An Initial Understanding of Task Interdependence in Software Development Teams: A Case Study

George Marsicano
UnB/FGA – UFPE/CIn
UnB - UFPE
Brasília – Recife, Brazil
georgemarsicano@unb.br

Victor Laerte de Oliveira
Centre for Informatics
Federal University of Pernambuco
Recife, PE, Brazil
vlo2@cin.ufpe.br

Leila M. R. de S. Mariz
Centre for Informatics
Federal University of Pernambuco
Recife, PE, Brazil
lmrsm@cin.ufpe.br

Fabio Q. B. da Silva
Centre for Informatics
Federal University of Pernambuco
Recife, PE, Brazil
fabio@cin.ufpe.br

Abstract – **Context:** Task interdependence is one of the social characteristics of work design, which is related to some authors to the level of interaction between team members and their results. In recent years, more research has been conducted aiming to investigate the interactions between people and teamwork in Software Engineering (SE). However, few initiatives are associated with work design, especially related to task interdependence in SE. **Goal:** To investigate the perception of the individuals in a software development team about task interdependence and their impacts on teamwork dynamics. **Method:** We investigated a development team from a Brazilian software development company. For data collection, interviews were conducted and qualitative coding techniques were used to analyze and synthesize our findings. In addition, we have the support of an analytical framework built at the beginning of the research. **Results:** Task interdependence increases the need of information sharing and synchronization of tasks, it also favors the creation of an environment of redundancy of knowledge and mutual help, and it is moderated by interpersonal relationships, sense of belonging, and individual competencies and skills, favoring the generation of better results in a software development team. **Conclusion:** Task interdependence is an important practice and an essential and impacting factor in the teamwork dynamics, which can enhance the performance of software development team.

Keywords: task interdependence, work design, software development teams, human factors, qualitative research.

I. INTRODUCTION

Work design theory focused on the experience of workers and individual work practices [1]. Other authors also began to emphasize the social interaction aspects of workers in their investigations [2]. One of the social characteristics of work design is task interdependence, which is related by some authors to teamwork and their performance [3][4][5][6].

In this sense, Katz-Navon and Erez [7] affirms that the level of interaction among the members of a team is determined, among other factors, by task interdependence. Thus, this factor affects the nature of teamwork processes, shaping relationships between the different roles, as well as the requirements of coordination among its members.

In Software Engineering (SE), activities are most often performed by teams, where human factors are vital to their effectiveness [8]. In recent years, teamwork, as well as interaction among its members, has been an increasingly relevant topic in SE, giving, even more, importance to people and their interactions as part of the success of software construction [9].

As far as research on work design in SE is concerned, the literature is at an early stage [10][11][12][13], especially when it comes to empirical studies on task interdependence.

In order to contribute to the evolution of studies on work design in SE, this research aims to investigate the impact of task interdependence in SE. Thus, this work is primarily guided by the following question: *What is the individual perception of a software development team about task interdependence and its impacts on teamwork dynamics?*

In this study, we intend to investigate task interdependence related to software team, specifically the team of developers. Thus, to answer our research question, a case study was conducted in a Brazilian company, with the objective of collecting data about the experience of the developers about task interdependence. This paper presents empirical evidence on the impact of task interdependence on team dynamics and proposes an initial model of task interdependence in SE.

It's important to report that this work is a pilot study and their results are preliminary. From that, other studies will perform to reinforce and promote adjusts in our initial results. Thus, this is the first step for a better understanding about task interdependency in software development teams.

II. BACKGROUND

Interdependence can be defined as a general sense that team members must depend on each other at work [4]. Therefore, task interdependence refers to a situation where the process and the result of a task affect the process and the result of other tasks [14]. A feature of interdependence is reciprocity, meaning that people are mutually interdependent. Task interdependence involves the design of work in the group or the degree to which group members interact and depend on one another to accomplish work [2]. For Kiggundu [2], task interdependence can be divided into two distinct forms. First, Initiated Interdependence when the job of one individual affects the job of another one (the result of the job of A is input to the beginning of the job of B). Second, Received Interdependence when an individual's job is affected by the job of others (to be started, the job of A depends on the result of the job of B).

Outside of SE, some studies suggest that employees react more positively to the initiated interdependence than the received one since the first increase the level of cooperation, mutual help and collaborative behavior and the second tends to reduce the level of autonomy, negatively impacting the

motivation and satisfaction [2][15]. Adams [17] believes that this can be explained by the notion of reciprocity in social exchange and by reciprocity norms. In this context, individuals who perceive to be more dependent on their peers (received interdependence) will be more motivated to be reciprocal, facilitating the work of others (initiated interdependence).

Referring benefits of task interdependence in teamwork, Johnson and Johnson [18] argue that such factor helps, among other things, improve learning and interpersonal relationships between their members [15][18]. De Dreu [19] complements by indicating that when team members perceive the interdependence of cooperative outcomes, they deal better with different opinions, learn more, and perform their tasks more efficiently. Additionally, Kiggundu [2] show that the members who have a self-sense of responsibility for the work of others produce better individual results.

In SE, task interdependence is a subject which has not been much explored yet. Rehman, Mahmood, Salleh and Amin [11] research shows that job interdependence is high in SE profession since developing software requires involvement from multiple specialists like software architect, designer, coder, and tester. In the same way, Ganesh [10] results indicate that task interdependence creates the need among team members of interacting, coordinating and sharing information, what is essential in software development.

Among the recent studies, one Acuña, Gómez and Juristo [13] suggests that interdependence is positively related to satisfaction and that the promotion of these factors by managers will reduce the team's possibility to produce low-quality software and another one Da Silva, et al. [12] indicates that task interdependence is related to role conflict. Moreover, the initiated interdependence is negatively related to the interchangeability of roles, indicating that if the individual performs a task that others depend on, he realizes his role as harder to be performed by others [12].

Some other researchers in SE investigate the interaction between interdependence and other constructs as autonomy [20], knowledge sharing [11], conflict resolution and coordination strategy [21], but some results are inconclusive and disconnected. In this study, we propose an initial model that shows the relation between task interdependence and other constructs related to the software development teams' work.

III. METHOD

Our objective in this article is to understand how individuals of a software development team (developers) perceive task interdependence and its impacts on teamwork dynamics. To achieve this, we performed a qualitative study, with semi-structured interviews based on [16][22][23][24].

A. Sample Selection and Analysis Unit Definition

The sample selection strategy adopted was intentional, based on the assumption that the researcher chooses the most appropriate sample to learn about the phenomenon investigated [23].

The criteria used for the sample selection was: (i) there will be no restrictions on the characteristics of the team; (ii) individuals performing the role and primary activities of building (implementing) software; (iii) individuals from the same software development team; (iv) individuals linked to the same software development project and physically located in the same work environment.

As for the unit of analysis, checks will be made on the perception of individuals within a particular team.

B. Data Collection

Data collection was performed with four semi-structured interviews [23], which occurred with all developers of the same team. In total, approximately 118 minutes of individual interviews were performed. All the interviews were guided by a script previously established, having been recorded and transcribed *ipsi literis*. It should be noticed that in all interviews, in addition to the interviewee and an interviewer, a scribe was present. He was responsible for recording and making notes of relevant points of the interview.

C. Research Steps

According to Sjøberg, et al. [22] the first step is to identify and define its constructs. For that, the qualitative analysis of the data was based on the principles of grounded theory for open, axial and selective coding [14].

Due to the participation of many researchers in the open coding process, we built an analytical framework [24], aiming at aligning the perspective of all and obtaining a consensus about the transcribed data. This framework was subsequently used to perform the coding of the other interviews. It should be noticed that, whenever necessary, adjustments and/or insertion of new codes and items into the framework were initially established. Details of data analysis process are available on the Technical Report (https://goo.gl/xWQSiF).

The second step was to specify the propositions [22]. In this sense, from the identification of relationships between the constructs, the statements that supported these relationships were identified and extracted from the interviews.

The third step was to present logical and explanatory justifications for each established proposition [22]. Such explanations have a greater level of detail than the propositions aiming to explain the phenomenon studied. Each proposition had one or more explanations associated with it, depending on the need.

Finally, we compared the findings of this work with data presented in the literature.

D. Ethics

In order to follow research ethics regulations, all participants signed an informed consent form that is in compliance with the Brazilian Resolution 466/12 - CNS-MS from National Health Council that regulates research with human subjects. The company signed an Authorization Term, and the researchers signed a Non-Disclosure Agreement.

IV. Results

In this section, we first describe the context of the participant organization. Then, we present two percenptions of participants about task interdependence. After, antecedents and constructs of Task Interdependence (TI) are defined, according to the coding process. Finally, the relations between constructs are described and the model of TI is presented. Interview quotations that represent the raw data and illustrate the constructs are omitted in this article due to space constraints and are available in a Technical Report (https://goo.gl/xWQSiF).

A. Context Description

The study was conducted in Brazil, in a company created in 2005, through an agreement signed between an Informatics Center of a Higher Education Federal Institution and a multinational corporation of mobile devices and general electronics business. This company has approximately 80 employees.

Only the implementers (development team) located in the company headquarters participated. Altogether four professionals, all invited and willing to be with the researchers. The participants have age between 25 and 29 years old, 3 to 7 years of experience in IT, and an average of 3 years working in the organization.

B. Perception of Task Interdependence

From our unit of analysis are perceived two types of point of view from team members regarding task interdependence: internal and external. The Internal one refers to the interdependence among members of the development team itself where participants recognize initiated and received interdependence, from all to all. On the other hand, external interdependence refers to the need of a relationship between the development team and the client, test team, usability team, and project leader. In this type of interdependence our findings point towards different relationships (initiated and received). These relationships are described in the following.

C. Task Interdependence Antecedents

In order to better the understanding of task interdependence in the context of the work dynamics on the software development team, some constructs that influence task interdependence were identified during the research. That is, depending on their change, task interdependence stronger, weaker, or non-existent. These constructs are: gradual planning, team structure, task structure, project moment and project leader intervention. Details about these constructions are available on the Technical Report (https://goo.gl/xWQSiF).

D. Associated Constructs to Development Team Affected by Task Interdependence

During our investigations and aligned with [22], we have identified constructs related to the work of the software development teams, which are affected in some way by task interdependence.

The first construct is the ***Information Sharing (IS)***, linked to the creation, registration, and access to the necessary information for software development, as well as constant communication among those involved. The participant's report indicates that task interdependence increases the need for sharing information among those involved to perform the tasks. The results point to two IS perspectives: external and internal. In the first one, the development team needs information from the customer, the test team, the usability team, and the project leader. Sharing information with external agents the development team work is done through tools, documents, and face-to-face conversations. From the internal perspective, information sharing is performed among the members of the development team, and it is also done through tools, documents, and face-to-face conversations. On this construct (IS) our findings indicate that the development team has an interdependence bond initiated and received in relation to its agents (external and internal).

The second construct is ***Mutual Help (MH)***, which is related to the internal work dynamics of the development team. In this context, each team member seeks to help others, either to realize a task or in need of asking a question. The goal is to make the whole team grow and evolve together, both in the technical context and in relationships. The team's help environment is reported to be quite informal. Therefore, task interdependence benefits the creation of a helping environment among team members.

The third construct is ***Task Synchronization (TS)***, which refers to the maintenance of sequential task accomplishment. The challenge of TS is reported by development team members, as being an object of concern among those involved in the sense of not generating delays and/or blocking tasks. Thus, task interdependence increases the need of synchronism between them. TS relates to both the activities between development team members (internal) and their activities with external agents (test team). In this sense, our findings point to a link, both of initiated and received interdependence, in relation to its agents (external and internal).

The fourth construct is the ***Knowledge Redundancy (KR)***, referring to the strategy adopted by the team, in what concerns to promote knowledge sharing among its members, i.e., team members should share the same knowledge in order to make possible to allocate any activity to any developer. This is a construct linked to the internal team dynamics.

About ***Interpersonal Relationships (IR)*** among team

members, point to people with close relations of friendship and partnership. When talking about interpersonal relationships with external agents (client), the team reports point in another direction, less close relation.

Acting closely to Interpersonal Relations, the ***Sense of Belonging (FB)*** emerges as an individual construct, from where each research participants perceive their relationship with the team, feeling part of and believing in the value of teamwork. This construct is linked to the internal team dynamics. In this research, it was possible to verify a strong team sense of belonging among its members.

The ***Competence and Skills (CS)*** of development team members moderate actions of mutual help and knowledge redundancy. This construct is attributed to the internal team dynamics.

Another important construct identified is the ***Guarantee of Norms and Development Standards (GD)*** associated with the relationship between information sharing and outcomes generated by the development team. Such construct is linked to the internal team dynamics.

From the perception of task interdependence in the development team, our research identifies some ***Feelings (FE)*** reported by the participants, which can moderate the relationship between the results obtained by the team and the phenomenon of task interdependence itself. Such feelings are generated, in part, by the discovery of "unexpected" interdependence. That is something that was not identified during planning and that somehow impacts teamwork.

Finally, the last construct refers to the team ***Performance (PE)***, i.e. the results generated. From the reports made by the research participants, the development team recognizes that internally, the relationships are of interdependence initiated and received among all its members.

E. Relation between the Constructs and Task Interdependence

After the reported findings associated with the software development team constructs affected by task interdependence, we returned to our data and identified five key relationships According to the methodological structure [22], we presented here the propositions and the explanations, of the relations between the constructs.

Proposition 1: the need of increasing **Information Sharing** mediated by **Interpersonal Relationships**, and **Task Synchronization** positively impact software development team performance.

Participants report that both the lack of information (business requirements, interface document, proofs of concept) needed to complete tasks, as well as the mismatch between them, generate direct impacts on the results obtained by the team. In this regard, it is necessary that the interaction among those involved (internal and external to the team) is extended, in order to make the flow of information constant. To do so, the reports point to an exercise in information conversations, keeping the synchronization between the activities of the project.

Proposition 2: the creation of a **Mutual Help** and **Knowledge Redundancy** mediated by individual **Competence and Skills**, **Interpersonal Relationships** and the **Sense of Team Belonging** positively impact the **Performance** of the software development team.

The report of good interpersonal relations between the members of the software development team associated with the strong sense of team belonging, as well as the diversity of knowledge and skills (seniority and mastery of technologies) facilitate the team's actions and willingness to give and receive help from each other, as well as sharing their knowledge, envisioning collective growth and improving team results.

Proposition 3: Information Sharing helps to guarantee the use of **Norms and Development Standards** positively impacting **Performance** of the software development team.

The participant's reports show the need for sharing information and attention to development standards, in order to guarantee good results and to minimize the impact between tasks of different developers.

Proposition 4: the perception of **Task Interdependence** can be mediated by the **Feelings** generated, from its impact on the **Performance** of the software development team.

From their experiences with task interdependence and the obtained results, team members report their feelings, which tend to direct their perceptions and actions to different paths, impacting the way they treat or they will address the task interdependence.

V. DISCUSSION

A. Literature Enfolding

In a similar way to that presented by Katz-Navon and Erez [7], our research points out that the level of interaction among team members is affected by task interdependence. In addition, our research also indicates the need of an increase in the interaction of the development team with external agents.

Another similarity identified by Katz-Navon and Erez [7] refers to the relationship between the team's performance, and its results, based on the presence of a high level of interdependence, i.e. team results are associated with the high degree of task interdependence, which influences the interaction between team members and in the sense of team belonging. On the other hand, the low level of interdependence favors individual performance [7]. In our study, the findings point to the same direction.

Starting from what is presented by Taggar and Haines [15] and Adams [17], our findings about the care and concern that the team has in ensuring the application of norms and development

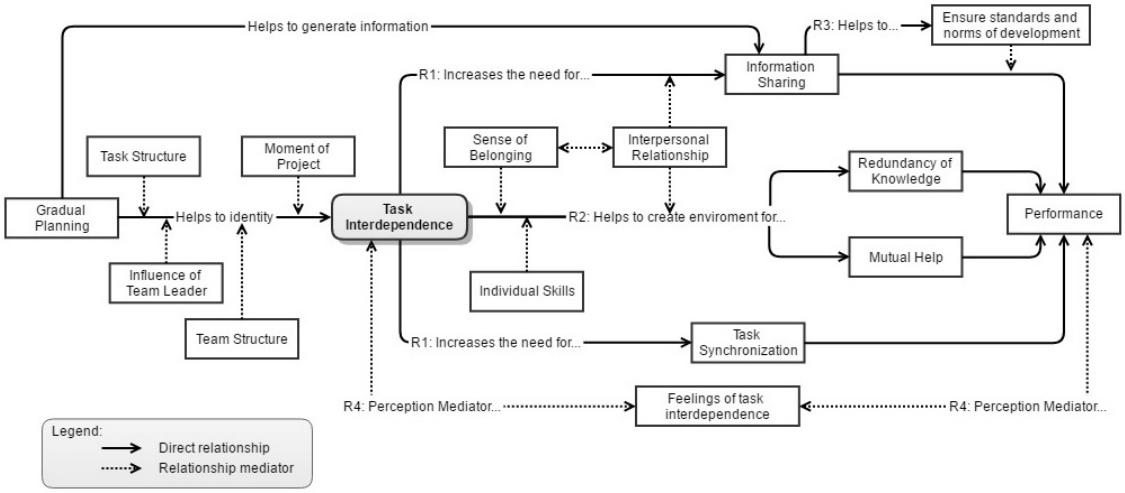

Fig. 1. Initial Understanding of Task Interdependence in Software Development Teams.

standards in order to facilitate the work of all can be related to what the authors call the norm of reciprocity. This norm is reflected in the significance between received and initiated task interdependence: "The more I receive, the more I give". Similarly, our results indicate a reciprocal movement among team members facilitating and ensuring the application of norms and standards. We have identified a different relationship from what is presented by Johnson and Johnson [18] presenting the interpersonal relationship as one of the benefits of interdependence. Our findings have pointed to interpersonal relationships as mediating processes of interaction (information sharing, knowledge redundancy, and mutual help), i.e. the interpersonal relationship would make it easier for the team to deal with interdependence, not interdependence helping the improvement of interpersonal relationships among team members. A factor that does not arise explicitly in this paper, but which may be generating benefits to the interpersonal relationship among team members is trust, which according to De Jong, et al. [6] favors making members more available to give and to receive help from colleagues.

Still on interpersonal relationships, our findings did not explicitly identify the emergence of conflicts or differences of opinion. According to De Dreu [19] the team's perception of the interdependence of cooperative results helps them to deal better with differences of opinion. However, due to the good level of the interpersonal relationship among team members, it is possible that such construct is also influencing the lack of evidence about conflicts or differences of opinion.

Regarding to the creation of a knowledge redundancy environment from the presence of task interdependence, our findings are related to what is presented by Cannon-Bowers and Salas [3] when they assert that when the team task requires high interdependence among its members, they have the opportunity to develop shared mental models and use this shared knowledge to guide their behavior and improve team performance.

A point that needs to be highlighted relates to the sense of team belonging that team members report in regards to feeling completely part of it. According to Katz-Navon and Erez [7], the more this happens, the greater is the possibility of directly affecting peers' activities, making collective work even more valuable.

Finally, regarding team's performance and its relationship to task interdependence, our findings indicate that work dynamics are affected by increasing the need for interaction among participants, teamwork and relating positively with performance. These results are in line with what is presented by Wageman [4], reporting that team's performance requires mutual interaction and coordination among its members. Otherwise, it will not be possible to obtain the expected results.

B. Validity, Reliability, and Limitations

The strategies used to guarantee the internal validity of this research were based on multiple investigators [16] supported by the analytical framework [24], and peer review [16]. Thus, multiple researchers (three) performed the open coding and construction of the analytic framework, which was later used by the first author of this study as a support for axial and selective coding. One expert and another researcher (authors) helped to validate the results. Finally, two other authors performed the peer review process.

Regarding reliability, the problem investigated by this research is associated with human behavior, which is not static and cannot be isolated [16]. The strategy used to improve the consistency of the results was the accomplishment of open coding by three researchers, with the revision of one expert.

External validity refers to the possibility of applying results in other situations [16]. Our result is transferable, instead of generalizable. In other words, is possible to learn from them and to see what extent they may be transferable to other situations. To enhance transferability, we seek to provide a clear description of the research method, the context in which the research was

conducted and its results.

Finally, we identified as a limitation the fact that a case study was performed with only one team. We recognize this limitation, but it does not invalidate research results, because it is the construction of an initial perspective, as well as because these results are aligned with several other studies in the literature.

VI. Conclusion And Future Work

In this research, we presented our preliminary results aiming to understand the perception of software developers about task interdependence and its impacts on the dynamics of teamwork. To this, our study was performed in a team of implementers from a Brazilian software development company with about 80 employees.

Our results indicate that task interdependence affects team dynamics, in order to promote the increase of cooperation and interaction among its members and to favor information sharing, redundancy of knowledge and mutual help. It is important to emphasize that the participants presented good levels of interpersonal relationship and a high sense of team belonging, which reinforces the identified evidence regarding the satisfaction of its members in obtaining a collective growth, more than individual.

Finally, the main conclusion of this research is that task interdependence is an important practice and an essential and impacting factor in teamwork dynamics. However, it is necessary for managers and professionals to pay attention to their antecedents and moderators, which can generate negative impacts if neglected, as well as potentiate the results when well accompanied. Thus, this is the first step for a better understanding about task interdependency in software development teams.

As future work, it is suggested other case studies will be performed using the same work methodology to reinforce and promote adjusts in our preliminary results. In addition, also will be conducted longitudinal studies to investigate task interdependence and its impacts on the team dynamics over time.

VII. Acknowledgments

Fabio Q. B. da Silva holds a research grant from CNPq #314523/2009-0.

References

[1] Hackman, J. R and Oldham, G. R., Work redesign. Reading, MA: Addison-Wesley, 1980.

[2] Kiggundu, M. N., Task interdependence and job design: test of a theory, Organizational Behavior and Human Performance,Vol. 31, pp. 145-172, 1983.

[3] Cannon-Bowers, J. A. & Salas, E., Reflections on shared cognition. Journal of Organizational Behavior, 22(2), 2001,195-202.

[4] Wageman, R., Interdependence and group effectiveness. Administrative science quarterly, 1995, 145-180.

[5] Ledoux, J., Team Task Interdependence Perceptions: Toward an Integrative Model of Teamwork. 68 pags. Master's Thesis. Louisiana State University, 2009. etd-03022009-085729

[6] De Jong, S. B., Van der Vegt, G. S., Molleman, E., The relationships among asymmetry in task dependence, perceived helping behavior, and trust. Journal of Applied Psychology, 2007. 1625-1637.

[7] Katz-Navon, T. Y., & Erez, M., When collective-and self-efficacy affect team performance the role of task interdependence. Small Group Research, 2005, 36(4), 437-465.

[8] Dingsøyr, T., Dyba, A. T., Team Effectiveness in Software Development: Human and Cooperative Aspects in Team Effectiveness Models and Priorities for Future Studies. In: Proceedings of the 5th International Workshop on Co-operative and Human Aspects of Software Engineering. Piscataway, NJ, USA: IEEE Press, 2012, p. 27–29.

[9] Schwaber, K., and Beedle, M. Agile Software Development with Scrum, Prentice Hall, Upper Saddle River, 2001.

[10] Ganesh, M. P., Climate in software development teams: role of task interdependence and procedural justice. Asian Academy of Management Journal 18.1, 2013.

[11] Rehman, M., Mahmood, A. K., Salleh, R., Amin, A., Work design characteristics and knowledge sharing behavior among Software Engineers. Computer and Information Sciences (ICCOINS) International Conference on. IEEE, 2014.

[12] Da Silva, F. Q., França, C., de Magalhães, C. V., & Santos, R. E. Preliminary Findings about the Nature of Work in Software Engineering: An Exploratory Survey. In Proceedings of the 10th ACM/IEEE International Symposium on Empirical Software Engineering and Measurement, 2014, p 10.

[13] Acuña, S. T., Gómez, M., & Juristo, N., How do personality, team processes and task characteristics relate to job satisfaction and software quality?. Information and Software Technology, 2009,51(3).

[14] Molleman, E., Nauta, A,. Jehn, K.A., Person-job fit applied to teamwork: a multilevel approach, Small Group Res., 2004, 35 515–539.

[15] Taggar, S., & Haines III, V. Y., I need you, you need me: A model of initiated task interdependence. Journal of Managerial Psychology, 2006, 21(3), 211-230.

[16] Merriam, S. B., and Tisdell, E. J., Qualitative research: A guide to design and implementation. John Wiley & Sons, 2016.

[17] Adams, J.S., Inequity in social exchange, in Berkowitz, L. (Ed.), Advances in Social Psychology, Vol. 2, Academic Press, New York, NY, 1965, pp. 267-99.

[18] Johnson, D. W., & Johnson, R. T., Cooperation and competition: Theory and research. Interaction Book Company, 1989.

[19] De Dreu, C. K. W., Cooperative outcome interdependence, task reflexivity, and team effectiveness: a motivated information processing perspective. The Journal of applied psychology, 2007, Vol. 92, pp. 628-638.

[20] Janz, B. D., Colquitt, J. A., & Noe, R. A., Knowledge worker team effectiveness: The role of autonomy, interdependence, team development, and contextual support variables. Personnel psychology, 1997, 50(4), 877-904.

[21] Andres, H. P., The Effects of Task Interdependence, Goal Conflict, and Coordination Strategy on Software Project Success. AMCIS Proceedings., 1995, paper 167.

[22] Sjøberg, D. I., Dybå, T., Anda, B. C., & Hannay, J. E., Building theories in software engineering. In Guide to advanced empirical software engineering,Springer London, 2008, pp. 312-336.

[23] Runeson, P., & Höst, M., Guidelines for conducting and reporting case study research in software engineering. Empirical software engineering, 2009, 14(2), 131-164.

[24] Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S., Using the framework method for the analysis of qualitative data in multi-disciplinary health research. BMC medical research methodology, 2013, 13(1), 117.