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Acceptance of a Tutorial-Creating Authoring System for Work-Based Learning in Industrial Manual Assembly

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Abstract

The article introduces a workshop for formally non-qualified persons aiming competence development and certification of skills and knowledge in manual assembly. Within the workshop, participants set up a workplace, define a work process and use authoring systems to create tutorials of an industrial assembly process. While filming, the tutorial creation process facilitates the target group to reflect the working process and to confront them with decision-making problems when optimizing details. In fact, the authoring system serves as an overlaying work-based reflection process. However, current research does not cover acceptance studies of authoring systems for this target group in this domain. Therefore, the study evaluates technology acceptance of an iPad-based authoring system with the help of a translated UTAUT questionnaire in context of industrial manufacturing. In the end, the article discusses the outcomes in view of the fact that several limitations may skew them.

Keywords

vocational education; German further education system; manual assembly; authoring system

1 Introduction

All manufacturing branches face trends of digitalization that can shift nowadays business models of small and medium-sized enterprises (SME) in Germany (Müller, 2019). One can observe efforts in digital enhancements and assistance, not only for tasks, operations and processes in manual assembly (e.g. Petruck et al., 2019), but also in learning (e.g. European Commission, 2018).

Work-based learning is a useful method to foster learning in the work process (Ellström, 2001, 2006; European Training Foundation, 2013). A contemporary approach (Goppold, Braun, Gerschner, & Frenz, in press) uses tutorial creation as an assisting method for reflecting

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and learning work processes in manual assembly (cf. Nyhuis & Wiendahl, 2012). When thinking about information and communication technologies (ICT) as an additional device for learning in a main work process, one has to ensure that ICT do not distract the main work process and the overlaying learning process. Therefore, the study collects user acceptance data within a selected target group in order to investigate whether ICT deliver help for learning or are one further obstacle.

1.1 Target group

Many employees working in manual assembly classify as formally non-qualified and process an increasing number of tasks in manual assembly (e.g. Gerschner, Molitor, & Frenz, 2017). These employees have rarely received vocational education and training (e.g. Kondrup, 2015). According to that, personnel in manual assembly are a heterogeneous target group.

Today, employees need to be qualified in dealing with challenges of digital transformation. Therefore, formally non-qualified employees in manual assembly need support and training in the field of digitalized work processes as well as changes in manual assembly technology. Trainings have to face with the fact that frequently customers are not participants in the training. Employers send their personnel and choose trainings.

1.2 Workshop concept

The study develops a SME based continuing vocational training to promote this diversified target group by tutorial creation in manual assembly. The main concept refers on constructivist didactics (e.g. Chisholm, 2012), which focuses especially on individual, interactive self-oriented learning processes that build upon existing competences and creativity. Thus, learning tasks consist of problems that enrich and upgrade participant's existing competences including new and unknown questions. Work-based learning settings enable to encourage learning of problem solving in professional environment. The didactic framework incorporates the learning field concept as standard approach in vocational education and training in Germany (cf. Kulturministerkonferenz, 2017) including reflexive handling competence (cf. Dehnbostel, 2005) as didactic goal. Furthermore, fostering of basic digital skills for manufacturing professions is an additional goal.

Developing a curriculum for highly diversified target groups uses a competence categorization of manual assembly occupations based on work-studies of Gerschner et al. (2017). Analysing manual assembly work processes enables to formulate competence level-dependent curriculum descriptions for manual assembly tasks. All curriculum descriptions fit into European Qualification Framework (European Parliament & European Council, 2017) and exist for EQF levels 1, 2 and 3. For a compatibility of competence models, integrated basic digital skills in the training rest mainly upon DigComp 2.1 (Carretero, Cuorikan, & Punie, 2017).

Detailing the training concept, the authors rely on modern interpretations of authoring systems such as Wiemer (2015) or Schröder (2014) suggest. These differ from known definitions of authoring systems or authoring tools such as those found in Locatis and Al-Nuaim (1999), Hand (2012), Ritter and Blessing (1998) or Ayub, Venugopal, and Nor (2005). When using authoring systems, learners become authors of learning material, for instance tutorials. Authoring systems complement operational tasks in manual assembly training situations well, because they consist of similar structures. To be an author, one needs process structuring skills that enable to derive singular, (non-)linear tasks from complex work processes comparable to industry-leading standards (cf. Schulmeister, 2007; DIN e. V., 2015; Deming, 2018). Therefore, the training concept adapts basic methods of authoring systems to utilize synergies with manual assembly processes. Within the training, participants describe and analyze their own work processes by producing learning tutorial videos. The tutorial creation hints at optimization potentials and structural problems in assembly processes. Participants identify them in the work process while filming or in the postproduction. Authoring systems help triggering different optimizations on work and assembly processes during the training, which root for example in economics (e.g. Atkinson, 1999) or ergonomics (Luczak, Volpert, Raeithel, & Schwier, 1987). Fundamentally, the authoring system serves as a work-parallel overlay to foster a reflection process.

1.3 Workshop implementation and authoring system description

The training implementation has taken place in a research and manufacturing plant environment of Demonstrationsfabrik Aachen (DFA). Participants assemble parts of an electric go-cart's front axle. DFA's plant provides multiple assembly process assistant systems for this process and produces karts as a supplier for e-go Mobile AG. This work process suits well for work-based learning in manual assembly, because it contains the most common joining technologies and is directly situated on the shop floor in the production line.

Within the training, participants describe and analyze their own work processes, by producing learning tutorials videos with the aid of iPads. Video production will use the recording app Filmic Pro (FiLMiC Inc., 2018), because it was the most functional app in a pre-test on a shop floor. For post-production, the iMovie app (Apple Inc., 2018a) completes the video production setup due to its resilience and reliability. When simulating an online situation, all data such as technical drawings are stored in a cloud solution as a pdf file. For training without internet connection, these files are stored in the internal storage of each iPad tablet. Apple's standard viewer and the app Pages (Apple Inc., 2018b) are in use for accessing and editing pdf files. Using a general setup, participants learn extracting the learning tutorials from one closed software system, iOS, in order to load and save it in a knowledge management system. For simulating a knowledge management system with administration and storage systematics, the authors use cloud storage within the sciebo tool (Sync & Share NRW, 2018).

1.4 Research questions

In literature, you cannot find studies that cope with the acceptance of a similar technical system in a comparable use case. In order to evaluate the acceptance of a tablet computer-based multi-application system in a work-based vocational training concept, there exist the following research questions:
How much technology acceptance of digital learning media exists within the target group of formally non-qualified employees in manual assembly?
Are there differences within sub-groups of the target group?

2 Methodology

Referring on the research questions, the study needs to conduct technology acceptance research on the application of the tablet computer setup processes on the shop floor of manual assembly work places. The study complements the holistic workshop evaluation concept on Kirkpatricks' and Kirkpatrick's (2005) bottom level.

The study refers to the commonly known technology acceptance model UTAUT by Venkatesh, Moris, and Davis (2003). The UTAUT model has its roots as its previous version TAM (Davis, Bagozzi, & Warshaw, 1989) in the theory of reasoned action (cf. Fishbein & Ajzen, 1975) and theory of planned behavior (cf. Ajzen, 1985). The UTAUT model generalizes empirically validated research findings of TAM and multiple other models (Venkatesh et al., 2003). Venkatesh et al. (2003) validate their model with two pilot studies and afterwards meta-studies confirm the model (e.g. Dwivedi, Rana, Chen, & Williams, 2011; Khechine, Lakhal, & Ndjambou, 2016;).

To measure technology acceptance, the authors choose the UTAUT questionnaire (Venkatesh et al., 2003) and translate its items into German language. Afterwards, there is a double check within multiple translations variations and a reference translation. A cross-validation with another translation by Vollmer (2015) confirms the effort. On top of that, a heterogeneous target group requires pre-testing, that establishes with three students and six members of the target group that do not speak German as mother tongue.

3 Results

First of all, pre-testing suggests to exclude two scales due to unsolvable understanding problems of multiple items. Especially in the “attitude toward using technology” and “anxiety” scales, the target group is not able to differ the meanings of the items (cf. Venkatesh et al., 2003). Even further declarations and explanation has not enhanced and improved their understanding issues within these scales. Therefore, the scales exclude completely from the main study.

3.1 Demography

41 out of 48 workshop participants who filled out the UTAUT questionnaire stated demographical details. In the whole sample, the mean age was 30.8, with a wide range between 17 and 56. Most were male (95%) and about half of the group had a mother tongue different from German (48%). Based on their current biographical activity, the target group subdivides into the groups of labour market, vocational school and manufacturing enterprise. The three groups differed especially regarding their age, and to a lesser extent to their mother tongue (see table 1 for detailed results).

Table 1 Demographic characteristics of the participants

	Total	Labour market	Manufacturing	School
n	41	19	10	12
Age				
Mean	30.8	39.7	27.3	18.5
SD	13.3	11.8	10.6	1.2
Minimum	17	19	17	17
Maximum	56	56	44	20
Gender				
Male	39	17	10	12
Female	2	2	0	0
Mother tongue				
German	16	9	8	2
Another language	19	7	1	8
German + another language	5	2	1	2

3.2 Prior experience

In order to better interpret the technology acceptance results, the study investigates items concerning participant's prior experience beforehand. The majority reported to be privately interested in technology (85%), having used an iPhone or iPad within the last 5 years (63%) and to be skilled or an expert with smartphones/tablets (69%). However, just about half of the group stated to be skilled or an expert with understanding technical drawings (51%). Only a small part (27%) had already written a screenplay/storyboard. Table 2 reports more details about group differences that appear to be rather small descriptively.

Table 2 Prior experience with technology

	Total		Labour market		Manufacturing		School	
	n	%	n	%	n	%	n	%
Privat interest for technology								
yes	35	85%	18	95%	6	60%	11	92%
no	6	15%	1	5%	4	40%	1	8%
Use of iPhone or iPad within in the last 5 years								
yes	26	63%	10	53%	7	70%	9	75%
no	15	37%	9	47%	3	30%	3	25%
Experience with smartphone/ tablet								
expert	8	20%	2	11%	3	30%	3	25%
skilled	16	39%	7	37%	3	30%	6	50%
rather inexperienced	14	34%	9	47%	3	30%	2	17%
absolutely inexperienced	3	7%	1	5%	1	10%	1	8%
Understanding of technical drawings								
expert	7	17%	3	16%	3	30%	1	8%
skilled	14	34%	7	37%	3	30%	4	33%
rather inexperienced	13	32%	5	26%	2	20%	6	50%
absolutely inexperienced	7	17%	4	21%	2	20%	1	8%
Writing a screenplay/ storyboard								
yes	11	27%	4	21%	3	30%	4	33%
no	30	73%	15	79%	7	70%	8	67%

3.3 Reliabilities

Regarding the scales, all showed good reliabilities of .75 and above, except facilitating conditions (α=.66). Table 3 illustrates the results.

Table 3 Scales for General Technology Acceptance: Reliability and Means

	Total			Labour Market		Manufacturing		School	
	Reliability	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Self-efficacy	0.75	47	3.9 (0.9)	19	3.8 (0.9)	10	3.7 (1.3)	13	4.2 (0.4)
Behavioral Intention to use the System	0.88	46	3.2 (1.3)	18	3.3 (1.5)	10	3.0 (1.4)	13	3.3 (1.4)
Facilitating Conditions	0.66	47	4.0 (0.9)	19	3.8 (0.8)	10	3.7 (1.1)	13	4.4 (0.7)
Effort Expectancy	0.87	48	4.3 (0.8)	19	4.4 (0.7)	10	4.1 (1.0)	13	4.2 (0.9)
Social Influence	0.86	42	3.5 (1.1)	16	3.4 (1.4)	8	3.3 (1.0)	13	3.5 (1.0)
Performance Expectancy	0.75	47	3.9 (0.9)	19	4.1 (0.7)	9	3.5 (1.1)	13	3.7 (1.0)

3.4 General technology acceptance

In total, 48 participants answer questions about their technology acceptance. All item means are in a range between Mean=3.1 (BI2) to Mean=4.4 (EOU4), and standard deviations move between SD=0.8 (PEU6) and SD=1.5 (BI1, BI2 and BI3).

The scale means are in a comparable range, with the “Behavioural Intention to use the System” as the minimum (Mean=3.2) and “Effort Expectancy” as the maximum (Mean=4.3). Table 4 reports the detailed results.

Table 4 Items for General Technology Acceptance: Means

	Total		Labour Market		Manufacturing		School	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Perceived Usefulness	48	4.3 (1.1)	19	4.6 (0.5)	10	4.0 (1.4)	13	4.1 (1.4)
Relative Advantage 1	47	4.1 (1.0)	19	4.3 (0.7)	9	3.6 (1.2)	13	4.2 (1.3)
Relative Advantage 5	47	3.9 (1.1)	19	4.5 (0.6)	9	3.3 (1.7)	13	3.5 (1.0)
Outcome Expectations 7	45	3.2 (1.3)	17	3.1 (1.5)	9	3.3 (1.3)	13	3.1 (1.1)
Perceived Ease of Use 3	48	4.2 (1.0)	19	4.4 (0.8)	10	3.8 (1.1)	13	3.9 (1.3)
Perceived Ease of Use 5	48	4.2 (1.0)	19	4.4 (0.8)	10	4.1 (1.3)	13	4.1 (1.1)
Perceived Ease of Use 6	48	4.4 (0.8)	19	4.4 (0.8)	10	4.4 (1.1)	13	4.5 (0.7)
Perceived Ease of Use 4	48	4.3 (0.9)	19	4.4 (0.7)	10	3.9 (1.4)	13	4.3 (0.9)
Subjective Norm 1	46	3.4 (1.3)	17	3.4 (1.5)	10	3.4 (1.4)	13	3.1 (1.1)
Subjective Norm 2	45	3.5 (1.4)	17	3.6 (1.5)	9	3.7 (1.2)	13	3.2 (1.5)
Social Factors 2	42	3.5 (1.4)	16	3.2 (1.5)	8	3.3 (1.6)	13	3.8 (1.4)
Social Factors 4	43	3.7 (1.2)	17	3.5 (1.5)	9	3.2 (1.3)	12	4.2 (0.9)
Perceived Behavioral Control 2	44	3.9 (1.2)	18	3.8 (1.4)	9	3.7 (1.4)	12	4.0 (1.0)
Perceived Behavioral Control 3	47	4.2 (1.0)	19	4.3 (0.9)	10	4.0 (1.4)	13	4.4 (1.1)
Perceived Behavioral Control 5	46	3.5 (1.4)	18	3.3 (1.3)	10	3.6 (1.6)	13	4.2 (0.8)
Facilitating Conditions 3	46	4.1 (1.1)	18	4.0 (1.1)	10	3.4 (1.4)	13	4.8 (0.6)
Self-efficacy 1	47	4.0 (1.2)	19	4.0 (1.3)	10	3.7 (1.4)	13	3.9 (1.1)
Self-efficacy 4	47	4.1 (1.2)	19	3.9 (1.6)	10	3.9 (1.3)	13	4.4 (0.7)
Self-efficacy 6	45	3.9 (1.2)	17	3.7 (1.4)	10	3.8 (1.4)	13	4.1 (0.8)
Self-efficacy 7	47	3.9 (1.1)	19	3.8 (1.2)	10	3.4 (1.4)	13	4.3 (0.6)
Behavioral Intention to use the System 1	47	3.4 (1.5)	19	3.3 (1.6)	10	3.7 (1.4)	13	3.2 (1.4)
Behavioral Intention to use the System 2	46	3.1 (1.5)	18	3.3 (1.6)	10	2.6 (1.7)	13	3.3 (1.4)
Behavioral Intention to use the System 3	46	3.1 (1.5)	18	3.3 (1.4)	10	2.7 (1.6)	13	3.4 (1.5)

3.5 Group differences

Because the one-way ANOVA is less robust against violations against variance homogeneity in case of unequal sample sizes across the groups, we used the Welch-Test to find out whether the groups differed in their technology acceptance.

Only two items revealed significant patterns: RA5 (F_W (2, 15.73) = 5.89, $p<.05$) and FC3 (F_W (2, 19.47) = 6.95, $p<.01$), indicating that at least two out of three groups differed significantly.

Table 5 Welch-test for group differences

	Welch-Test	Significance
Self-efficacy	Fw(2, 19.27) = 1.37	p= .28
Behavioral Intention to use the System	Fw(2, 22.69) = 0.21	p= .81
Facilitating Conditions	Fw(2, 20.87) = 2.52	p= .10
Effort Expectancy	Fw(2, 19.29) = 0.59	p= .56
Social Influence	Fw(2, 19.73) = 0.10	p= .90
Performance Expectancy	Fw(2, 17.06) = 1.73	p= .21
Perceived Usefulness	Fw(2, 15.60) = 1.35	p= .29
Relative Advantage 1	Fw(2, 15.93) = 1.25	p= .31
Relative Advantage 5	Fw(2, 15.73) = 5.89	p= .01
Outcome Expectations 7	Fw(2, 20.62) = 0.14	p= .87
Perceived Ease of Use 3	Fw(2, 18.76) = 1.35	p= .28
Perceived Ease of Use 5	Fw(2, 18.65) = 0.59	p= .56
Perceived Ease of Use 6	Fw(2, 20.53) = 0.13	p= .88
Perceived Ease of Use 4	Fw(2, 18.45) = 0.58	p= .57
Subjective Norm 1	Fw(2, 21.97) = 0.30	p= .74
Subjective Norm 2	Fw(2, 21.72) = 0.46	p= .64
Social Factors 2	Fw(2, 18.10) = 0.64	p= .54
Social Factors 4	Fw(2, 19.96) = 2.03	p= .16
Perceived Behavioral Control 2	Fw(2, 19.72) = 0.23	p= .79
Perceived Behavioral Control 3	Fw(2, 19.13) = 0.24	p= .79
Perceived Behavioral Control 5	Fw(2, 20.63) = 3.08	p= .07
Facilitating Conditions 3	Fw(2, 19.47) = 6.95	p= .01
Self-efficacy 1	Fw(2, 21.83) = 0.15	p= .86
Self-efficacy 4	Fw(2, 20.69) = 1.10	p= .35
Self-efficacy 6	Fw(2, 20.47) = 0.48	p= .63
Self-efficacy 7	Fw(2, 20.24) = 2.47	p= .11
Behavioral Intention to use the System 1	Fw(2, 22.83) = 0.36	p= .70
Behavioral Intention to use the System 2	Fw(2, 21.77) = 0.69	p= .51
Behavioral Intention to use the System 3	Fw(2, 21.35) = 0.57	p= .57

4 Discussion

4.1 Results

In order to answer the first research question – the degree of technology acceptance within the given sample – it is most helpful to look at the scale means: First, it becomes evident that all means are above "neutral", indicating that the average attitude is closer to positive than negative. Further, except the behavioural intention, the means are all closer to "rather agree" than "neutral", showing that the technology acceptance is generally high.

Moreover, it seems that no major problems exist concerning the system itself, as effort expectancy – which contains system attributes such as clear, easy, understandable – are not far away from the highest rating. This can be explained by the finding that most participants stated to be familiar with technology beforehand.

However, participants appear to be rather neutral towards actually using the system (behavioural intention towards the system), with a relatively big gap to effort expectancy. A possible explanation for this finding is the result for social support, indicating that they feel low support from the colleagues/management/organization to use the system.

To summarize, the results for the degree of technology acceptance are satisfying, as attitudes generally seem to be positive. However, despite the apparently given abilities (effort expectancy) and resources (facilitating conditions), the intention to use the system is comparably small. This suggests that the social component should not be underestimated, e.g. negative colleagues could potentially stop the actual use of a system.

Regarding the second research question – the degree of technology acceptance differences between groups – only few conclusions can be made. They only displayed differences in two items, namely relative advantage 5 ("Using the system increases my productivity.") and FC3 ("A specific person (or group) is available for assistance with system difficulties."). The descriptive results indicate that the labour market group believed more than the other groups that the system would increase their productivity and that the school group rather assumed assistance in case of system difficulties.

This suggests that the labour market offers the best opportunities for higher productivity levels through the system. An explanation for the other significant result might be that the pupils have a particular person – e.g. a teacher – in mind who seems to be especially supportive.

4.2 Method

Despite these promising results, the study faces some limitations: On the one hand, the setting might have caused problems. As the participation in the labour market group was rather voluntary than in the other groups, there could have been a sampling effect, leading to more motivated participants in this group. On top of that, there could have been a bias effect within the labour market group, because only motivated participants have shown up on site.

Whereas the study has taken place in a real laboratory for the labour market and school group, it was a field study for the manufacturing group in their well-known workplace. This lead to a different focus of the workshop that tilts towards the tutorial creation part. Consequently, the internal and external validity of the results between the groups differs.

In total, the heterogeneous target group held individuals with a variety of attitudes towards questionnaires due to cultural biases and comprehension of all items. Therefore, the study carries a risk that the results do not cover their intentions.

Next to these points concerning the setting and the sample, some statistical issues might have caused problems: In general, the sample size has been small. Consequently, the mean values have to be regarded cautiously. Because of even smaller sample sizes within the groups, the statistical detection of potential differences has been low in order to answer the second research question. However, descriptive group differences were small anyway. Thus, the missing significances must not have been necessary due to the sample sizes.

The two significant Welch-tests also have to be viewed carefully: Because 29 tests were conducted, the probability of a few significant results just by chance are quite high. On the other hand, these were highly significant, which is much more convincing in this case than significance at the 5%-level.

5 Conclusion

Overall, the investigation of technology acceptance of authoring systems in workshops in industrial manual assembly has been successfully. In general, the use of UTAUT technology acceptance methodology and obtained data face different obstacles and biases in the field of application and within the target group. Nevertheless, the results suggest a good technology acceptance of the incorporated authoring system for tutorial creation.

The study identifies the overlay use of authoring systems for vocational work processes as promising and accepted approach to conduct further research. One alternative is a broader use case scenario within manufacturing industry incorporation physical operations and mental work occupations. Additionally, a transfer to vocational teacher education could help when reflecting explorations of work processes in didactic courses and offer at the same time one teaching method.

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