How Artefacts Influence the Construction of Communications and Contexts during Collaboration in an Agile Software Development Team

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Abstract

This paper reports a cognitive ethnography study on the communication process of an Agile software development team in an industry. The aim of the study is to understand how physical artefacts influence the construction of communications during collaboration. We used a stimulus and response method to uncover correlation patterns of the physical artefact-communication during specific contexts of communications. We found preliminary evidence that the physical artefacts influence the communication process in a *mutually constraining relationship* with the *contexts*. In which the context is made up of the teams' practice that includes how they collaborate, the physical setting, situations, and participation role.

Introduction

Since the late 1980s and the 1990s there has been an interest in cognition to consider agents as situated in their specific context as it was realized that people are strongly affected by, and possibly dependent on their environment (Susi & Ziemke, 2001). With this shift of focus, new interactive theories of cognition have emerged. These interactive theories such as situated cognition (Clancey, 1997), and distributed cognition (Hutchins, 1999), are noted for their emphasis on the relationship between cognition, and artefacts.

Situated cognition (Clancey, 1997) emphasizes the relation between knowledge and action in context. The context of the action is extremely important and artefacts must therefore be considered to have an important role in any action, being part of the environmental conditions. The aim of situated cognition research is to explore the relation between knowledge and action, and the particular circumstances in which these occur. The unit of analysis is the individual and the environment in which the individual is taking actions. Distributed cognition seeks to understand the organization of cognitive systems (Hutchins, 1995). It looks into a broader class of cognitive events by considering how the information to be processed is arranged in the material and social world, and to consider the cognitive roles of the social and material world as well. The theory considers agents and artefacts as part of a complex cognitive system, which is regarded as the proper unit of analysis. Despite the emergence of these theories, to date there has not been much emphasis on the relation between artefacts and communication process with the aim to understand how the artefacts influence the construction of communications during collaboration.

Therefore in order to investigate into our research inquiry we have conducted a cognitive ethnography (Williams, 2006; Hollan et al, 2000) study of an Agile software development team in a large telecommunications and media industry. We used a stimulus and response method (Binti Abdullah et al, 2010) to uncover correlation patterns of the physical artefact-communication during specific contexts of communications. We found preliminary empirical evidence that the physical artefacts influence the communication process in a *mutually constraining relationship* with the *contexts*. In which the context is made up of the teams' practice that includes how they collaborate, the physical setting, situations, and participation role. Thus, the paper is organized as follows. We give the background of our study. Then, we introduce our study setting and research methods. Next we discuss our findings, followed by conclusion and future work.

Background

In this section, we offer a brief description of the Agile software development process. Then this is followed by a brief description and the functions of the commonly used physical artefacts in Agile teams' practice — the wall, and the story cards. Agile is a software development process that emphasizes communications and collaboration with customers while downplaying the role of formal tools, and documentation. A typical day in Agile teams practice will begin with a stand-up meeting and is followed by pair-

programming sessions. This is carried out everyday until the team members reach their software development goals.

A stand-up meeting is held every morning before the team begins their Agile practice. When possible, customers and developers will participate together. The meeting is normally held next to the 'wall', where the team must stand-up, and it generally lasts no more than 15 minutes. It is during this meeting, that each team member reports on what they did the day before, what they will do today, and any problems they had encountered. It ends when the participants have come to understand and agree together on: a) which story cards they will be working on that day; and, b) who pairs with whom on developing which story cards. The pair-programming session takes place with the pairs coding on the chosen story cards. The pairing sessions are intensive collaborations during which time developers will talk out loud to each other (Beck, 1999). The terms 'driver' and 'navigator' describe the role of each developer during the pairing. The driver is the programmer who currently has control of the keyboard, while the navigator contributes to the task verbally and by other means.

The wall is a public vertical space: e.g., a physical wall (see Figure 1). Story cards (index cards) are organized and displayed on the wall (see Figures 2, and 3 for illustrative examples). Story cards are created based on the concept of *user story*. A user story describes functionality that will be valuable to either the user or purchaser of a software or system (Cohn, 2004). Usually the customer writes the user story but because the story card is small, it can only capture an abstraction of what is required. So, for example, 'As a jobseeker I want to post my resume to the jobs website so that I am more likely to secure new employment', is a user story. Thus, story cards can be seen as the only visible part of a user story. *Acceptance tests* (see Figure 3) are written at the back of the cards, and they result from the discussions between the developers and customers. It provides basic criteria that can be used to determine if a user story is fully implemented

Related work

In the study by Sharp & Robinson (2008, 2009), the authors reported that the story card and the wall are seemingly simple artefacts yet are used in disciplined and sophisticated ways; this combination of discipline, simplicity and sophistication provides powerful team support. A recent study conducted by the authors Binti Abdullah et al (2010) on an Agile team found that the Agile physical artefacts helped team members to *define the boundaries of the context of gathering requirements* during their collaboration. This paper is a continuation from this work. We look further into other contexts (i.e. not requirements contexts) where the physical artefacts were used as part of their communication process. The aim is to find empirical evidence about how the artefacts influence the construction of

their communication process during situated contexts in Agile team collaboration.

Research methods

We use cognitive ethnography as a research method (William, 2006; Hollan et al, 2000). Cognitive ethnography relies on small-scale data collection based around representative time slices of situated activity. It looks at the process of the situated activity — at the moment-to-moment development of the activity and its relation to institutional (i.e., group practice) processes that is unfolding on different time scales. Therefore in our study, we focus on analyzing the situated activity of team members where the physical artefacts are used as part of their communication process. Thus we needed to collect the teams' communication exchanges. We organize this section as follows: we introduce the study setting, the data gathering and then the research methods used for data analysis.

Study setting

The agile development team observed is based in a large telecommunications and media company in the UK. The observation lasted for three days in March 2009. The team consisted of 5 developers and 2 customers, one of whom is a technical architect and another is a project manager. All the studies were conducted at the agile development team's office. Here, we describe the team's physical artefacts, followed by their practice. Different teams will have a different structure for their physical artefacts, and how stories are written, and used. Thus the description below is only for the team that we have observed. In this team, the wall (see Figure. 1) was a cabinet where the developers positioned the story cards (white index cards). In front of the wall, is the whiteboard, which was used during the first day of observation. Story cards under development are organized on the right-hand side of the cabinet into categories from top down such as: *backlog* (story cards still to do), and *live stories* (story cards they were currently working on). These categories were labeled by pink index card (see Figure. 2). Written on the story card is a short description of what needs to be developed, and in this example (Figure 2) one of the story card says: 'PORTAL'. Acceptance tests are written at the back of the story card (see Figure 3).

In Figure 3, one of the acceptance tests is written as 'USER ID SHOULD BE STORED IN CUMULUS'. The team also used a small whiteboard to write and sketch the customer's requirements of the system (see Figure 4 and 5). On the first day of observation, the team started off with a stand-up meeting using the whiteboard. Then the meeting was followed by pair-programming sessions (see an example in Figure 7). During the next two days' observations, the team started off with the standard stand-up meeting (see Figure 6) and similarly followed by the pair-programming sessions. During the pair-programming ses-

sions, the pairs frequently verbalize out loud what they are doing, thinking, or are about to do. The pairing partner and the role are not fixed.
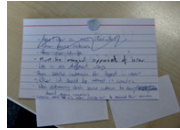

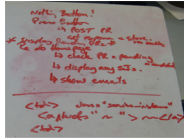Figure 1. The wall.   Figure 2. Story cards.   Figure 3. Acceptance tests.

Figure 4. Small whiteboard side 1.   Figure 5. Small whiteboard side 2.

Figure 6. Stand-up meeting.   Figure 7. Pair-programming.

Data gathering

Cognitive ethnography uses together many specific techniques such as interviews, participant observation, and video and audio recording (Hollan et al, 2000). Therefore in our data gathering and analysis method, we use several techniques. First of all we collected audio and video recording of the team's communication exchanges that included verbal and non-verbal interaction during stand-up and pairing session. The data consisted of: 1 hour 7 minutes of audio and video recordings of stand-up meeting and of 11 hours and 14 minutes of audio recording of different pairs of each day observations. These data were complemented by - photographs of the physical artefacts, office setting, and team members' interaction, 50 pages of field notes, and 80 photographs. For data analysis, we used the method to uncover physical artefact-communication relationship by Binti Abdullah et al (2010). The method employs a pragmatics analysis on how to find correlation patterns where there is a repeated occurrence of the physical artefact-communication during situated contexts. The reason for using this method is the following. As stated, our research aim is to find evidence about how the artefacts influence the construction of the teams' communication contexts. Since they are several types of artefacts used in the teams' collaboration, the goal is the following. Firstly is to identify which artefact is used, and how it is used as part of their collaboration. Next is to relate the influences that the artefacts played in the communication process during the situated contexts. As a consequence, we have adapted the method (Binti Abdullah et al, 2010) to our study into the followings steps, shown in Figure 8.
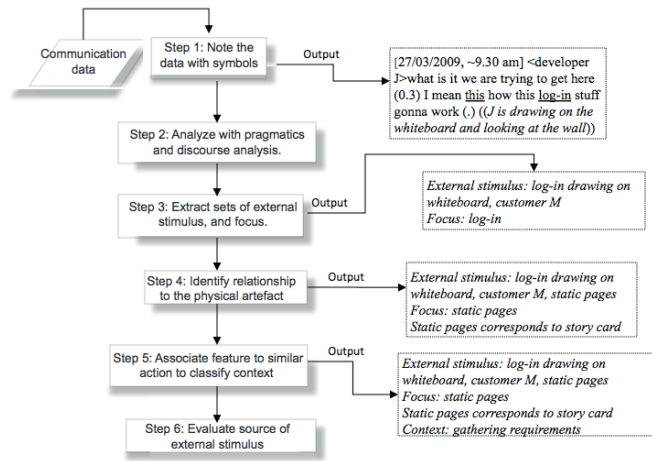

Figure 8. Data analysis.

Refer to Figure 8. The method consists of step 1 till step 5, represented by the rectangles. In our study we have made adaptation to step 3, and added a new step 6. The arrows labeled with output shows the examples of the kind of output that we obtained from each steps.

At step 1 'Note the data with symbols', we note the data with transcription symbols (see Appendix A) to all the stand-up meetings during the three days observation, and two pair-programming sessions (about 3 hours), of the first and second day observations. At the moment, the pair-programming data were randomly selected. At step 2 'Analyze with pragmatics and discourse analysis', we use pragmatics and discourse analysis (Binti Abdullah et al, 2010) to capture overlapping actions that team members take while communicating with each other. Overlapping here means the moment when the verbal communication and action takes place at the same time. For example if the team is talking about the software requirements, while drawing out the design - we capture this action into a simple commentary text, i.e., *J is drawing on whiteboard*. We aligned the video and the audio record in a timeline in order to capture the overlapping actions. The total transcription contains about 1,550 lines of dialogs. It took in total about 1 week to do the transcription.

At step 3 'Extract sets of external stimulus, and focus', we extract sets of {external stimulus, focus} from the analyzed communications. Each set is called a 'feature'. The *external stimulus* is defined as specific details from the environment (that includes the artefacts) that may have caused the individual to react in such a way at the present moment. *Focus* is defined as the beginning and end of a set of utterances that is about the same issue. At step 4 'Identify the relationship to the physical artefacts', we identify whether or not the feature refers to the physical artefact. For example we may have a transcribed data that notes that the developer uttered the word 'STATIC PAGE', while pointing to the story card 'STATIC PAGE' on the wall. Thus,

we note the output as an example '*Static page corresponds to story card'*.

At step 5 'Associate feature to similar action to classify context', we associate the feature to similar actions for classifying contexts. Context has been defined in the method as pattern taken by a series of events, knowledge of which can help inform a future event (Binti Abdullah et al, 2010). As an example, suppose we have speaker J, who is a developer who is replying to customer M on customer M's story. Thus, we identify the customer and the whiteboard as the external stimulus, and 'system log-in' as the focus. This feature is then associated to J's action – which is on capturing customer's story on the whiteboard. The associated feature to this type of action occurred in similar manner during different times throughout the meetings. Thus we classify the context as gathering customer requirements. The classification is agreed together by the authors. At step 6 'Evaluate source of external stimulus', we evaluate the source of the external stimulus –i.e., whether it is from the story card, or the wall. Then we relate how the sources are used together as part of the teams' communication process. It took us about 3 weeks to apply the above data analysis steps to our communication data. In this paper we will only discuss the results obtained from step 6, discussed in the following section.

Findings

Readers refer again to Figure 8 on the data analysis method. At Step 5, we have identified two contexts where the physical artefacts were used repeatedly to support the team's communication. They were classified as the following:

i. *Evolving non-functional system requirements*. A context of communication exchanges where team members propose to one another how to relate smaller parts of customer user stories to story cards that consider the constraints of technology, and programming languages.
ii. *Clarifying system requirements*. A context of communication exchanges where team members ask, or discuss the ambiguities of system requirements that they have encountered.

The two contexts took place from time to time during all stand-up meetings. However for the selected pair-programming sessions, we only found the contexts of clarifying requirements. We show the first finding for the context of evolving non-functional requirements during stand-up meeting below (refer to Appendix A for the symbols).

Ln-21: A: one thing to think about there (*A gestures to the whiteboard*), is the portal or CMS counter management (*M points to the wall*) (…)

Ln-25: A: what we're thinking we could all of that (.) merge forum, login could just be enaction (*A points to the whiteboard and to the story cards on the wall*) (…)

Ln-26: J: well, I don't like that idea at all (*J listens to A, while looking simultaneously to the story cards and at the whiteboard*) (…)

A, and J are developers. J also played the role as the teams' facilitator. We show the identified stimulus, and focus in Table 1 below.

Table 1. Context evolving non-functional requirements during stand-up.

Ln-n	External Stimulus	Focus
21	'user registration', front page, story cards	'user registration', story cards portal and CMS counter management
25	front page, customer zone, story cards	Merging story cards portal and CMS counter management
26	Merge story cards, story cards,whiteboard	Merging story cards portal and CMS counter management

Refer to Table 1, the words in brackets denotes the user story. Following Step 6, we identify the source of the external stimulus, and then relate how it influences the focus of the speakers' utterances. What we mean as the source of external stimulus is the following. For example, if we have identified that the user story 'user registration' as the external stimulus, then we simply label that the source of this stimulus is the concept 'user story. If we have identified that the external stimulus are drawings on the whiteboard, then we label the source of the stimulus simply as 'drawings'. Then we relate how they are used together, and influence the focus (i.e., topic) of the teams' communications. For Table 1, the sources of the identified external stimulus can be generalized as the following:

1. 'user registration'. The source of the stimulus is the concept of user story. Customer M was narrating the user story 'user registration' which is part of the user story 'portal'.
2. 'front page on whiteboard'. The source of the stimulus is the rough sketches of how the Web pages would look like. The sketches depict series of customer's possible interaction with the Web pages.
3. story cards. The source of the stimulus is the concepts, i.e., 'Portal'.

All three sources were used in each of the situated utterances of developer A, and J. It is used to help the members' focus their discussion on the issue of merging two story cards 'Portal', and 'CMS counter management'. Next we look into an excerpt of the dialogs for the context of clarifying requirements during the stand-up meetings.

Ln-8: J: right (*J looks at M and looks at the whiteboard*) (.) and that's (*J looks at the wall*) our registration story (*J gestures at the story card and then back to the whiteboard*) which is (.) registration number then (*J writes down on the whiteboard while verbalizing it out loud*) (…)

Ln-85: P: provision and managerial stuff (.) (*P looks at the wall and continues to contribute to J's drawing on the whiteboard*)

Ln-86: A: so uhm (.) (*A looks at the whiteboard, at the wall, and others*) is that all there is on the portal?

P is the developer. The identified stimulus, and focus is shown in Table 2 below.

Table 2. Context clarifying requirements during stand-up.

Ln-n	External Stimulus	Focus
8	Sketches on whiteboard, user registration story card	User registration story
85	Sketches on whiteboard, wall	Manage account
86	Sketches on whiteboard, wall	Drawings on whiteboard

The sources of the identified external stimulus as shown in Table 2 can be generalized as the following.

1. Sketches on whiteboard. The source of the stimulus is the rough sketches of how the Web pages would look like.
2. Story card. The source of the stimulus is the concepts, i.e., 'User Account'.
3. The wall. The source of the stimulus constitute of concepts, schedules and planning, and activities.

The three sources were used to help the developers to focus on what issues to clarify from customer's user stories. Next we show the findings for the pair-programming sessions, where only the contexts of clarifying requirements took place. We show the excerpt below.

Ln-67: A: yup so that will put it in the right place (.) over there (.) just checking where in the specs …in goes (.) (*A picks up the story card from the wall and check the acceptance tests. Then he looks to a small whiteboard*) yeah so it is independent of the-se two (*A points to the small whiteboard while looking at the story card*) (…)
Ln-68: A: ahhh (.) phrase (.) should ask cumulus for ? the service instance details (.) service instance (*reads out from the monitor and looks a the small whiteboard and story card*) (*silence*) so that's (…)

A is speaking to his pair, R where the pairs is seated next to each other and the both of them were looking at the computer screen. The identified stimulus, and focus for the above excerpt are shown in the following Table 3.

Table 3. Context clarifying requirements during pairing.

Ln-n	External Stimulus	Focus
67	Code and test, Acceptance test on story card, small whiteboard	Acceptance test service instance
68	Code and test, small whiteboard, Acceptance test on story card	Acceptance test service instance

The sources of the identified external stimulus as shown in Table 3 can be generalized as the following.

1. Code and test. The code and test refers to using a specific testing tool (Cucumber[1]) that allows the team members to implement the acceptance criteria through describing the behavior of the system. Each acceptance criterion that is described is tested using this tool. The tool represents the results of the criterion that is being tested in colored tagged text. If a text line is in red, it means the criteria implementation has failed. If it is green, then it has passed, and if there is an exception, then it is is yellow. Hence, the source of the stimulus is in text and colors.

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[1] Cucumber. Behavior Driven Development with elegance and joy. Website: http://cukes.info/

2. Acceptance tests on story cards. The source of the stimulus is in short instructions such as, 'Get user id in cumulus'. See Figure 3 for an example.
3. Small whiteboard. This stimulus comes from two sources (see Figure 4 and 5 respectively). The first source is in brief description on the steps of what the system is expected to generate. The second source is in tables to represent structural design for the system.

The three sources were used by developer A, and R to focus on clarifying why the code did not pass the test. The next section discusses the analysis of the findings.

Analysis of Findings

Based on the sources of the external stimulus that we have identified, we discuss how the sources are used as part of the teams' collaboration. Refer to Table 1, 2, and 3. User story is used to communicate what the system should behave or do from a customer's perspectives. The sketches on the whiteboard are used to communicate with all the team members — the perspective and understanding of user stories from the facilitator's point of view. The story cards and the wall are used to communicate the existing concepts of the system behavior that can be related to the sketches and user stories between customers and developers. The test and code is used to communicate with one another on how to implement the user stories and sketches and whether the implementation fulfills the acceptance criteria. The acceptance criteria on the story cards were used to communicate with each other on how the criteria should be designed if the criteria fail. Meanwhile the small whiteboard is used to communicate with each other on the logical steps of the system design and data structures. Let's look at the contexts on clarifying requirements that took place both during the stand-up, and pair-programming session (see Table 2, and 3). During the stand-up meeting, the team used sketches on the whiteboard, story cards, and the wall to communicate with one another. Meanwhile, during the pair-programming sessions, the team used code, and test, acceptance tests on story cards, and the small whiteboard to communicate with one another.

This specific finding highlights a small but significant empirical evidence that the use of the various artefacts influence the communication process in a *mutually constraining relationship* with the *context*. What we term as *mutually constraining relationship* is that the context constrains how the artefacts are used. At the same time the artefacts constrains how the team members communicate. Thus, the collaborators rely on various levels of information sources in order to collaborate together. For example clarifying requirements during stand-up involves clarifying customer's needs of the system. Hence, the developer uses story cards together with the whiteboard, and the wall to communicate with the customer. Meanwhile clarifying requirements during pairing involves clarifying the requirements at the technical level with another pair. Thus

the developer uses code and test, story cards, and the small whiteboard to communicate with his pairing partner. Thus, the term context based on our empirical evidence is redefined as—being made up of the teams' practice that includes *how they collaborate* (i.e., the use of story cards during stand-up meeting), the *physical setting, situations*, and *participation role*.

Conclusion and Discussions

The aim of our research is to understand how artefacts influence the construction of communications during collaboration. Thus, we have conducted a cognitive ethnography study on an Agile team in the industry focused at uncovering the physical artefact-communication relationship during situated contexts of communications. We found preliminary evidence that the use of the various artefacts influence the communication process in a *mutually constraining relationship* with the *contexts.* In which context is made up of the teams' practice that includes how they collaborate, the physical setting, situations, and participation role.

How may we relate our preliminary analysis to what is known in situated and distributed cognition? In situated cognition (Clancey, 1997), the *notion of context* or *situation* is with respect to the person as a social actor, constrained by social norms, playing an interactive role in some persona. Within this framework of situated context, situated cognition views the process of interpreting messages (i.e., verbal, or non-verbal) as occurring within — as part of – an individual's ongoing process of constructing what their current activities are and that includes the use of tools within their work activities. Distributed cognition (Hutchins, 1995), takes a view that the way of thinking comes with the techniques (i.e., practices) and physical tool (i.e., artefacts). Hutchins reported that the introduction of the calculator as a tool created a new context of interaction between the plotter and recorder. On one hand, the contribution of the calculator as a tool was that it changed the relation of the workers to the task.

Our findings revealed that from a situated cognition perspective — context when studied from the communication process point of view is not only influenced by the person's role as a social actor but it is also influenced by the teams practice. From a distributed cognition perspective, the mutually constraining relationship of the physical artefacts and the situated context – changed the relation between how the artefacts are used with the level of information that is needed. On one hand, the collaboration among different participation role changed the relation of how the artefacts are used together. Understanding how the artefacts influence the communication process can contribute to modeling contexts in AI systems. In Agile software development, one of the aims is to allow co-located Agile teams to work in a distributed setting. However as we have

shown through the findings, the Agile communication process relates to how the artefacts are used during situated requirements contexts. Furthermore, each requirements context occurs interactively according to the current situation. Thus is it important to distinguish between situation and context for designing an AI system that supports Agile practice in distributed setting.

How can our study contribute to the above? In situated cognition, contexts are sometimes referred to as situations. While our preliminary finding indicates that situation is part of context. Thus *is situation a part of context,* or *is situation a context*? Therefore our ethnography study can help to distinguish the notions of situation and context for the modeling of context in AI systems for distributed Agile practice. We acknowledge that our finding is preliminary as it was observed on one particular team. Thus, our future work will investigate into other Agile teams' practice to gain further empirical evidence on how artefacts influence communication process – with the emphasis on the *notion of context*.

References

Binti Abdullah, N.N., Sharp, H., Honiden. S. 2010. A Method of Analysis to Uncover Artefact-Communication Relationships. FLAIRS conference 2010.

Clancey, W.J. 1997. Situated Cognition on human knowledge and computer representation. Cambridge University Press.

Cohn, M. 2004. User Stories Applied. For Agile Software Development. Addison-Wesley.

Hollan, J., Hutchins, E., and Kirsh, D. 2000. Distributed cognition toward a new foundation for human computer interaction research. ACM Transaction on Computer-Human Interaction.Vol 7. Pp. 174-196.

Hutchins, E. 1995. Cognition in the Wild. The MIT Press.

Sharp, H. & Robinson, H. 2008. Collaboration and Co-ordination in mature eXtreme Programming teams. International Journal of Human-Computer Studies, 66, 506-518

Sharp, H., Robinson, H., Petre, M. 2009. The role of physical artifacts in agile software development: Two complementary perspectives." Interacting with Computers, 21(1-2), 108-116.

Susi, J., & Ziemke, T. 2001. Social cognition, artefacts, and stigmery: A comparative analysis of theoretical frameworks for the understanding of arterfact-mediated collaborative activity. Journal of Cognitive System Research 2 (2001) 273-290

Williams, F. 2000. Using cognitive ethnography for studying instruction. Proceedings of the 7th International Conference of the Learning sciences, Bloomington, Indiana: pp. 838 – 844.

Appendix A

Transcription symbols	Definition
(.)	A micro-pause
Underlining	signals emphasis
((*text*))	Additional comments from transcriber