEs in the Capital Region of Denmark through training activities in individual companies. The training activities were tailored to fit the needs and digital capabilities of the individual company and its employees. We were responsible for a digital peer-tutoring training program that aimed to encourage and train workers to share their job-crafting solutions with fellow workers by means of low-fidelity videos recorded with a smartphone or tablet [12]. The videos could describe solutions to operational or collaboration problems, such as how to adjust a collaborative robot, solve an operational problem with a machine, or resolve a coordination issue between two workstations. Digital peer tutoring was designed to support job crafting, but there has also been interest in applying the approach to other types of knowledge sharing, for example instructional videos [12]. The training program was supported by an iPad app with instruction videos, quizzes, and example solution videos. In addition, the iPad was used for recording the videos that were created by the workers during the training program. The training program took four weeks (see Table 1), during which workers studied the material in the app and produced short (1-3 minutes) videos documenting the identification of work problems and the sketching, prototyping, and evaluation of solutions to the problems. Two project assistants facilitated the workers' discussions and video production.

Table 1. Overview of the digital peer-tutoring training program.

Week	Theme	Topics	Worker-created, how-to videos
1	The problem	Personas Interaction Collaboration with tech.	1. A persona 2. An interaction problem 3. A collaboration problem
2	Solution sketch	How to sketch a solution Interaction Collaboration	Three design ideas for 4. Interaction 5. Collaboration
3	Design of prototype	Interaction and collaboration prototypes	6. Elaboration of one design idea into a prototype
4	Evaluation of prototype	How to evaluate prototypes	7. Feedback on the prototype from a colleague

The case company was a Danish SME with around 50 employees. The company produced precision metal components on stamping machines in large series of up to millions of delivered items for a range of sectors, such as pharma, electronics, and automotive. The company's production and quality-assurance processes were ISO certified and, in some cases (pharma), subject to external regulatory requirements. The stamping machines used custom-made tools to cut the products from rolls of metal band that were fed into the machine. Each production worker was responsible for 2-3 machines, including set-up, quality control, and fault correction. The peer-tutoring

program targeted the production workers on the day shift, and the tool smiths who built the cutting tools. We met with the company six times over a six-week period. In Week 0, we explained the digital peer-tutoring program and were introduced to the company, employees, and production facilities. Weeks 1-4 were the training program itself. In Week 5, the program was evaluated. Two researchers, a consultant, and two project assistants participated during Weeks 0 and 5, together with management and workers from the company. The project assistants facilitated the training sessions for the workers during Weeks 1-4.

4 Results

There were 16 participants in the peer-tutoring training program. They had completed 3-4 years' education and training (e.g., as automation technicians, production workers, and tool makers) on top of 9 years of basic education. The participants had worked for an average of 12.8 years (range: 0.3-34) in the case company and had an average of 13.5 years (range: 1.9-30) of experience with the stamping machines.

4.1 Job Crafting Data

The participants were asked to fill out a job-crafting scale at the end of the peer-tutoring program (in Week 5). We used the scale proposed by Wrzesniewski and Dutton [17] and further developed and validated by Niessen, Weseler, and Kostova [8] as our job-crafting scale. It measured self-initiated changes in one's tasks (task crafting), social relationships (relational crafting), and job perception (cognitive crafting). We added three new items (questions) about time-place crafting [7, 18]. The items were translated into Danish and subsequently back-translated to validate the Danish wording of the items. All items were preceded with "So that the job I do suits me…" and rated on a five-point rating scale from 1 (not at all) to 5 (absolutely). We named the enhanced scale the self-oriented job-crafting scale (SO-JCS).

From the theory we would expect a four-factor structure in the data corresponding to the four types of crafting (see Table 2). Indeed, an eigen value of 1 in the Scree plot suggested a four-factor structure that explained 79% of the variance in the data. However, the 12 items did not consistently load on the four factors, possibly due to the few data points. Therefore, we proceed by only discussing those items that loaded highly on the factor that they were expected to load on.

First, for task crafting, Item 3 – the time and effort that a worker put into a task – loaded highly on the factor (.928). The ratings on Item 3 indicated that the workers focused on enjoyable tasks (mean 3.85, SD 0.69). Second, for relational crafting all three items loaded positively on the factor. Item 5 with the highest loading (.955) indicated that the workers invested in relationships with their favorite colleagues to a high degree (mean 3.92, SD 0.76). Third, for cognitive crafting, Item 7 that measured the workers' perceptions of their tasks as important loaded highly (.898) on the factor, but the ratings on Item 7 (mean 3.38, SD 0.65) indicated that the workers did not put much effort into seeing their tasks as important and meaningful. Finally, for time-spatial

crafting, all three items (10, 11, 12) loaded highly on the factor (.865, .809, and .668). These high loadings were somewhat surprising since this factor was home-made. The ratings indicated however only mediocre efforts from workers to design their work so that they worked at their favorite machine (mean 3.00, SD 0.58) and in their favorite room (mean 2.92, SD 0.64); they did more to choose the hours that they worked (mean 3.68, SD 0.63). Overall, the participants tended to do job crafting (mean 3.53, SD 0.68).

Table 2. Job crafting factor structure and wording of items.

Items	**Mean**	**SD**	**SO-JCS factor loadings**			
			Task	Rela-tional	Cogni-tive	Tem-poral-spatial
1. I concentrate on specific tasks.	4.08	0.64		.375		.527
2. I undertake or seek for additional tasks.	3.69	0.63			.838	
3. I work more intensively on tasks I enjoy.	3.85	0.69	.928			
4. I usually limit the amount of time I spend with people I do not get along well with, and only contact them for things that are absolutely necessary.	3.00	0.71		.470	-.806	
5. I invest in relationships with people whom I get along with the best.	3.92	0.76		.955		
6. I look for opportunities to work together with people whom I get along well with at work.	3.85	0.56		.686	.431	
7. I try to look upon the tasks and responsibilities I have at work as having a deeper meaning than is readily apparent.	3.38	0.65			.898	
8. I find personal meaning in my tasks and responsibilities at work.	3.54	0.88	-.681	.485	.359	
9. I view my tasks and responsibilities as being more than just part of my job.	3.46	0.78		.532		-.711
10. I try to be as much as possible at my favorite workplace (machine, workstation)	3.00	0.58				.865
11. I try to be as much as possible at my favorite work location (room, building)	2.92	0.64				.809
12. I actively choose my working hours	3.69	0.63				.668

Note: $N = 13$ participants. The rotated component matrix was constructed to determine what the components represented. The rotation was done with the principal component analysis extraction method, and the rotation method was varimax with Kaiser normalization. The rotation converged in five iterations. The table shows loadings > .3

4.2 SUS Scores

To investigate the participants' experience of the stamping machine, we asked them to rate it at the first and last workshop. Among the instruments for measuring how systems are experienced, we chose the System Usability Scale (SUS) because it is widely used and easy to administer [26]. SUS consists of ten items, which are aggregated into a single score. The SUS items were translated into Danish and back-translated to validate the Danish wording. We also wanted to investigate the participants' experience of the peer-tutoring app. For this purpose, we asked them to give their SUS ratings of the app at every workshop.

With mean SUS scores of 63 (Week 1) and 60 (Week 4), there was no significant change in the participants' experience of the stamping machine, $t(11) = 0.03$, $p = .97$, during the training program. Scores of 60 and 63 are in the lowest quartile of the corpus of SUS scores reported by Bangor et al. [27]. Thus, the participants experienced the stamping machine as a low-usability system. The peer-tutoring app received SUS scores of 59 (Week 1) and 55 (Week 2). SUS scores of this magnitude correspond to a system that is marginally acceptable [27]. In line with this assessment, during the two remaining workshops, the iPad was only used for creating videos; the peer-tutoring concept was instead communicated orally.

4.3 Qualitative Data

We documented all empirical sessions in written notes. This involved the start-up and wrap-up meetings with the participants and management (Weeks 0 and 5) as well as the four peer-tutoring workshops with the participants (Weeks 1 to 4). An additional source of qualitative data was the 76 peer-tutoring videos produced by the participants during Weeks 1 to 4. The qualitative data provided further insights into the effects of the peer-tutoring training program on different aspects of job crafting.

With respect to need identification (Week 1), the participants identified needs specific to concrete persons in other departments as well as needs with more general audiences, such as newcomers to the company. Several of the identified needs involved transferring knowledge from the day shift to the night shift. Currently, some of the machines operated at reduced capacity during night shifts. The CEO learned that the participants had constructive ideas about how to solve many of the identified needs.

With respect to sketching solutions, designing prototypes, and evaluating prototypes (Weeks 2-4), the participants for example sketched how QR codes could solve a production problem by providing ready access to needed information, how 3D images could visualize and simplify a control problem, and how an event-triggered text message from a machine could prevent that it was standing still without anyone noticing. At the same time, the peer-tutoring program made the participants realize how they were important, what special knowledge they held, and how to help each other get their daily work done.

In the wrap-up meeting (Week 5), the workers assessed their production of instructional videos and refresher videos as valuable. The CEO emphasized that the video format helped disseminate knowledge in an approachable and unintimidating manner that reduced the distance among the workers: "*You dethrone them [i.e., the expert workers] when you video their knowledge.*" He particularly appreciated knowledge sharing between day shift workers and the less experienced workers at the night shift. The CEO also expressed interest in using videos instead of written Standard Operating Procedures (SOPs), which were required by certification but difficult to write and read for workers.

According to a development manager, several participants wanted to continue making peer-tutoring videos, but others were not accustomed to making videos and found it awkward to disseminate their knowledge in this medium.

5 Discussion

Our data support that job crafting can be achieved in a manufacturing SME with low-usability automation. With a mean overall job-crafting score of 3.53, the workers in our study were job crafting at about the same level as participants in other studies. For example, Niessen et al. [8] found a mean score of 3.28 in a 466-participant study that did not include time-spatial job crafting and Lazauskaite-Zabielske et al. [28] found a mean time-spatial job-crafting score of 3.4 in a sample of 176 employees in an IT company. Contrary to Niessen et al. [8], the workers in our study did not put a lot of effort into seeing their tasks as important and meaningful. Instead, they focused on their enjoyable tasks and invested in their relationships with their favorite colleagues. Our qualitative data showed that the workers identified needs specific to concrete persons and had constructive ideas about how to solve many of the identified needs. Furthermore, the peer-tutoring program enabled conversations among the workers about the problems and their solutions. In this way, the peer-tutoring program was more like a co-design activity [29] than the training activities provided to support job crafting in other studies [19]. In addition to facilitating the workers' individual job crafting, the peer tutoring also shaped it by encouraging information sharing, such as in the instructional and refresher videos. We contend that the format of the peer-tutoring program helped the workers appreciate that they were producing something of value to themselves, their peers, and the company. These are important elements in achieving sustainability through design [3].

Sustainability through design can be studied at individual, group, and societal levels [3]. A major aim with this study was to evaluate whether the value produced by job crafting in a low-usability manufacturing situation included sustainability improvements such as a more sustainable work life, worker wellbeing, or job engagement. The study outcomes can be interpreted as the result of sustainability through design at the level of the individual worker and at the level of the peer group. First, individual workers co-designed more sustainable ways of working. In addition, the finding that the digital peer-tutoring tool made the workers appreciate that they created something of value could be interpreted as increased job engagement [19]. However, designing a more usable app will be key to the possibilities for easily transferring the peer-tutoring program to other companies. Furthermore, the relation between job crafting and the usability of the automation in the companies is currently not clear. Low-usability automation may increase the need for job crafting, reduce the possibilities for it, or both. Second, at the group/organization level, our findings indicate that manufacturing companies can be supported in further developing sustainable ways of production. There is, however, a caveat to this positive result. While the digital peer-tutoring training program aimed to support shopfloor workers' bottom-up job crafting, it was the CEO's expressed wish to strengthen standardization – including standardization across shifts – by replacing written SOPs with worker-created videos. These opposing aims united to push the outcome of the peer-tutoring training program from sharing creative ideas about changes or improvements toward knowledge sharing about existing jobs, and from worker initiatives toward management plans and strategies. The resulting tension raises questions about how the organizational context influences job crafting

interventions such as the digital peer-tutoring program. If job crafting interventions are interpreted by management as their initiative or as a standardization activity, then the defining feature of job crafting as self-initiated and the related benefits in the form of long-term improvements in worker engagement and well-being [22] may fail to materialize. Designing a digital tool for job crafting interventions should therefore be considered a sociotechnical HCI design that mediates *sustainability through design* by balancing the interests of workers and managers.

6 Conclusion

Overall, this study finds that job crafting is possible in a situation with low-usability manufacturing automation, as evidenced by our quantitative and qualitative data. We contend that the value produced by the job crafting exemplifies how sustainability improvements can be achieved through human work interaction design. The improvements have conceptual, practical, and methodical implications.

Conceptually, the participants' job crafting in the peer-tutoring program focused on improved information sharing and other ways of making work more efficient. This focus aligned well with management interests but also begs the question of how increased efficiency relates to work engagement and wellbeing. Initiatives such as the digital peer-tutoring program may need to address this relation more explicitly to maintain a focus on job crafting. It is for future work to resolve this issue.

Practically, the peer-tutoring program enabled conversations among the staff in the case company about identifying and solving recurrent problems in their work. Other companies may apply the program, provided that the supporting iPad app is revised. Future work should investigate the long-term impact of the program and its integration into organizational processes: Are the prototypes turned into changes in work practices? Does the creation of videos continue? Do the videos engender collaborative discussion among staff? How is a focus on work engagement and wellbeing maintained?

Methodologically, we find that time-spatial crafting is an additional dimension of job crafting, as suggested by [18]. Our three items for gauging time-spatial crafting were well intercorrelated and did not cross-load on the other factors. We consider time-spatial crafting important in manufacturing, where time and place are often to a large extent dictated by machinery, as well as in digital workplaces, where time and place are often more flexible because the work can be distributed and remote.

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