Lappeenranta University of Technology
LUT School of Industrial Engineering and Management
Degree Program of Computer Science

Master's Thesis

Jarno Lehto

INTENDED QUALITY: RELATIONSHIPS BETWEEN DEVELOPMENT, TESTING AND QUALITY

Examiners: Professor Kari Smolander
D.Sc. Ossi Taipale

ABSTRACT

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89 pages, 3 figures, 5 tables and 2 appendixes

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Keywords: Software Development, Testing, Quality, Standards

An empirical study was conducted in the area of software engineering to study relationships between development, testing and intended software quality. International standards served as a starting point of the study. For analysis a round of interviews was kept and transcribed. It was found that interaction between humans is critical, especially in transferring knowledge and standards' processes. The standards are communicated through interaction and learning processes are involved before compliance. One of the results was that testing is the key to sufficient quality. The outcome was that successful interaction, sufficient testing and compliance with the standards combined with good motivation may provide most repeatable intended quality.

TIIVISTELMÄ

Lappeenrannan teknillinen yliopisto
Tuotantotalouden tiedekunta
Ohjelmistotuotannon koulutusohjelma

Jarno Lehto

Haluttu laatu: tuotekehityksen, testauksen ja laadun vaikutussuhteita

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Diplomityössä suoritettiin empiirinen tutkimus ohjelmistotekniikan alueelta, jossa tutkittiin tuotekehityksen, testauksen ja halutun ohjelmistolaadun välistä vaikutussuhdetta. Ohjelmistotuotannon kansainväliset standardit tarjosivat lähtökohdan tutkimukselle. Tutkimusta varten suoritettiin haastattelukierros ja haastattelut litteroitiin. Ihmisten välinen vuorovaikutus havaittiin kriittiseksi, erityisesti tietämyksen ja standardien prosessien välittämisessä. Standardit kommunikoidaan vuorovaikutuksen kautta ja niihin liittyy oppimisprosessi ennen noudattamista. Yksi tuloksista oli, että testaus on avainasemassa riittävän laadun saavuttamisessa. Lopputulos oli, että onnistunut ihmistenvälinen vuorovaikutus, riittävä testaus ja standardien noudattaminen hyvällä motivaatiolla voi tarjota parhaiten toistuvasti haluttua laatua.

PREFACE

This thesis work has been done at the Lappeenranta University of Technology and it is a part of the research project Software Testing for Intended Quality. I thank you all who have participated in the interviews for the study. Thank you for your time and patience.

I would like to thank all faculty employees who have participated in teaching for their motivating attitudes.

Special thanks to Leah Riungu-Kalliosaari, Ossi Taipale and Kari Smolander for their support in person in my effort for meaningful results. Tero Pesonen does deserve being mentioned separately for selling an idea about participating into the research project.

Separately for the general public: We have taken a giant leap for ourselves but a small step for the mankind.

Lappeenranta, March 2013

Jarno Lehto

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ABBREVIATIONS

DIS	Draft International Standard
IEC	International Electro-technical Committee
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
LUT	Lappeenranta University of Technology
MCMM	Measurement Capability Maturity Model
OU	Organizational Unit
PCI DSS	Payment Card Industry Data Security Standard
SPL	Software Product Lines
SQuaRE	Software product Quality Requirements and Evaluation model (ISO/IEC 25010 model)
STX	Software Testing for Intended Quality -project
TDD	Test-driven Development

1 INTRODUCTION

Software development is labor intensive due to complexities in it. People just have to do the work. Costs accumulating in a software project are difficult to reduce without reducing quality. In general, minimizing the costs has always been an interest in software development organizations. Many approaches for reducing spent time and costs have been suggested over time, for example methodologies and programming languages. Nowadays, not even faster hardware can provide significantly reduced spent hours as, for example, compile times have become relatively short due to technological advancements. However, increasing amount of features and growing software size seems to increase the costs instead. Software testing is a part of the software process and it is known to generate approximately 50 per cent of the total software development costs, depending also on the business domain of the software being created. To put it in short, the software testing attempts catching human introduced mistakes in work products during development and before actual use, and it is limited to best effort by its characteristics. Everything cannot be tested as the software size typically increases complexity exponentially. The cost of software testing is high and money spent seems to be growing as the average software size goes up. A natural consequence is to look for what can be done.

Research project Software Testing for Intended Quality (STX) studies software testing and its cost issues. The project intends to explain how software development, testing and quality depend on each other. Its objective is to ease the cost problem by lowering testing and development costs (STX, 2012a). One proposed answer could be sufficient and not the extreme overall quality called intended quality. The intended quality means tolerating minor annoyance, but not show stoppers as a consequence. For better understanding of such intended quality, relationships between development, testing, and quality in context of software systems was studied in this thesis. The thesis is part of the STX results.

For this thesis the research primarily focuses on following two questions. Does development and testing produce intended quality when standards and their processes are applied? Which relationships exist between development, testing, and quality in the context of software systems? People usually form a team to create software. This is why our interest includes such issues as communication, cultural difference, change, change resistance, workplace dynamics issues, conformance to standard and how physical distances affect. The objective is to report relationships between standards and realized quality. We are also interested in how well software industry in Finland meets the intended software quality. Hypotheses were derived from the analysis of two separate data sets. The focus of this study is limited to some relations of interest.

An empirical study was conducted using grounded theory method. Managers, systems analysts and testers were interviewed to obtain data. Interviews with software professionals are often used in empirical studies for gathering research data. A literature review was conducted after analyses to avoid influence from other researchers. Unit best suited for dealing with different sized organizations was found to be the organizational unit (OU). The international standard ISO/IEC 15504-1:2004 (ISO/IEC, 2008) defines the OU as a part of an organization which is the subject of an assessment. It is likely that the OU is a part of larger enterprise, but a small organization can be the OU itself. The OU operates having a set of business goals and a business process. The use of the OU normalizes company size and makes possible to compare different types of organizations. The first data set was analyzed to get leads and to create questions for the second interview round. The second data set was analyzed for gaining results for this thesis.

The schedule was pre-defined as a six-month-period. The study for the thesis has been conducted at Lappeenranta University of Technology (LUT) from the beginning of September 2012, until, ending at the end of February 2013. The interviews of the study were conducted in October and November in 2012.

Chapter 2 discusses software development, testing, quality and describes background information. Chapter 3 unfolds how the study was conducted and used methods are described. Results of the study are presented in Chapter 4. Findings are discussed in Chapter 5 and conclusions of this study are given in Chapter 6.

2 SOFTWARE DEVELOPMENT, TESTING AND QUALITY

Relationships associated with software quality may be numerous and it is a challenging area for researchers due to multidimensional factors involved in it. The quality has been approached in many ways in the literature. One generally accepted viewpoint is that people make the software. The approach in this study considers the quality including human activities which may reflect to the quality. We assume that it is vitally important to study more than methodologies because people make the software. This kind of interest requires a peek into areas of human sciences. However the standards and the activities in software process are important.

Software industry is relatively young when compared to, for example, construction industry. In the construction industry standards provide a ground for a common understanding. In the software industry ad hoc practices may lose ground, if international standards and terms become conformed. However software systems require software testing in order to achieve sufficient quality (Kats, et al., 2011). Humans make mistakes in non-ideal real world. Economically feasible software quality is a real challenge for testing (Rakitin, 2001). The standards in software industry are important (Pettersson, et al., 2008) and are discussed in the literature (Codur & Dogru, 2012). Testing has standards (IEEE, 2012 & ISO/IEC, 2013) and is discussed in the literature too (Munson, et al., 2006). It is reasonable to have attention over these.

In human sciences, communication (Haxby, et al., 2002), transfer of knowledge (Dewatripont & Tirole, 2005), cultural differences (Hofstede, 1984), group dynamics (Tajfel, 1982), learning (Baddeley, 2000), effects of changes and change resistance (Tavakoli, 2010), have been studied. In general communicating purpose of use and semantic meaning of data are critical in the software industry (Salles, et al., 2001). Meeting face-to-face is the most effective way to communicate between two persons

(Winger, 2005). However communication has requirements for success. For example do these two people speak the same language? Addressing a professional team is different from discussing with a customer representative, how communicated matters are expressed. Same level of detail may be beyond comprehension for customer management. Communication issues clearly need additional attention. In communication and interaction humans can experience distances (Xie, et al., 2009). The distances may be both physical and emotional (Xie, et al., 2009). The communication between people may include extreme physical distance enabled by current technology. The distances in interaction are better known in human sciences like sociology and psychology (Liviatan, et al., 2008). Such areas of science are intertwined with most matters in daily life, especially dynamics of the workplace. It is assumed that these matters affect efficiency of the work and may reflect into the quality as when the face management becomes concerned (Holtgraves, 1992). Holtgraves includes person perception into his discussion about having face in front of others. The distances and the group dynamics of the workplace in literature deserve additional attention. Cultural difference may be detected between organization's units in the same organization, however more likely when the units of the organization are located in different countries or completely between separate organizations. This refers to organizational culture. Cultural difference caused by increasing physical distance (Molinsky, 2005) needs to be considered as it is assumed that it may affect efficiency and success of communication. Molinsky discusses about language fluency and evaluation of culturally inappropriate behavior. Therefore the cultural difference in literature requires additional attention.

Offices and industrial buildings around the world offer physical working environment. People are needed there in order to co-operate with their needs and hopes. The needs are material, physical, social and psychological. The hopes of the people are highly personal, but when related to work, most likely it is less edgy personalities to work with (Hargreaves, 2001). It is assumed in Bluyssen et al. (2011) that these needs and hopes affect the successes and the working efficiency. The

basics of dynamics of the workplace and related literature need to be discussed. Working over a period time, the surrounding world, introduces changes at a changing pace and created software is tied to technologies. Change in technology is continuous and requires learning in order to stay up to date. Nowadays changes in organizations ownership, working hours, requirements and working environment cause so called distress (Tavakoli, 2010). It is assumed in Gonçalves and Gonçalves (2012) that any greater change affect human's behavior. Introducing changes and resisting changes can be found in the literature and are worth of short discussion.

Plenty of human behavior related things becomes discussed in this Chapter. Based on the improvement proposition 3 in Taipale and Smolander (2006) it is plausible that software project outcomes in software industry depend somehow on interaction between individuals. It seems also plausible that the interaction between human individuals reflects to the achieved quality. Therefore existing research covering relationships between these areas deserves to be shortly discussed.

2.1 SOFTWARE QUALITY AND INTENDED QUALITY

Lochmann and Goeb state that software quality is highly complex and multi-faceted topic. It is intermingled with almost all software engineering activities, as well as with the artifacts created by those activities. (Lochmann & Goeb, 2011) Their approach for quality model in the example is based on maintainability and usability. A completely different quality model by Pareto and Boquist deals just with design document artifacts and ends up considering 23 qualities in the area (Pareto & Boquist, 2006). These articles give a hint on how challenging it is to define the quality of the software. Many approaches in measuring software quality have been produced over time. Jørgensen (Jorgensen, 1999) concludes, for example, that calling the measure of error density as a quality measure is misleading and unnecessary.

Any silver bullet for defining software quality in a single sentence has not been found. It is widely known that requirements engineering at the beginning of software project, software architecture and level of artifacts created in activities are critical for the software quality. Software testing is a known way to detect issues in need of correcting; therefore it has an impact on the quality. How the end user experiences the software quality may depend on the data quality. The complexity grows with the quality of processed data itself. The data quality is a research topic itself and for example Madnick et al. have studied it (Madnick, et al., 2009). Decision support system may behave in unexpected way if the data is of poor quality and give an impression that the software has a quality issue. Due to the complexity a common approach has been to create international quality standards. Standards are developed by national and international standardization bodies, for example ISO (International Organization for Standardization), IEC (International Electro-technical Committee) and IEEE (Institute of Electrical and Electronics Engineers).

Table 1: ISO/IEC 25000 Quality Characteristics and Sub-characteristics

Product quality	Functional suitability	Functional completeness
		Functional correctness
		Functional appropriateness
	Performance efficiency	Time-behavior
		Resource utilization
		Capacity
	Compatibility	Co-existence
		Interoperability
	Usability	Appropriateness recognizability
		Learnability
		Operability
		User error protection
		User interface aesthetics
		Accessibility
	Reliability	Maturity
		Availability
		Fault tolerance
		Recoverability
	Security	Confidentiality
		Integrity
		Non-repudiation
		Accountability
		Authenticity
	Maintainability	Modularity
		Reusability
		Analyzability
		Modifiability
		Testability
	Portability	Adaptability
		Installability
		Replaceability
Quality in use	Effectiveness	
	Efficiency	
	Satisfaction	Usefulness
		Trust
		Pleasure
		Comfort
	Freedom from risk	Economic risk mitigation
		Health and safety risk mitigation
		Environmental risk mitigation
	Context coverage	Context completeness
		Flexibility

In the standardization work, software quality has been described using quality models. Most common are ISO 9126 (ISO/IEC, 2001) and ISO/IEC 25010 (ISO/IEC, 2011a). The ISO/IEC 25010 is the successor of ISO 9126 and will replace it. These standards describe high level quality characteristics and their sub-characteristics for software, shown in Table 1. In the ISO/IEC 25000 quality model's quality characteristics exist in two categories. In the 'product quality' the eight characteristics include Functional suitability, Performance efficiency, Compatibility, Usability, Reliability, Security, Maintainability and Portability. In the 'quality in use' the five characteristics consist of Effectiveness, Efficiency, Satisfaction, Freedom from risk and Context coverage. Under quality characteristics there are 31 and nine sub-characteristics respectively. These are internationally agreed as characteristics and sub-characteristics which can be used when discussing or negotiating software quality. Actually many software quality assessment frameworks in literature are based on this standard. Problematic is that outside software producing organizations the standard is not known. In our study the ISO/IEC 25000 way of describing software quality served as the starting point.

For an average end-user the sufficient quality may be that the software does not stop operating pre-maturely and the output result is correct. This does not say much about other areas. The quality characteristics have to be balanced and they have to take into account the purpose of the software. Having just one quality characteristic at top-notch level is not sufficient or good quality. The intended quality means purposefully balanced characteristics which have defined sufficient levels, not the most expensive quality that have been tested extensively. The intended software contains defects in areas which are less critical and the defects do not cause show stopping but minor annoyance. The intention is to limit development costs when the software size grows.

2.2 TESTING AND DEVELOPMENT

Software testing is strongly intertwined with development. Its purpose is to check developed artifacts. Software development artifacts are produced by people and professionals make mistakes as anyone else. Many types of mistakes can be made, for example, implementing differently than specified, implementing something that was not specified or omitting something from implementation. As software has a lifecycle from original idea to removal from use, the mistakes can be made even after the initial development during the maintenance period. Perfective, corrective or adaptive changes may introduce regressions. Munson et al. have defined a fault or a defect as a structural imperfection in a software system that may lead to the system's eventually failing (Munson, et al., 2006). Equally specification documents should be subject to static testing in order to avoid incorrect specification from advancing to implementation, while inspecting behavior of a running program is dynamic testing (ISO/IEC, 2013).

Testing has a wide range of specific areas and responsibilities in software quality assurance. In general it is supposed to inform development about found imperfections. (Rakitin, 2001) Kats et al. introduce testing as one of the most important tools for software quality control (Kats, et al., 2011). They also discuss about test-driven development (TDD). According to Kats et al. development is an engineering discipline which is controlled by testing. One important area of testing is usability testing when software has a user interface, Molina & Toval (Molina & Toval, 2009) describe many usability issues in web-based information systems. User interfaces can be the make-or-break on the Internet. Other specific and very important area is security testing as malicious intrusions are not going to fade away; rather increasing amount of networked devices has enabled a business case for the organized crime. Testing of security issues may require different thinking and specific training for finding vulnerabilities, as Zimmermann et al. (Zimmermann, et al., 2010). International standards covering information security exist, but fast pace of change in threats give room for industry standards (Owasp, 2012). Because testing is so important in terms of quality, it has been defined in national and international

standards. IEEE std-1012-2012 defines testing as system and software verification and validation (IEEE, 2012). Taipale (STX, 2012b) has generalized verification and validation as “Are we doing the right product?” and “Are we doing the product right?” He also added that in order to be more precise the verification and validation include formal proofing of correctness. International standardization workgroup 26 has been preparing a standard for testing. The standard will be the ISO/IEC 29119 software testing standard (ISO/IEC, 2013).

The software testing is labor intensive work. Costs incurred from testing have been always high. New software versions have usually become larger and therefore there has been an interest to reduce overall costs and costs of testing especially. In testing of executable code there are repetitive tasks that can be automated using scripting language or software tool. Sabbatini et al. (Sabbatini, et al., 1999) discuss automated testing. They suggest a formal language as a test automation tool. Idea of automated testing in not new, but test automation is challenging and expensive to build and maintain. Even manual testing environments and tools incur significant costs. Cost effectiveness in software industry usually forces some combination of manual testing and test automation.

Development practice has its own subjects in algorithms, programming languages, documenting, version control and software architectures. Algorithms which get implemented must be efficient in order to avoid slow-down with multiple users. Programming languages have their area of best suitability. The language specific issues need specialization as, for example, Orso et al. discuss pointers (Orso, et al., 2004). Documenting is part of development practice. All work products need to be documented in a traceable way between related ones (Santiago, et al., 2012).

2.3 STANDARDS

National and international standards cover many areas of life. Early standards for software engineering covered a very small area; mostly data communication protocols and certain types of interfaces adopted from electrical and electronics engineering. Nowadays proper international standards for engineering software exist; some are at the verge of publication. Latest standards describe processes and sub-processes, not only activities and work products. Being a proper industry might depend on the conformance to these standards. However, it is known that large amount of customer base are unaware of the standards. A standard does cover a defined area of knowledge. Conformity to the standard could facilitate getting similar quality from different competing software contractors. Many standards cover a specific area of the body of knowledge in software engineering.

ISO/IEC 15504 is about assessment of processes in software developing organization (ISO/IEC, 2004). Its interests are in process improvement and process capability determination. In order to learn from the current performance the organization must have metrics. ISO/IEC 15393 defines software measurement process for software engineering and management (ISO/IEC, 2007a). The new SQuaRE (Software product Quality Requirements and Evaluation model) -series' ISO/IEC 25020 (ISO/IEC, 2007b) contains a measurement reference model and guide for measuring quality characteristics described in ISO/IEC 25010 (ISO/IEC, 2011a). In the SQuaRE-series quality requirements are addressed in ISO/IEC 25030 (ISO/IEC, 2007c) and evaluation of the product quality in ISO/IEC 25040 (ISO/IEC, 2011b). Díaz-Ley et al. have described a measurement capability maturity model (MCMM) which is based on ideas presented in the ISO/IEC 15504 (Díaz-Ley, et al., 2010). To facilitate actual software quality, software testing has a significant role. For the software verification and validation IEEE has a standard 1012-2012 (IEEE, 2012). ISO/IEC will publish the latest software testing standard 29119; three parts out of the 29119's four parts have reached Draft International Standard (DIS) in Mid-January 2013 (ISO/IEC, 2013).

Confidentiality, in-repudiation and accessibility are standardized as well. ISO/IEC standards from 27000 to 27019 describe information security processes and security techniques of information technology (ISO/IEC, 2012). For software systems it is highly important that unauthorized persons cannot copy confidential data from the system and alter behavior of the system. Vaughn et al. have discussed the need of awareness and teaching information security in educational institutions (Vaughn et al., 2004). Standardization does not take place in international standardization bodies, but rather in associations or foundations initiated by certain industry or interest group. These so called industry standards are standards for specific need when international standard is not specific enough for the need or international standardization reacts too slowly. An important example for banking and insurance is the Payment Card Industry Data Security Standard (PCI DSS) which is in use around the world (PCISSC, 2013). Hizver and Chiueh have studied PCI DSS and payment card data flow (Hizver & Chiueh, 2011). In their study they were able to track card data in a payment card processing system which was running on virtualized servers.

When a software system controls moving parts, safety of humans in nearby area gains critical importance. Automation system in manufacturing industry should conform to relevant safety standards, for example, IEC 61508 which covers many safety issues (IEC, 2005). Safety in other contexts has its own standards, for example, in electric power networks, nuclear power generation, automotive, chemical, buildings, etc.

At some point of time the standard becomes aged even it has been revised. It is likely that following new standard will be developed to fit better in the surrounding world. For the transitional period of time the previous standard is supported as it has been applied by organizations. An example would be ISO 9000-3 for development, supply and maintenance of software (ISO, 1997). It was meant for applying ISO 9001 processes in software industry. It has been withdrawn by ISO. Withdrawal means it will not be supported anymore. Documentation of old software may have references

to standards which were in use decades ago. Standards do have lifecycle as well as software has.

2.4 COMMUNICATION

Passing pieces of information can have many means. It can take place between two individuals, from one to many and vice versa possibly forming a group discussion. Nowadays it can take place from information system to individual and vice versa or from information system to many and vice versa. More than 80 years ago in the end of 1920s the term communication included means of transportation as meeting in person was the most natural way of informing other person. Back then professor of sociology Ernest W. Burgess reported about technological change in communication (Burgess, 1930). Telephone, moving picture theaters, applications of radio, cars and airplanes initiated a change in society and how it communicates information. Today we access wirelessly multitude of information networks consisting of multiple information systems interconnected as the Internet. Development has made group video calls self-evident. However nature-evolution of human has not taken sudden leap. We experience different kinds of misunderstandings throughout the lifetime. Perfecting technology didn’t remove limits or hindrances. Denning and Bell discuss humans in assigning meaning and Shannon’s information theory (Denning & Bell, 2012). According to Denning and Bell, Shannon created the theory for communication systems which do not consider meaning of information. The information may experience disruptions from noise on the signal path or it may contain errors that change the information. Thinking of low resolution facsimile could remind how people have experienced misinterpretations, for example, of digits in the information.

Meaningful communication between humans has many modes and requirements. Communication is largely spoken and written, but also drawn, painted, sung, facial

expressions and bodily expressions. Communicating is context dependent where receiver has to have some background information of the topic or domain knowledge. Domain knowledge includes comprehension of terms. Missing knowledge may cause repetition of passed information and, or failure. (Dewatripont & Tirole, 2005) Dewatripont and Tirole have discussed communication mode and transfer of knowledge. Their considerations include willingness, terms for commitment, motivation and abilities. Success in communication does improve when sender and receiver have nearly similar education and profession. Good command in same natural language provides for efficiency in communication and efficiency in general. Issues in communication can be intentional and included in information. Reliability, honesty and reputation in international disputes are discussed in Sartori's paper (Sartori, 2002).

Communication is used for transfer of knowledge (Dewatripont & Tirole, 2005) and intention of a standard, qualities, inputs and work product. For the standard, passing ideas of processes and artifacts, to many is centric. For creative working phases, understanding what is processed and why, may be important. For customer in software industry cost, qualities and level of quality characteristics are subjects of interest. If related standards and conformance to standards are communicated to the customer, the standards may become better associated as a part of the good quality. Whether the customer prefers just lowest cost then the situation may include knowingly ignoring the good quality.

Amount of communication channels and equipment along with massive and increasing amount of information has made most people's reception ability saturated (Soucek & Moser, 2010). Person cannot increase limited capacity of concentration for more information and cannot participate in all activities which have become accessible (Paul & Nazareth, 2010). Also publishing an own opinion and interest group writings on-line are easier than ever for an individual (Ryan & Xenos, 2011). At the same time validity of free information should be healthily doubted (Ryan &

Xenos, 2011). This flood of information may make many persons selective. Filtering e-mails, deliberately not following certain medium and turning calls to an answering machine service are examples of behaviors limiting communication (Soucek & Moser, 2010). Possible adverse effects could be missed higher priority knowledge and exceeding deadlines due to ignoring the received content. Guthrie has studied locating information in documents (Guthrie, 1988). His study included observing combining the information from separate documents. Although importance in accessibility of wanted information and condensed format of information have increased. The increased importance has created new business opportunities in gathering, classifying and processing of information (Feelders, et al., 2000).

2.5 DISTANCES

Means for communicating enabled by technology allow greater physical distances than just meeting in person (Soucek & Moser, 2010). Extreme physical distances introduce even cultural differences (Holtgraves, 1992). Measurement of physical distance is expressed in meters as the international norm (BIPM, 2006). For our study the sufficient accuracy is less exact for the interest in how growing distance affects communication and working. For our purposes meaningful distances have been defined as in the same room, in the same building but not in the same room, in the next building, in the same city, in the same country but not in the same city, in different country but nearby and in different continent. In the same room may allow easily transfer of knowledge in person or as a group (Paran, et al., 2004). In the same building and in the next building may allow meeting in person with minor effort of walking to other floor or the next building however increasing probability of use of communications equipment instead of meeting face-to-face. In the same city may increase the effort required, time consumed and probability of use of communications equipment (Walther, 2007). It may be possible that frequency of meeting in person declines already when persons are located in different areas of the

same city (Wilson, 2003). In the same country but not in the same city may introduce need for schedule planning, travel arrangement and may consume many hours typically. In the same country may have a high probability of switching over to using communications equipment (Wilson, 2003). In different country and in different continent may make use of communications equipment likely and visiting in person rare (Valley, et al., 1998 & Park, et al., 2012). The visiting in person may be ceremonial politeness or true need of problem solving, and may require days for schedule planning, travel arrangement and the travel itself.

It is assumed that use of communication equipment reduces effectiveness of expression even when telephony, video conferencing, shared desktops, virtual whiteboards, file sharing, document scanners and e-mail are accessible for use (Frohlich & Oppenheimer, 1998). Everyone do not know how to use all features available and time required for learning may be restricted luxury for some (Tynjälä, 2008). In many cases the equipment serves sufficiently but users may have to adapt to restrictions of each equipment. Other remarkable issue is command in language being used as some will have difficulty expressing themselves using spoken foreign language (Molinsky, 2005). Effect of differing thinking orientation and language barrier due to physical distance have been one part of our interest. We have assumed these to affect success of communication and efficiency of processes (Paul & Nazareth, 2010).

Other measurable differences between organizations that have been considered are age and rank if hierarchy exist in the organization. Age difference can be expressed in number of years and rank in number of levels in hierarchy. These were considered as if they could have an effect to communication. Our interest is in willingness to interact and communicate, and whether there are identifiable thresholds before commitment to interaction. Common knowledge is that people at different ages are interested in different things and possibly age-mates having similar interests and maturity. Reacting to differing rank depends on personality but may cause

interferences to interaction. For example something related to work at hand is left untold. Schafer and Shippee have discussed age identity (Schafer & Shippee, 2010). Their paper considers changes in age identity over a ten years period.

Social and emotional distances (Liviatan, et al., 2008) between individuals have lot to do with dynamics of the workplace (Ahmed, 2007). As humans perform software creating activities in organizations they have to share knowledge instead of just passing on own work product. Social acceptance (Stephan, et al., 2011) into team has significant effect whether person becomes productive. Does person emotionally sense being welcome (Ahmed, 2007) into discussion or selectively ignored? Do colleagues trust in work quality? Do they trust in word? Do organizational units's management representatives trust in word? Frowe has studied trust (Frowe, 2005). His study discusses the trust in a profession. Roby and Lanzetta have discussed group structure and task performance (Roby & Lanzetta, 1956). They have considered that exchange of information amongst team members may be as important as individual abilities. On the other hand Wilhelm and Bekkers have discussed helping behavior (Wilhelm & Bekkers, 2010). The care of others and emotional reacting with concern, have great but not easily measurable importance between the team members in providing spontaneous help.

2.6 CULTURAL DIFFERENCES

Customer-provider relationship or subcontracting over national borders and possibly over continental distances brings cultural differences into picture. In Western hemisphere the term outsourcing has been used in addition to subcontracting, instead of making self, and the term off-shoring from the quest for low cost in other continent having large population, instead of making self. The cultural differences may appear in many areas. One might first consider languages which may be numerous in single country and being bound to area. Finding common language is

just one issue, likely attempting English first. Usually national holidays and religious holy days differ. Reaching a person may depend on calendar date. Most likely thinking orientation may prioritize family and family ties (Hirschman & Loi, 1996). Hirschman and Loi have studied Vietnamese family and household structure in their study. Priorities have an effect to relationship to work (Bielby, 1992). Bielby discusses the interrelationship between the spheres of the home and the work. Hofstede has studied work related value patterns (Hofstede, 1983). Hofstede's research has continued to differences in management philosophies and techniques (Hofstede, 1984) and later with Richard Frankein and Michael Bond about effect of cultural roots to national economic performance (Frankein, et al., 1991).

Working culture may include working hours spent discussing with family members and closest friends. In some cases presence is extended just to stay at work at least as long as closest superiors. In major parts of Asia the working relationship with superior is often authoritarian where worker does what one understood the superior instructed, and avoids thinking oneself serious alternative approaches. The avoidance ensures not being stepping on toes, lesser responsibility of outcome and preserving own face in front of colleagues. In project work the transfer of knowledge may become the responsibility of the superior. Gained knowledge may be valuable and not lightly shared with just someone nearby. Who and what person knows are of value. Such arrangement hinders passing all properties of the knowledge in question. In contrast Finnish working culture prefers compact working days, likely eight hours, discourages dealing with personal matters and requires personal thinking for finding a solution. If the independent thinking fails, likely the person is held responsible for being lazy or less smart. The contrast is significant between Finnish and continental Asian cultures and should be kept in mind when planning large multicultural off-shoring projects (Li, 2004 & Sumelius, 2009).

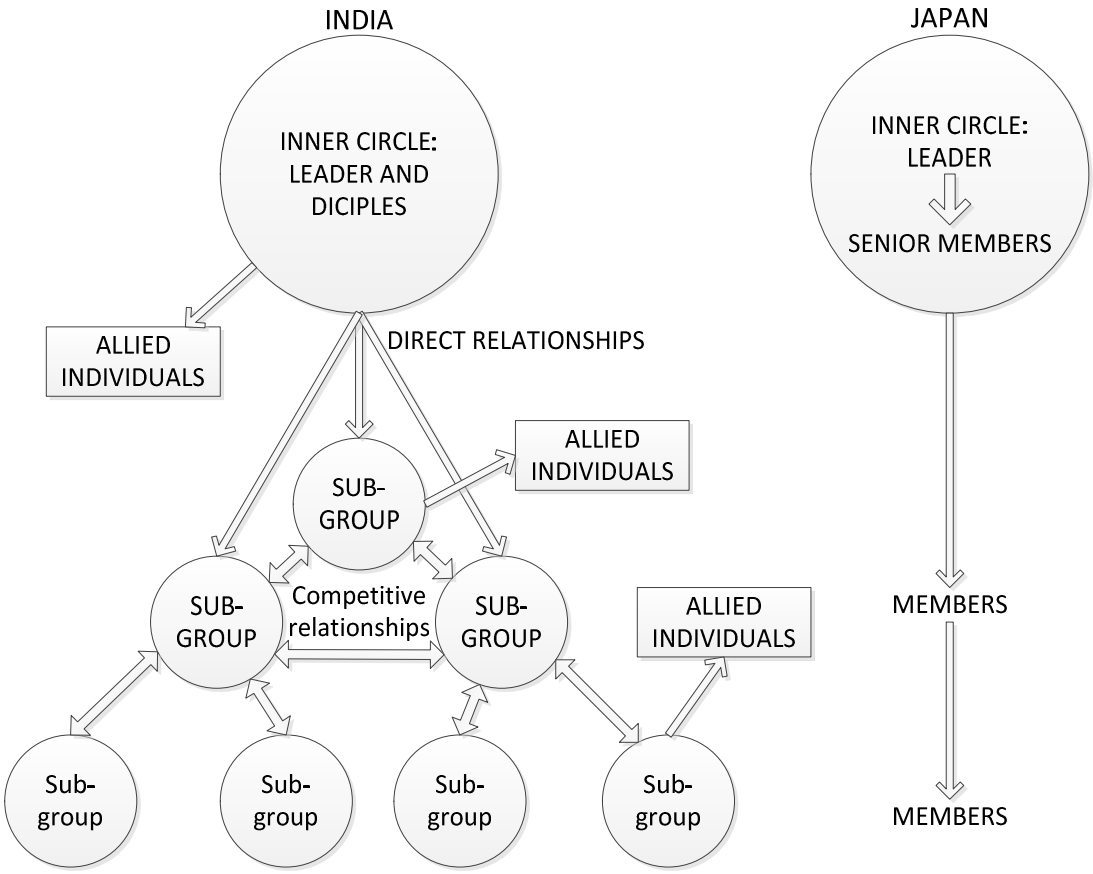

Figure 1: Comparative Model of Factional Structures (Hoffman, 1981, p. 234)

Cultural differences are an area of study in social, history and economic sciences. Hoffmann has studied structure of political factions and decision making in India and Japan (Hoffmann, 1981). Hoffman depicts in Figure 1 how big the difference really is. Hashimoto and Miyasaka discuss the class structure in 20th century Japan (Hashimoto & Miyasaka, 2000). They have included the presence of immigrants in their discussion. In a special issue on social identity, Yuki has discussed the social identity theory framework by Tajfel and Turner (Tajfel & Turner, 1979) and compared North America and Japan (Yuki, 2003). Chinese culture and history has been studied from many perspectives. Joel Andreas has studied an era which begun from the culture revolution (Andreas, 2006). The commercialization of the Chinese culture has been popular topic too. Landes has taken economic and technological views in his research (Landes, 2006). In his work he questions why greater

development advanced in Europe instead of China. Kommonen has studied what meanings the Chinese may associate with colors (Kommonen, 2011). On the other hand the study of national literature describes past history and national identity. Suh (Suh, 2011) has studied Korean culture, literature and effects of colonialism. Even language studies of an individual and non-scientific translated literature can provide about fine sensitivities and differences from the culture of interest.

2.7 WORKPLACE DYNAMICS

Efficiency of working comes from complex combination of areas. Basic physical needs in modern society may be met with safe surrounding buildings having stabile electricity supply, heating, air ventilation and desk. Infrastructure may provide hardware for Inter-network access for information processing tasks. (Bluyssen, et al., 2011) Irritation from organization's non-operating items or lack of tools and materials may reduce productivity through varying levels of emotional disappointment. Persons with specific skills are major challenge for organizations human resources management (Gruman & Saks, 2011). Some people may have plenty of specific skills, but too much edgy personality may finally prevent use of their services. For example, probably bullying person creates a negative distortion to otherwise harmonic working environment. Plain money form of compensation may not be enough for solution oriented independently thinking people in the working environment. These people have to feel that they care to come back in the following days (Gruman & Saks, 2011). Social contacts between participating people are one area of the workplace dynamics. Schaefer and Kornienko have studied positively connected exchange networks (Schaefer & Kornienko, 2009). They report that relational cohesion and positive connections allow people to interact even if their relationship is imbalanced in terms of power. Honesty connects with social contacts. The use of problem hiding white lies should be discouraged in organizations. Trust in person and trust in word are very important in exchange of information and team

building (Frowe, 2005). Cheshire et al. have studied trust and changes in social modes of exchange (Cheshire, et al., 2010). In their research they have focused on two forms of uncertainty, first uncertainty in the social exchange and second uncertainty from an experience of non-cooperation. The experience of the uncertainty in the working environment may affect the people and the work results. Their results describe that socially risky relations cannot lead to more trust between exchange partners, if individuals do not repeatedly demonstrate trustworthiness through cooperation over time. In their domain specific language the exchange means interacting socially.

Other kind of consideration is whether a person is doing the work which is most fit for oneself. Assumed required skills are present, but experience of satisfaction and fulfillment are only partially met. This kind of person may become fully efficient in regular activities, but there is greater chance that this person will continue looking for personal fulfillment elsewhere. Maslow has described similarly the need for self-actualization in his theory of human motivation (Maslow, 1943). Leaving for other type of work from the organization creates at least a short discontinuity in productivity and rearrangements of responsibilities. If hiring process is not truthful about actual tasks in the work, exchange rate of employees in organization may rise uncomfortably high due to mismatch with true occupational expectations. Reynolds et al. have studied the fulfillment of occupational expectations (Reynolds et al., 2007). Their scope of research covers development until midlife of a person. People have the ability to act on their ambitions and plans if they are given an opportunity they are willing to master (Reynolds et al., 2007).

Internal training and external training consulting of technology and management skills are possibilities to make people feel they are in the right place. They are challenged with new and supported in learning at the same time. Managers who have subordinates may have to improve planning and reacting to changing technology and environment. Employees at implementing positions have to keep up with change of

technology. Aguinis and Kraiger have reviewed training and development literature (Aguinis & Kraiger, 2009). Their discussion describes how the training activities can produce benefits for individuals and teams. Even trainings on mental attitude and alignment of values should not be seen as nonsense, but presenting person has to be talented and objectives designed. Change in attitudes and organizational culture most likely may require specialized professional's instruction in a reflective self-study and work-shop meetings. Change generating an innovation, instead of no innovation, does not have to be big. Bas ter Weel (ter Weel, 2006) reminds us about history and pace of change in information technology industry. Technology of the next year has to be brought in by well-motivated people.

2.8 CHANGES AND CHANGE RESISTANCE

Changes planned and announced plans of action likely release emotions and even actions resisting the change that is tried to put in place. Owner or owners of an organization may require restructuring of operation, lay-offs, hiring people with specific skill or use of different technology. Carbales et al. have studied social preferences, skill segregation and wage dynamics (Carbales et al., 2008). In their paper they consider hiring and firing policies of a company and partial skill segregation. Introducing new technology into use in organization creates technical type of change (Gonçalves & Gonçalves, 2012). Technology acceptance has been studied by Nov and Ye (Nov & Ye, 2008). Their interest has been in innovativeness in information technology, openness and change resistance. Reactions disclosing during change process in employees may vary from liking of the new to damaging property (Tavakoli, 2010), and at the same time group dimension of the employees ranging from reaction of an individual to inter-team reactions. Tajfel has studied group membership and intergroup behavior (Tajfel, 1982). His research approaches intergroup issues from a perspective of social psychology.

Attempts of fine-tuning organization's performance (Buller & McEvoy, 2012) using various training methods face resistance too. Re-arranging objectives using change preparing motivational training or training of thinking orientation, from management training consultancy could be effective; much more effective than just sending an e-mail announcing a new order. However some individuals may decide not to attend and see such training as nonsense for themselves. Other form of resistance may come from project and middle management referring spent time relating to cost. Brown and Treviño have discussed the ethics of leadership. At times management prevents advances or change process due to watching quarterly result (Brown & Treviño, 2006). Having expectation of improving productivity and least spending, they may keep avoiding arranging the training. Competing with previous quarterly results and showing off competitiveness may make unable to see over longer span of time (Gadhoum, 1999). On the other hand, Egan and Fjermestad have studied advancing change from a context of information systems (Egan & Fjermestad, 2005).

2.9 POSSIBLE RELATIONS BETWEEN SOFTWARE DEVEVELOPMENT, TESTING AND QUALITY

Researchers have discussed about developer activities, testing processes and software quality. For example, Lochmann and Goeb have discussed software quality (Lochmann & Goeb, 2011). Interesting is how the relationships between these areas are defined by others. Effects of resourcing testing have been studied, for example, by Kasurinen (Kasurinen, 2010). Effectiveness of testing in finding defects has also been studied, for example, in regression testing (Nagahawatte & Do, 2010). New testing methodologies have been suggested, for example, software-implemented fault-tolerance and fault removal (Slåtten, 2010).

Measuring test coverage has been studied, for example, by Siniaalto and Abrahamsson (Siniaalto & Abrahamsson, 2007). Transition to agile methodology has

been studied, for example, Kircher and Hofman have studied it in software product line (SPL) environment (Kircher & Hofman, 2012). Multitude of studies and development work to development and testing metrics has been made, for example, by Munson et al. (2006) to automate fault counting. However besides testing standards document, publications describing relationships between standard, development, testing and quality at the same time are not very common to find. Most related seem to be frameworks that are based on specific existing standard specification, for example, by Lochmann and Goeb (Lochmann & Goeb, 2011). The column writing by Watts says most clearly that people, software professionals and their managers, are the key to software quality (Watts, 2004).

3 RESEARCH PROCESS

The topic of this thesis was intended quality and whether there are relationships between development, testing, and quality in the context of software systems. The qualitative grounded theory research method was selected for the study because the data came from interviews. The samples of the study consist of organizational units from the information technology industry. The organizational units were interviewed in order to collect the data. The interviews were conducted during two subsequent years. Activities for the thesis generated the second set of research data for the project, in Figure 2, in addition to results found in the thesis.

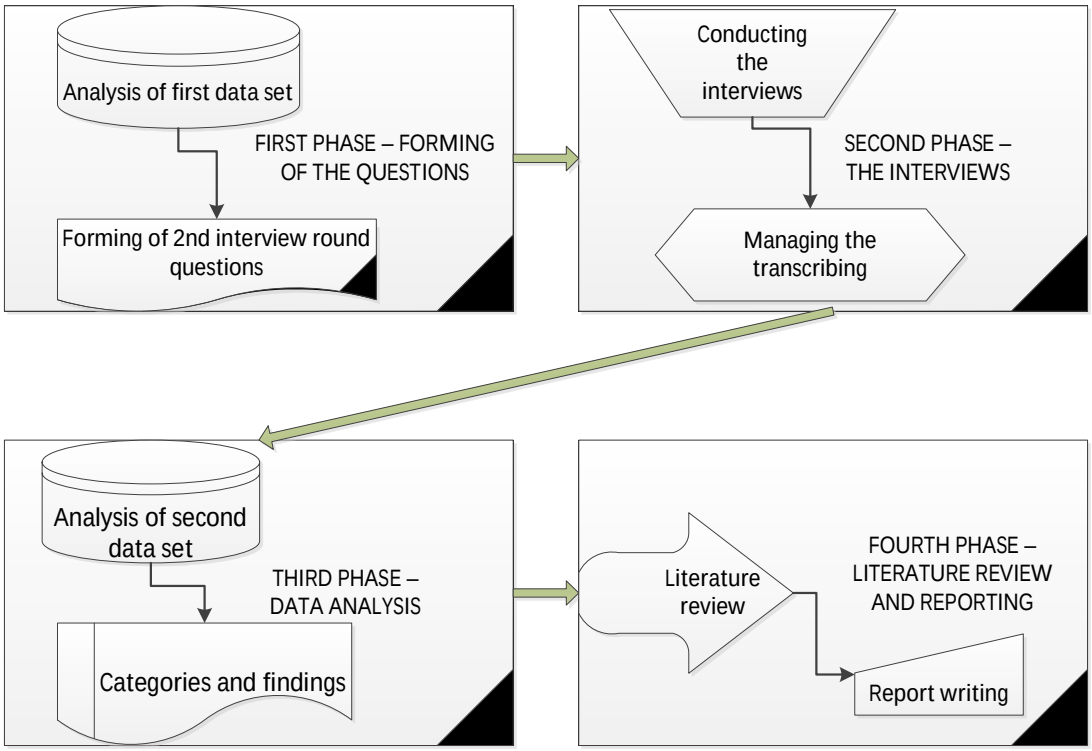

Figure 2: The research process

The interview rounds complement each other and they have separate sets of questions which can be found in appendices (Appendix 1 and Appendix 2). Both data sets have been used for the thesis. The second data set was needed in order to gain

understanding in greater depth. The first round's interviews were accessible for analysis in addition to second interview round's data which the author collected. Both data sets were analyzed and they form the basis for findings in this study. Activities of the thesis have been divided into parts which remind sub-projects of the study. There are four parts altogether. Systematical advancing was important so that it would be theoretically possible to reproduce the same results. Justification for validity and research design are depicted in the following phases of study.

The planned study for this thesis is a part of a greater whole, the STX-project. The thesis is a part of the research project STX results. The research project has previously collected the first data set from the first year's interviews. Research project team members can analyze and publish using the same data sets. The entire research project has been originally planned to consist of qualitative and quantitative studies, and the plan for the near future includes a quantitative survey.

3.1 FORMING OF THE THEME-BASED QUESTIONS

In the beginning it was necessity to get acquainted with research data that the project team had collected previously. It was important to read through the STX's first year interviews so that there would be a proper idea about the context. Researcher must have a clue about what is at hand when continuing the work of others. Forming questions for the second interview round was the main issue of first phase. A new set of questions for the data collection was a defined requirement of research method which was used.

The grounded theory research method was applied for the thesis as the qualitative research method. The first data set interviews were planned and conducted according to the grounded theory method. The interviews followed themes of open ended questions. For the analysis, ATLAS.ti (Atlas.ti, 2013) software was used. It allowed

efficient way to store and manage notes. The analysis provided with categories or themes for the research. Questions for the coming second interview round were formed from the themes and area of interest. The area of interest guided forming of questions.

The questions were tested with project members in order to figure out potential difficulties for interviewees. Following discussions revealed need for changes and awareness that one of the initial questions cannot be asked. A question cannot be asked if it has unknown topic for most interviewees. During development of questions those questions which were finally included were modified slightly in order to be least misunderstood. Slight anticipation of difficulty was recognized as the working language of the research project is English and therefore the questions have to be in English. The interviewees were expected to be native Finnish speakers. The difficulty is that command of English language amongst the interviewees varies. The anticipated difficulty with the questions was that some individual might comprehend the question differently than the original meaning was in it.

3.2 THE INTERVIEWS

Second phase is a logical continuum from questions to interviews. Collecting research data was one critical issue for the thesis and the entire research project equally. Managing transcribing for the research was important in the second phase as well. Having interviews required searching for and selecting potential software producing organizations and contacting management to agree that some of personnel are available for the interviews.

Population for interviews was selected from OUs where the smallest can be the entire company itself while the largest may be part of a globally operating enterprise. Selection aimed for theoretical sampling (Eisenhardt, 1989) where participating

organizational units represent polar points in the contexts of business orientation, locality and organizational size of operations.

After agreement to participate in the study, persons were contacted by an inviting e-mail. The person was contacted a couple of days later by phone, if he or she had missed the e-mail. In most of cases it was possible to agree on the date and time for the interview by e-mail. The sample for the interviews consisted of seven organizational units. 15 interviews were conducted in total. The OU's and interviewees can be found in Table 2. The length of an interview was around one hour 30 minutes. The interviews were conducted in face-to-face situation in interviewees' office premises. The interviews were recorded using digital voice recorder and persons were informed in advance about recording the discussion.

Due to defined schedule in the entire research project it was decided in the beginning that the actual transcribing is acquired as a service. Therefore such a service provider was invited for a bid. Project management found the received offering acceptable and a contract was made. The transcribing was managed in such a way that during the same day as the interview, the audio file from the recorder was transferred to service provider's on-line system. This allowed an early receiving of first transcribed data so that activities of the following phase were able to begin as soon as possible. This was seen as preventing slipping in relatively tight schedule.

Table 2: The Organizational Units and Interviewees

Organizational Unit	**Business**	**Company size / Operation**	**Personnel interviewed**
A	Custom made software, consulting	Medium / National	Testing consultant, testing director
B	Software product	Small / Local but global sales	Quality manager
C	Banking and insurance	Large / National	Designer/developer, security specialist, tester, test manager, head of testing vice president
D	Insurance	Large / National	Director of financial services in information systems
E	Government agency	Large / National	System special advisor
F	Software based product	Large / International	Software platform and software requirement manager, developers 1 and 2, testing developer
G	Unique embedded software	Small / International	Project manager

3.3 DATA ANALYSIS

Analyzing the data was the third phase. The grounded theory method has three steps in analysis: open coding, axial coding and selective coding. The objective of open coding is to extract the categories from the data. During the analysis 168 codes were created from the entire second interview round data. From the first data set analyzed earlier 54 codes existed, which were used as support data for understanding history of phenomena, for analyzing the second data set. After coding categories were

formed. The objective of axial coding is to identify connections between categories. Categories which were closely related became merged. In total 13 main categories were formed, for example, the physical distance in table 3. Analysis of main categories allowed figuring out how different main categories relate and affect each other. The objective of the selective coding is to identify the core category. In the process a new category was found. The new category was named "Human interaction" and was selected as the core category.

Table 3: The Category Example

Category name	**Description**
Physical distance	Distance to own team members and, or to other stakeholder group members
Transcript: "In the same room."	

3.4 LITERATURE REVIEW AND REPORTING

Literature review took place after analysis as the fourth phase. The objective of the timing was to avoid affecting analysis results. Otherwise results could have been distorted from views and opinions of other researchers. This decision is recommended by Strauss and Corbin (Corbin & Strauss, 2008) and in a research paper by Hoda et al. (Hoda et al., 2012). During the fourth phase writing the report has taken place hand-in-hand with the literature review.

4 RESULTS

In grounded theory method pre-formed theories are not used. The nature of the used qualitative method is inductive. In the beginning there is only a plan to gather research data regarding area of interest. The method advances towards theory or hypotheses creation. This study ended up with findings presented in this chapter. The findings are grounded to the data gathered in the interviews. The second interview round yielded 1 532 minutes' of audio data which meant 365 A4-pages transcribed text.

Table 4: Categories and codes

Category name	**Codes in category**	**Description**
Agile development method	2	Feasibility for the organization? Whether attitudes are pro agile or against it.
Change	6	What measures have been taken, in order to achieve improvement or change.
Change resistance	7	What kind of difficulty can be noticed. Some behaviors can hinder entering to a new state.
Communication	3	Communication issues and communication tools.
Cultural difference	3	Understood here between countries, so that thinking and values differ.
Emotional distance	10	Emotional acceptance of person and personality (in a team environment), and trust in person.
Learning	14	People may improve their skill set. Provided opportunities?
Physical distance	17	Distance to own team members and, or to other stakeholder group members.
Quality	50	Many viewpoints related to software quality, for example, important characteristics.
Social distance	11	Acceptance of social behaviors, and participation to social activities.
Standards	11	Awareness and compliance in the organization? Quality management and industrial standards.
Testing	23	Software testing activities and tools.
Test case detail	11	Existence of test cases, and details; how detailed.

During the analysis 168 codes were created from the data. The codes reflected matters identified in interviewees' answers. Most popular codes were around the area of interest of the study. At the end of coding some popular codes gave a hint of

categories. The codes were in the areas of communication, distances, standards, testing and quality. The codes were sorted and combined into categories. The analysis of categories ended up in 13 categories based on the data. The categories can be found in Table 4. The codes in category does not equal to number of appearances in the data. One of the main interests, the quality, is strongly present in the categories. The categories include human issues in software development which were included in the study. Based on the categories, human issues and quality issues seem to have relationships.

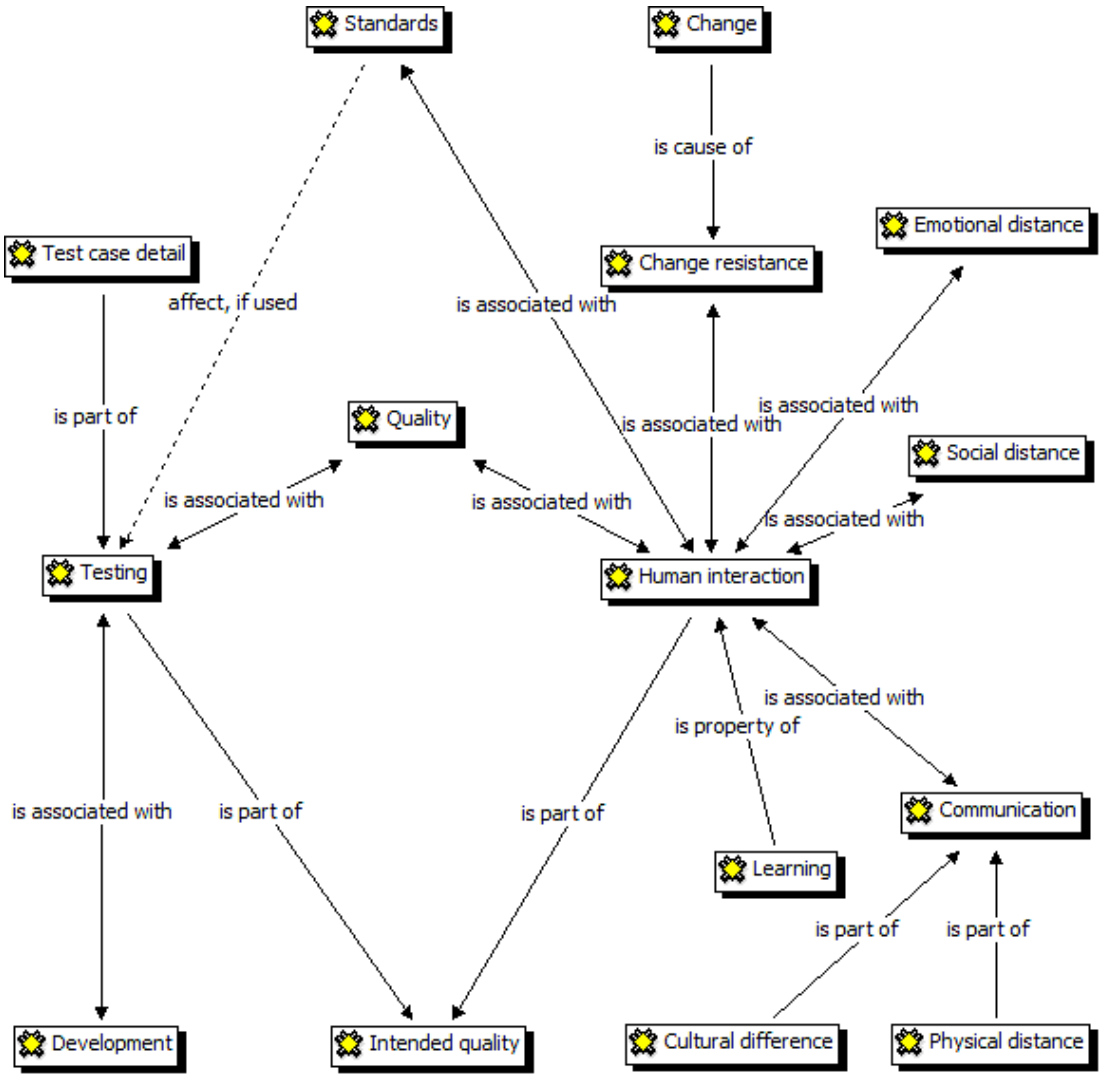

Figure 3: Simplified relationships

Analyzing relationships between categories using visual tools revealed existence of a new category. The new category in Figure 3 got the label “Human interaction”. The new category is the core category. The core category participates to activities of other categories, because people do the activities, transfer of knowledge and decision making while working. The figure 3 is simplified and does not represent all the relationships. The findings with conditional existence and business domain dependencies are discussed in the next chapter.

The original interest in the study was to describe which relationships exist between development, testing and quality in context of software systems? Here we have assumed that software quality standards have been applied. The main result of the study is that standards for software quality affect through human interaction with intended quality.

4.1 AGILE DEVELOPMENT METHOD

This category is the result of following up feasibility of agile development method in OUs. The interest included the interest in OUs towards agile development, but in this study the codes were either pros or cons.

> “*Well, at least we are not following any agile method, such like Scrum or anything like that. I guess, the development is kind of incremental development and testing, mainly. So it’s not pure waterfall.*” (Developer 2, OU F)

The person told that the OU is not using agile methods. This kind of responses was given, for example, when a specific standard or law was the requirement. However the agile development has been considered in these OUs.

> "*So organisation, yes and no, has been able to implement. In our system we are still learning.*" (Designer/developer, OU C)

The person told that the OU is adopting agile methods. The OU was already using agile development, but still perfecting the practices.

> "*So, when user story is ready, it can be tested right away,..*" (Quality manager, OU B)

The person told that the OU is using agile methods. The OU uses agile development having successful experience. Based on interviews, the agile methods have gained popularity amongst studied organizations which may indicate that doubt against agile methods has reduced.

4.2 CHANGE

This category is the result of reported attempts to improve issues in OUs. In order to improve, changes are made. In general the following outcomes vary from success to poor impact. The outcomes may depend on the context.

> "*One year ago, our defect percent [was] about 34. And nowadays our defect percent is 4. And we have thousands of test cases. I think that, the change has happened because we have done the test case more and more detailed. My opinion is that, the decision was made by myself and my superior, we only started to do so.*" (Testing consultant, OU A)

The person told about the change they took. The person described the positive effect associated with reduced defects. Changes in OU's may introduce a desired

improvement. A change could also introduce undesired effects which may require further adjustment or cancel of the change.

4.3 CHANGE RESISTANCE

When changes are decided and made, some people react with varying kinds of emotional bursts. The reactions may include taking sides over matters that are or have been decided. The reactions may also include emotions reflecting to individuals.

> "*When I told that we started to do the more detailed test case, we were criticized very much of it. Because of it.*" (Testing consultant, OU A)

One view of the tester that the management resisted the change, until later, it was understood how the quality was affected.

> "*..the problem that we have currently is that they are so used to that Olli and Paavo and Pekka is doing the testing here. And we want to go that it's a testing process and it doesn't matter who's doing the testing.*" (Head of Testing Vice President, OU C)

One management level view considering change resistance appearing amongst the subordinates. Intention to change or actual change indicated reactions and attitudes related to the change. Standpoints that people take may affect the software quality.

4.4 COMMUNICATION

The category is the result of interest in communication issues in OUs and the methods used for communication. The communication issues relate to interferences of varying types. The communication may be successful as well and may include use of applying equipment.

> "*Currently, in principle in this project we all work in the same office here, but there are a couple of persons who work from home several times a week. But, I wouldn't say it affects quality in any way because we have direct communication with using Skype and because we see each other a couple of days a week anyway, then let's say in that case it doesn't have any effect, only possible positive effect when the people can work at peace at home and not having to commute for a long distance. And our customer at the moment is quite close as well, only their offices are half an hour away, if you walk.*" (Project manager, OU G)

The person in question here explained how arrangement of working can be flexible and technology allows for asking questions related to daily tasks remotely. However the OU has found useful meeting face-to-face the agreed on times weekly in office premises. Discussions held face-to-face are still the most efficient for transfer of knowledge especially when the knowledge is meant to be shared between many people. The other kind of note was made here about the OU location being close to customer that eases communication with the customer. The communication overall is interesting because fluent communication in software projects could be important for successes.

4.5 CULTURAL DIFFERENCE

Those who had to deal with off-shored development reported communication difficulties. The difficulties mostly originate from cultural difference how thinking

differs and there is lack of communication ability using foreign language. Most of the time management level persons are involved in passing information between the implementing organizational levels.

> "*They can't do that, it's not in Indian culture. Indian culture is authority belief, so if they get an order that's the highest authority, goes to the boss, that's next level. Goes to an employee, they just have to do what the authority is saying. There's no other way, the culture doesn't allow you to put in your opinion as a small worker. That of course there are exceptions to the rule and better achieving teams, but that is general feedback we hear. And that's also what we see when we test. Software, that has been developed partially in India. Most of the time it's like that. But again, that's minor part of the customers and the projects we see. Most of them are actually done by Finnish developers. Or at least Nordic area, or European area developers.*" (Testing manager, OU A)

The person here told that an average team member in India does what the specification says and nothing else. Disagreeing could be an insult towards the superior. Private ideas of an individual how to accomplish the task differently are less likely. If the software specification is not precisely correct, then there are many possibilities to fail in communication as information gets passed via many people. Changes to specification cause an additional challenge. If something is unclear, then many questions are going to be asked because an own opinion is not assumed to be valid.

> "*We need to know how to express ourself to them [in India]. They, because Finnish people are quite straight, when we are saying for example "no", it really means that and they have to understand our way of saying. That kind of things but of course at least those people [from India] who are here, we are now very good friends and we understand each other and, but of course there is always that little barrier. They are not working directly for us. They are*

working for their company. And, we are, that kind of in different sides of the table. Although we have the same target. We should have the same target." (Test manager, OU C)

The person explained the cultural experiences of offshoring in India. The cultural difference had brought many situations where developers perceive the context slightly differently than in the own country. Getting common understanding of the details required cultural learning by the both parties. Though learning it was possible to reduce the effort required for communication. Plain sending of the short description document what the organization wants is not enough. The communication over very long distance requires many types of human interaction.

"*Because there are cases that, because I'm not present in China, I didn't exactly know what they are doing. They tell me, by e-mail or, by telephone, what they are doing and how they are doing but you cannot see the actual result. That's the thing that might sometimes get the quality little bit bad. Even if I think it's okay, they convince that it's okay, but it's little bit, there might be some misunderstandings or things like that. It's very difficult sometimes to get the quality to the same level than in [OU in Finland]*." (Software platform and software requirement manager, OU F)

The person here was working with Chinese colleagues. The Chinese working culture has its own kind of characteristics where who you know and what you know are of value. It is possible that information sharing between the Chinese is more restricted or reconsidering when compared to northern European working cultures. The cultural difference includes different thinking orientation and values which requires active consideration from Europeans. Good software quality can be achieved however it may require learning the language skills.

4.6 EMOTIONAL DISTANCE

This category is the result of including emotional sensitivities amongst people in OUs. The acceptance of person and personality on the emotional level is present in the daily working environment. The trust in word was also the interest in this category. The trust in word may change when the emotional distance has been "reduced."

> "*Yeah, but the chemistry doesn't meet each other.*" (Testing consultant, OU A)

The person here was discussing about differences in personalities. The personalities can differ so that the persons may not find anything common and would not have open discussion on a daily basis. In such a case the transfer of knowledge would happen only by a request.

> "*We have quite [a] good team here but of course if somebody doesn't get along, the information won't travel. Something might, intentionally or unintentionally hold back information that might help the other to do its job.*" (Designer/developer, OU C)

The person in question here considers the effects of a colleague whose decision, not to share existing information, might prevent success in performing the task at hand. The decision may be arising out of lacking interest in importance. In the worst case it could be intentional for driving personal objectives in the OU.

One questioned thing was the trust in word which appeared good in most cases, but could be on harmfully low level in real life. In social distance the interest was in teaming, team building and transfer of knowledge where differences in data were tiny. Interviewees reported being well accepted in their current working environment.

> "*I think we have really good team spirit here and we are basically, how do I say, pulling the one rope. I think there's no emotional distances or conflicts here with each others.*" (Quality manager, OU B)

Here the person was describing own senses about working together in the OU. The person reports all-in-all satisfaction personally and as a group. The person did not notice any kind of distrust in the working environment.

> "*I think this organization, I've been here half a year is respecting people. The culture is open. And people listen and take care of each other. So it's really a nice organization as such to work in. But as I said, then the other hand is, it's kind of stubborn to do changes.*" (Head of Testing Vice President, OU C)

The person in question works in a management position and was telling that the OU has relatively long and friendly culture. The person was telling that people trust and try to help each other, but from the management perspective making changes is slow as the people in the OU tend to keep their current practices.

> "*It works really well, and accepted by other people. But of course, if you are talking with other parts of the organization, then it takes some time at least. So that you need to know the guys. I guess, when you talk with someone first time, it's always I guess someone doubts what you are saying. But I guess it needs some time to get the trust from other people and that kind of things. I haven't seen any big problems with that here.*" (Developer 2, OU F)

The person here was expressing being trusted in own OU but estimated the relevance of own talks to different OU's members. The person links the relevance to knowing people and getting acquainted with people. The person found being well accepted

and felt being part of the team. Overall getting along better than just doing utilitarian messaging could have an impact to achieved result.

4.7 LEARNING

The person who interacts with the standards documents also activates some learning processes within oneself. Later this person possibly enforces own additional learning through communication with colleagues. Some interaction and communication may continue in form of arranged training which improves the learning. In context of testing, applied standard affects processes, not directly the software quality.

> "*Yeah of course there is.. we can learn everything new but it's difficult thing to get those really, in the working methods. How can you really use them right. Or how is it [applied]*." (System special advisor, OU E)

The written standard does not drop-in into quality as-is. The applied standards are first interpreted by skilled employees aware of computer programming. Understanding the meaning of the standard is vital. After understanding the standard, the standard complying processes for the OU can be composed. Creation of fit processes is one kind of capability in organization, if such resources exist. In general, learning happened as an individual and an organization may have effects to future successes in software process and in change of technology.

4.8 PHYSICAL DISTANCE

This category included interest in effect of physical distance between person and other members of interest group. Most satisfied were those working in the same building. Those working in different physical locations in the same country were still

satisfied with communication. Microsoft Lync or Skype were popular communication tools in addition to e-mail.

> "*But basically same room. Yeah, there are few contacts in Tampere site but there is no physical contact, we use other communication system to communicating. But basically the most of the connections or things like that are in physical, we are in same hall or same room, and we can connect with words. Yeah, face to face, but of course some meetings are allocated and that are used, some, Microsoft tools for that communication, but it's possible to communicate face to face.*" (Testing developer, OU F)

The person here was telling that the major part of their team in the OU is placed in a large open area office. In such an office multiple persons can participate into the same discussions easily. The person was satisfied with the arrangement. Communicating with colleagues who work in a different city requires traveling if a meeting requiring personal presence is arranged. Otherwise accessible technology allows discussions between sites without plenty of effort.

Projects where development was outsourced in the same country were experiencing management as a men-in-the-middle from time to time. In off-shoring to different continent the middle-men were quite persistent due to more authoritarian culture.

> "*My nearest colleagues work in the same room. And other people who works in the same project, they work in maybe another floor in nearby rooms. But the supplier who makes this system and develops the programs, they work on the other side of city. And we have distance between us. And we have no connections, or very very little connections with these developers.*" (Testing consultant, OU A)

The person here told that they do the software testing, however interaction between their OU and the developers in different organization was mostly restricted to passing requests and information via their superiors. Communication through middle-men was introducing minor lack of understanding and scheduling issues. In general the middle-men slow down interaction and may non-intentionally alter the message if they have to comprehend first the semantic meaning what they are dealing with. Growing physical distance may introduce signs of reducing communication. Technology can overcome many issues with the physical distance, but richness of communication and feeling of working together may remain reduced.

4.9 QUALITY

The testing is not different from other areas. The human interaction brings in the standard, if there are skills and holistic motivation. Persons with industry skill-set and planned intention can create standards applying software quality. The standards affect indirectly through human interaction.

> "*Yes, we have a standard, which we are following so.., I mean I don't like defining quality by the end product but within the process, as a whole, so software quality isn't just what's the output. It's the whole process. So, in that sense, we know that we have to use criticality level in our work and we have to have this traceability and we have to have this amount of metrics.. so on. And in that sense we do know what our quality, what our target is.*" (Project manager, OU G)

The person is saying that they have a specific standard which they have to comply with. Thinking objectives through the standard specified processes helped reaching the targeted quality.

4.10 SOCIAL DISTANCE

The human interaction may have interferences in many ways which hinder development and testing activities. In the worst case, the interferences block the advancing of the work. Behaviors caused by changes in organization are difficult to detect but minor thoughts of protesting are likely. Most persons were liked in their working environment, but a difficult personality participating in project can cause trouble and misery for colleagues as stated by people in the data.

> "*It was hard to co-work with the person. And I think it affected the whole team and everybody, for some reason.. We have different people, we have those who are quiet and we have those who say everything they think, and those who question everything. But for some [reason] there was this one that wasn't accepted as well and, it was a bit difficult to communicate with and, it wasn't.. To do quality with in that kind of situation and transfer knowledge, I'm sure it was harder to the co-workers and communicate, [one] should at least get along so the knowledge transfers better and everything works out.*" (Designer/developer, OU C)

Here the person tells about a colleague whose personality made transfer of knowledge challenging for many. If the colleague places obsessive conditions for providing pieces of information or for communicating with certain persons, the frustration in the OU grows quickly.

> "*I have had some tough discussions with someone who thinks that he knows how something should go. And then we had to have kind of tough discussions and.. but I have usually been right about it. It has been so, there has been one example that after a year he came and said, "you were then right" and I said,*

"why didn't you believe me then?" It need to be changed, now." (Test manager, OU C)

The person here tells about an incident in the past where the personality caused a problem. In practice, the pride of one can change the schedule of others. The schedule changes at least when something in the software has to be changed later in the near future. Possible unfortunate by-product may be the infected relationship with varying level of distrust between the individuals. In general, social well-being and experiences in a team may have an effect to achieved software quality.

4.11 STANDARDS

The standards and the standards described quality are not present instantly in an organization because applicable standards happened to exist. An understanding is needed as well. One experienced person stated that one have to take the standard, understand what the standard says and apply according to the standard after it was understood. The person uses comparison to physical building roof structure and its strength under load during wintertime.

"*Engineers know that.., on wintertime we have so much snow on the roof. And it must be durable. And I think that we don't have such standards here, in information technology. And of course the [construction] engineer doesn't invite himself to this, how could I plan this house. He every time takes the standard, the standard says so, and if I fulfill this standard, I can be sure that this building is[safe]. But, nowadays when we do our systems, we can't be sure, that if it is safe or good enough. We only test the systems and try to get them good enough, but we think that building, so that we don't take 1,000 men to the roof and jumping there. Is this building good enough? We have to rely on our calculations and standards.*" (Testing consultant, OU A)

The statement says also that nowadays implementing software systems quickly without standards the end-users cannot be sure whether the system is safe or sufficient quality.

4.12 TESTING

In the analysis, development was consciously associated with and controlled by testing. This view has support in the literature. Ad-hoc practices were not under consideration. Testing can help in meeting sufficient quality. The view has strong support in the data as the statements of different persons.

> "*It's not safe if it's not tested. But I guess you can do anything if you just test it with security tests. I don't see a reason why there would be something that you can't do. So whatever, a nice idea, we just need to think what kind of security threats might be there, concerning that area. And then you just do security tests and then you are happy. That's how it works.*" (Testing manager, OU A)

The person in question here was discussing about security specific testing. The information security in software is one important area in testing.

> "*And what they need to do, those people who are coding this. They should have some kind of unit testing there but I don't know if they are having that. We are little skeptics about that but they should have.*" (Test manager, OU C)

The person here was discussing about unit testing, but had a second thought with a doubt of their current situation. The person considered unit testing important. The doubt was a slight dissatisfaction with achieved quality.

> "*I think that it's, code review is important. It's always useful and I don't understand why we don't use it more than nowadays. I think that, because it's the way to learn. Always, to both. If I read your code I learn something, and I suppose that you too learn something, if we find something*" (Director of financial services in information systems, OU D)

The person in question here was talking about source code review. The statement supports peer-review of the code. Reviews in general are static type of testing of work products where the work product is inspected by people. The peer-reviews help finding a part of mistakes in the source code in the early phase.

> "*When we move to the release test phase, so every project is end and, all user story testing is done, and then we move to release test phase. Basically regression testing that everything works OK and no new bugs are created in some points. Then we are using the.. for calculating the amount of bugs we found in that phase. That kind of bugs which are created during the implementation phase, not old bugs already in old releases. But it's quite simple and effective.*" (Quality manager, OU B)

The person here was discussing about regression testing and collecting data for metrics. The person considered regression testing important so that development implemented new features should not introduce defects to previously working features. The other thing in this statement is user story testing in agile method. In general the user stories refer to requirements.

> "*Usually when you make enough time for testing and verifying the software, so you don't end up in problems with it later on.*" (Developer 1, OU F)

The person in question here was talking about importance of testing in general through personal experience. One point in this is that plain developing won't do

because missed problems grow big later. The person has to do unit testing and verification of work products in general among other things. The testing overall was found important for controlling the software quality.

4.13 TEST CASE DETAIL

This category included interest in test cases and their amount of detailed information. In the study the interest is in areas that may affect the software quality. The test case details may also affect the intended quality.

> "*We received a set of test cases when we took off the project. And we have added more details to those tests than there have been previously. I think at least, according to the customer compared to what the situation was before there are less problem reports after delivery than previously. So I think that, the improved testing is a major factor in that.*" (Project manager, OU G)

The person here tells about the change in test case details. The original test cases were given to them. In order to attain better quality they improved test cases for actual testing. The improvement was to make the test cases more detailed. The person stated that the improved testing played a major role in reducing problems. More specific test case details may have reduced defects but as well introduced additional work when defining the test cases.

4.14 SUMMARY OF THE RESULTS

The same level of quality can be achieved by different approach, having differing amount of hardship. As an example, imaginary project 1 may have sloppy development practices and a lot of defects to correct while imaginary project 2 may

have great development practices and low amount of defects to correct. The testing is the key, if nothing causes interferences to performing of it. For the intended quality the human interaction associated behavior of people should have minimum amount of interferences, also discussed in Benczúr (2003), as a minor misunderstanding could cause further unsuccessful interpretations later. Both should be in good shape in practice for meeting intended quality. Both the testing and the development work include varying amount of the human interaction though it has not been graphically depicted in figure 3 due to differing level of abstraction. The Table 5 puts the relationships between the categories into tabular form. It shows in condensed way part of the analysis process activity and the interpretations.

Table 5: Relationships between categories

Category	Agile development	Change	Change resistance	Communication	Cultural difference	Emotional distance	Learning	Physical distance	Quality	Social distance	Standards	Testing	Test case detail
Agile development	(same)												
Change	Relate	(same)											
Change resistance	Indirectly	Directly	(same)										
Communication	Relate	Indirectly	Indirectly	(same)									
Cultural difference	-	-	Indirectly	Directly	(same)								
Emotional distance	Relate	Indirectly	Relate	Relate	Indirectly	(same)							
Learning	Relate	Relate	Indirectly	Relate	Relate	Relate	(same)						
Physical distance	Indirectly	Indirectly	-	Directly	Relate	Indirectly	-	(same)					
Quality	Relate	Relate	Indirectly	Relate	Indirectly	Relate	Relate	Indirectly	(same)				
Social distance	Relate	Indirectly	Indirectly	Relate	Relate	Relate	Relate	Indirectly	Relate	(same)			
Standards	Relate	-	Relate	Relate	-	-	Relate	-	Relate	Indirectly	(same)		
Testing	Directly	Indirectly	Indirectly	Relate	Indirectly	Indirectly	Relate	Indirectly	Directly	Indirectly	Indirectly	(same)	
Test case detail	Relate	Indirectly	Indirectly	Relate	-	-	Indirectly	-	Relate	Indirectly	Indirectly	Directly	(same)
Human interaction	Has	Relate	Directly	Directly	Relate	Directly	Directly	Relate	Directly	Directly	Directly	Has	Relate
	Note:	Grayed area indicates duplicate area without additional information.											
	-	No, or not confirmed.				Relate	Affecting relationship.						
	Indirectly	Effects indirectly only.				Directly	Directly affecting relationship.						
						Has	Includes into activities. Mentioned in written report.						

The result is that interactions between the people seem important. The human interaction is involved in everything that has been done by the people including learning. Additional attention to communication between groups of people seems important and may have room for improvement. Trust between different organizations seems slightly challenging that may indicate slight reservations in co-operation. The transfer of knowledge is still important in distributed software

projects. If one of the stakeholders is in another country, it seems to introduce a small amount of additional confusion because cultural literacy is not perfect right away. When consideration comes to quality the software testing is very important. The test case detail is part of testing and affects to it. If the key role of the testing is not dismissed in practice, it can be used to control the achieved quality to the level of intended quality. However in form of the hypothesis, the intended quality is not from testing alone, the people and how they interact are possibly the greater factor.

Implications for research, from the results, may be the need to find improvements how to control software quality from non-technical area of study. The non-technical area may need wider than process kind of studies of people and behavior. There may be room for studies how to support desired behaviors in software industry. Mostly technical areas may have been studied more and technical improvement proposes may offer mostly minor improvement to practice. Implications for day-to-day practice could be including continuous monitoring of motivation and repetitious discussion about motivation and why in the organizations. The why could be individually unique because tasks and responsibilities vary. Improved reflections about tasks and their specific goals could improve software testing in achieving the intended quality more efficiently.

Research in the future could have focus in communication within software testing teams. One topic of interest could be effects of communication in and for testing activities. Also a new study by another researcher could further verify findings of this thesis. Even confirming findings are a proper result.

Validity of this study could be considered sufficient as the process has been described. The grounded theory method used in this study is known qualitative research method (Corbin & Strauss, 2008) and should support the validity of this study. The data for this study have been considered sufficient, and even larger data set would not allow extrapolating the results to large set of organizations. In addition,

the study had full economical support from the research project's funding without necessity to cut corners. Possible threats to validity of this study may be the relatively tight schedule whether something affecting was not included into the study and lack of researcher triangulation. The lack of research triangulation meant that multiple investigators (Denzin, 2006) did not take part into data collecting and analysis process, so further studies by others should further validate the results of this study. The other studies might have slightly differing standing point and could have more than one method to collect the data (Denzin, 2006). Other issues did not appear during the study.

5 DISCUSSION

Software testing and interactions between people were found important in software process. The findings were not in conflict with what has been known previously. In this chapter the people, their attitudes and software quality related issues are discussed. The discussion here considers matters affecting software process towards intended quality. The intended quality is in interest because it has been expected to be less expensive for the software industry than best achievable software quality.

Standards are a good starting point for approaching repeatable work effort in software industry. Standards are good for creating a common language between professionals. People in software industry can refer to a definition or a term in a specific standard. Unless OU produces new versions of a single product, the software created are greatly different and interfaces with other software systems are likely customized for unique needs. For example, core Web Services have a stronger standardization status and a need for compatible browser technology. In general software components do not use a widely accepted interface standard for interconnecting components in the real life. In software, custom made adapters or interfaces are likely needed as most of actors decide to do their own way. One of the implications is that standards affect if people care to conform relevant standards instead of ignoring. It is tempting in the software industry to consider that revenue comes first without the need for time consuming processes.

The standards are actually written by humans, like any collectively written novel, play or a law. A law is actually a good example about a standard. The law is defined and agreed on by a group of people for use in the midst of defined group of people or the nation. However, not complying with software standard does not likely cause a prison sentence. A consideration of conscience should still exist. Another implication is that the law or a standard is read and interpreted by group of humans including cognitive interaction and learning processes. A standard and its' defined processes

are not in place and conformed to, instantly, when the standard starts to exist in written form. Education of software quality standards could be taken to even deeper levels and in OU's similar trainings should increase awareness of individuals.

Software created without conforming to relating standards is similar to craftsmanship over millennia. It is created basing on human interaction with previous generation of craftsmen how they have done something similar and how improvements were made. Different opinions, working methods, way of use and transfer of knowledge made final product look different in every village. Best known practices without tied order have remained popular. There is some wisdom though. Knowing how to is needed as well as transfer of knowledge when working together and conforming to the standards. Another practical implication is that the transfer of knowledge and knowledge about standards too requires interaction between humans. Such transfer of knowledge does need some forms of communication.

Even showing how to push a button without common natural, spoken and written, language skill is communication. It is then just non-verbal. It has been previously noted in Chapter 2 that having common natural language improves success of communication. The successful communication and interaction can pass knowledge about meanings of a standard and ideas how to arrange it into work practices. However all communicated knowledge is not beneficial or work related. In the era of advancing technology when smoke signaling is no longer needed, part of communicated messages are not utilitarian but rather amusement, advertising or socializing. Such communication competes in attention of a human or larger group of people. Another two implications are that communication is part of human behavior, interaction of humans, for transferring semantic and contextual meanings. If there are software systems in between, it is equipment. The communication may experience various kinds of interferences, even intentional.

Classic and still valid interference is differing professional language and lack of technical knowledge in information systems. It could be equally valid to say that software engineering professionals lack knowledge about customer's business. Choosing to prefer either view will require getting over the difficulties in communication. Adding more physical distance between premises increases likelihood of different working culture and natural language as mentioned in chapter 2. For reducing skill-based interference mentioned in chapter 3's section 2, it could be suggested that participating to language courses could be encouraged in OU's. The globalization has changed the world irreversibly. Another kind of challenge is the not interested attitudes. Getting a person to accept something, for example applying standard in work activities, comes to motivation and thinking orientation of an individual. Saying that this never exists may be in denial. Shah and Harrold have studied social aspects of testing in a software company (Shah & Harrold, 2010). They discuss attitudes in testing teams and ended up with division to junior and senior attitudes, where the seniors should provide the good example. Getting up with the wrong foot in general reduces motivation. Even partial lack of motivation brings in possibility of missing relevant points in communication. Temporary loss of motivation could introduce great social distance and inhibit communication, if person becomes ignored or even dismissed as well. Checking own thinking orientation could be recommended for anyone. A variation in daily creativity is different. The creativity cannot be re-checked and forced to a higher level. Negative end of motivation range is known to include deliberate preventing others from succeeding. However nobody reported such behaviors in the interviews. In OU's could still be some frustration even no harmful behavior exists. Direction or ambition could be missing. Working culture fluctuates over time. In management literature, several approaches have been chosen in creating frameworks for analysis whether working culture in an OU is improving, degrading, stagnated or infected. Juuti and Virtanen have discussed views for an organization in their framework in a book (Juuti & Virtanen, 2009). Another implication is that motivation and culture of an OU should be studied repeatedly, not just once. Turning present working culture and habits can

be laborious. In general, having early enough some consulting in re-arranging thinking orientation of employees may become an investment.

Because people interact with other stakeholder group members while working, their success depends on what they know and communicate. Quality in software industry comes from interaction of people; it does not depend on soil. Based on findings, so far, it is suggested that intended quality in the same context is about interaction, testing work and controlled motivation.

In real life some unconditional matters exist. Organization cannot sell something that physically moves without complying with industrial safety standards during planning and designing. An elevator or escalator would be an example. Any event causing any degree of physical injury is possibility for reputation damaging legal case in the court of law. In safety critical applications the organizations have to acquire the industrial safety standard awareness. The awareness includes additional testing of software which participates in controlling the automation. The practical implication is that ambiguous states of operation must be found and corrected before release of a final system.

Conditional matters, as well, in real life do exist. Those OUs which produce software for physically static systems, for example retrieving information for a user, may have opportunities to be flexible. Taking such an opportunity does break out of defined processes. In case of missing resources like time, personnel and money for testing or unwillingness to spend resources for testing, then there unfolds a vague link between development and quality. This does mean skipping areas in testing work deliberately. Reducing testing and taking chances produces quality which developers are capable of as is with current skills. Then the output quality will be dependent on luck how well the software project matches with current developer skills and mood changes.

5.1 POSSIBILITIES IN THE FUTURE

All collected data in the project, together, is already a large enough for a couple of scientific papers. It is possible to set more specific research problem in the same area and study it using the same data. A new research could further verify findings of this thesis. Even confirming findings are a proper result. One topic of interest could be effects of communication in and for testing activities.

A research in the future could enlarge the body of knowledge in software engineering towards less studied and written. The research in the future could have partial basis in the thesis or publication about it. By referring to the thesis or paper any effort in current study becomes more valuable. Even software engineering has been studied for a significant period of time, the area is vast and may have uncovered niche areas for many future generations of researchers.

6 CONCLUSION

Previous research combining software development, testing and quality including human related issues was not easy to find. Therefore conducting this study was found feasible. For the study interviews were conducted in order to have enough data for a qualitative study. Due to grounded theory method the literature review was conducted after the analysis. The main interest in the study was in how relationships exist between development, testing and quality in the context of software systems. For completeness some human sciences related concerns were included in the study because people are assumed to perform a multitude of activities defined in standard's definitions and in defined processes in general. Human related issues included communication and areas of workplace dynamics. The human related issues included cultural difference, distances, conformance of standard, change and change resistance. The second interest in this study was to observe whether software industry in Finland meets intended quality.

According to the project's definition the intended quality has deliberately weighted quality attributes which define sufficient software quality but not the most expensive quality for the targeted use of the software. The aim is to control the development and testing costs of the software, therefore the software is allowed to contain non-show-stopping errors causing minor annoyance. The findings in this study were that the human interaction in software process and the software testing have significant role. Because people interact with other stakeholder group members while working, their success depends on what they know and communicate. Based on findings the result is that intended quality in the same context is about interaction, testing work and controlled motivation. The interaction combines many areas, for example, passing opinions and values, learning and transfer of knowledge.

The second interest in the study was to observe whether software industry meets intended quality. Majority reported in the interviews that they achieve their defined

qualities. It seemed that missed goals of the few referenced to communication issues in the end.

Based on the findings a couple of proposals may be given. For the intended quality the software industry should tie strongly the software testing with the development and use it to emphasize the desired quality attributes. When participating into distributed responsibility projects, communication between implementing employees should be organized excluding mediating men in the middle in order to reduce interferences. Organizations having activities outside their own country should have cultural training as the part of practice as readiness in global thinking should be improved, because the closed country environment is already in the past.

The results presented in the thesis may become part of growing area of research. Future topics of research should continue further in the research of the human interactions in software industry. Software engineering researchers have been quite active in human related topics in recent years, so relationships between people and software quality could become better known. In the future one topic of interest should be effects of communication in and for testing activities. Such research could cover something partially or wholly into body of knowledge in software engineering.

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APPENDICES

APPENDIX 1. First Interview Round Questions

STX Interviews / WP 1 / Autumn 2011
Tero Pesonen, Leah Riungu-Kalliosaari, Ossi Taipale
Software developers and testers

BACKGROUND

1. What is your position and what does your own work involve in your unit?
2. What kind of software development work is your unit involved in? (software products sold as licenses, tailor-made software systems, software that is hosted online (in the cloud))

SOFTWARE DEVELOPMENT

3. Tell me about how you build the software at a high level. Do you use any agile methods (ketterät menetelmät, esim. extreme programming, scrum, ...) or design-driven methods (such as spiral or prototyping models), or something else? Why?
4. How do you discover the requirements for the software?
    1. How are requirements processed by developers? (analysed, re-defined for clarity...)
    2. How do you document requirements?
    3. Are there problems with how you manage requirements? (e.g. missed customer requirements, requirements changing...)
    4. What benefits do you see in your approach in managing requirements?

QUALITY

5. What kind of quality is important to you when building your product? (i.e. functional suitability, reliability, performance efficiency, operability, security, compatibility, maintainability, portability). Does this vary between products?
6. How do you discover from the requirements what the relevant quality is?
7. How are these quality requirements then documented, processed and communicated?
8. What advantages and disadvantages do you see in your approach in managing quality requirements?

TESTING & QUALITY

(continues)

APPENDIX 1. (continued)

9. What is your objective in testing, and how is your testing process documented and defined?
10. How do you make use of standards in testing? (IEEE, ISO) How do they affect your testing?
11. At which points of the software development do you do verification testing? Verification testing is manual testing where work products are examined by people alone or in groups by reading and discussing the documents or work items under review.
    1. What kind of
       – reviews (*one or more people study a work item together to discover faults in it*)
       – walkthroughs (*step-by-step study of a work product, e.g. line-by-line code analysis*)
       – checklists (*used for systematic error detection for probable faults in a work item*)
       – inspections (*a formal review where each participant may have a specific role (moderator, author, recorder, …) in the review session*)
       do you use?
    2. How do you address quality requirements in verification testing?

12. At which points of the development do you do validation testing? Validation testing, in contrast to verification, involves executing software code – checking e.g. that modules work together, simulating the system, running test scripts, etc.
    1. What kind of
       – unit testing (*a single code module is tested*)
       – integration testing (*multiple code modules are tested to work together*)
       – usability testing (*e.g. how the user interacts with the software, or is the interface easy to use for the intended audience, for example?*)
       – functional testing (*does the software do what the customer needs it to do? Does it accomplish the desired functions the right way?*)
       – system testing (*testing the complete, fully-integrated system*)
       – acceptance testing (*is the software ready to be delivered to the customer?*)
       do you use?
    2. How do you address quality requirements with these dynamic testing techniques?

13. How do testing tools affect quality?
14. How do test data and test result documentation improve quality?
15. How can test results improve software development work?
16. Why have you adopted this testing approach?

(continues)

APPENDIX 1. (continued)

17. What problems have you encountered with your testing approach? What improvement ideas do you have for it?
18. What benefits do you see in your testing approach?
19. Do you expect your hands-on testing work to change in the future? Why yes/no?

CHANGE MANAGEMENT

20. How do cloud and open source technologies affect your work?
21. How has your unit's work changed, due to e.g. growth of your business, product changes, changes at the customer end, analysis of project feedback data, or any other such reasons?
22. What is causing it?
23. How does this change show in your own daily work?
24. Has the change been sudden or anticipated (i.e. managed/unmanaged?)
25. Is this change good/bad/neutral...?

APPENDIX 2. Second Interview Round Questions

STX Interviews / WP 2 / Autumn 2012
Jarno Lehto, Leah Riungu-Kalliosaari, Frank Seth and Ossi Taipale

1 Generic
1.1 Identification
Name, organization, position and area of responsibility.

2 Implementation
2.1 Effect of physical distance between employees
What is the physical distance between you and other employees whose work is directly connected to yours? You could describe for example in same room, in same building, in same city, in same country or in different country. Please, use your own words shortly.

2.1.1 How about these physical distances between employees whose work are not directly connected to yours?
2.1.2 In your opinion, how have these distances affected the achieved software quality?

(continues)

APPENDIX 2. (continued)

2.2 Effect of social distance between employees
How do different working relationships between you and other positions affect the achieved software quality? For example relationships between you and your team members, boss, subordinates etc.

3 Quality
3.1 Product variants
Does your software have variants/versions for different users or customers?

3.1.1 Does your implementation process follow any of standards for Software Product Lines? For example ISO/IEC 26550 – 26556. If so, then which SPL-standard and to what extent?

3.2 Information security
Have you applied data security processes from international standards such as ISO 27001:2005 (*Information technology -- Security techniques -- Information security management systems -- Requirements*) or similar industry standards such as PCI DSS (Payment Card Industry Data Security Standard)? Both are in general about secure processes that reach even down to implementation. How relevant this is for you?

3.2.1 How well you have achieved your objectives in this area to this date?
3.2.2 Ever told to business management that a proposed new idea is not safe or secure enough to implement?

3.3 Metrics based software process improvement
In your current state, how well are you capable of collecting measurement data? We would like to have your views separately from viewpoints of requirements, implementation, testing and customer detected faults.

3.3.1 How much of this data is discarded for various reasons? For example range from everything currently to none of it. Please explain using your own words. Also why?
3.3.2 How often does data analysis lead to software process improvement? For example range from not at all currently to all the time repeatedly. Please, describe using your own words.

3.4 Effects of budget and schedule
Do you use a work estimation methodology which is publicly known? What and why?

3.4.1 Have you included requirement change management processes into estimates?
3.4.2. Has the use of work estimation method improved software quality, or would it improve?
3.4.3 Have you ever skipped an entire process task/phase because of so called hard limit (budget overrun must stop growing)?

(continues)

APPENDIX 2. (continued)

3.5 Changes in quality
Do you know what level of quality you should end up with? In your current work practices, do you end up with defined or wanted quality?

3.5.1 If yes, what changes it did require, maybe you reduced or added something, for example personnel, defined method, process, organizational unit, or something else? If no, why do you think it is so?
3.5.2 Any ideas that would improve meeting defined quality?
3.5.3 Would some organizational training, orientation training or motivational training help in meeting defined quality? (Psychological views and organizational culture)
3.5.4 What kind of changes in educational institutions could be made in teaching to meet defined quality better? (Long term view)

4 Testing and quality
4.1 Testing specific questions
How do different organization personnel prepare for reviews, walkthroughs or inspections? Possibly not at all, lightly or fully, but in your own words?

4.1.2 Can testers review actual source code? So to say, not just execute binaries. If possible, to what extent do you do this code review in your organization? How does this affect the achieved software quality?
4.1.3 Should such a code review activity be conducted (especially when an external organization is involved in implementation) or can it be seen as a waste of resources/money?

4.2 Testing tools
Have testing tools ever caused incorrect test results due to a bug in the tool? (so called false positives?) Could you please give an example of such an incident?

4.2.1 Can you describe the rate of these incidents (how many per month or year)?
4.2.2 An expression: “During gold rush you had all the mining equipment you could imagine. You wanted all the gold that was accessible that time, but greed caused indirectly an incident where you shot into your own leg (instead of competitor), and you were unable to carry all that gold.” Does this bring up any additional thought?

5 Management of change
5.1 Test coverage
Please describe, how detailed your test cases are.

5.1.1 Has there been any change in details in recent history? Have you noticed any change in software product quality relating to this change?
5.1.2 Has this change come by an accident, long term plan, management demand, customer management demand, legislation or industry standard?

(continues)

APPENDIX 2. (continued)

Please, describe in your own words.

5.2 Knowledge transfer
How do you experience/sense personal acceptance (emotional distance) when communicating with other co-workers?

5.2.1 How well do different parties trust in your word? We have four views: in own team, in own organizational unit, in own organization and in customer organization.

5.2.2 Has it changed? How has it affected the software quality?

5.3 Learning
How easy is it to learn and use new tools, and how long does it take?

5.3.1 Is training possible. Do you have active training processes for Information Technology personnel in your organization?

5.3.2 Would you explain why you adopted this approach?

5.3.3 If we exclude assumed advantages and seek objectivity, has software quality improved because of the training so that you were able to notice it?

5.4 New working tools and methods
Should your organization or at least its development related personnel become familiar with testing standards such as ISO/IEC 29119 (new, not officially published yet)?

5.4.1 To what extent should such standards be taken into use in your organization? I.e. range from none to fully. Please, describe in your own words.

5.5 Agile
Has your organization been able to implement agile development mode testing instead of plan driven (i.e. waterfall) mode testing? To what extent (i.e. range from none to fully)? Please, describe in your own words.