Software Development Team Dynamics in SPI: A VSE Context

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Abstract. Teams of software engineers working together in a collaborative manner to execute a software development process complete most software development work. Whilst there is much literature examining the software process and how to improve the software process, less attention has been paid to the issues of team working and specifically the impact of team dynamics on the software development process. Teamwork is more effective with the existence of positive team dynamic, as it encourages a better working environment with satisfied, fulfilled employees who will in turn be more productive. However, achieving and maintaining positive team dynamics in Very Small Entities (VSEs) is particularly challenging given the unique characteristics of VSE and limited resources in particular. This paper discusses the dynamics of software development teams (*structure, process, communication, learning and sharing)* and its impact on Software Process Improvement (SPI) in software VSEs based on empirical data collected in a groups of software VSEs. This paper shows that VSEs have a high level of team dynamics although their SPI initiatives are conducted on a small scale and in an informal and indirect manner. The results also indicated that this situation occurs due to the following factors in a team: working and social relationship, willingness to share, having a good interpersonal skill, and work closely with each other.

Keywords: **SPI, VSEs, Team Dynamics, Grounded Theory**

I. INTRODUCTION

Software processes are highly dependent on human decision-making and judgement. Human factors have also been acknowledged as a determiner in any software project success [1]. Moreover the ways people involvement in software process related activities are among the most important factors in organization development and change [3]. It has also been found that, in specific peoples participation is one of the strongest influencer on Software Process Improvement (SPI) success and, in general, employees are the main factor in software process improvement that needs to be encouraged and support in an organization [3]. Hence software process improvement will fail if employees are not committed to all the proposed change activities. The strength and weaknesses of the current SPI activities are inside the employee knowledge's and experiences [5]. Moreover it has been claimed that even though employees are the main driver for software quality but the processes have been given more attention [6]. Therefore to be success in SPI, organization must have a solid support from the software developers and management team. In addition, the development and management team's dynamics characteristics must exist to be able to work together, share the knowledge and able to communicate with one another effectively. The essence of software development is good relationship, effective communication, and high esteem of teamwork among software development and management team in process improvement. This

situation is becoming more important especially in Very Small Entities (VSEs) that have limited resources, particularly in financial and human resources. Therefore, this paper aims at presenting a more comprehensive perspective of software VSEs team dynamics towards SPI initiatives.

This paper is divided into 5 sections. Section 2 presents the background study of VSE and describes the characteristics that distinguish a VSE from other organizations. Section 3 explains the overall research processes that have been applied in this study. Section 4 discusses all the findings and results of the study. Section 5 presents some concluding remarks and discusses future work.

II. BACKGROUND

A. Very Small Entities (VSEs)

All software companies are not the same. They vary according to factors including size, market sector, time in business, management style, product range and geographical location. The fact that all companies are not the same raises important matters for those who develop both software process and process improvement models and for those who conduct research into software development teams. However, to date most research into team and other factors affecting the software development process has been conducted in the context of large and very large organizations, with very little research into very small companies.

The term "Very Small Entity" (VSE) had been defined by the ISO/IEC JTC1/SC7 Working Group (WG) 24 and subsequently adopted for use in the emerging ISO/IEC 29110 software process lifecycle standard, as being "*an entity (enterprise, organization, department or project) having up to 25 people*" [8] [9]. Micro enterprise including VSEs whose have limited resources, particularly in financial and human resources, are basically practicing unique processes in managing their business. These unique characteristics and unique situations have influenced VSEs in their business style compare to large companies. In addition, these limitation and characteristics have given an impact to companies' software process infrastructures [10] such as limited training allocation, limited allocation in performing process improvement, low budget to response the risk and many other constraints. Moreover due to the small number of people involved in the organization project, most of the management processes are performed through an informal way with most of the decision-making, communication and problem solving discussed orally and little documented. This indicates that people-oriented and communication factors are very important and significant in VSEs [11]. For example, compared to small companies, very small

companies often had an informal project meeting and minimum documentation take place [8].

B. SPI

The primary goal of software development has changed from "conforming to plan" to "satisfying the customer - at time of delivery, not a project initiation" [2]. Therefore the improvements of software processes in order to be handle the rapidly changing environment and requirement is very significant. There are 4 factors that could influences an organization involve in SPI as listed by Hall et al, namely the economic, people, organization and implementation factors [12]. Researched in small team organization, have shown that implementing SPI could give a positive benefit especially in development cost to the organization [13]. However the impact period of SPI programs is an important issue. The action time frames must be planned carefully in order to maintain practitioner interest [3]. The people factors that related to SPI have been discussed seriously in literature. The success of software project and process is determined by the interest of software team on the project and process itself [14]. Moreover the influences of key individuals, such as the company founder or a talented employee are not enough without sufficiently educated developer [15]. Hence staff participation also is essential in improvement activities and should be involved in improvement initiative because they have the knowledge and the firsthand experience on strength and weakness of the current process [16]. Furthermore the staff and management roles, opinions and commitments play an important role in the success of SPI programs [17]. The lacks of these factors could give a negative impact when starting to improve software process. In software project the lack of management commitment is considered to be risk number one [2]. There are varieties of implementation factors that can cause the failure of a well-planned SPI initiative. A clear action plan is needed after the assessment and SPI should be treated as a project [18].

C. SPI and Teams

The basis of every software development organization is a team, be it a management team, a development team, a trouble-shooting team or a testing team. A team is a collection of individuals who are inter-dependent in their tasks, who share responsibility for outcomes, who see themselves and who are see by others as an intact social entity embedded in one or more larger social systems, and who manage their relationships across organizational boundaries. The foundations of the team and team dynamics are laid down during team-building. To remain competitive, organizations must focus on forming and maintaining high-performing, successful teams.

Team member's involvement in software process improvement activities is important because employees must adopt process innovation in their day-to-day activities. In a quantitative survey of 120 software organization stated that employee participation and the way people are treated are the important factors in organization development and change [3]. He found that employee participation is the strongest influence on SPI success. The lack of involvement will disturb the improvement process because if employee did not commit themselves to all the propose change activities, the aim of process improvement will fail [4]. [5] add that the strengths and weaknesses of the current process are inside the staff experience and knowledge. Since the nature of software development work is done in team, the involvement and full commitment from teams in process improvement is critical.

The dynamic performance software project, which involved many processes are always, depends on team especially in quality of communication within the team and between the teams. Communication can be applied in many ways, not only in verbal, but also in term of documentation form such as version control, guidelines, reports and many more [19]. [20] points out that the level of communication in software process depends on the size of software project. They claimed that for a small project the interaction between team members is adequate but for a larger project a mix interaction between team member and specification are required. Communication also has a related impact with the team proximity [21] in that the increase distance from one team to another could affected the team dynamics in which it will interrupt team communication, coordination, mutual support, effort and cohesion. Hence the link between team member also becoming more difficult with the increase of the team member and this will impact the team dynamics [22]. Therefore in order to be success in SPI, organization must have a solid support from the software development and management team.

D. Teams Dynamics

Participation in a team should be of benefit to team members on both a personal and professional level. When a team member feels that the task they have been assigned is compatible with their expertise and that the task is a worthwhile contribution to the team, this will lead to increased levels of self-worth and motivation. It is also important that each member of the team knows and understands their role and knows what the team expects from them.

Team dynamics is the term used to define how people work and interact together in teams. Team dynamics are the hidden strengths and weakness that operate in a team between different peoples or groups and they affect how a team reacts, behaves or performs and the effects of team dynamics are often very complex. Team dynamics are the hidden strength and weakness that operate in a team between different peoples or groups. Team dynamics could affect how a team reacts, behaves or performs and the effects of team dynamics are often very complex [23].

There are various forces that could influence team dynamics, these include nature of the task, the organizational context, and team composition. The dynamics of successful software team identified four characteristics of team dynamics; positive, negative, internal and external team dynamics [24]. Positive team dynamics is referred as positive forces that could lead the team to create a high performing successful team. The present of social relationship in a team could increase team productivity and enhance social and interpersonal skill [25]. Hence, the positive mode of leadership (such as well focus directive, well plan and others) in software organization could enhance the positive team dynamics [26]. Negative team dynamics is referred as negative forces that could lead to the decrease of team performance and preventing people from contributes with their full potential [24].

From management point of view, in software development, organization people required three types of needs to be fulfilled and satisfied: social, self esteem and self-realization needs. Internal

team dynamics are referring to the forces that exist within the team itself [24]. Team members will not cooperate if they do not feel they are part of the team. Hence within a team, roles and norms must be clear and cohesiveness is essential for an effective team performance and will enhance team cohesiveness [27, 25]. A cohesive team will freely challenge each other's and easily sharing new knowledge with other team members. External team dynamics are referring to the present of external forces that beyond the team control and could impact the team performance [24]. The intrinsic and extrinsic factors in projects may motivate team. Intrinsic factors are the internal factors that consist in the task and team activity itself [28]. Extrinsic factors are external factors that influence team from the outside such as reward and recognition, feedback from the organization and customer, team member pressure and the working environments.

III. RESEARCH PROCESS

The goal of this research study was to explore the dynamics of software development teams (structure, process, communication, learning and sharing) and its impact on SPI in VSEs in order to understand the relationship between these two variables.

The study was divided into two main phases: The first phase consists of a series of detailed Structured Interviews with senior management staff within the chosen organizations; whilst phase 2 entailed conducting a Focus Group with software development staff from the phase 1 companies, in order to get an understanding of the issues from a non-management perspective;

To ensure the participation of software development professionals who would be familiar with the considerations involved in using both software process and process improvement models, it was decided to limit the scope to software product companies whose primary business is software development. In addition, given the geographical location of the researchers, it was decided to confine the study to Irish software product companies, which has the added advantage of restricting the study to within the same economic and regulatory regime. Furthermore, restricting the study to indigenous Irish software product companies significantly increased the prospects of obtaining the historical information required to understand process foundation and evolution which would not be the case with non- Irish multinationals operating in the country, as their process would likely have been initially developed and used within the parent company prior to being devolved to the Irish subsidiary. Overall, the data collection process took 8 months, which included identifying suitable companies, contacting and confirming potential respondents' process, conducting individual and focus group interviews process.

The individual interview approach was also used in this study in order to discuss the topics in depth, to get respondents' candid discussion on the topic and to be able to get the depth of information of the study situation for the research context [29]. This process followed by semi-structured interviews approach which includes the open-ended and specific questions. This approach allowed us to gather not only the information foreseen, but also unexpected type of information [30]. The respondents for the individual interview session are the managers from the identified Irish Software VSEs and went around 20 to 30 minutes in duration. The second interview method is the focus group interview. The focus group interview approached was used in this study because team members develop the software and the existence team interactions helped to release inhibitions amongst the team members and are from the same company as the individual interviews participants. Focus group interviews were also chosen because it was the most appropriate method to study attitudes and experiences; to explore how opinions were constructed [31] and to understand behaviors, values and feelings [32].
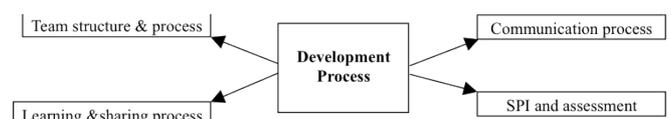
The study data analysis process was divided into 2 main stages. In stage 1, all qualitative data gathered from individual interviews was analyzed and in stage 2, the focus group data analyzed. These 2 phases of data analysis were conducted over a four-month period. The analysis of the qualitative data (interview and focus groups) was completed utilizing the coding mechanisms of grounded theory. The Grounded Theory analytical process involves a series of coding strategies, which is the process of breaking down interviews, observations and other forms of appropriate data into distinct units of meaning, which are labeled to generate concepts. These concepts are initially clustered into descriptive categories. The concepts are then re-evaluated for their interrelationships and, through a series of analytical steps, are gradually subsumed into higher-order categories, or one underlying core category, which suggests an emergent theory. Closely following the tenets of grounded theory meant that, after initial open coding, the interviews were then re-analyzed and coded axially across the higher-level categories that had emerged from earlier interviews. Any memos or propositions that emerged through the coding process were recorded for further analysis and inclusion as questions in subsequent interviews. A consequence of this was that the interview guide was constantly updated.

In analyzing the data, the answers were group, coded and list into a table in respect to the study category issues as guide by the qualitative contents analysis approach in analyzing the open-ended answer [33]. In details, we analyze and categories the data according to the category that this study intends to understand. The answers were group, coded and list into a table in respect to the study category issues. Furthermore, in order to produce details analysis result, we have divided the survey respondents into 2 main group namely the Micro VSE (M) (1-9 employees) and Larger VSE (L) (10-25 employees).

IV. STUDY FINDINGS AND DISCUSSION

As stated above, by following the coding mechanisms of grounded theory the researcher can formally document data concepts, which are clustered into descriptive categories surrounding a central core category. The finding for this study are illustrated in figure 1 and are represented by the core category of Development Process and four supporting categories, each of which is discussed in detail in the following four sub-sections.

Fig 1. Main category diagram

A. Team Structure and Process

From the qualitative data analysis process we categories in VSEs could be divided into 2 categories; the organization and team structure category and the team process category as shown in table 1.

Table 1. Team Structure and Process

Sub Category	Category	Main Category
Team Size - Small	Organizational and Team Structure	Team Structure and Process
Organizational and Team Flat Structure -		
Team Role - informal	Team process	
Team Involvement - direct		
Team Culture – informal		

The organizational and team structure category indicates that due to the small number of people working in the organization, the team size is also small and this leads to a flat team and organizational structure. From the interviews analysis results indicate that all interviewees admitted that the companies have no formal team structure or a team structure only exists occasionally as maybe required for a particular project. The following extracts from interviews/focus groups clearly depict this situation:

"Basically is a team of one. We can have a larger team of 2 or 3. But no formal team structure as everybody equal within the team"

"There are 5 developers including me and peter. No we don't have a formal team development structure at the moment, we all have the same skill and it is very flat."

In additional during the analysis researchers found that due to the small number of employees, flat organization and team structure and informal environment, interviewees perceive that all people in the company are at the same level. In addition the analysis show that they have the similar level of working experience, skills and very much depends on each other in performing their task. Besides the close working space or area, high frequent and informal communication are also influences this perception. All these criteria have leaded VSEs in narrow down the gap between the management and the team development. An interview answer quotes below best represents the above situation.

"We don't have that [formal team structure] but I can see in a large company where might have that. In small company I think it is a bonus we know each other very well"

"There are really 2 levels; the level above me is IT manager and General management. But it's such a small company almost like family here, so that not really a divided there just like a structure in place inside."

The second category is the team process category which indicates the team role, team involvement and team culture issues. The analysis shows that the staff role which includes the role in team and the task they perform in development process is very informal and very general. This could imply that the development staff could work or be assigned a different role at any time in organization development project. In addition they also can work with others or different people and different position as and when they are

required. These situations have explained that team involvement process in VSEs is direct and informal in development activities. An interview answers quote below represents the above situation.

"I mean usually either be face to face between 2 developers or over Skype through 2 developer remotely communication. In general the developer kind of work independently sometimes have a project, we have a sole responsibility for the project. Other time they assist each other in strategic and help each other for the output for a single project."

"It doesn't mean the notion of team isn't clearly set out in our company but just because of our size."

B. Communication Process

During the interviews sessions, the researchers have asked several questions on communication in order to understand this issue in VSEs. From the analysis, the researchers could divide the communication process in VSEs into 2 categories namely open and informal communication category and online communication category. The analysis also shows that the communication process in VSEs is influenced by the companies team structure and process and the working and management style as shown in table 2.

Table 2. Communication Process

Sub Category	Category	Main Category
Team Structure and Process Working and Management Style		Communication Process
Open Communication	Open and Informal Communication	
Informal Communication		
Communication tools	Online and Electronic Communication	
Internet/ Electronically		

In the open and informal category, the researcher has identified interviews extracts that represent the category where people are more towards informal and direct/casual communication. This can be identified in the ways meeting are conducted, which are more informal, 'stand up', periodic and individual. In addition, the interviewees also agree that their day to day communication between staff is very direct and autonomous, due to the working environment in their company. This situation is confirmed by the interviewees, stating that because of the small team size that exists in the organization and the working style culture which is more toward autonomous work have create this situation. Below answer quotes represent the above situations.

"We have a formal meeting once a while but most of it is more informal. It is informal when we discuss development stuff like over the coffee. We usually share our code esp. with peter and he will look at it and share the idea. Later we will introduce to others and ask for feedback. We have informal meeting for a few minutes just to inform others regarding process before we start our tasks."

"We have a daily stand up meeting and we have an iteration planning meetings but very fairly loose. Generally communication is very informal on daily basis."

In addition the analysis also indicates the relationship between staff in the company also influences the communication process in VSEs. The analysis shows that

the family and flexible environment, frequent social interaction between people and flat organization structure have given an impact on communication process in VSEs. Beside that the closeness people working space or area and high frequent of sharing activity have contribute to the communication process in VSEs. Below answer quotes have explain the above situations.

"I see a very open, very congenial very friendly and professional environment… I see people on the equal sourcing, openly discussing, There no very rigid formal hierarchy. The team easily talks to management as we sit side by side. "

"We work very close, meet for morning coffee. We always mix together and are very dynamic because we are small and easy to communicate each other."

The second category in this part is online and electronic communication category. From the analysis, the researchers found that the use of communication tools such as email, phone, blog, Skype and internet are very active in VSEs. Such communication tools are vital to the company that has a staff member working in different locations. From the analysis researchers found that the main purpose using communication tools beside to communicate between staff members, it also the tools that could close the gap between remote and collocated staff. The analysis also indicates that the use of communication tools is to allow staff to share and document all work related information or knowledge in informal way. Below quote extracts explain this.

"We always Skype with and other tools chat message, VPN, blog and others. We have company internal blog to share the information among us"

"Yeah, email is obvious… Skype and telephone communication is our 90% communication tool. We work on VPN connection so we can share our LAN… I build a model that they can work with us without any problem"

C.   Learning and Sharing Process

Our data analysis elaborates how the learning and sharing process occurs in VSEs, with two main categories namely self-learning category and sharing category, which are also influenced by the communications process. The interview data analysis elaborates how the learning and sharing process happens in VSEs. The analysis shows that the learning and sharing process main category could be detailed up into 2 important categories namely self-learning category and sharing category as in table 3.

Table 3. Learning and Sharing Process

Sub Category	Category	Main Category
Communication Process Working and Management Style Team Structure and Process		Learning and Sharing Process
Training	Self Learning	
Self Learning		
Continuous Guidance		
Internal Training	Sharing	
Meeting		
Document		

In the self learning category, the analysis shows in VSEs there are no formal training given to employees in enhancing their knowledge or skills. In the analysis informal training has been defined as internal training, sharing and self learning. The analysis also has explained that people in VSEs are more dependent on self learning in mastering the technology or process that is used in the organization. Besides self learning, the analysis also shows on the job training, self exploring and continues guidance from expert within the companies are the main process that frequently been practiced in enhanced staff knowledge and skills. The following extracts are illustrative of this point.

"We haven't done any formal training but we do give our employee an opportunity to attend various courses and seminars."

"It wasn't a formal training… what I mean once you get started you could find out, who to do certain things, someone have experience can show you the way of the main resources or he can read article with your interest you want to carried out certain task. It wasn't a formal training period, I just call training because I actually learn and still learning but now is not as before"

The second category in this part is the sharing category. The analysis shows that in VSEs the knowledge sharing process happens in 3 ways: informal training, informal meetings and document sharing. Informal training happened through informal and guidance from expert, peer to peer programming process, shared books and others material, internal training, high frequent open and direct discussion with team member and online sharing with others. The informal meeting process happens through an informal stand-up meetings, direct and open discussion and online meetings via email and Skype. While the document sharing process have been done through note sharing and online sharing (e.g. blog, email) which are informal and very personal. In relation, the analysis indicate that the learning and sharing process in VSEs is been influenced and shaped by 3 main factors which are VSEs team size and process which are small team size and flat organization structure; working and management style which are more toward autonomous work and macro management process and, communication process which are indirect and informal process. In addition from the interviews data analysis shows that in general knowledge sharing activities either via electronic or personal means are important in maintaining and evolving the current VSEs software development process. The quotes below have explained the above situations.

"However when you want to do a new things and you want to introduce a new methodology you discussed with the rest of the team, that is good and also we are supporting, if you want to do something but you not sure, you can go to any others who has more an expertise in the same area"

"We shared books and we buy books and we pass around. Generally it is informal process just asking question, grasp him and talk. Sometime we did pair programming but not always. Generally it is some kind of informal."

D. SPI –Process Improvement and Assessment

The results from the survey questionnaires have indicated that in general respondents are agreed that their software development processes rapidly change and evolve overtime. They also claimed that their development process are regularly assesses and staffs always followed or applied the latest development process method. Moreover the analysis also shown that 90% of respondents felt that their development process evolves over time. They stated that following the best practice, client requirement, team size growth, new idea and keep up with the technology change are the reasons for the improvement and evolution of development process. The following two extracts from the open-ended questions give an indication as to how the development process have been improved and evolved with a company:

> "Software process change is due to growth of the organization. We started out as 2 people 4 years ago and now have 11, so things had to change along the way"
> "It will evolve as we grow in size and get more applications in production environment"

Furthermore that in question on related to the process loss issues shows that almost all of respondents' claimed that their software development processes are not affected by the process loss problem. They claimed that by using standard development tools, similar development process, having frequent guidance and mentoring activities, active in knowledge sharing and proactive coaching could avoid the process loss problems in software development process. The following extracts from the open-ended questions illustrate this situation:

> "As a manager, I don't believe in using the latest and greatest techniques for the sake of it. We'll use something that fits our team dynamics and we'll spurn something that doesn't… whether that counts."
> "Our document process mostly electronically…we always sharing knowledge informally. Since this is family business, we always having informal regular meeting".

However the respondents also admitted that "laziness" attitudes among the staffs and practicing informal and rapid changes in software development process are among the factors that could lead the process loss problem in software development process.

V. CONCLUSIONS

This research sought to identify the effect of team dynamics in the context of software development teams and its impact on software process and process improvement activities in the context of VSEs. This investigation was achieved through a set of structured interviews and focus groups with VSEs and also a series of questionnaires. The data was rigorously analyzed using the coding mechanism of grounded theory and a framework produced.

The findings of this research indicate that VSEs unanimously agree that the software development process used within their company is constantly evolving over time. Furthermore, they also state that they regularly assess and update their development processes. In addition the finding show that these processes are informal, indirect, highly reactive and are dependent on/linked to customer requirements, developers' initiatives and technology changes. From a team perspective, the data also indicates VSEs operating processes were highly influenced by the team structure and process, which is very flat and informal. These issues have determined the level of formality in the software process improvement activities undertaken within

VSEs. Furthermore the data indicates that these issues also affect the other main categories, which are related to VSEs software development process.

The close working relationships described by VSEs between the software development team members and frequent informal communications helps to create a high level of positive team dynamics and knowledge sharing activities in software development activities, as shown in both the communication, learning and sharing category. In addition, the external environment such as macro management style; autonomous working style active feedback from peers and management and direct involvement of management in software activities has also contributed to the formation of a conducive environment for the software development team in VSEs.

Additionally this study has shown that all respondents believe that there exists a high level of positive team dynamics within the software development. This could be identified from how the communication, relationship and learning and sharing environment is operating in the VSEs who partook in this study. The results also indicate that the smaller the team in VSEs, the higher level of team dynamics will be presents in the organization. In addition, the analysis also has indicated that VSEs staff have all the important criteria such as high skills, high motivation, active in sharing, direct involvement and open communication, which are important in the software development process.

From the analysis of team development issues, it can be seen that VSEs, which employ a very small number of staff, operate a very flat team structure and operates in an informal manner. The analysis showed that due to the small team size and an open working environment, the team dynamics in VSEs are very high. Even though some of the employees are working remotely (separate geographical location) the results show that the team relationship, socializing, information/knowledge sharing and interpersonal skill level are high.

There are a number of potential avenues of further research related to this study. Of primary interest to the researchers is to widen the current research spectrum. Specifically, to test current research findings and also to produce and provide more valid findings and results, a similar study could be deployed in other geographical locations. This could help to create more generalizable research findings and assist with validation of the present research. In addition, the involvement of non-IT companies having a small IT department could assist future researchers to compare and produce a pattern of research results which could also add to the present research.

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