Evaluating a Questionnaire for Contextual Inquiries on Industrial Robot Teaching

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***Abstract*—We present our analysis of a questionnaire that we used for Contextual Inquiries in the context of teaching industrial robots. Our main findings are that open questions are useful for starting the inquiry and should be followed up by closed questions. We also found that emotionally loaded questions are met with caution by the study participants.**

I. Introduction & Background

Industrial contexts are complex settings. Actors in these contexts operate under different and often conflicting conditions, such as maximum output vs. zero-defect. Interfaces are deployed to ease the actors' workload, although, sometimes this implicates adding complexity. In order to maximize the added value of these interfaces, the context and the working routines and conditions need to be thoroughly explored to design the interfaces accordingly. Ethnographic research methods are well-suited to explore contexts on a firsthand basis from a user-centered design perspective. Such methods have proven their feasibility as a valuable tool for gathering a basic understanding of a certain context, as well as to identify user experience factors relevant for that context [1], [2].

In our case, we wanted to explore how robot programmers teach industrial robots with teach panels. We performed *Contextual Inquiries* (CI) [3] in five different production companies to delve into the context and study the working routines of robot teachers and the teach panel usage on site.

The CIs followed the student-teacher principle. Here, the researcher takes on the role of the student who observes the user within the context while performing his/her daily routine of tasks. The user takes on the role of the teacher, as the expert in the domain. By observing and asking questions, it is the task of the researcher to understand the context, tasks, and challenges of the domain expert. The questions are usually asked in a semi-structured interview with a predefined questionnaire. For our semi-structured interview, we used a questionnaire which was previously deployed in the industrial context, but not with robot teaching. It was our aim to validate our questionnaire design for evaluating the usage of teach panels for robot teaching in the industrial context. Although the use cases varied between the companies, the task we observed was, in all cases, the teaching of an industrial robot arm by means of a teach panel. The robot teacher uses a teach panel to navigate the robot arm to specific positions at which the robot has to perform an action, e.g., spot welding. After the teaching is finished, the robot performs the task automatically.

In the following section, we shortly describe the individual CIs we conducted using the questionnaire. Next, we present our semi-structured interview questionnaire. We conclude our paper with discussing the suitability of individual questions and categories of questions for the purpose of exploring robot teaching with a teach panel in the industrial context.

II. Contextual Inquiries

CI	Dur	SP	Robot Task
1	1	3	Robot for grinding weld seam on a window profile
2	2	8	Team of 21 robots for spot welding of car bodies in a production line
3	0.5	1	Robot for inserting and removing a box in/from machine
4	2	3	Robots for fitting hinges into car door and for car body painting
5	1	3	Robot for removing finished pieces from machine

TABLE I
STATISTICS FOR THE CONDUCTED CONTEXTUAL INQUIRIES (**CI**), SHOWING THE DURATION OF CI IN DAYS (**DUR**), NUMBER OF OBSERVED STUDY PARTICIPANTS (**SP**), AND OBSERVED **ROBOT TASK**.

Table I shows the statistics and description of the observed robot tasks for the five CIs we conducted. Overall, we observed 17 study participants with an average age of 29.54 years (sd = 6.80, numbers are from 13 study participants, four study participants did not want to disclose their age). Of the 17 participants, 15 were male and two were female.

III. Questionnaire

We used an existing questionnaire for our semi-structured interview which we previously deployed in CIs in the context of semiconductor fabrication. Since this questionnaire had not been used before to study robot teaching, we adapted the questions slightly to meet the specifications of this context.

The questionnaire consists of 73 questions. For better handling, it is divided in two parts. The first set of 33 questions targets the teach panel, the second set of 40 questions the

teaching process itself. Since the panel and the process are two interwoven elements that are mutually dependent, the division of questions into these two sections is not exactly selective and some questions in the teaching section might also target the teach panel, and vice versa. For data analysis purposes, the questions of both sections are structured into categories. The questions of the teach panel section are presented in these nine categories: pre-experience with robot teaching, emotion, work flow, ergonomics, skills, feedback, teach panel functionality, maintenance, and aesthetics. The teaching process questions are presented in the following 15 categories: pre-experience with robot teaching, emotion, cooperation, work flow, expectations, ergonomics, skills, feedback, awareness, control, trust, safety, perceived intelligence, robot motion speed, and robot motion behavior. Some of the questions are posed in an open format so the user can elaborate (e.g., "What do you expect from a teach panel?"), and some are closed questions (e.g., "Does the teach panel meet your skills?").

IV. Discussion

In this section, we discuss, which questionnaire items were suitable for CIs in the context of industrial robot teaching. This discussion is based on an analysis of all given answers to the questionnaire items over all CIs and the notes that the observers took after each inquiry.

We found that *open questions are especially suitable* for CIs on robot teaching. Questionnaire items such as "What is important for you when you think about a teach panel?" help the observer to start the conversation with the study participant and leaves space for additional and related topics.

Questions about *future improvements of robot teach panels* need to be *used with caution*. People are often caught in their current reality and, as a consequence, their imagination is limited. For example, we found that study participants gave only short answers to "What would you change on the teach panel?" The most common answer was that study participants would like to have a joystick on the teach panel, since they had already seen this feature on other teach panels.

Questions on the *emotions of the robot teacher* (question category *emotion*) are answered only with a short statement, given they are answered at all (e.g., "How does it feel to teach with a teach panel?"). We found that the study participants did not speak a lot about their emotions when they are within their work context. Of course, emotions do play a role at the work place; however, a CI seems to be not an adequate tool for observing emotions in this context. We propose to elicit emotional information when the user is not in the context, for example in a workshop together with a small group of robot teachers. Similarly, we found that *questions that contain an emotional judgement* also did not work as intended, since we received mainly technically oriented answers. Thus, we propose to reformulate these questions without emotional judgement (e.g., "Are you sometimes afraid to break the teach panel?" $\rightarrow$ "Does the teach panel break easily?").

Finally, we found that asking *similar questions* to verify a concept (as it is done in scaling procedures) did *not provide the expected verification*. Instead, the first question was answered in detail (e.g., "What is important for you when you think about a teach panel?"), while the second was not commented on much by the participants (e.g., "What do you expect from a teach panel?"). Some of the closed questions also did not work as intended, since they were specific but nevertheless too imprecise (e.g., "Do you understand the interaction with the teach panel?"). We suggest asking more specific, closed questions (e.g., "Are the error messages understandable?").

Besides the evaluation of the questionnaire items, we also made some general observations. When composing questions for a CI, *researchers do not need to worry that they forget to ask questions* about areas of interest. Our observations show that important topics will be addressed during the CI. For example, almost all study participants reported that the cable connection from the teach panel to the robot control server disturbed their work routines, although we did not prepare a specific questionnaire item for this problem.

A *mix of open- and closed questions* is fruitful for CIs in industrial contexts. Certain closed questions will trigger more elaborated answers by the study participants. We found it helpful to ask closed questions so that they trigger the participant to provide more information (e.g., "Would you change certain keys or buttons on the teach panel?"). Closed questions that leave little space for interpretation, on the other hand, will probably result in simple yes/no answers (e.g., "Are the buttons big enough?"). Such questions are only helpful if the observer has an interest in a very specific topic. Open questions should be asked first and then narrowed down into more specific, closed ones. If the order were reversed, the closed questions will prime the participant's answer on the follow-up open questions.

Finally, questions should be asked so that it is clear that *the teach panel is assessed, but not the participant*. If participants fear that they are being evaluated, it is unlikely that they disclose their ideas for improvement. For example, we found that the question "Does the teach panel meet your skills?" was always answered positively and without much explanation.

Acknowledgment

We gratefully acknowledge the financial support by the Austrian Federal Ministry of Economy, Family and Youth and the National Foundation for Research, Technology and Development (Christian Doppler Laboratory for "Contextual Interfaces").

References

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