Five Agile Factors: Helping Self-management to Self-reflect

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Abstract. In this paper a tool is proposed to foster reflection in agile software development teams. Based upon the qualitative model of Moe et al. [11], we contribute a quantitative questionnaire organized along five dimensions of agile teamwork analogous to the "Five Factor Model" in contemporary psychology. To test this survey tool and its alignment with existing studies, we have executed an empirical validation of the tool with 79 individuals and 8 international Scrum teams. We find that inter-team agreement on the factors is high and that the survey tool is found very useful. The instrument offers a comparable measure to agile teams and gives recommendations for each of the factors helping to understand individual as well as organizational level barriers.

Keywords: self-management, software development, agile teams, scrum, organizational management and coordination, process implementation and change.

1 Introduction

With the introduction of agile methods [4] such as Scrum and Extreme Programming (XP), the emphasis on people and their integration into the organizational process of software development has become increasingly important. Scrum, as an adaptive and empirical process, for example, aims to replace *command-and-control* management with *collaborative self-managing teams* [11].

Self-organizing project teams have been found successful by Takeuchi and Nonaka [19] while studying product development projects in large Japanese companies. Since then they have been confirmed to have high productivity and increased speed in problem solving [7,20]. While recognized as a premise for innovative projects, they are considered to be one of the biggest challenges for the adoption of agile methods. Benefits and limitations of agile development have been repeatedly reported to be dependent on human and social factors. The related changes in company culture and the awareness necessary were found to be difficult to adapt in practice [4,11,10]

While more embedded within the process surrounding software development than the pure function of writing code, agile teams are exposed to organizational

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barriers to a greater extent. In traditional and plan-driven *command-and-control* environments there exists a clear separation of roles, driven by self-managing professionals. In collaborative self-managing teams instead it is more important that team members understand individual as well as organizational level barriers [10]. We aim to improve understanding of these barriers in this contribution.

2 Objectives

Implementation of agile and self-organizing teams can be aided by increased development team self-awareness. In order to protect themselves from management, agile teams have been observed to give the impression that the team is better than they were [10]. This *impression management* [10] has been found to be a reason for failure to learn and change operating modes inside agile teams, preventing key issues of the process to be addressed.

In this paper we propose a tool for self evaluation to improve reflection of agile software development teams. To this end, we developed an instrument providing a comparable and practical measure for team members and have linked it to feedback for reflection based upon the study design and findings of Moe et al. [11]. We pose the following research question:

> *To what extent can we use the findings of Moe et al. [4,11,10,13] to measure self-management in order to support reflection in agile teams?*

Our objective is to promote discussion inside agile teams through the adoption of an impersonal survey tool in order to better understand mechanisms of effective teamwork and organizational requirements.

3 Related Work

In contemporary psychology, the *Five Factor Model* (FFM) also known as the *Big Five Personality Traits* is a model describing human personality through lexical analysis. The five factors were discovered and defined by factor-analyzing hundreds of measures of known personality traits [3].

Dybå and Dingsøyr conducted a structured literature review on empirical studies to address the scientific level of evidence behind agile software development methodologies identifying 36 out of 1996 studies matching their criteria [4]. To examine teamwork in agile software development teams the group developed five dimensions of agile teamwork [11] building up on work of Salas et al. [17]. They have placed their dimensions based upon a set of open-ended interview questions within an action research program with companies applying Scrum and evaluated their qualitative design conducting interviews with all team members in three longitudinal projects [11]. In the scope of the three years lasting program they found the absence of redundancy and the conflict between team level and individual level autonomy as one of the biggest barriers in implementing self-managing agile teams [10].

This instrument as originally developed by Moe et al. [11] consists of the five dimensions *shared leadership*, *team orientation*, *redundancy*, *learning* and *autonomy* as outlined in table 1. They have developed a set of open-ended interview questions for each of the dimensions to be conducted with all respective members of a Scrum team. Build on theoretical and empirical ground [4,12,17,10] their five dimensions of agile teamwork and their qualitative questionnaire forms the basis of our quantitative research design.

4 Method

With the goal to promote understanding and reflection on organizational and team level barriers [10] from a development unit's perspective we provide an instrument to be applicable from within the team. To simplify the collection process we have thus developed an anonymous questionnaire to promote more objective answers.

To reduce bias we encouraged the team members to provide their honest opinions by emphasizing the anonymous treatment of data. No results other than the processed outcome for the whole team would be distributed or given to their superiors. While we provided personalized links for each team member to ensure the consistency of input, no personal details were stored or used within the examination. Furthermore, some of the questions would only strengthen the agile factor when disagreed upon. This prevents a high ranking when answering all questions positively.

To furthermore increase transparency of the data we documented the level of agreement, the variance of answers given by the team members. This should help pointing at inconsistency within the team.

4.1 Questionnaire Design

To enable data collection via online surveys we adapted the qualitative questions of Moe et al. [11] into a quantitative design. The question sentences (table 1) have been held as close as possible to the original design. A screen shot of the online questionnaire page can be found in figure 1.

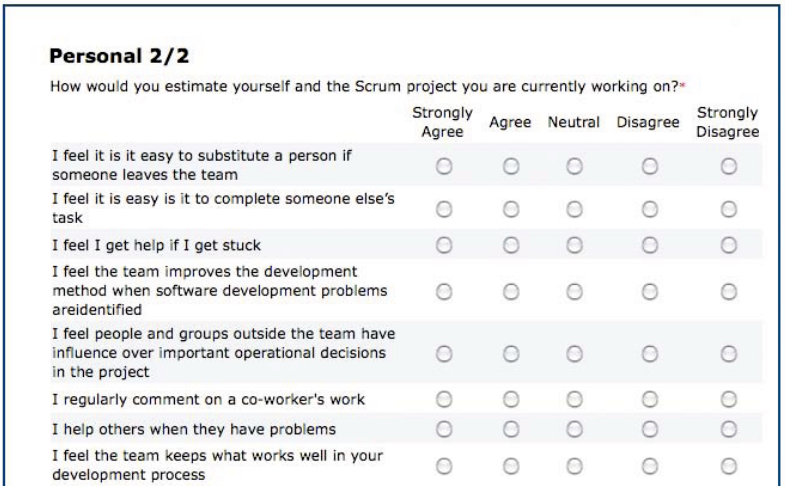
The questionnaire has been changed by adding "I feel" at the beginning of each sentence. This has been done to enable team members to better identify themselves with the research while keeping a comparable measure to original findings. Then, for each of the questions the participants were given a standard Likert scale to express their perceptions. To prevent inconsistency among the rating items we used a standard Likert scale consisting of 5 items: *Strongly Agree* = 5, *Agree* = 4, *Neutral* = 3, *Disagree* = 2, *Strongly Disagree* = 1.

4.2 Team Agreement

Variance (σ^2) is a measure of how far each value in a set of responses is from the mean. Variance is a useful measure for the level of agreement within a team, based on our survey, because variance is proportional to the scatter of the response metrics and independent of the number of responses.

Table 1. Five dimensions of agile teamwork and related personal questions for the agile team radar as inspired by Moe et al. [11]

Shared Leadership *Creation and maintenance of the team's shared mental model and transfer of leadership according to key knowledge, skills and abilities, shared decision authority* – I feel everyone is involved in the decision-making process – I feel team members make important decisions without consulting other team members – I feel the team vision is well defined and presented – I feel the team is designed (and redesigned) according to its purpose
Team Orientation *Promotion of team cohesion counteracts social loafing and increases individual responsibility, team goals are given priority over individual goals* – I feel the team takes into account alternative suggestions in team discussions – I feel the team values alternative suggestions – I feel team members relate to the tasks of individuals – I regularly comment on a co-worker's work
Redundancy *Cross-functionality avoids bottlenecks and enables possibility to shift workloads and mutual assistance* – I feel it is easy to complete someone else's task – I feel I get help if I get stuck – I help others when they have problems – I feel it is easy to substitute a person if someone leaves the team
Learning *Interdisciplinary knowledge acquisition to promote self-optimization in a wider environment* – I feel the team keeps what works well in the development process – I feel the team improves the development method when software development problems are identified – I feel the team gives feedback on all aspects of each others work
Autonomy *External influences on the activities of the team, a precondition for self-management. Although sometimes beneficial, such influences can discourage group thinking.* – I feel the team looses resources to other projects – I feel people and groups outside the team have influence over important operational decisions in the project – I feel decisions made by the team are respected by people and groups outside the team



Personal 2/2

How would you estimate yourself and the Scrum project you are currently working on?*

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I feel it is it easy to substitute a person if someone leaves the team	○	○	○	○	○
I feel it is easy is it to complete someone else's task	○	○	○	○	○
I feel I get help if I get stuck	○	○	○	○	○
I feel the team improves the development method when software development problems areidentified	○	○	○	○	○
I feel people and groups outside the team have influence over important operational decisions in the project	○	○	○	○	○
I regularly comment on a co-worker's work	○	○	○	○	○
I help others when they have problems	○	○	○	○	○
I feel the team keeps what works well in your development process	○	○	○	○	○

Fig. 1. Online Questionnaire

The variance is defined as

$$\sigma^2 = \frac{\sum (X - \mu)^2}{N} \tag{1}$$

where μ is the mean.

A lower variance therefore corresponds with a greater level of agreement within a team. The maximum variance in a team is the variance of the maximum and minimum values that can be given in response to an answer. The minimum variance is 0, denoting complete agreement. On a Likert scale from 1 – 5, the maximum variance is

$$\sigma^2 = \frac{\sum (X - \mu)^2}{N} = \frac{\sum X^2}{N} - \mu^2 \tag{2}$$

$$\text{MAX}(\sigma^2\{1,5\}) = \frac{1^2 + 5^2}{2} - \left(\frac{1+5}{2}\right)^2 = 4 \tag{3}$$

5 Results

To test our questionnaire and to inquire its matching to existing research, the questions have been presented to a group of international project teams, practitioners and experts applying the Scrum methodology. The instrument has been provided to the participants as a set of online survey questions in random order. The participants had to be actively involved in a Scrum development team. All questions had to be answered in order to count the respective data set as valid.

To look for international Scrum teams interested in the study, one of the authors searched Scrum/Agile oriented groups within business related networks.

After identifying related individuals from different online community platforms, user groups as well as originating from direct and indirect contacts, the author sent invitations for participation to 150 Scrum related professionals. Those who were interested in participation received an anonymized link allowing identification of teams within the online survey system. In addition each ScrumMaster of a potentially interested Scrum team received a set of open-ended questions regarding the project environment.

After data collection, the given answers were accumulated into global and team samples as shown in table 2 and figure 2. The total number of valid data sets collected contains 79 individuals and 8 teams from 13 countries. Most of the participants belong to the group of software developers (47%) and ScrumMasters (18%). Other groups, however, emerged within the data collection phase. Their data has been taken into evaluation as long as the individuals were committed to a *Pig* role within the Scrum project: Product Owner (8%), Quality Assurance (6%), Agile Coach (6%), Consultant (9%), Interaction Designer (1%), CTO (5%). The gross amount of relevant working experience among the participants is situated around a work record of 1-5 (38%) and 6-10 (29%) years.

After primary analysis, the author decided on 8 teams to be taken into team analysis. The teams had to consist of at least four members with, depending on the team size, at least two-thirds of the team having answered the survey in order to represent a consistent group image. The remaining survey answers were only analyzed globally.

5.1 Team Sample

Table 2 contains each team's self-assessment scores based on the Likert scale data from the questionnaire as mean values for each team.

The minima reveal a consistency towards the dimension of autonomy and there is a noticeable tendency towards learning among the maxima. Autonomy consistently earns the smallest score for all teams, while learning is the highest perceived characteristic for half of the eight teams and changes between redundancy and team orientation for the other half. This results show a similar trend in distribution as those presented in the original findings of Moe et al. [11].

Team agreement, expressed by variance (σ^2) is mentioned in table 2 below the aggregated team level measurements. We observe a pretty high (0.06-0.33) level of agreement within the teams as represented by a fairly low variance. Also the agreement on the five factors is pretty high (0.18-0.20). Teams agree least on redundancy and shared leadership and most on team orientation and autonomy.

The consistent low rating on low autonomy and high agreement that rating among the team members are a pointer to organizational level barriers and can be tracked back to our first two questions for the factor (table 1). The least agreement on redundancy can be a pointer to contended ideas regarding specialization in agile teams. Many participants reacted skeptical towards the implementation of cross-functionality. Although being aware of the "quagmire" effect of specialization [10], many could not think of how to overcome the idea as a waste of resources.

Table 2. Descriptive variables, radar results (x) (**min** & **max**) and agreement (σ^2)

		T1	T2	T3	T4	T5	T6	T7	T8	AVG. AGR.
country		UK	US	UK	NO	NL	SE	IN	NZ	
team size (pers.)		4	9	5	12	6	4	8	6	
collected answers		4	6	5	6	5	3	8	4	
avg. exp. (yrs.)		7.75	13.7	6.6	12.7	2.6	10	7	3.5	
shared leadership	x	**4.13**	**3.83**	**3.90**	**3.83**	**3.10**	**3.17**	**3.59**	**3.69**	
	σ^2	*(.05)*	*(.08)*	*(.29)*	*(.47)*	*(.06)*	*(.22)*	*(.08)*	*(.36)*	*(.20)*
team orientation	x	**4.56**	**4.21**	**4.15**	**3.88**	**3.30**	**3.83**	**3.69**	**3.88**	
	σ^2	*(.14)*	*(.15)*	*(.27)*	*(.34)*	*(.01)*	*(.06)*	*(.09)*	*(.39)*	*(.18)*
redundancy	x	**4.38**	**3.67**	**3.85**	**4.10**	**3.30**	**3.67**	**3.94**	**3.25**	
	σ^2	*(.08)*	*(.22)*	*(.14)*	*(.16)*	*(.32)*	*(.18)*	*(.28)*	*(.22)*	*(.20)*
learning	x	**4.58**	**4.22**	**4.20**	**3.50**	**3.33**	**3.56**	**3.58**	**3.75**	
	σ^2	*(.02)*	*(.25)*	*(.03)*	*(.32)*	*(.36)*	*(.25)*	*(.13)*	*(.19)*	*(.19)*
autonomy	x	**3.50**	**3.61**	**3.27**	**3.17**	**3.07**	**2.78**	**3.13**	**2.92**	
	σ^2	*(.03)*	*(.16)*	*(.24)*	*(.33)*	*(.32)*	*(.18)*	*(.11)*	*(.08)*	*(.18)*
average agreement	σ^2	*(.06)*	*(.17)*	*(.19)*	*(.33)*	*(.15)*	*(.18)*	*(.08)*	*(.25)*	*(.18)*

Members of T1 (UK) and T7 (India) agree most. T1 (UK) provides a back-end software for a major Massive Multiplayer Online (MMO) game publisher. T7 (India) worked on a e-commerce solution. Both were collocated development teams with similar roles and good team consistency. Members of T4 (Norway) and T8 (New Zealand) agree least. T4 (Norway) is employed by a company providing smart card based public key solutions for security transactions, consisting of developers from 2 separate locations running "several parallel projects". Team T8 (New Zealand) consists of a business analyst, a quality assurance specialist and two developers working for a state insurance agency. Both are rather diversified teams with different roles. T4 and T8 have a notably increased variance for shared leadership and team orientation while T1 and T7 agree on those. Although the level of agreement does not reflect on agile values, it indeed seems to correlate with the consistency of the teams.

5.2 Global Sample

To have a more detailed view on the data we have compiled a global team radar consisting of the answers of all 79 participants, as depicted in figure 2. In consistence with the findings of Moe et al. [10] we found autonomy to be significantly lower than the rest of the factors. We could not find a significant difference between the means of redundancy and learning, team orientation and shared leadership.

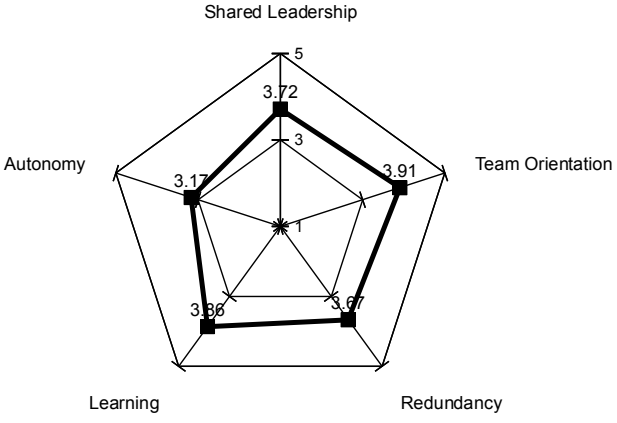


Fig. 2. Global Team Radar

5.3 Validity Considerations

Due to the low amount of data sets containing 79 individuals conclusions should be drawn carefully. Here we have stressed particular attention to the quality of collected data. Throughout the whole process of data collection we encouraged participants in giving realistic answers and emphasized the anonymous treatment of data to establish a reasonable level of trust. Only complete data sets and teams with a minimum amount of participants were taken into evaluation.

Quantitative data collection typically grounds evidence on big data sets. As we base our evidence on small team data sets instead, we have improved the transparency of data by adding the variance of given answers among the team members.

The distribution of given answers reveals an expected bias of participants towards positively perceived answers. In psychology this effect is being referred to as Socially Desirable Responding (RDS) [15]. This effect can be lowered by anonymous self-administration, meaning that when the subjects' personal details are not required the person does not feel directly and personally involved in the answers he or she is going to give. The second provision we applied to reduce social desirability, is the self-administration of the survey through a computer. The self-administration of the survey through a computer neutralizes here social desirability through the impersonality of the machine.

5.4 Discussion

The noticeable tendencies reveal a global minimum for measured autonomy and maxima for learning and team orientation. The data suggests that Scrum teams seem not to be well prepared, to cope with the cultural environment existing in their companies in order to maintain a level of autonomy required to apply the methodology. It seems that the internal factors are indeed supporting Scrum within a team, by the willingness to share leadership and good team orientation

- values which arguably might be perceived as being passive and existing within small development teams with divided roles anyway. Redundancy, scoring the second lowest value here, resulting in a lack of cross-functionality could in fact create a breeding ground for interpretations that some teams are not actively prepared for a faithful implementation of Scrum. This strengthens the need of further involvement of developers in discussions regarding implementation of agile processes.

The application of our questionnaire was met with interest. This is also reflected by the relatively high response rate: 79 respondents out of circa 150 inquired professionals. During data collection we received questions and suggestions from participants, especially from those with most experience in application of agile methods. However, it was not always easy to collect consistent data from a whole team, and thus out of 79 participants just 8 teams could be taken into team analysis. This might be partially caused by the invitation offered through superiors. In two cases there was direct interest of clients or *Product Owners* with an offshore development team. In this case the contractors were assumed to be interested in learning about the consistency of the hired development team, leading to poor commitment to the survey. Data collection should be motivated by the desire to learn and improve inside the team and should not be used by means of organizational control. Commitment thus is to be expected when executed on team initiative.

6 Recommendations

After data collection we have been repeatedly asked by the teams and *Scrum-Masters* for recommendations with respect to the findings as during the design of the study we did not think of recommendations. As the five factors alone provide a comparable measure but little practical advice to the audience we would like follow-up on this. In the following section we thus provide a list of advices on each of the five factors from current literature.

6.1 Shared Leadership

Literature argues that leadership should be transferred accordingly to the key knowledge, skills and abilities necessary for a particular issue at a moment in time [16,8]. The team leader's task as argued by Salas et al. [17] therefore should be the creation and maintenance of the team's shared metal model while the teams collaborative process. Moe et al. [10] give the example of a "chief architect" on one hand and of a newly hired developer on the other: while the chief architect took over most of the decisions in one company, leading to frustration of team members, a newly hired software developer had to fight for attention in another company. Team members should share decision authority to promote commitment [19]. Communication plays an important role here and the common goal should be known and respected within the team and organization [10].

6.2 Team Orientation

This dimension can be directly found in the framework of Salas et al. showing improved individual effort and performance. Lack of team orientation respectively leads to demotivation, social loafing, diffusion of responsibility and sucker effects, thus lowering the cohesion of the team [22]. Moe et al. [10] have found out that team members gave a too high priority to individual goals rather than team goals. Shared team orientation promotes cohesion of the group and counteracts social loafing as team members perceive that the task and the team itself is important [9]. Organizations [23] with greater influence of task skills as well as rewarding systems for team performance increase team cohesion and team orientation [18]. Job rotation and a culture of trust in collaboration can help to improve this and cross training can be valuable by increase the team's flexibility [10].

6.3 Redundancy

The concept of redundancy is equivalent to the characteristics of Backup Behavior described by Salas et al. [17]. Cross-functionality allows members to substitute each other in case of demand creating involvement and innovation of team members due to broader expertise. It is reported as crucial for self-managing teams [14] and appears as "multiskilling" in socio-technical literature [5]. Lack of Redundancy means specialization of team members, dependency of task accomplishment on availability of certain team members leading to bottlenecks when these are unavailable. It also leads to a general lack of diversified views enhancing the product due to concentration of knowledge.

To improve redundancy literature generally recommends to collocate the team in the same room [1]. Moe et al. [10] recommend to appreciate generalists inside the team and company culture and to select them during team building and recruitment. Job rotation can further contribute to improve knowledge redundancy by integrating knowledge from different domains [6].

6.4 Learning

Learning describes a team's ability in identifying weak points and improving the development process. It is one of the ideas of Scrum originating from the new product development literature [19] known as *multi-learning*. Multilevel and multifunctional learning allow team members to acquire broad knowledge outside their direct product scope, allowing the team to respond quickly and to solve problems fast [19]. Job rotation can help to integrate knowledge from different domains and appreciation of organizational concerns [6], but must be legitimized by the organization. Efforts to collect data and to improve should be motivated by the desire to learn and improve inside the team and should not be used to push organizational control.

6.5 Autonomy

Team autonomy is necessary so the Scrum team perceives its total responsibility over the product without external influence on the team's work plan inside a sprint. It is described as the influence of management and other individuals outside the team. Lack of team autonomy is believed to lead to excessive overtime, high defect rates and personnel burnout. In Scrum, it damages the concept of self-organization [2], thus disturbing the team cohesion. Autonomous and self-organizing teams are recognized as a premise, but also as one of the biggest challenges of agile methods [4].

Autonomy of a team is affected by individual as well as organizational level, self-management thus must be fostered on both levels [10]. Assigning people on more than one project at a time leads to competing for team members and unequal distribution of resources, thus should be avoided [10]. Collocation of the the team in the same room further helps [10] .

7 Conclusion

In this paper we presented and empirically validated a tool to improve reflection of agile software development teams. With this survey tool, we measured the cornerstones of agile teamwork in 5 dimensions. We found that the organizational and individual levels of autonomy and redundancy are the dimensions with the lowest scores as given by the users of this tool. This finding is consistent with the original findings of [11,10]. We introduced a measure for agreement regarding the dimension measurements and found that it was high in our empirical study. This indicates both that team members have similar notions of each dimension and how it applies to their particular team situation. In addition, the teams found the survey tool in general a useful method to reflect.

For future use a dedicated web application can be provided to improve the usability and accessibility of the tool, as the current data has been collected with a generic survey application. Data collection via a customized online tool would furthermore allow the collection of additional teams contributing to the framework's improvement and recommendations could be provided and updated online according to latest research. Psychometric scale questions [21] could be incorporated into future versions of the survey tool to be able to measure the degree of accuracy or truthfulness the participant tends to give to the answers.

Although processes and routines are recognized as organizational capital there is currently little tooling to support their design and the effects are much more uncertain. We believe that quantitative data collection methods applied within teams can provide intermediate feedback and help us to understand organizational process implementation and change.

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