

How Agile Teams Regard and Practice Universal Design During Software Development

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Abstract. It is essential to focus on universal design in agile software development to ensure that the software developed is usable by as many people as possible. This work studies how members of agile teams regard universal design, how the team is organized to focus on universal design, and how the team practices universal design. We have questioned 89 members of agile software projects including developers, tester, designers and project leaders. We present a detailed breakdown of the results based on roles, domains, experience and other factors that explain the differences and similarities among teams. Our findings show that there is a significant difference between what members think, what management think and what members actually do to ensure universal design.

Keywords. Universal Design, Software Development

1. Introduction

Universal design (UD) is not a new concept; the term was coined over 20 years ago [1]. Both the United Nations [2], the European Commission [3] and many countries have embraced and legislated the principle of UD [4]. There are also countless studies that highlight the advantages and importance of making accessible digital solutions that are usable by all people [5]–[7]. However, studies indicate that the education of specialists that will develop tomorrows digital solutions is neglecting proper training of UD concepts and practice [8].

It is challenging to apply UD properly during software development. The reasons are diverse, and even though many countries have legislation that requires solutions to be accessible for everyone, it is not enough to only rely on the law to force awareness and responsibility into the industry. It is for example not uncommon for user-testing to be neglected in software development because it is resource demanding [9]. However, companies state that UD is important, and want more focus on accessibility [10].

Some studies have tried to discover criteria for successful implementation of UD in development [11], [12]. Although a few studies have investigated how UD is

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implemented in various companies [13], there is a shortage of research that has investigated how intentions and practice are connected.

Most software development members today work in agile software projects [14]. Therefore, we wanted to study how the motivation of agile team members is connected to team practice and team focus of UD. We decided to focus on the mindset and practice of key members in an agile team and how it relates to UD. We present the results of a study of 89 people involved in agile software development. We gathered feedback from the most typical roles in a software process: developers, testers, designers and project leaders.

The remainder of the paper is organized as follows: After a background of the current knowledge state within UD and software development in Section 2 we present the method used to gather data and feedback from participants in Section 3. We then continue with a presentation of the results in Section 4, followed by a discussion of the results in Section 5. The limitations of our work in presented Section 6. Finally, we summarize and highlight research directions in Section 7.

2. Related work

On organization level, Nordli [12] has identified organizational barriers for UD, and further how they can be overcome to ensure universally designed content for the public. He found technical, organizational and awareness barriers within the organization he studied, and he suggests, among others, to increase awareness and knowledge with employees, create and enforce internal policies, and to assemble a dedicated UD team. Some of the same results were found by Sanderengen [13], who investigated how Norwegian consultancies work with UD through design and development of ICT solutions. Her study shows that individual's attitude and attention to UD is essential.

Harder [11] have investigated promoting and obstructing factors for successful UD in ICT. They have identified factors on an organizational level, process level and individual level. The factors obstructing UD is on organizational level the "Lack of anchoring", on process level it is "Focus", "Process issues", "Technical challenges" and "Constraints", and on an individual level, the "Lack of competence". The most critical success factors for UD is identified and discussed in Harder [4].

When it comes to methods and practices used by experts to approach UD, Begnum [15] has conducted a survey on approaches used by Norwegian UD experts. The most used methods include sketching, prototyping, workshop and formative user tests, whereas the least used methods are eye tracking, market research, storyboard and persona. Law [16] point out that the developers must be more involved during the process to ensure a good accessibility focus. Developers control the code, and need to have knowledge and enthusiasm in order to solve accessibility-related tasks. They have also found that developers commonly comment that it would be much easier to incorporate UD from the project beginning and not as retrofitting, as they often are exposed to.

There is some research investigating how to combine UD and agile software development. Kane [17] highlights the lack of usability testing in agile development and proposes techniques to incorporate more usability testing into already established agile practices. In our earlier research, we have suggested how different accessibility testing methods may be integrated into agile software development [18], [19]. Ferreira [20] found that usability testing in iterative environments can lead to increased testing if it is

made part of the development strategy and integrated into the work process. Florea [21] highlight the need for agile testers to possess soft skills to test for accessibility issues.

3. Method

The target population for our study was agile project members. The survey contained questions regarding knowledge about UD, attitude towards UD and how their internal processes incorporate UD. In total there were 28 questions, and we received 89 complete answers. Not fully completed submissions were omitted from the results. Most of the participants were recruited by team leaders and projects owners. A total of 50 participants were recruited in this manner. Another 27 people were recruited from a consultancy company. The rest was recruited on Facebook from a special group for UD in ICT. We collected all answers through Google forms [22], and all answers were submitted anonymously.

It is common for members in software projects to contribute on many projects at the same time, and we gave these instructions to the participants at the start of the survey: "In all questions where we ask about your project, you should refer to your main project if you are part of multiple projects". For most of the questions, a Likert-scale from 1 to 7 was used, where 1 represented strongly disagree and 7 represented strongly agree. Because of limited space we cannot cover all the questions in this article, and a detailed description of all the answers and results can be found in Bai [23].

The age of the participants was well distributed, with a mean of 37.8 years ($\sigma = 9.2$). For the rest of the paper we will use standard notations for mean, standard deviation and standard error which is μ , σ and $\sigma_{\bar{x}}$. We had a higher representation of males (71%) than females (29%), and this is not unexpected since the ICT industry is dominated by males.

The experience of the participants also had a good distribution with a mean of 12.4 years ($\sigma = 8.2$). Since we have many recently graduated participants together with participants that have many years of experience, it will be possible to see how experience plays a role when considering different questions.

All participants reported working in agile settings, although 12% indicated that they did it in combination with the waterfall method. The majority followed Kanban (48%) or Scrum (42%). Of agile techniques, the two most common were daily stand-up meetings [24] employed by 74%, and retrospective meetings [25] that 65% reported conducting.

We asked the participants what kind of domains they were working on and what type of role they have. They could use predefined choices or input their own answer. For domains, the majority (49,4%) of the members work in the frontend domain with user interfaces, either as interaction designers, developers or both. 24,1% worked in the backend domain, which indicates that they don't have a direct connection with the end-users. However, the backend can still influence the user interfaces in numerous ways. It's not uncommon for backend services to generate graphics, tables, content and so on, and therefore also backend developers must know about UD and usability. The last large group of 12,6% defines themselves as full-stack developers, which involves both backend and frontend. The last two groups of design and other (they did not specify) were equal at 7%.

For the distribution of roles, the majority (43,8%) define themselves as developers while 30,3% label themselves as designers (both graphical and interaction designers). In

total, we have a population of participants that typically represents the members of agile teams. We also have members with a management role (7%) and tester role (19.1%).

Both the age and experience distributions are wide, and the most prominent roles like developers, testers, and designers are well represented. In total, we have a population that we, from a statistical point of view, can draw some general conclusions from.

We also asked the participants to do a self-evaluation of their own knowledge of UD by asking: "How do you rate your own competence within UD?". The rating scale was a Likert scale from 1 to 7 where 1 was very poor and 7 was very good. The average response as shown in Figure 1 was 4.0 ($\sigma = 1.4$, $\sigma_{\bar{x}} = 0.15$). However, there was large differences between the groups as Figure 1 shows. Testers ($\mu=3.59$, $\sigma = 1.00$), developers ($\mu=3.62$, $\sigma = 1.52$) and management ($\mu=3.83$, $\sigma = 1.17$) were very similar and rated their competence a below average (4.0). Designers regard their competence very high ($\mu=5.00$, $\sigma = 1.18$) compared to the others.

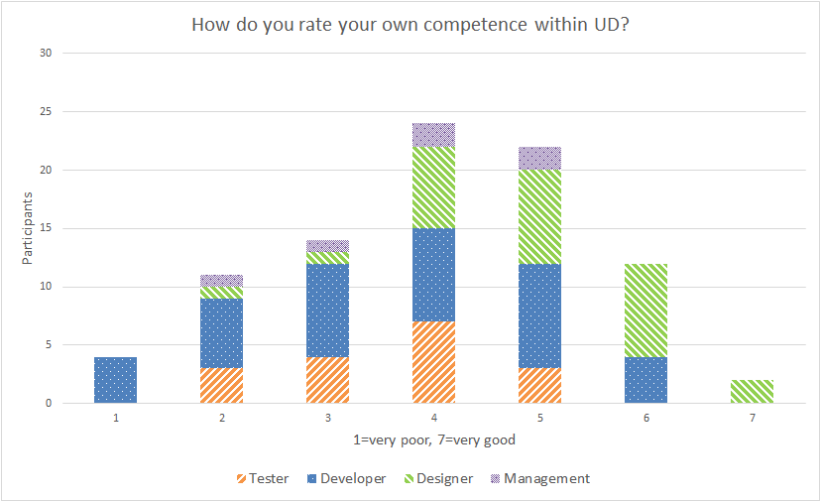


Figure 1. Self-evaluation broken down for roles.

In Table 1 we have listed all the questions we will analyze in Section 4. The questions in Table 1 have been shorten in order to provide a quick overview over the different categories and questions. We have also given each question a code so referencing will be easier. In Section 4 the full questions are presented.

Table 1. Questions grouped by categories.

How participants regard universal design
PR1 & How does UD increase usability?
PR2 & How does UD increase the marked potential?
Team focus of universal design
TF1 How is UD anchored by the management?
TF2 Who is responsible for ensuring UD?
TF3 What processes and routines exists for UD?

How participants practice universal design

PP1 How often do you consider UD?

PP2 Which tools for testing UD have you used in the last six months?

PP3 What kind of user testing has your project conducted?

We have separated the questions and answers from Table 1 into three groups: 1) How participants regard universal design, where we wanted to investigate the internal motivation and attitude towards UD. 2) Team focus of universal design, where we wanted to investigate the motivation and attitude of UD in teams and organization. 3) How participants practice universal design, where we wanted to investigate how participants apply UD in their daily routines. Our goal with the three different groups was to see if the mindset and focus of agile teams was reflected in the work activities.

4. Results

We will use the background information of the participants when analyzing the results from the questions. We will only present analysis where the results are interesting and show differences between roles and domains or deviation between answers.

4.1. How participant's regard universal design

In the first question (PR1) we asked the participants: "How do you think UD helps to increase usability for your projects?". The mean was quite high with 5.4 ($\sigma = 1.6$, $\sigma_{\bar{x}} = 0.16$). It is positive that the participants find that UD helps to increase usability, but it's more interesting if we consider the results based on the role of the participants as shown in Figure 2. Here we see that some roles are generally more positive than others, like management ($\mu=5.50$, $\sigma = 0.55$) compared to developers ($\mu=5.26$, $\sigma=1.68$). The roles are not statistically distinguishable from each other ($p > 0.05$) based on multiple 2 sample t-tests.

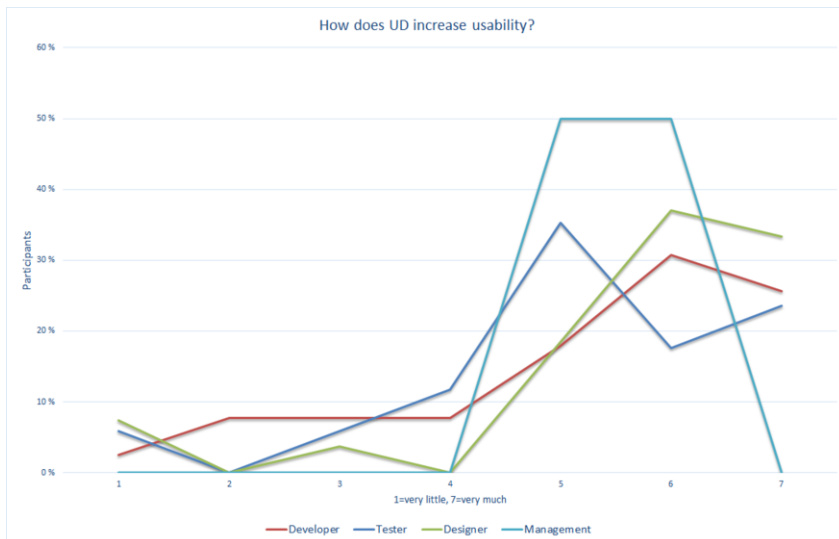


Figure 2. How does UD increase usability broken down for roles.

If we look at the domains the participants work with as shown in Figure 3, we see that the backend ($\mu=4.43$, $\sigma = 1.80$) and frontend ($\mu=5.68$, $\sigma = 1.60$) domain are significantly different ($p = 0.0038$), and we also see that the backend and design ($\mu=6.63$, $\sigma = 0.82$) domain are significantly different ($p = 0.02$). We did an ANOVA [26] analysis which indicated that there were not any other pairings with significant difference above the 95% threshold. In other words are the participants working in the backend domain less inclined to think that UD helps increase usability.



Figure 3. How does UD increase usability broken down for domains.

In the second question (PR2) we asked the participants about market potential: "How do you think UD helps increase the market potential for your projects". The mean was 4.1 ($\sigma = 1.7$, $\sigma_{\bar{x}} = 0.2$) which is just about neutral regarding how much UD increases market potential. The breakdown of the results based on domains are shown in Figure 4. Also here statistical analysis showed that the backend domain was significantly different from groups like design ($p = 0.0004$) and frontend ($p = 0.0134$), and this is also quite easy to see directly in the figure.

Another viewpoint is to look at years of experience that each participant has, and how that relates to market potential. As Figure 5 show, most of the experience groups follow the same patterns, and are not significantly different from each other. However, participant's with over 20 years of experience ($n = 11$) have a different pattern than the rest, and they have a very polarized view of how they think UD helps increase market potential.

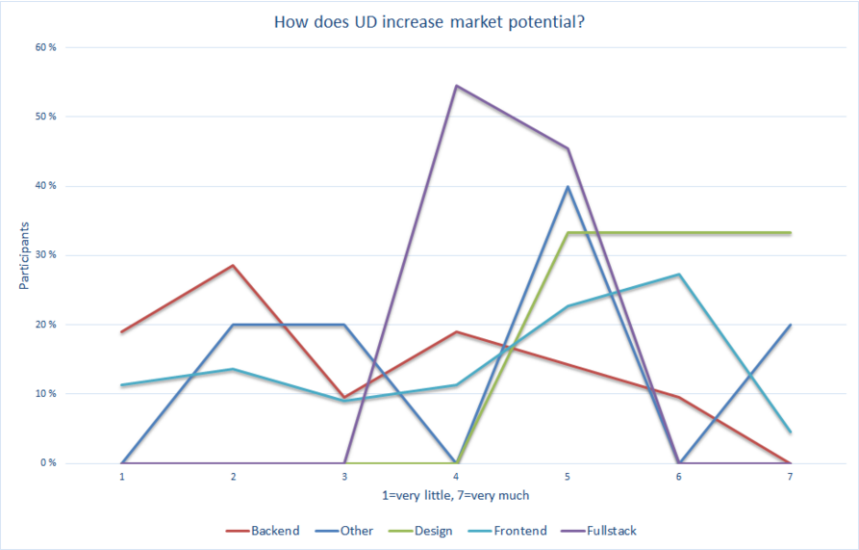


Figure 4. How does UD increase market potential broken down for domains.

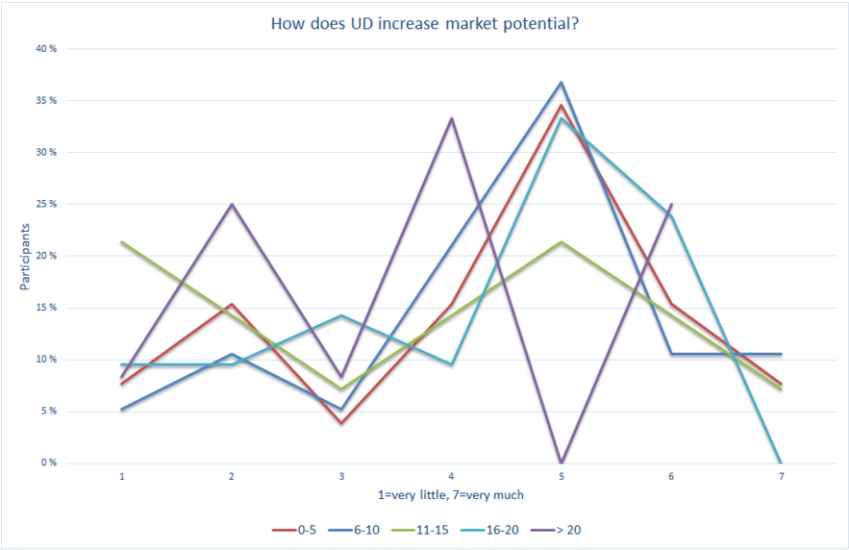


Figure 5. How does UD increase market potential broken down for experience.

4.2. Team focus of universal design

We asked the participants several questions related to team focus of universal design, and we have here focused on three questions that illustrates the differences among team members when it comes to commitments.

First we asked the participants (TF1): "How is universal design anchored by the management in your project?". We got feedback from some participants that we should have an "unknown" option, and that they selected 4 since they did not know. We could argue that if a participant is unaware of the commitment of UD in their projects, it reflects poor anchored by the management. Figure 6 shows that UD seems to be OK anchored by the management with a mean of 4.2 ($\sigma = 1.5$, $\sigma_{\bar{x}} = 0.16$).

It is interesting to see that the management role ($\mu=5.33$, $\sigma = 1.63$) is the role that sticks out the most, with a much more positive attitude about anchoring. Correlation analysis show that management has the lowest correlation with all the other roles with a correlation coefficient of around 0.1 (90% significance level) for all roles (the management and test roles which have a correlation coefficient of 0,30, but not 90% significance level). The other roles have a medium to strong correlation with each other.

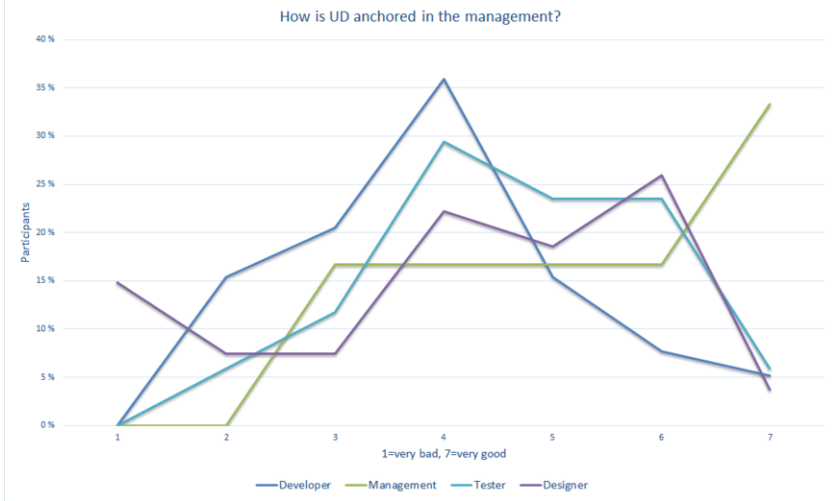


Figure 6. How is UD anchored in management broken down for roles.

In order to investigate how UD is integrated in the participant's project, we asked them to indicate which of four statements they agreed most with (TF2): a) There are no processes or routines for UD, b) There are some processes and routines for UD, c) UD is integrated in the processes and routines, and d) UD is done ad hoc. They also had the option to provide their own statements, but nobody choose to do that. As indicated in Figure 7 a surprisingly large number (19%) says there are no processes or routines for UD in their projects, and 22% says UD is done ad hoc. One may argue that ad hoc is the same as no process or routines, which means that 42% of the projects does not have any processes or routines for UD. Only 13% says that UD is integrated in their processes and routines.

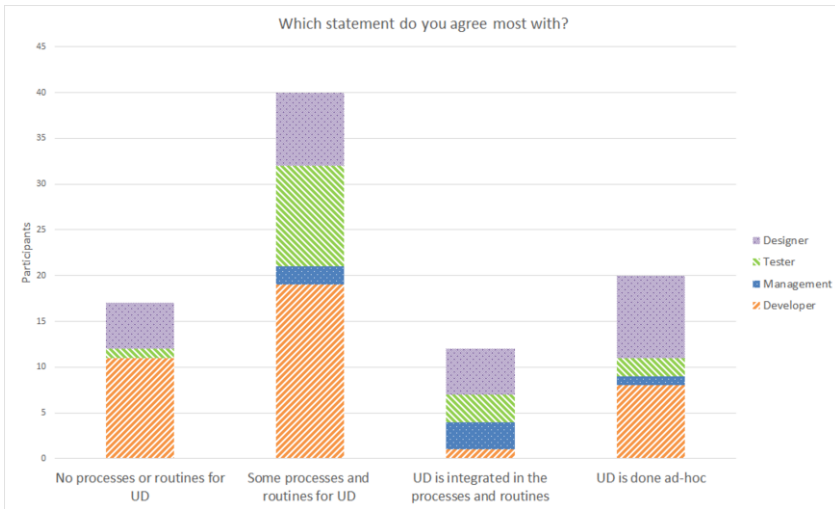


Figure 7. How does UD integrated in processes broken down for roles.

Then we asked the participants (TF3): "Who is responsible for ensuring UD in your projects?". The participants could select among four options: a) everybody shares the responsibility, b) one person has the responsibility, c) multiple persons share the workload, but one person is responsible, and d) nobody has the responsibility. As shown in Figure 8 over 1/3 of all the participants said that nobody has the responsibility, which is quite surprising.



Figure 8. Who is responsible for ensuring UD broken down for roles.

In Figure 9 we have plotted the answers from Figure 7 together with the answers from Figure 8. We merged those who answered no process together with those that answered ad hoc processes, since we believe they both indicate no processes or routines. It is not surprisingly to find that projects without any processes or routines do not have anybody responsible for ensuring UD.

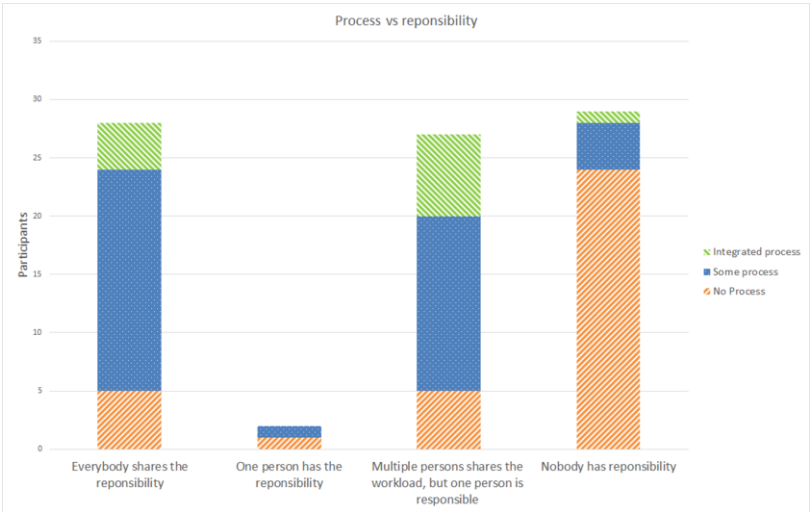


Figure 9. Who is responsible for ensuring UD broken down for processes.

4.3. How participant's practice universal design

We wanted to investigate how participants practice universal design by asking questions that together form a complete picture of how often UD is assessed. Here we presented two questions that show the same trend in terms of practicing universal design.

First, we asked the participants (PP1): "How often do you assess UD in your working activities in your projects?". They could choose from five options or fill in their own values. A total of 18.8% of the participants never do any UD assessment in their project as shown in Figure 10. On the positive side, 28.2% do UD assessment daily, 51.8% do it weekly or more and a whole 72.9% does it monthly or more often. It is not unexpected that it is the participants working in backend domains that assess UD rarely or never. However, it is very surprising that 9.1% of all frontend participants never assess UD.

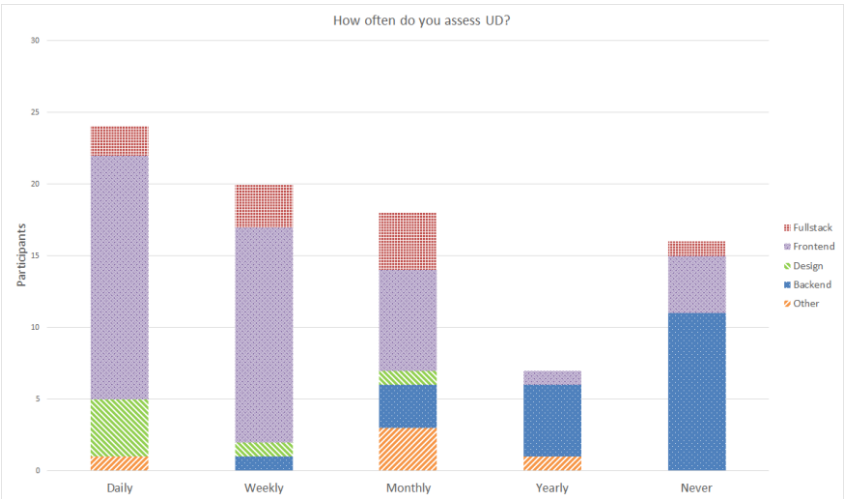


Figure 10. How often do you assess UD broken down for domains.

Next we asked the participants about tools they have used (PP2): "Which of the following tools or methods have you used for testing UD in the last 6 months? They were given 8 options and could add their own values. As shown in Figure 11 a high number of participants (39.3%) have used WCAG, checklists or screen reader during the last 6 months. Almost 41% of the participants say that they have not used any tools or methods for testing UD in the last 6 months, which was quite surprising for us since almost 72% say they assess UD monthly or more often. One explanation may be that some participants rely on their knowledge and experience, and feel that they do not require any tools or method.

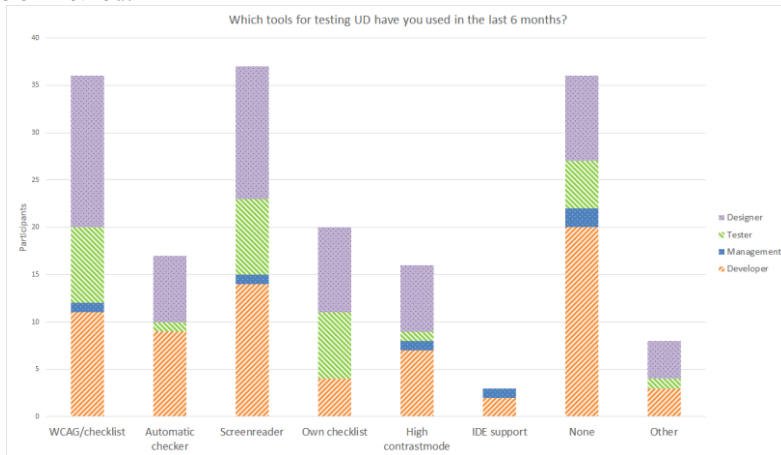


Figure 11. Which tools have been used broken down for roles.

5. Discussion

We have asked the participants questions that give insights into how they regard UD, how their team focus on UD, and how they practice UD. It would be reasonable to assume that if a participant think that the effects of UD is minimal, then that participant will probably not care or practice UD in any extent. And the same reasoning applies if the team focus is minimal, then participants will probably not practice UD much.

Most participants reported that they believe that UD contributes much to increased usability. This is expected and in line with the general notion that if a digital solution has poor usability then customers will use other services [27]. However, the participants do not believe that UD contributes equally strong to increasing the market potential. There are few studies that have investigated how UD is related to market potential, and it is therefore difficult to estimate the direct effects of UD on market share. However, by using the correlation between bad usability and loss of customers, it would be reasonable to think that UD has a direct impact on market potential. UD will also increase the potential customer pool since more people can use a digital solution [28], and we therefore expected participants to have a stronger opinion about UD's contributions to increase the market potential.

Our results show that management has a job to do in terms of communication internally. The participants with a management role have a strong notion of good anchoring compared to the rest of the team. We think it is very positive that management

itself feel that UD is well anchored, since this shows willingness and commitment in terms of UD, but this has not been communicated clearly enough to other team members. Exactly how this should be communicated better is difficult to say in general terms, but focus and discussion during iterations, meetings and testing will help.

Sadly, the anchoring that management believe UD has is not reflected in internal processes and routines either; only 13% of the participants say they have UD integrated in their processes and routines. This suggests that UD is not prioritized during software development. A surprisingly large number (42%) of participants do not have any processes or routines for UD, and this means that there is still a long way to go before UD has the required focus. To increase attention of UD, the right routines must be established. These routines will eventually turn into norms which may promote adaptive and effective behavior because agile team members feel compelled to act in ways that are consistent with the norms [29]. Our results also show that almost 1/3 does not have a responsible person for ensuring UD, and other studies have shown that a responsible person or team for ensuring UD is a vital for successfully implementation of UD [12].

We were surprised to see that there are many participants in the frontend domain that do assess UD very rarely or never. When over 1/4 (27.2%) of frontend team members assess UD monthly or less frequent, then something must be done with the team prioritizing and focus. Lack of knowledge or experience can also be possible reasons, since our results show that not too many tools or methods are utilized by the participants. More training on how to test accessibility internally is required to increase the toolbox of testing methods, more focus on both what issues methods discover [18] and triangulation of methods [30] is needed. It is positive that the majority of the project members use agile practices such as daily stand-up meetings and retrospective meetings, since these meetings provide opportunities for the members to communicate and discuss UD challenges and share experience of using accessibility testing tools.

6. Limitations

Some of the respondents were recruited from Facebook (22.5%). These participants were probably more motivated than the other participants since the majority were from a group dedicated to UD in software development. In general, we may assume that the majority of the participants are more motivated than the average population. However, this does not invalidate our results since it would most likely make the differences larger, in particular on how team members regard and practice UD.

We did not ask participants if they worked on projects without user interfaces or end users. In those cases, it would be expected that the participant and the project do not evaluate UD or conduct user testing. If we assume that all participants working in the backend domain have nothing to do with end users, there are still unexpected differences in the other domains.

7. Conclusion

In this study, we investigated how members of agile teams regard and practice UD during software development. We approached this question by examining three aspects: 1) how participants regard UD, and 2) the team focus of UD and 3) how participants practice

UD. Based on the answers we received from 89 participants, we can draw some general conclusions.

First, we can conclude that team members, in general, have a very positive view of UD and its consequences. Secondly, we can conclude that the team focus on UD is both diverse and lacking in agile teams. It is diverse because management thinks UD is anchored very well, while all the other members do not share that opinion. Also, there is a lack of integrated processes and routines for practicing UD and having a responsible person for ensuring UD. Finally, we can conclude that participants have much room for improving the practice of ensuring UD, both regarding frequency and knowledge.

Future work should investigate the connection between how teams work with UD and how well their solutions and products are, so it will be possible to form a picture of how investments are related to the actual cost of applying UD. Furthermore, more empirical research should be carried out with the use of interviews and observations to see, for example, how UD challenges are discussed in agile meetings.

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