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Predicting Digital Accessibility Through a Self-Assessment Test of Process Traits

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Abstract. We have developed an 11-question self-assessment test that predicts whether a team is likely to develop accessible digital solutions – or not – based on the characteristics of the development processes. Our results indicate the test can predict both successes and failures with regards to accessibility of digital solutions. As such, teams and product leaders now have an easy way to identify whether the team's knowledge, practices and mindset makes them likely to deliver accessible digital solutions. Further, the test identify which changes are needed for the team to better ensure digital accessibility.

Keywords. Accessibility, Self-assessment test, Universal design, Agile software development, Best practice.

1. Introduction

Current legislation on universal design of ICT is mainly concerned with technical accessibility and tells you *what* to achieve – but not *how*. Lazar, Goldstein and Taylor [1] point out that a shortcoming in accessibility regulations is they leave out organizational aspects like enforcing the implementation of compliance monitoring and process guidelines. According to Fuglerud and Sloan [2], there is a heavy focus on adhering to the regulations and standards set forth by the legislations while there is a lack of emphasis on the development process. This article is focused on the practices within development processes of digital solutions who are being acclaimed for achieving accessibility. The paper presents an effort to identify and communicate their common key characteristics – thus supporting teams in implementing practices that will better ensure the development of accessible digital solutions. We ask the following research questions:

1. What are the key characteristics of the development processes of digital solutions that achieve accessibility?
2. Can these key characteristics help predict whether a team is likely to develop accessible digital solutions?

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2. Research Approach and Results

Our research is a qualitative, empirical, and exploratory case study. This is appropriate for studies seeking to understand how people interpret their experiences and insights into informal, unstructured and complex practices in organizations [3,4]. The research is divided into two parts. The first part is focused on providing insight into practices from Norwegian ICT-projects having successfully achieved universal design or accessibility. The first research focus is thus on investigating which practices should be implemented to achieve accessibility. The second part explores the possibilities of indicating the likelihood of achieving accessibility. This part suggests a predictive self-evaluation tool specific for UD in IT-projects. The self-assessment tool is based on a feature analysis of the findings in part one. Through prototyping an evaluation tool measuring the compliance of ICT-projects to our identified success factors, the ability to predict success is explored. Finally, the study tests the suggested self-evaluation tool to tentatively confirm or refute initial validity.

2.1. Interview Study to Identify Key Characteristics

To answer the first research question, we identified a set of creditable awards related to accessibility and universal design. It should be noted that the criteria differ between the awards, but all include accessibility as one of several central criteria. For each award, we identified digital solutions that had either won the award, or received an honorable mention or were a runner-up. Some solutions received more than one award. To make the selection criteria more transparent, an overview of the identified awards (from 2010-2017) is presented in Table 1. Two awards remain unnamed, due to traceability concerns.

Table 1. Awards from which included digital solutions winning/receiving honorable mentions are sampled

Award	Distributor	Digital solutions sampled
Public Website of the Year, Online Quality	DIFI	6
Badge for Good Design	DOGA	6
Innovation Award for Universal Design	DOGA	5
Design for All Award	DOGA/Delta Center	3
Farmand Award	Farmand AS	3
Digital Service of the Year, Online Quality	DIFI	1
Unnamed: Young design	-	1
Unnamed: International	-	1

Next, we identified individuals having a direct affiliation with the development of a digital solution winning these awards or receiving honorable mentions and reached out to them to ask for participation in a semi-structured in-depth interview. The informants consisted of 15 designers, 9 developers (front- and back-end), 2 project managers, 2 creative directors and 3 advisors; 1 senior UD advisor with developer background, 1 web advisor and 1 communication advisor. We asked all respondents what characterized their development processes while simultaneously allowing for follow-up questions [5]. Interviews were recorded and transcribed verbatim.

An initial sample included 13 participants affiliated with 12 digital solutions [6]. A thematic content analysis was used for emergent coding. Because of overlapping responses to the open-ended questions, transcripts were analyzed as a continuous text, as opposed to questions consecutively. Researcher 1 identified 103 unique codes regarding characteristics: 75 promoting and 28 obstructing and Researcher 2 identified 104 codes, 75 promoting and 29 obstructing. Inter-coder reliability was calculated, with a 98 %

overlap between the 150 promoting codes and 95 % overlap between the 57 obstructing codes [7]. The sample was increased to make findings more statistically significant. We added 18 additional participants from 9 digital solutions – totaling up to data from the development of 21 accessible solutions. Before treating all the data as belonging to the same sample, empirical background data was converted from semantic to numeric to check for significant differences between the first 13 and the subsequent 18 participants. As most variables were at nominal level, Pearsons Chi-Square was used, and no statistical differences were found. The expanded data set of transcriptions is analyzed using a directed content analysis approach [8].

The goal of qualitative content analysis is recognition of significant themes and categories within a body of content through careful coding and interpretation [9]. The directed approach does not use a strict a-priori coding scheme or a fully emergent approach. Instead, a-priori codes and categories described in [6] are used as a basis while still allowing new codes or categories to emerge. Only minor changes to coding were done based on the expanded sample (7 new codes added, 3 obstructing and 4 promoting). As the data increased, the transcripts were imported into the NVivo program, linking relevant transcript sections to categories (nodes).

Our thematic analysis of this qualitative data set identifies 86 characteristics described as promoting or obstructing accessibility. An interesting observation is that promoting and obstructing characteristics seem connected, where obstructing factors may be viewed as missing promoting factors. The characteristics were categorized across four categories: Societal, Organizational, Processual and Personal (see Figure 1) with 22 subcategories (12 promoting and 10 obstructing) and 45 sub-subcategories.

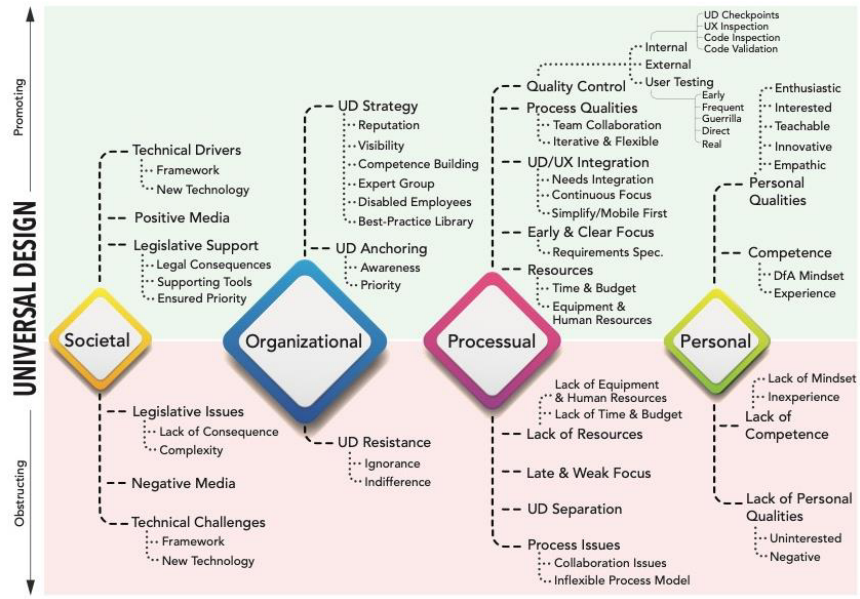

Figure 1. Characteristics of processes achieving accessibility.

Key characteristics were identified by looking at the *frequency of mentions* of each characteristic in the interview transcripts. To be as precise as possible, a key characteristic was always set on the lowest possible category-level reaching the threshold. If a sub-subcategory reaches the threshold, it is a key characteristic. If not, but its

subcategory reaches the threshold, the subcategory is a key characteristic. The threshold was set at a characteristic being coded more than 50 times in the data set *as well as* mentioned by at least 2/3 of the participants. This resulted in 15 key characteristics (see Table 2).

Table 2. Key characteristics for ensuring accessibility in the development of digital solutions

Key Characteristic (category)	Description
Legislative support (societal)	Legal consequences in place; supporting how-to tools.
Awareness (organizational)	Management levels understand and are aware.
Priority (organizational)	Positive culture, not resistance to accessibility efforts.
Competence building (organizational)	Strategic; to ensure universal design/accessibility how-to.
Requirement specification (Processual)	Early and clear focus on accessibility/universal design.
UX-needs integration (Processual)	Integrating accessibility as part of user needs/usability.
Continuous focus (Processual)	Continuous low-cost accessibility/usability testing.
User Testing (Processual)	Early and frequent, direct feedback from real users.
Internal quality control (Processual)	Early and frequent inspections of code/design/content.
Team Collaboration (Processual)	Cross-disciplinary quality discussions & (user) testing.
Time & Budget resources (Processual)	Enough time and economic resources to not obstruct.
Equipment & Human resources (Processual)	Available test-equipment, users and test support.
Design for All competence (Personal)	Experience; Knowledgeable, Design for all Mindset
Enthusiastic (Personal)	At least one person on the team enthusiastic.
Interested (Personal)	Not negativity or lack of interest to contribute/cooperate.

2.2. From Key Characteristics to a Predicting Self-Assessment Test

Inspired by the PEVS tool for project evaluation [10] a self-assessment test was iteratively developed and tested to explore if the 15 key characteristics could help predict whether a team is likely to develop accessible digital solutions based on process traits.

2.2.1. Assessment Scores for the Sampled Accessible Solutions

The final self-assessment test had a minimum score of 0 and a maximum score of 18. An initial assessment of the test's validity was conducted by the authors, scoring the sampled accessible solutions' process characteristics based on transcribed interview data. This yielded scores from 12-17 points, with an average of 14.3 points (see Table 3), which indicated internal validity [14]. Some transcripts cover several solutions, and as it was unclear which solutions were referred to, these were assessed as one.

Table 3. Assessment scores for the transcribed accessible solutions development

Solution	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score
1	2	2	1	1	1	2	2	1	1	1	0	14
2	2	2	2	2	2	1	1	0	1	1	1	15
3	1	2	2	1	1	1	2	1	0	1	1	13
4,8,9,21	1	2	1	2	2	1	2	0	1	1	1	14
5,11	1	2	1	2	1	2	2	0	1	1	1	14
6,7	1	2	0	2	2	2	2	0	0	1	0	12
8	1	2	2	1	1	2	1	0	1	1	0	12
10	1	2	0	1	2	2	1	0	1	1	1	12
1,12	1	2	2	2	2	2	2	1	1	1	1	17
13	2	2	2	2	2	1	1	0	0	1	1	14
14	2	2	2	2	2	2	1	1	1	1	1	17
15	2	2	1	1	2	2	2	1	1	0	1	15
16	2	2	2	1	2	2	2	0	0	1	1	12
17,18	2	2	2	1	2	2	1	1	1	0	1	15
19	1	2	1	2	2	1	2	1	1	0	1	14
20	2	2	2	2	2	2	1	0	1	1	1	16
Average												*14.3*

2.2.2. Self-Assessment Scores for Low/Inaccessible Solutions

Also, we investigated whether low/in-accessible solutions may lead to low test scores. We now move from researchers assessing the test against transcribed data, to participants self-assessing their own development processes. We formulate the following inclusion criteria for participation as an assessor: 1) you were involved in the development process or accessibility efforts (e.g. as a designer, developer or project manager) of 2) a digital solution that has received negative press coverage for lacking accessibility.

Using personal connections, 20 potential assessors were identified within a private company, that had recently received a negative accessibility review by Funka. Funka is a reputable company specialized in accessibility evolutions. The potential assessors were contacted by email and asked to participate in the study, assessing their projects in retrospect using our self-assessment tool and return these per e-mail along with any comments. E-mail was chosen for convenience, to be less invasive and increased likelihood of participation. 12 assessors returned assessments for 10 low/inaccessible solutions. Returned scores were from 2-11 points, averaging at 5.25 points (see Table 4).

Table 4. Self-assessment e-mail scores for low/inaccessible solutions development

Solution	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score
A	1	1	0	1	0	1	2	0	0	1	0	7
B	0	2	0	0	0	0	2	0	1	0	0	5
C	1	1	0	1	0	0	1	0	0	0	0	4
D	0	2	0	1	0	0	1	0	0	0	0	4
D	0	1	1	1	0	0	2	0	0	0	0	5
E	1	2	1	2	2	0	2	0	1	0	0	11
F	0	0	0	1	0	0	1	0	0	0	0	2
G	1	2	0	1	0	1	2	0	0	1	0	8
G	0	2	0	1	0	0	2	0	0	0	0	5
H	1	2	0	0	0	0	2	0	0	0	0	5
I	1	0	0	0	0	0	2	0	0	0	0	3
J	1	2	0	1	1	0	0	0	0	0	0	5
Average												*5.25*

Table 5. Self-assessment phone interview scores for accessible solutions development

Solution	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score
1	2	2	0	2	1	1	2	0	1	1	1	13
1	2	2	2	2	2	2	2	1	1	1	1	18
1	1	2	2	1	1	1	2	0	1	1	0	12
2	2	2	2	1	2	1	2	0	1	1	1	15
3	2	2	2	2	1	1	2	1	1	1	0	15
3	1	2	1	2	1	2	2	1	1	1	1	15
4	2	2	1	2	2	1	2	0	1	1	0	14
6	2	2	2	1	2	0	2	0	0	1	0	12
7	2	2	2	1	2	0	2	0	0	1	0	12
8	1	2	0	2	1	0	0	0	1	0	0	7
8	2	2	0	2	2	1	2	1	1	1	0	14
9	2	2	2	2	2	2	2	1	1	1	1	18
12	1	2	0	2	1	0	1	0	0	1	0	8
13	2	2	2	2	2	2	2	1	1	1	1	18
14	2	2	0	2	1	1	2	1	0	1	1	13
15	2	2	1	1	2	2	2	1	1	1	0	15
15	2	2	2	2	2	0	2	1	1	1	0	15
16	2	2	1	2	1	2	2	0	1	1	1	15
20	2	2	2	2	2	2	2	1	1	1	1	18
24	2	2	2	2	2	1	2	1	1	1	1	17
Average												*14.2*

2.2.3. Self-Assessment Scores for Accessible Solutions

Furthermore, we investigated how participants having developed accessible solutions self-assess and score their own processes. First, as a trial run a focus group interview was set up with new winners of the previously identified awards. This added 2 solutions and 3 participants to the existing sample. The interview was transcribed, added to NVivo and coded using directed content analysis. The insight aligned well with the codes and categories and did not change which characteristics are considered key. The focus group ended with self-assessment tests, giving the scores: 7 (solution 22) and 14 (solution 23).

Finally, we investigated how participants in the interview study self-assessed and scored the processes which lead to accessible solutions. This was done by phone interviews with previous participants. Phone interviews balanced convenience better than focus groups, while still providing the opportunity to ask their opinions about the usefulness of the test. 16 participants were interviewed via phone, giving 20 assessments for 14 accessible digital solutions (of which 13 already in the sample, while one new fulfilling the inclusion criteria was added). Scores ranged from 7-18 points, averaging at 14.2 (see Table 5).

Self-Assessment Test for Accessibility

Step 1. Indicate if your project fulfills the UD critical success factors on the scale:	**Disagree**		**Agree**
1. There is a common understanding of UD in the project team and at all management levels (including any customer), and achieving UD is supported and viewed as positive.	**0**	**1**	**2**
2. The team has at least one person enthusiastic about UD, having a personal interest and motivation for ensuring universal usability.	**0**	**1**	**2**
3. The team has all the resources needed to ensure UD criteria; adequate time, budget and human resources; including access to assistive technologies, users and external competence.	**0**	**1**	**2**
4. The team has relevant UD competence and experience, e.g. UD principles in coding, IxD, content & visual design. Focus is on making design accessible and usable for everyone.	**0**	**1**	**2**
5. UD perspectives are integrated into all project activites; design, coding, UX/UCD & needs.	**0**	**1**	**2**
6. UD aspects are early and continously evaluated throughout the project, both through expert inspections and through user testing and real-user feedback including persons with disabilities.	**0**	**1**	**2**
7. The team embraces cross-disciplinary collaboration, open discussions and dialogue.	**0**	**1**	**2**

Step 2. Recieve 1 bonus point for:

a) A strategy for developing the UD competence in a team or organization.	**0**	**1**
b) Requirement specification includes criteria for UD, ensuring early and continuous focus.	**0**	**1**
c) An iterative or flexible process model, utilizing feedback from UD evaluations.	**0**	**1**
d) Extending internal evaluations with external inspections adds to UD quality control.	**0**	**1**

Step 3. Summarize your total:_____ point(s)

0-5 points: As you do not adhere to best practice for ensuring accessibility, you risk producing inaccessible digital solutions.
6-11 points: As you fulfill only some of the best practices for ensuring accessibility, you may not produce accessible digital solutions.
12-18 points: Gratulations! You fulfill most of the best practices for ensuring accessibility, and should be able to produce accessible digital solutions.

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Figure 2. Final Self-Assessment Test

2.3. Final Self-Assessment Test and Prediction Levels based on Score

Through a collaborative design process by the two authors, we moved from a first draft with 7 questions rated on a Likert scale from 0-6 points to a final test with 11 questions (see Figure 2). Its rating process is based on the feature analysis score model design [11-13]. For each question you receive 0, 1, 2 or 3 points based on how well your team is aligned with the identified key characteristics. The minimum total is 0 and the maximum

is 18 points. Based on the preciseness as indicated by empirically testing the scoring model´s internal and external validity [15], these tentative prediction levels are proposed:

- 0-5 points: indicates one does not adhere to best practice key characteristics and is at high risk for producing inaccessible digital solutions.
- 6-11 points: indicates one fulfill some key characteristics ensuring accessibility and is quite likely to produce an accessible digital solution – but might also not.
- 12-18 points: indicates one fulfills enough of the key characteristics for ensuring accessibility to be predicted to likely achieve accessible digital solutions.

Using these prediction levels, the test was able to correctly predict accessibility in 28 of the 35 participants self-assessments (80 % success: 19 accessible and 9 low/inaccessible). The mid-level of 6-11 points was self-assessed for 3 of the low/inaccessible solutions and 4 of the accessible solutions (thus encompassing the 20 % fail of prediction). This mid-level score may thus lead to both accessible solutions receiving awards and solutions lacking in accessibility receiving bad press.

The empirical testing of the score model against the questions also included qualitative insights on the usefulness of the test. About half of the participants felt the test would be useful to create a shared understanding in the team of what is needed to succeed with accessibility, and that early self-assessment would likely increase user testing and accessibility quality control. Eight participants stated the assessment could be useful at the start of a project: for defining requirements, planning the process and ensuring sufficient resources.

Discussion and Conclusion

Our rich qualitative data provide new insight into the relationship between factors promoting or obstructing accessibility. The final qualitative data set holds verbatim interview transcripts from 34 informants across 23 digital solutions assumed having a high accessibility, as they have won awards or receiving honorable mentions related to accessibility and universal design.

By comparing the commonalities between the characteristics of teams and processes producing accessible solutions, 15 characteristics appear key for ensuring accessibility. We formulated questions measuring the 15 characteristics and developed a scoring model based on the coded data. This was validated against 34 self-assessment tests –12 from non/inaccessible solutions and 22 from accessible solutions practices. Our work indicates characteristics related to the development process can predict the accessibility of resulting digital solutions to some degree. The validity tests show however that the prediction works best for min/max identification – those processes that lack many key characteristics, and those that adheres to most of them. It is interesting that a self-assessment test may be used to indicate a rough process quality score related to accessibility – even if the test needs a mid-level level to account for uncertainty.

The research might benefit from further validation, such as broader testing of the scoring model across diverse teams beyond these samples. When put to real use as self-assessment, questions may be interpreted differently, challenging the external validation. The self-assessment test and its question set and scoring model is ready for international testing and comparison and may be used on a free basis by everyone, including translations to other languages, adapting to business environments and so forth.

It would also be interesting to research whether the self-assessment test could support teams in improving their practices. User feedback indicates the self-assessment is fitting for a collaborative team test, and has the potential to increase UD awareness, promote best practices, aid project planning and communication and improve resource allocations. Our assumption is that a free-of-use practical contribution to measuring process-level practices key for achieving accessibility could aid product leaders, development team members and management in transferring research insights on how to ensure accessibility into the practice field. Future research could investigate this.

Our process ultimately condensed best-practice into an alignment tool. This could only be done due to a set of publicly acclaimed awards. Instead of using only technical compliance, investigating award-winners within a professional community, we tried to ascertain what characteristics may *lead to* accessibility – as it is ought to be understood.

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