Measuring the Impact of Communication in Agile Development: A Research Model and Pilot Test

Completed Research Paper

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ABSTRACT

While experience from practice provides evidence for the success of agile development, research lacks behind in explaining and understanding the theoretical enablers of this success. To address this gap, we present a theoretically grounded research model that highlights the role of communication within the project team as a critical success factor. We develop measurement instruments and present findings of a pilot test that we distributed in a medium-sized software development company. The goal of the pilot test is to validate our measurement instruments and to gain first indications of construct validity. We present the results of a confirmatory factor analysis and, in consequence, we reflect on our findings and highlight the implications for future research.

Keywords

Agile Information Systems Development, Software Engineering, Organizational Communication, Pilot Test.

INTRODUCTION

The increased adoption and acceptance of *agile methods* for information systems development (ISD) such as Extreme Programming (XP) (Beck, 1999) or Scrum (Schwaber and Beedle, 2002) entails a growing interest of the research community in these methods. The key characteristics of agility in the ISD context are summarized in the Agile Manifesto (Beck, Beedle, van Bennekum, Cockburn, Cunningham et al., 2001), which builds on many lessons learned by practitioners about ISD, for example, the importance of human and social factors (Cao, Mohan, Peng and Ramesh, 2009; Dybå and Dingsøyr, 2008; Vidgen and Wang, 2009). Research-based definitions of agile ISD emphasize that agile methods enable the capability to react, embrace, and learn from change that is induced, for example, by changing customer requirements (Conboy, 2009).

Many practice reports indicate the success of agile ISD (Erickson, Lyytinen and Keng, 2005; Lee and Xia, 2010). However, research lacks behind practice because empirical evidence of agile ISD success is inconclusive and contradictory (Iivari and Iivari, 2011). One reason for this is that the underlying theoretical foundations of agile ISD are not well understood, which has been coined as the "missing theoretical glue" (Conboy, 2009, p. 330). For this reason, researchers call for more theory-based approaches in studies on agile ISD (Dingsøyr, Nerur, Balijepally and Moe, 2012).

In this paper, we argue that *communication* is one of the constituting factors of agile methods, enabling ISD success. Our conjecture is based on the critical role of communication for agile ISD, which is mentioned by practitioner literature (Beck et al., 2001) as well as by previous exploratory studies (Sarker, Munson, Sarker and Chakraborty, 2009; Sarker and Sarker, 2009; Wang, Conboy and Pikkarainen, 2012). In consequence, we focus on the following research question: *"What is the impact of agile ISD practices on the communication mechanisms of ISD project teams and, in turn, on the development outcome?"* Specifically, we develop a research model and propose that specific, communication-related agile practices have a positive effect on the communication behavior in agile ISD teams, which in turn positively affects ISD success.

We present the results of a pilot study in a medium-sized software development company. We carry out a confirmatory factor analysis that is based on 21 returned questionnaires collected from project team members in order to gain first indications on construct validity. Due to the small sample size, we only investigate the measurement model and not the structural model, so this paper is an important first step towards answering our research question by providing validated measurement instruments.

The remainder of this paper is structured as follows. We first discuss related work on agile ISD and communication. Next, we present our research model. This is followed by the evaluation of the pilot test, including descriptions of the setting, the

measurement scales, as well as the statistical results. Finally, we highlight the implications of our results and give an outlook on future research based on this work.

RELATED WORK

Although the importance of communication in agile ISD is widely recognized in research as well as in practice (Beck et al., 2001; Korkala, Abrahamsson and Kyllonen, 2006; Melnik and Maurer, 2004), empirical investigations are scarce (Pikkarainen, Haikara, Salo, Abrahamsson and Still, 2008). Furthermore, existing studies provide contradictory results. For example, some studies find that communication is not contributing to agile ISD success (e.g., Abbas, Gravell and Wills, 2010; Misra, Kumar and Kumar, 2009), whereas the majority of studies emphasize that communication is one of the key success factors (e.g., Koskela and Abrahamsson, 2004; Mishra and Mishra, 2009).

Many previous works have focused on the effects of communication stemming from differences in team distribution or team size. For example, agile ISD methods were originally proposed for small, co-located teams that are able to communicate efficiently due to high physical proximity (Beck, 1999; Mishra, Mishra and Ostrovska, 2012). If the team is distributed across several time zones and countries, communication tools such as videoconferencing and instant messaging have to be employed in order to ensure frequent communication among team members (Paasivaara, Durasiewicz and Lassenius, 2009). More formal communication such as documentation is also playing a more important role in distributed and large contexts (Hansson, Dittrich, Gustafsson and Zarnak, 2006), although relying extensively on formal documentation is contradictory to the concept of agility (Beck et al., 2001).

Furthermore, most of these findings are based on exploratory studies, whereas confirmatory studies are in the minority (e.g., Nevo and Chengalur-Smith (2011) who find that there is a positive effect of agile methods on communication convergence and on virtual team performance).

THEORETICAL FRAMEWORK

The common reasoning line of our research model is provided by the Unified Model of ISD Success (Siau, Long and Ling, 2010) that includes several individual, team, and organizational factors that affect the ISD process. For agile ISD, important *input factors* that influence the ISD process and ISD success are "team distribution", "team size", and "project domain" (Ågerfalk, Fitzgerald and Slaughter, 2009). We therefore consider these factors as control variables. More importantly for our study, the employed *ISD methodology* also affects the ISD process, which is in our context agile ISD. The *output* of the process is ISD success. In previous research, the ISD process itself is often neglected, which is summarized as the "black box" (Siau et al., 2010, p. 92) of the ISD process. Figure 1 summarizes the previous discussion and presents our conceptual model.

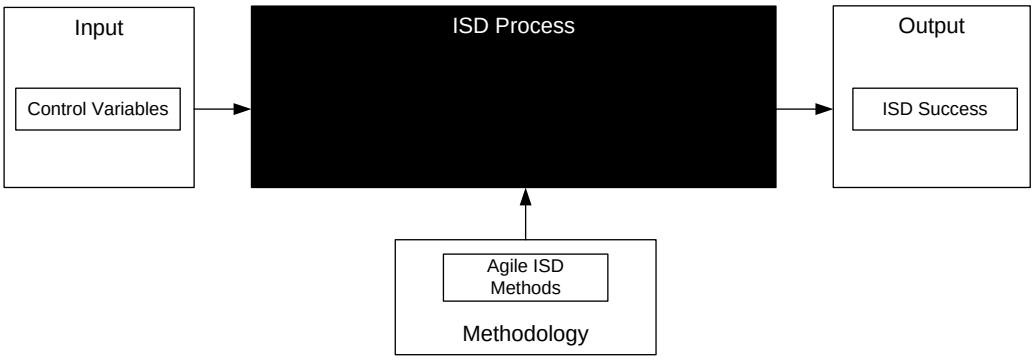

Figure 1. Conceptual Model (adapted from Siau et al., 2010)

Specifically, we aim to uncover the black box of the ISD process by focusing on the communication mechanisms of project teams employing agile ISD methods. For doing this, we deliberately focus on a subset of agile practices that have been found to have a strong impact on communication, collaboration, and interaction among team members (Maruping, Venkatesh and Agarwal, 2009; So and Scholl, 2009; Wang et al., 2012). We differentiate those practices from more technical agile practices such as refactoring that are not directly connected to the communication mechanisms of agile ISD teams. Consequently, what we call *social agile practices* are a subset of agile practices, which are connected to interactions, collaboration, cooperation, and communication of team members. Table 1 presents a short description of these five social agile practices.

Social Agile Practice	Description
Co-Located Office Space / On-Site Customer	Close proximity of the team members and the customer entails positive effects on the collaboration among team members (Cao et al., 2009; Dorairaj, Noble and Malik, 2012).
Daily Scrum	Team members meet up every day for 15 minutes in order to talk about the current status of the project (Schwaber and Beedle, 2002). Communication is the glue that links all the team members together (Moe, Dingsøyr and Dybå, 2010; Ramesh, Cao and Baskerville, 2010).
Pair Programming	Programming in pairs promotes social interactions because it forces the developers to talk about the current tasks (Beck, 1999; Pedrycz, Russo and Succi, 2011).
Sprint Planning	During sprint planning meetings, the team and the customer(s) decide which user stories will be implemented in the next sprint (Schwaber and Beedle, 2002).
Sprint Review / Retrospective	Sprint reviews / retrospectives are used to talk about the results and lessons learned of the last sprint (Schwaber and Beedle, 2002).

Table 1. Social Agile Practices

The importance of communication for agile ISD has been widely recognized (Beck et al., 2001; Pikkarainen et al., 2008), which is supported by qualitative findings that show a positive effect of agile practices on communication within the development team (McHugh, Conboy and Lang, 2011; Wang et al., 2012). Based on those insights, we propose that there is a positive impact of social agile practices on *communication informality*, which is characterized by spontaneous, unstructured communication media, preferable face-to-face conversations (Katz and Kahn, 1978; Kock, 2004; Smith, Smith, Olian, Sims, O'Bannon et al., 1994). We also expect that the employment of social agile practices changes both the way people communicate as well as the amount of communication among team members, that is, c*ommunication frequency* (Katz and Kahn, 1978; Smith et al., 1994).

The central proposition of Media Naturalness Theory (Kock, 2004) is that informal face-to-face communication is the most efficient form of communication because more or less transmitted information increases the cognitive effort for developing *mutual understanding*. The Cognitive-affective Model of Organizational Communication (Te'eni, 2001) also refers to mutual understanding as an essential part of the communication impact. Mutual understanding is defined as "the degree of cognitive overlap and commonality in beliefs, expectations, and perceptions about a given target" (Cohen and Gibson, 2003, p. 8). In consequence, we expect that communication frequency as well as communication informality have a positive impact on mutual understanding among the team members. In addition, we include the *relationships* of the team members in our model because relationships are the second important component (the affective part) of the communication impact (Te'eni, 2001). Three essential characteristics constitute good relationships (Guinan, Cooprider and Faraj, 1998): (1) team members share positive feelings for each other, (2) there is a sense of loyalty and responsibility, and (3) there is a common goal. Following this, we propose that communication informality and communication frequency positively impact on the relationships of team members. We also expect that relationships are positively influenced by mutual understanding, because having a cognitive overlap with team members eases the establishment of good relationships (Garrod and Doherty, 1994).

We conceptualize ISD success in terms of *process performance* (Wallace, Keil and Rai, 2004) and *user satisfaction* (Bhattacherjee, 2001). We expect that good relationships have a positive impact on ISD success, as already indicated by earlier studies (Guinan et al., 1998; Iivari and Iivari, 2011). The same proposition holds for mutual understanding because a cognitive overlap within the team as well as with the customer is expected to contribute towards ISD success.

Figure 2 presents the derived research model.

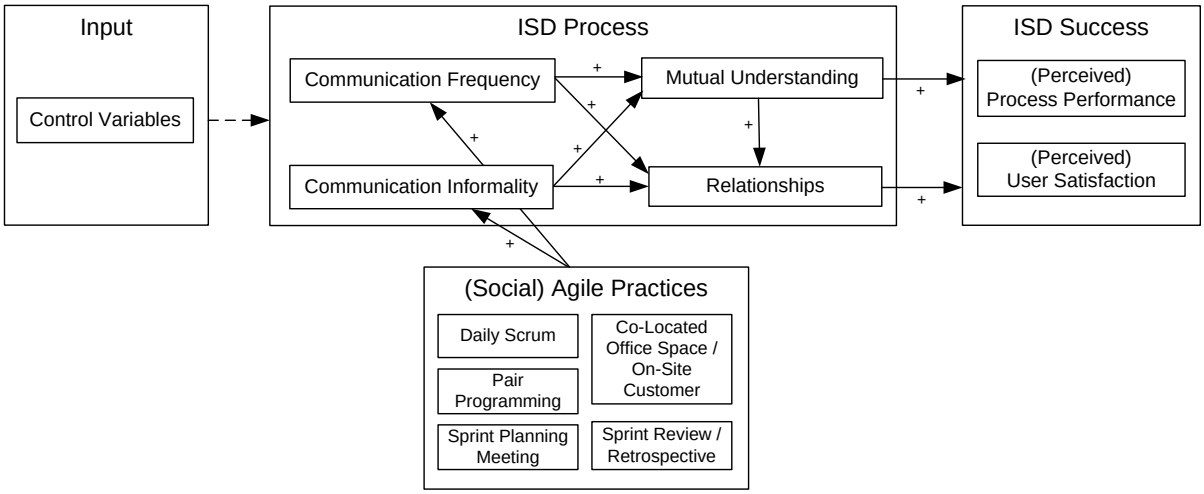

Figure 2. Research Model

RESEARCH METHOD

We conducted a pilot test in order to obtain first indications of construct validity for our measurement items before testing the survey in larger contexts (e.g., a cross-sectional study or a cohort study with multiple teams). The setting for our pilot test is a medium-sized software development company that uses Scrum. The company mainly develops an e-mail and collaboration software suite for enterprise customers. We focus on two project groups that are working at different locations. Members from different teams in both groups participated in the pilot test, including developers, product owners, and Scrum masters. Since product owners and customer representatives are actively involved in the development process, customer satisfaction may also be judged by all team members including developers. The questionnaire was anonymous and distributed to all members of both groups using an online survey. In total, 23 complete questionnaires were returned.

Measurement

We conducted a content validity assessment in order to generate the items for our constructs (Moore and Benbasat, 1991; O'Leary-Kelly and Vokurka, 1998). All our items are based on existing scales, except for the construct "social agile practices". Following established guidelines (Jarvis, Mackenzie, Podsakoff, Mick and Bearden, 2003; Petter, Straub and Rai, 2007), we concluded that this construct should be measured with a formative scale because the different agile practices comprise the construct. Table 2 presents the scales.

Construct	**Item**		**References**
Social agile practices (formative)	SAP1	We followed the agile practice "Daily Stand-Up Meetings" by meeting up every day.	Newly developed
	SAP2	We followed the agile practice "Co-Located Office Space" by locating team members close-by.	
	SAP3	We followed the agile practice "Iteration Planning Meetings" by meeting up at the beginning of an iteration for deciding which requirements will be implemented within the iteration.	
	SAP4	We followed the agile practice "Pair Programming" by doing our software development using pairs of developers.	
	SAP5	We followed the agile practice "Sprint Review / Retrospective Meetings" by meeting up at the end of an iteration for discussing the results of the last iteration and lessons learned.	
Communication informality (reflective)	CIF1	Team meetings tended to be very informal in nature.	Smith et al. (1994), Kock (2004), Te'eni (2001)
	CIF2	Meetings between team members were very informal.	
	CIF3	Communication between team members was always face-to-face.	

Communication frequency (formative)	CF1	The frequency of formal face-to-face meetings between you and other team members in your last project.	Smith et al. (1994), Katz & Kahn (1978), Te'eni (2001)
	CF2	The frequency of informal face-to-face meetings between you and other team members in your last project.	
	CF3	The frequency of formal written communication between you and other team members in your last project.	
	CF4	The frequency of informal written communication; personal notes, etc., between you and other team members in your last project.	
	CF5	The frequency of telephone conversations between you and other team members in your last project.	
	CF6	The frequency of e-mail conversations between you and other team members during the last project that you were involved.	
Mutual understanding (reflective)	MU1	My opinions were clear to other team members.	Biocca et al. (2001), Kock (2004), Cohen & Gibson (2003)
	MU2	The opinions of other team members were clear to me.	
	MU3	My thoughts were clear to other team members.	
	MU4	The other team members' thoughts were clear to me.	
	MU5	Other team members understood what I meant.	
	MU6	I understood what other team members meant.	
Relationships (reflective)	R1	I had friendly relations with the other team members.	Guinan et al. (1998), Te'eni (2001)
	R2	The other team members often got on my nerves.	
	R3	I was often disappointed with other team members.	
ISD success (reflective)	IS1	Our last project was completed within budget.	Wallace et al. (2004), Lee & Xia (2010), Bhattacherjee (2001)
	IS2	Our last project was completed within schedule.	
	IS3	How did the customers feel about the software that the team had developed? Very dissatisfied…Very satisfied.	
	IS4	How did the customers feel about the software that the team had developed? Very displeased…Very pleased.	
	IS5	How did the customers feel about the software that the team had developed? Very frustrated…Very contented.	
	IS6	How did the customers feel about the software that the team had developed? Absolutely terrible...Absolutely delighted.	

Table 2. Measurement Scales

All items refer to the last project that the participant was involved in. Most scales are based on 7-point Likert scales and the scale labels are typically ranging from "strongly disagree" to "strongly agree", except the scales for "communication frequency" and "ISD success". The items for "communication frequency" are open-ended, whereas the items IS3-6 for "ISD success" are based on semantic differential scales (cf. Table 2).

Results

We evaluated construct validity of the reflective constructs by conducting a confirmatory factor analysis using PLS (cf. Table 3). The accepted threshold for the item loadings is 0.7 (Hair, Ringle and Sarstedt, 2011). The results show that most items are well above this threshold. Only two items (CIF3 and R2) are below the 0.7 threshold. The reliability of the scales, indicated by Cronbach's alpha, show good values because all values are higher than the recommended threshold of 0.7 (Gefen, Straub and Boudreau, 2000; Straub, Boudreau and Gefen, 2004), except "relationships". A value of 0.55 indicates weak reliability. Finally, all reflective constructs show acceptable values for composite reliability (> 0.7) and average variance extracted (> 0.5) (Hair et al., 2011).

Construct	Item	Standardized Loading	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Communication Informality	CIF1	0.92	0.71	0.82	0.62
	CIF2	0.86			
	CIF3	0.53			
Mutual Understanding	MU1	0.85	0.94	0.95	0.77
	MU2	0.85			
	MU3	0.93			
	MU4	0.85			
	MU5	0.90			
	MU6	0.90			
Relationships	R1	0.82	0.55	0.76	0.52
	R2	0.58			
	R3	0.75			
ISD Success	IS1	0.80	0.95	0.96	0.80
	IS2	0.81			
	IS3	0.92			
	IS4	0.93			
	IS5	0.95			
	IS6	0.93			

Table 3. Item Loadings and Reliability of Reflective Scales

Table 4 illustrates the loadings and cross-loadings of the items of the reflective constructs. In terms of the cross-loadings, established guidelines suggest that the item load should be considerably higher than any cross-loading (Gefen et al., 2000; Hair et al., 2011), which is supported in our results.

Construct	Item	1	2	3	4
1. Communication Informality	CIF1	**0.92**	0.06	-0.06	0.15
	CIF2	**0.86**	0.11	-0.02	0.01
	CIF3	**0.53**	0.27	0.05	0.30
2. Mutual Understanding	MU1	-0.12	**0.85**	0.34	0.39
	MU2	-0.08	**0.85**	0.26	0.37
	MU3	0.16	**0.93**	0.35	0.61
	MU4	0.15	**0.85**	0.41	0.65
	MU5	0.32	**0.90**	0.23	0.50
	MU6	0.15	**0.90**	0.19	0.51
3. Relationships	R1	0.08	0.47	**0.82**	0.47
	R2	-0.12	-0.03	**0.58**	0.41
	R3	-0.08	0.20	**0.75**	0.55
4. ISD Success	IS1	0.26	0.62	0.48	**0.80**
	IS2	0.28	0.68	0.44	**0.81**
	IS3	0.12	0.40	0.66	**0.92**
	IS4	-0.01	0.47	0.62	**0.93**
	IS5	0.01	0.53	0.62	**0.95**
	IS6	0.07	0.47	0.68	**0.93**

Table 4. Loadings and Cross-Loadings of Reflective Items

For the formative constructs, we checked the variance inflation factors (VIF) (cf. Table 5). Established guidelines suggest that the VIF values should be below 3.3 in order to ensure that the formative items are not correlated (Diamantopoulos and Siguaw, 2006; Petter et al., 2007). The values of all formative items are well below this threshold. We did not evaluate the weights due to the low sample size of the pilot test.

Construct	Items	VIF
Social Agile Practices	SAP1	1.530
	SAP2	1.134
	SAP3	1.029
	SAP4	1.136
	SAP5	1.550
Communication Frequency	CF1	2.122
	CF2	2.415
	CF3	2.261
	CF4	2.197
	CF5	1.139
	CF6	1.535

Table 5. Variance Inflation Factor (VIF) of Formative Scales

DISCUSSION AND CONCLUSION

We developed a theoretically grounded research model that opens up the "black box" of the ISD process. We conducted a content validity assessment in order to develop measurement scales and obtained first indications of construct validity by carrying out a pilot test in a medium-sized software development company. The confirmatory factor analysis revealed that the reflective constructs "mutual understanding" as well as "ISD success" load appropriately, whereas the items for the "communication informality" and "relationships" construct have to be revised due to partially weak loadings. In terms of the formative constructs, the VIF values show that there is no correlation among the items, which is desirable for formative constructs (Petter et al., 2007).

Due to the small sample size and the previously discussed problems with the measurement model, we did not conduct a regression analysis of the relationships among the constructs. This entails that we are not able to answer our research question in this pilot study. The main contribution of this paper is the analysis of the measurement scales. In our future research, we will finalize the measurement model by revising the two scales that showed weak loadings. We will conduct an in depth literature search in order to find existing scales that may be employed for improving the measurement model in our setting. During the literature search, we will also look for additional mediators and moderators of communication and ISD success. In addition, we will check whether constructs such as social agile practices or ISD success should be modeled as multidimensional constructs. After fully establishing content and construct validity, we will conduct a large-scale survey in order to ensure nomological validity, in other words, hypothesis testing (O'Leary-Kelly and Vokurka, 1998). The results will help both researchers and practitioners to understand the underlying mechanisms of agile ISD methods.

Again, we would like to stress the fact that the analysis of this study is based on a very small sample size. This means that our results are only indications of construct validity. To fully establish construct validity as well as nomological validity, we need a larger sample size and more controls (e.g., a cohort study). A sample size of at least 60 individuals is needed for testing our measurement model (Chin, 1998). Nevertheless, by conducting a pilot study, we have taken important steps towards establishing construct validity and providing first insights on a possible explanation for the success of agile ISD.

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