Collocation Impact on Team Effectiveness

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ABSTRACT

The collocation of software development teams is common, especially in agile software development environments. However little is known about the impact of collocation on the team's effectiveness. This paper explores the impact of collocating agile software development teams on a number of team effectiveness factors. The study focused on South African software development teams and gathered data through the use of questionnaires and interviews.

The key finding was that collocation has a positive impact on a number of team effectiveness factors which can be categorised under team composition, team support, team management and structure and team communication. Some of the negative impact collocation had on team effectiveness relate to the fact that team members perceived that less emphasis was placed on roles, that morale of the group was influenced by individuals, and that collocation was invasive, reduced level of privacy and increased frequency of interruptions. Overall through it is proposed that companies should consider collocating their agile software development teams, as collocation might leverage overall team effectiveness.

KEYWORDS

Collocation, Team Effectiveness, Systems Development, Scrum

1. INTRODUCTION

Throughout the history of software development, efforts have been placed towards improving time, cost, quality and productivity of development projects [3, 7]. In that respect, since teams are considered as the optimal working structure whilst working on projects [12, 18], team structure improvement is one method employed to improve software development. In particular, an approach known as 'radical collocation' has been devised, whereby team members are located in the same room, the 'team room', for the duration of the project [8].

The radical collocation approach has been advocated by agile methodologies, as it largely supports the values on which these methodologies are based [5, 7]. In particular, the agile values relate to focusing on individuals and interaction over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan [1].The collocation of software development teams supports these values by increasing the ease, frequency and interaction of communication within the team, reducing the time taken to complete a project, and improving the productivity and performance of the team [8].

Collocation is thus a popular approach to software development and is of increasing interest to many organisations. But the question still remains as to how does collocation impact on factors contributing to effective team performance. The study bridges this gap by investigating the following research question: Does collocation of agile software developers in South Africa impact on team effectiveness factors in the same way as contemporary literature suggest. These team effectiveness factors relate to Feedback, Goal, Communication, Team Identity, Performance Targets, Role, Individuality, Resources, Morale, Trust/Mutual Accountability, Conflict

Management, Work Approach, Commitment and Fun and were uncovered following a thematic analysis of literature.

This paper is structured as follows; the literature describing various team effectiveness factors is first reviewed and a description of the Scrum methodology is provided. The research methodology is then further detailed, while the data analysis section presents the results. The Implications section then consolidates all of the implications as indicated by the findings pertaining to the team effectiveness factors. The paper is then concluded by summarising the findings and providing recommendations.

2. TEAM EFFECTIVENESS FACTORS

Team effectiveness refers to the extent to which a team has been successful in meeting the objectives of their project [27]. Eighteen articles were retrieved through a search of four databases and through a thematic analysis of this literature, a number of team effectiveness factors have been identified namely Feedback, Goal, Communication, Team Identity, Performance Target, Role, Individuality, Resources, Morale, Trust/Mutual Accountability, Conflict Management, and Work Approach, and are further discussed below.

2.1 Feedback

According to [27], feedback is the most important factor contributing towards team effectiveness. In essence, due to the extensive level of communication occurring within a collocated environment, feedback between team members is quick and easy [23]. Another concept closely related to feedback is coupling.

Coupling refers to the extent and type of communication required by a work situation [19]. In a software development environment, "tightly coupled work" is common [19], implying that team members are strongly dependent on each other in completing the work. Components of tightly coupled work are

highly interdependent and the team members require frequent and complex communication. Managing tightly coupled work in the software development environment requires immediate feedback from fellow team members [19]. For that purpose, multiple streams of information within the collocated environment allow team members to get rich feedback from multiple sources, thus contributing towards successful work execution.

2.2 Goal

Highly successful teams share a common understanding of the project goals and the value of these goals to project success [27]. Ensuring that all team members involved in a project are actively working towards the same goals enhances communication and productivity [12].

Common goals in the team can be achieved through the use of shared artefacts. The use of shared artefacts within the collocated environment enhances project coordination, progress assessment and task dependencies identification. Examples of shared artefacts can be represented by the walls of the team room covered with visual representations relating to the project the team is currently working on [20]. The walls act as "information radiators" [5] which allow the team members to assimilate the information displayed.

2.3 Communication

Communication is defined as "the sending and receiving of information" [7]. For the purpose of this study, communication will refer to the sharing of information and knowledge between team members to ensure that the teams are able to operate and make decisions efficiently and effectively.

The collocated environment encouraged by agile methodologies promotes extensive communication between team members during work sessions [7]. For instance, less than 30% of the time spent during software projects is used for traditional programming tasks whilst less than 20% is spent on coding [8]. The majority of the remaining time is spent in meetings for systems design, and resolving problems and misunderstandings caused by ambiguous system specifications.

A form of communication facilitated by the collocated environment is called "osmotic communication" [5]. Osmotic communication is described as information flows that go through the team environment, where team members have the option of assimilating the information as they wish [5]. Osmotic communication is ideal in a team environment as it reduces the cost of communication, facilitates quick identification of errors, and allows for knowledge to be disseminated fast [6].

2.4 Team Identity

Team identity is created by the norms, rules and behaviours that allow team members to identify with each other [27]. A "strong sense of team identity" can have a positive impact on the effectiveness and productivity of a team [27]. Team identity can be developed through frequent interaction of team members with each other. This enables the team members to develop relationships with each other, and to identify with the characteristics and work ethics of the various team members [8].

As the collocation of teams in a team room is said to facilitate continuous and interactive communication between the team members, they are able to develop good relationships with each other and tend to exhibit a greater level of familiarity [28]. As a result teams have a stronger "group mentality"[8]

and thus a stronger team identity, leading to an improvement in team effectiveness.

2.5 Performance Targets

Performance targets are significant incentives which encourage team members to work hard and excel as much as possible. Highly effective teams are able to set and achieve high performance targets. Achieving these targets leads to increased levels of satisfaction within the teams, and further drives the teams to increase their team effectiveness [27].

In addition to performance targets, the collocated environment also supports "social facilitation" [18]. This term refers to the situation whereby an employee works visibly hard, hence enticing fellow employees to follow their example and work harder than they would normally have [18]. Employees also commented that this environment prompted them to reconsider when performing non-business activities such as private phone calls or web surfing [8].

2.6 Role

According to [27], the team member role is an important factor that influences team effectiveness. In order to ensure that a team performs effectively, it is necessary to identify and bring together the correct mix of people in terms of skills and roles. This ensures that a project team has the right balance of resources necessary to efficiently and effectively meet project objectives.

Although the roles of the agile software development team members in particular have changed to include more generalists rather than specialists [21], there has been little evidence to suggest that collocation has any impact on the definition of the roles of team members.

2.7 Individuality

Individuality refers to the individual strength and character of each team member, and whether these factors define the team or are detrimental to the team [27]. By encouraging team members to develop their individual knowledge and skills and express their creativity, they become greater assets to the team [27]. As a result, the team as a whole benefits and team effectiveness is improved [12].

Team members involved in a collocated team are generally talented people that have been chosen by their managers because of their individual skills [8]. However, collocation results in emphasis and recognition being placed on the team as a whole. As a result, team members working in collocated teams reported being concerned about whether their individual contributions are distinguishable and recognisable by their management [18]. This is a valid concern that needs to be dealt with in the team room environment.

2.8 Resources

Resources are identified by [27] as an important aspect that contributes to team effectiveness. Resources include: authority, clear targets, resources in terms of time, money and people, information, training, feedback and technical assistance [27].

Shared artefacts such as whiteboards and flipcharts are physical resources. These resources are recommended and promoted in the collocated working environment, and can contribute to increased team effectiveness in a number of ways [16, 20]. These include increasing the visibility of the project progress and thus promoting a common goal within a team, improving the motivation of the team members, and improving the ease of communication within the team [19, 18].

2.9 Morale

[14] hold the belief that morale within the team is the most important factor in determining the quality and productivity of a software development project. Factors that contribute towards the morale of a team include an environment that supports learning, autonomy and social activities [14].

In addition, the collocated team environment has been rated highly with regards to the level of satisfaction experienced by the project team members, customers and sponsors working in the environment. These increased levels of satisfaction contribute to the improvement of morale within a team [8].

2.10 Trust/Mutual Accountability

Trust within a team is closely related to many of the other effectiveness factors including conflict management and feedback [27]. Trust is defined as a "firm reliance on the integrity, ability, or character of a person or thing" [29]. Therefore trust within a team is "the common belief" among the team members that another group or individual is honest, does not take advantage of the team members, and is effectively working towards the same goals as the rest of the team [2]. High levels of trust and mutual accountability are necessary in order to enable team members to operate efficiently and effectively within their teams [27].

Collocating teams has been shown to support "interactive, continuous communication" [8] thus improving the ease of communication within the teams and promoting trust. In addition, having a common goal or focus within a team is facilitated by collocating the team members [19], who will then experiences and norms which further develop trust relationships [19].

A relationship between trust and mutual accountability is present as team members must to be able to trust each other before they can acknowledge that they are mutually accountable for a task [9, 27]. Mutual accountability stems from the dependency of each of the tasks and team members in a project on each other [9]. The most important factor in creating mutual accountability is the presence of a common goal within the team [9].

2.11 Conflict Management

Conflict is essentially "a difference between two or more people about the meaning of some information" [24]. Conflict is inevitable in a team as members often do not share the same views. Some level of conflict is therefore necessary within a team to ensure that all team members are aligned in their understanding of the project on which they are working [24]. However, if conflict is not effectively managed it can lead to deterioration in team effectiveness, resentment, and reduced motivation level within the team [27].

Conflict management is the process of resolving the differences existing between team members [24]. There is a relationship between conflict and team performance [11. 24], and so by having good conflict management in place a team is able to improve its effectiveness level.

Collocated teams are able to resolve conflicts more easily [15, 23]. This is because collocated teams often share greater levels of trust and respect, and are focused on a common goal [7]. The ease and frequency of communication afforded by collocation is also a major contributing factor to reduced conflict within a team. In addition, the physical closeness of the team members allows for most conflicts to be identified and dealt with early [11].

2.12 Work Approach

The approach taken by team members to achieve the set goals is as important as the act of actually reaching and completing the goals [27]. The work approach within the context of software development environment often involves following some kind of specified process or methodology in order to complete a project [27].

Face-to-face interaction is the best method to achieve an alignment of interests between team members. Face-to-face interaction is emphasised when a team is fully collocated and thus it is easy for team members to establish common ground. Visibility of a co-worker will transfer his/her emotions without verbally communicating, and this will prompt the person to change the form of communication depending on whether the person is happy, stressed or sad [19].

It is known that team members develop trust relationships with each other which strengthen their aim to accomplish their team objectives, commitment, and for the most part teams have more fun than individuals [12]. This tends to suggest that collocation might have an impact on fun and commitment. However, limited information is available on these constructs. This study seeks address this gap by incorporating the constructs in the questionnaire to understand the resulting impact on them in the South African context.

3. THE SCRUM METHODOLOGY

The companies involved as participants in this research adopted the scrum methodology of software development. A brief description of this methodology follows to facilitate an understanding of the context in which the participants operate.

Scrum is a methodology which focuses on software development management [13]. [25] identified six roles in Scrum namely Scrum master, product owner, Scrum team, customer, user, and management. According to Scrum, a clear distinction should be made between the team members who are responsible for delivering the system (programmers, testers, analysts, and technical writers) and others (stakeholders, business users, and upper management). It is the responsibility of the programmers to manage the system development on a day-to-day basis while the other stakeholders select the systems features to be implemented and regularly inspects the team's activity [26].

Customers can only exert pressure on the project at the end of the 30-day sprint (an iteration in a Scrum). During the sprint, customers are not allowed to interfere and the team is allowed with enough, time, clearance and trust to perform the work. Any issues reported by the customers at the end of a sprint are then addressed in the next Scrum [25]. The project team leader is known as the Scrum master and is responsible for liaising and facilitating communication between the customer and the project team. The team leader's role is to ensure that both parties are adhering to the rules [25].

4. METHODOLOGY

The research was exploratory, interpretive, and both quantitative and qualitative in nature. Data was collected from three Cape Town based software development companies working with collocated teams namely Company I, Company II and Company III. In particular, a quantitative survey was employed to gauge the impact of collocation on the various team effectiveness factors and qualitative interviews were undertaken to validate and support the findings of the quantitative research, and consequently create a new

understanding of the effects of collocation on team effectiveness factors. The qualitative and quantitative data gathered provided empirical evidence which assisted in the identification of relationships and trends, on which the findings and conclusions of the research were based.

Quantitative data was collected through an online questionnaire consisting of 52 questions and based on a five point Likert scale with the following options: Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4 or Strongly Agree = 5. It was also clearly conveyed to the respondents that participation in this study was completely voluntary.

For the questionnaires to be included in the final sample and considered valid, they had to be fully completed only by respondents working in South Africa. This is because quantitative data collection had to followed by qualitative face-to-face interviews and South African respondents were easily accessible as opposed to international ones. The validity of the responses was also determined by including some questions phrased in a negative manner (E.g. I do not sense a strong team identity within my collocated team). Answers provided for the questions were then correlated with the rest of the respondent's answers.

In total, 95 respondents completed the online questionnaire. 68 of these questionnaires were fully completed. Of the 68 completed questionnaires, 54 were completed by respondents currently working in South Africa. Questionnaires received from the respondents in the USA, Germany, Brazil and Argentina were not included in the final sample as the aim of the study was to understand collocation impact in South African software companies. In addition, 5 questionnaires had to be removed from the sample as a result of them failing the validity check. Therefore, the final sample size of the questionnaire respondents was 49. Two of the sample companies (Company I and Company II) each provided five teams, to be interviewed once the data collected from the questionnaires was analysed. Company III did not allow their staff members to be interviewed and was thus not included in the qualitative data collection. The average team size across the interviewed sample was 7 team members per team. Each team employed the Scrum software development methodology was composed of Scrum Master, Product Owners, team members (developers) and other (management).

Upon completion of preliminary analysis of the results of the questionnaires, face-to-face interviews were conducted with five teams from each of the two sample companies. The interview questions were compiled once the questionnaire data had been analysed, and each team was questioned on different aspects according to their particular questionnaire results. The interviews were informal and open-ended, were conducted in order to gather rich feedback and different opinions regarding aspects of collocation and team effectiveness, and were recorded using a video camera. However for privacy reasons, when interviewing the teams from Company II only voice recordings were made. All of the interviews were later transcribed.

Table 1 shows the names of the companies and the teams as they will be referred to throughout the research:

Table 1. Company and Team Identifiers

Company I	Company II
Team A	Team F
Team B	Team G
Team C	Team H
Team D	Team I
Team E	Team J

5. DATA ANALYSIS

The following section evaluates and discusses the relevant aspects of collocation identified from the questionnaires and interviews. In the analysis the Cronbach Alpha test was used as a measure of internal consistency to validate responses. In line with [4], a Cronbach Alpha of 0.6 or higher for a factor was considered acceptable, due to the exploratory nature of the study and it was these responses which are included in the analysis.

5.1 Years of Experience

Figures 1 and 2 illustrate the number of years of experience that the respondents have had in a collocated working environment, and the number of years of experience that the respondents have had in the Information Technology (IT) field respectively.

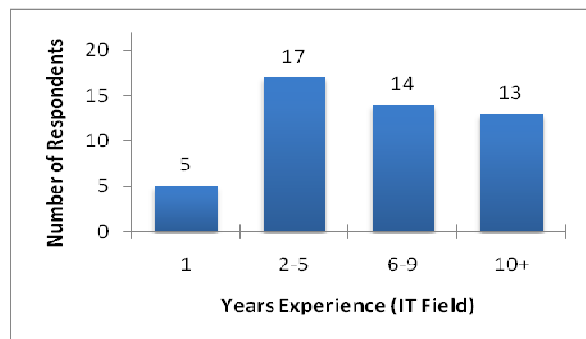**Figure 1: Years of Work Experience within the IT Field**

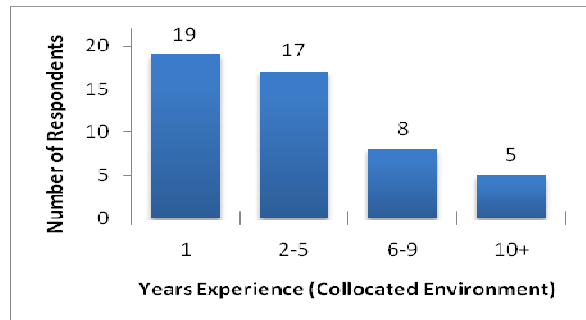**Figure 2: Years of Work Experience within a Collocated Working Environment**

Figure 1 shows that a majority of the respondents have had more than one year experience within the IT field. Figure 2 indicates that a large amount of the respondents have worked for less than a year in the collocated environment. 73% of the respondents have less than 5 years experience in the collocated environment.

5.2 Differences in Responses by Gender

The questionnaire was completed by 33 males and 16 females. Figures 3 and 4 represent the overall mean responses of the males and females respectively, grouped according to the team effectiveness factors.

Figure 3: The Overall Means of the Male Respondents per Team Effectiveness Factor
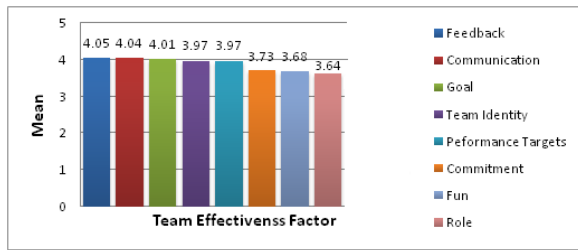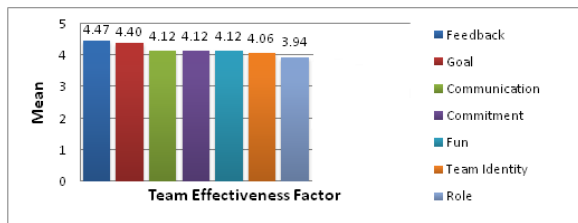

Figure4: The Overall Means of the Female Respondents per Team Effectiveness Factor

Figures 3 and 4 confirm that high level differences exist between the overall mean responses of the males and females. The most noticeable differences are that the first seven factors from the female responses have a mean higher than 4, whereas only the first three factors from the male responses have a mean higher than 4. In addition, Feedback was identified by both parties as the team effectiveness factor that is impacted the most by collocation. The ranking of the rest of the factors differed for the males and the females. Although it is clear that differences exist between the responses of the males versus the females, the combined overall means of the responses from both groups have been used for the purposes of this research.

Information pertaining to the respondents language groups, age and educational attainment were not captured during the study and could be further investigated as further research on the topic of collocation impact on team effectiveness.

5.3 Team Effectiveness Factors

The data collected from both the questionnaires and the interviews was collated in order to present how team effectiveness factors being investigated are impacted by the collocation of agile software development team members. The team effectiveness factors investigated include: Feedback, Goal, Communication, Team Identity, Performance Targets, Commitment, Fun, Role, Individuality, Resources, Morale, Trust / Mutual Accountability, Conflict Management and Work Approach.

The first ten factors have been ordered according to the ranking of their respective overall means. The overall standard deviations for these factors range from 0.66 to 0.97. Figure 5 illustrates the order and the overall means of each of the nine factors that were found to have reasonable Cronbach Alpha results. Low Cronbach Alpha results were found for Resources (0.55), Morale (0.59), Trust / Mutual Accountability (0.40), Conflict Management (0.21) and Work Approach (0.20) factors.

Figure 5: The Ranking of the Overall Means of the Team Effectiveness Factors
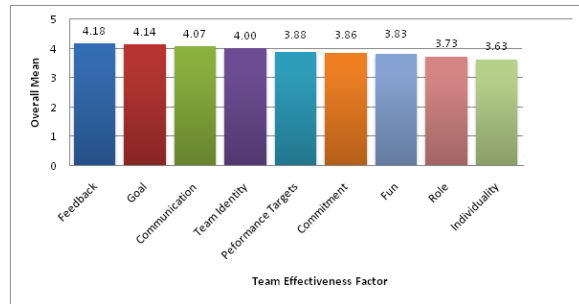
5.4 Quantitative Results Discussion

From the questionnaire data, the factors being the least positively impacted by collocation are Individuality (mean = 3.63, standard deviation = 0.67), Role (mean = 3.73, standard deviation = 0.86), Trust and Mutual Accountability (mean = 3.78, standard deviation = 0.79), Fun (mean = 3.83, standard deviation = 0.89), Morale (mean = 3.84, standard deviation = 0.74), Commitment (mean = 3.86, standard deviation = 0.74), and Performance Target (mean = 3.88, standard deviation = 0.97), as they all have means below 4. However, respondents' opinion on Role, Fun and Performance Target varied across a wide range as indicated by their high standard deviation. On the other hand, standard deviation values for Trust and Mutual Accountability, Individuality, Morale, and Commitment showed a stronger consensus across the sample.

Three questions were presented to the sample with regards to conflict management in the collocated environment and each are discussed individually. 67% of the sample responded positively that the physical closeness of the collocated environment allows for earlier identification of conflict, 24% of which agreed strongly. The mean for this question was 3.80, and the high standard deviation of 0.96 represents significant divergence across the sample. 61% responded positively to the question that collocation allows for easier conflict resolution. This question had a very low mean of 2.84 and also the highest standard deviation at 1.01. It is thus questionable as to whether conflict resolution is made easier by collocating team members. In addition to this, 47% of respondents disagreed with the view that conflict occurs more frequently than in other environments, whereas only 29% agreed. The question had a mean of 3.53, and consensus across the sample was fairly distributed with a high standard deviation of 0.89.

The quantitative survey also reveals that Team Identity (mean = 4.00, standard deviation = 0.66), Communication (mean = 4.07, standard deviation = 0.72), Goal (mean = 4.14, standard deviation = 0.67), Feedback (mean = 4.18, standard deviation = 0.74), are the most positively impacted by collocation. In particular, the standard deviation for the Team Identity factor was 0.66, which equates to the strongest consensus across the sample for a particular factor. With an overall mean of 4.18, it appears that collocation has the highest positive impact on the feedback factor followed by the goal factor with a mean of 4.14. Both factors also have low standard deviations of 0.74 and 0.67, indicating strong consensus across the sample. There was also strong agreement that communication is easier and more effective as a result of collocating team members.

For both questions used to evaluate the impact of collocation on the resources factor, the overall response across the sample was a rating of 4 on the Likert scale. This indicates that a

majority of the respondents believe that a team's resources are positively impacted by the collocation of team members. The standard deviations of the responses for each question relating to this factor are however somewhat different, at 0.68 and 0.84 respectively. This indicates that the respondents may be unsure of their opinions regarding the impact of collocation on resources within a team.

5.5 Qualitative Results Discussion

The team effectiveness factors have been grouped under four main categories namely team Composition (Role, Team Identity, Individuality), Team Support (Resources, Morale, Trust/ Mutual Accountability, Fun, Commitment), Team Management and Structure (Conflict Management, Goal, Performance Target, Work Approach) and Team Communication (Communication, Feedback). Qualitative results for these factors are further discussed below.

5.5.1 Team Composition

- **Role**

Few teams commented on the role factor and whether it was emphasised within a collocated team. One member from Team G mentioned that that the roles of team members are less emphasised due to the team members taking on more generic roles and tasks within their teams. This team member also said that the roles within teams extend beyond the job description because team members assist each other in analysis, coding and testing situations: "You play more roles than just your job specification. You tend to help out where you can". This was supported by one member of Team I who mentioned that the roles within a collocated team are intermingled: "you do things that you wouldn't normally have done".

As was mentioned in the literature review, little evidence was found to suggest that collocation has any impact on the definition of the roles of team members. This position was confirmed by the both the questionnaire and interview data, which imply that collocation does not have a much influence on the definition of roles within a team in the South African context.

- **Team Identity**

The Scrum Master of Team A noted that collocated teams have a strong sense of team identity due to the fact that team members worked in close proximity to each other, thus forming strong team units: "we belong to the Scrum team, and the fact that we work together in one room helps a lot". This was supported by a respondent from Team D who noted that collocation definitely improves team identity due to the ease of communication within the team. Team B also displayed high level of team identity and also mentioned the use of personal mailing lists to keep members in contact with each other.

In spite of those comments, less mention was made of the team identity factor in the interviews as compared to quantitative data. This implies that collocation may not have as strong an impact on team identity as the questionnaire data suggests. The results of the interviews do support the literature to some extent, but did not identify any new ideas as to why collocation improves team identity in the South African context.

- **Individuality**

During the interviews conducted at Company I, consensus was reached among team members that there is individual recognition within the collocated environment. These were based on the fact that due to the collocation of team members, the Product Owner is always fully aware of which team members are committed to a piece of work: "Team members are recognised individually by product owner and he knows which

person is working on which piece". The members of Team C commented that in previous working environments where the Product Owner was separated from the team, this was not as clear. According to a member of Team G, in a collocated environment team members are more aware of what deliverables their fellow team members are working on, stating that:

"You depend on the individuals to do what they are best at, so in that way we know the strengths of our team members".
One respondent from Team J also said:
"When you're working on something, everybody knows it because you are able to communicate the facts easily and let everybody know about your progress".

The teams from Company I mentioned that they have performance reviews in place to evaluate not only the performance of team members, but also to allow team members to rate management. The Scrum Master from Team C was satisfied that this action contributed to the company being able to recognise the performance of individuals. However, one member from Team B disagreed with the idea that collocation improved the level of individual recognition within a team, stating there is not more individual recognition than in the traditional environment. This team member acknowledged that, since he is in a team of only three members, his perception might be different if the team size was larger. These mixed results might be due to the different attitudes of management towards recognition of individuals.

The literature suggested that the collocation of team members may raise concern as to whether the contributions of the individual team members will still be recognised. The results of the research imply that this concern is not valid in the South African context. The questionnaire and interview results differ slightly in that the results of the questionnaire suggested that collocation does improve the recognition of individual contributions, whereas the results of the interviews were not as supportive of that idea. The overall results therefore indicate that although collocation does improve the recognition of individual contributions, the improvement is not very significant.

5.5.2 Team Support

- **Resources**

Few comments were made about the resources factor during the interviews. However, only positive comments were made. The main observation was that in a collocated environment resources are much more readily available than in a distributed working environment. This was attributed to the close proximity of the team members and, to the agile development approach being adopted by the teams, the managers and customers. A member of Team H noted that when considering the team members as resources:

"we're much more aware of what everybody is doing and how much time it takes to do things, as opposed to previously when it was just pass the task along and it happens, you didn't see it happening".

Another member from Team F noted that due to collocation *"there is a lot more visibility as to what the team is doing, and the team members within that team".*

With regards to the use of shared artefacts such as whiteboards, flip charts and Scrum boards, much mention was made about the extensive utilisation of these artefacts within the teams in order to facilitate project execution. At least four team members stated that shared artefacts have contributed to their team effectiveness. A number of the teams expressed that collocation of their team members increases the visibility of the

shared artefacts across the team, and consequently increases the visibility of the progress and goals of the team. Team F, however, said that they paid little attention to shared artefacts and remarked that "shared artefacts do not improve team effectiveness".

The results of the research agree with the literature in that the collocated environment in the South African context has been found to encourage the use of shared physical resources, which increases visibility and communication within a team. In addition, the results indicate that collocated team members are more aware of the available resources within a team. The results of the interviews seem well aligned with the data collected from the questionnaire responses. For the most part the team members are in agreement that collocation in the South African leads to increased availability and use of resources within a team.

- **Morale**

The statistics from the questionnaire were supported by the information gathered from the interviews where morale was identified as having a major influence on team performance. According to Team A, due to the fact that collocated team members are located in close proximity, the morale of individual team members has a significant influence on the morale of the team as a whole: "Collocated makes morale a big issue, because the team members influence each other". The Scrum Master of Team A commented that if a team member is "down", the whole team will be affected and as a result the morale of the team will also decrease. Team C supported this view by saying that having a good vibe within the team is important in order to ensure that a team is able to perform effectively.

Team B was of strong opinion that being collocated with the team meant that the Product Owner could clearly understand the team's situation at all times and take appropriate action well in advance, without running the risk of being unrealistic and basing decisions on incomplete information:

> *"Traditionally what would have happened in a non-collocated environment in case of project delay, the owner would have gone into "bitch mode", everyone would have worked till 00h00 each night, the system would have been launched and everything would have broken… a week later, 3 members would have quitted".*

The collocated environment has thus increased the morale of the team members in that the team is less likely to be subjected to unfair treatment or criticism. This would in return prevent the morale of the team being decreased unnecessarily.

The results of the research confirmed the literature, although no mention was made about the impact of shared artefacts on morale. The research also identified that by being collocated with management or team leaders leads to decreased stress and improved morale. The overall results of the research indicate that collocation leads to increased morale within a team within the South African context.

- **Trust/Mutual Accountability**

The trust / mutual accountability factor was not often selected during the interviews as one of the factors that are the most positively impacted by collocation. Team members from Teams H and J did however select trust / mutual accountability:

> *"it is very visible that you are working and that you're working on team tasks because you are much more inclined to talk to your colleagues about what you're working on. And so it becomes evident what you're working on, and you have that much more of a feeling that you trust each other and you can feel that you're all accountable for the same goal".*

From the results of the interview and questionnaire data it can be deduced that, generally speaking, the sample believe that trust and mutual accountability within a team is positively impacted by collocation, though there are a number of team members that do not agree or do not have an opinion with regards to the matter. The results of the interviews are perfectly aligned with the literature, as both the ease of communication and the increased presence of a common goal were mentioned by the team members as factors of collocation that increase trust and mutual accountability within a team.

- **Fun**

The analysis of the interviews found that Team A and Team D from Company I, did not think that collocation improves the level of fun within their teams. However, across the remainder of the team interviews there was a fairly common opinion that the collocation of agile software development team members does positively influence the fun factor within a team. A team member mentioned that as a result of being collocated,

> *"You start to know the people a bit better and you can start to interact with them on a social level as well and the fun level builds up as well".*

From the interviews, the underlying basis for the perceived increase in the level in fun within teams seems to be the ease of communication and interaction facilitated by collocation.

Although the fun factor was identified as one of the team effectiveness factors, there was no evidence in the literature to suggest that collocation would have an impact on it. Hence, a major contribution of the study is that according to most of the interviewees, collocation has a positive impact on the fun factor within agile software development teams in the South African context. In addition, both quantitative and qualitative results were in line with each other.

- **Commitment**

Commitment bears some resemblance to motivation in that they can both be described as energising forces with implications for behaviour. However, differences between the two terms still prevail and the two were investigated separately during the course of this study. For instance, according to [22], motivation is rather a set of energising forces while [17] define commitment as a force which binds an individual to a course of action. Base on those definitions, motivation can be considered as a broader concept than commitment. In addition, it leads to the notion that motivation is a force which can further lead to commitment.

Team G believed that the commitment factor is significantly impacted by collocation. In particular, one member from Team G commenting that:

> *"You don't want to disappoint your team members because now you are friends and you're sitting together".*

A number of team members commented that they definitely experience a higher degree of team identity, which is a result of being more committed to each other:

> *"For us as a team, the commitment is very visible and it is shared by the team, so everybody works on something together so they have the same commitment. Whereas previously it was easy to commit for a certain date whereas somebody else was committing for another date and it got a bit hazy. Because of communication and transparency it makes the commitment a lot better"*

In addition to this, the respondent also noted that team members would rarely take the blame for other teams, because they are seen as outsiders to their team. These findings suggest that in the South African context, teams in a collocated environment are highly committed to each other.

The interviews also identified a different type of commitment, namely the commitment between a team and its work. Work within the collocated environment was seen by teams as a "shared commitment". The results from the interview of Team I suggested that commitment to work products within the team is visible and shared between members due to members working on similar items at the same time. Due to the ease of communication and also the transparency of information, commitment to the work products is deemed to be easier as a result of being in a collocated environment.

Although commitment was identified as one of the factors that contribute to team effectiveness, there was little evidence in the literature to suggest that the collocation of team members would improve commitment within a team. However, a major contribution of the study is that in the South African context, collocation does have a positive impact on the level of commitment within a team, thus further improving team effectiveness.

5.5.3 Team Management and Structure

- **Conflict Management**

Team B agreed that the level of conflict within a team has been reduced due to collocation. In addition to this, Team B believed that the conflicts between the business and technology functions has decreased as a result of the collocation of the different team member roles such as business analysts and developers. One member from Team B noted that the fact that team members are located in close proximity to each other, and with managers, has put a face to the business and technology functions: *"The level of politics has been reduced and business has put a face to the technology"*. Because team members are located closely to each other, all of the unimportant and irrelevant issues can be omitted.

The South African collocated teams appear to have taken a self managed approach where team members are encouraged to talk to each other immediately with the goal of resolving the issue at hand. One member from team B commented that they are able to discuss and resolve any conflicts that arise very easily due to the close proximity of all of the team members. Team member H4 was quoted as saying:

> *"I don't think conflict is an issue, but that depends on the people I suppose. If you want to say something we're all mature adults so just say it".*

This team member was of opinion that the collocated environment does not have any more or less conflict than the traditional distributed environment.

On the whole the results of the research seem to agree with the literature, although the team members tended to be less enthusiastic about the impact of collocation on the conflict management factor than was expected. The results of the research suggest that collocation does have a positive impact on conflict management within a South African team, but there is no consensus across the sample with regards to this factor.

- **Goal**

The teams from Company II commented that they set goals for themselves on a day-to-day basis, as well as on a sprint level basis. They also reported that both of these actions contribute towards the team as a whole being more aware of the goals and objectives set for their projects. The general opinion of the teams across the interviewed sample was thus that collocation results in team members being more able to share a clear and common understanding of the goals set for a project. It was also emphasised that goals are usually set for the teams and not necessarily for the team members:

> *"You are working towards a goal every week. Every day you have to finish your task, so there's a day-to-day goal and there's also a sprint goal".*

In addition, team size was identified as an influencer for the sharing of a common goal. Members of Team J felt particularly strongly that the size of a team has a great influence on the maintenance of a common goal within a team:

> *"The smaller the team is, the more likely it is that you will be working on common things, so you have a common goal."*

This team consisted of seven team members and there was consensus amongst the members that the team would struggle to accommodate an additional team member. It was suggested that members of a small team would be more likely to work on similar work items, and when doing this in close proximity to each other, they would be more likely to share a common goal.

On the whole, it can be deduced that collocation in the South African context has a positive impact on the existence of a common goal within a team. These results agree with the literature in that collocation has been found to increase the use of shared artefacts and improve the communication and understanding of the objectives and goals of a team.

- **Performance Targets**

Throughout the interviews, a number of comments were made with regards to the performance targets factor most of which were from team members from Company I. The general opinion of these team members was that, as a result of collocation, performance targets are clearer within their teams. They found that due to the close proximity of team members and visibility of team artefacts, all team members are consistently aware of and well informed about the performance targets for the projects:

> *"In terms of work performance, the development team does not work any faster, but everyone can see what's going on and it can be directed more appropriately and constructively"*

Some team members mentioned that they did not believe that increase in visibility of performance targets necessarily improves their team efficiency. However, they did mention that it allows for more appropriate and constructive management of project deliverables, which would ultimately translate into increases project efficiency and thus increased team effectiveness.

Another group of team members expressed that the increased visibility of performance targets resulted in better buy-in from team members. This means that "work becomes lighter and easier for everyone in the team" (I4), which is believed to be a key contributor to improved team success.

The overall results of the data suggest that the sample believe that the visibility of performance targets within a team is increased through the collocation of agile software development team members. The information gathered from the interview data also shows that the team members in South Africa believe that this increase in visibility has a few of its own positive outcomes. These results thus confirm the findings of the literature.

- **Work Approach**

The Work Approach factor was not measured in the questionnaire, as the questions required to obtain sufficient data to effectively measure the construct were too complex. The factor was however included in the interviews, and a number of comments regarding the impact of collocation on work approach were made by the team members. These comments were predominantly made by the teams from Company I.

From the interviews, it appears that due to the team members working closely together, the work approach followed becomes

more transparent. Team members learn about each others' work ethics and are able to follow the work progress within the team. This implies that team members are able to assess each other's performance and gauge whether they are underperforming or need assistance and support. As a result collocation encourages team members to adopt similar work approaches in order to keep up with each other and maintain a consistent level of progress within the team:

> *"People have different work ethics, but collocation puts people together to achieve the same goal"*
>
> *"If a team member falls behind, then everybody knows about it, and they are able to provide help and support"*

This is extremely positive in terms of leveraging team effectiveness. One member from Team A added that maintaining a consistent level of progress by improving the work approach promotes working together towards a common goal within a team. Another member from Team B said that due to collocation, all of the team members are aware of each others' work approaches and strengths, which enables more efficient delegation and completion of tasks within a team. Hence, although the factor was not tested in the questionnaire, the interviewed sample largely believed that collocation has a positive impact on the work approach of team members and thus improves the efficiency and effectiveness of the team as a whole.

5.5.4 Team Communication

- **Communication**

The results of the interviews were consistent with those of the questionnaire data. Three main points were identified that seemed to be common across the teams. The first point was that respondents found that they are more able to communicate directly with their team members when working in a collocated environment: In a collocated environment, speaking to people across the room becomes very easy". The second point was that communication is open within the team, as can be seen in this statement: "the team is talking all the time, having a conversation". This open communication leveraged team efficiency as team members are able to easily ask for help and advice. The third point was that team members often overhear the conversations of other team members, and can easily get involved:

> *"We overhearing other team members' conversation and are able to identify if they are putting effort into something that is unnecessary"*

This type of communication assists team members in finding new approaches to tasks and identify when they are doing things in the wrong way. A final aspect mentioned by some of the respondents was the importance of inter-team communication. Within a collocated environment where the different teams are also located in close proximity to each other, team members from the different teams are able to communicate easily with each other, which they find extremely beneficial especially when working on cross-platform or related projects.

From the analysis of both the questionnaire data and the results of the interviews it can be deduced that the communication factor is positively impacted by the collocation of agile software development teams in the South African context. In addition, the research also found that by working in an environment in which a number of teams are collocated in the same area, communication and knowledge transfer between the teams is improved. This further increases the effectiveness of a collocated team as the team members are easily able to discuss inter-team issues with and get support from people that may not necessarily be part of their team.

- **Feedback**

None of the team members made any comments about collocation having a negative impact on their team effectiveness. A general comment made by the respondents was that, because they are all seated in close proximity to each other, they are able to easily obtain direct feedback from their team members. In addition, a majority of the team members said that sending and receiving feedback is much faster and sometimes even immediate, as can be seen by the statement:

> *"The turnaround time for feedback is much quicker. Whereas previously you would have to wait until you were all together in a meeting, now you can just shout over to your team member or you even overhear conversations that you normally wouldn't have been involved in"*

Another interesting point noted during the interviews was that several team members also believed that the ease with which they are able to send and receive feedback result in a more positive atmosphere within the team.

The results of both the questionnaire data and the interviews suggest that there is consensus across the sample that the feedback factor is positively impacted by the collocation of agile development team members in the South African context. These results confirm the literature which found feedback to be the most important factor in distinguishing a highly effective team from one that is not, and suggested that the close proximity and ease of communication that could result from the collocation of teams would positively impact feedback within a team.

6. IMPLICATIONS

The following section consolidates the implications of the impact that collocation has on each of the team effectiveness factors.

The study reveals that collocation indeed impacts the above mentioned team effectiveness factors. Fifteen team effectiveness factors in total were identified and explored during the research, of which only thirteen were initially discussed in the literature review. Of the fifteen factors that were investigated, six were found to confirm the literature but did not provide further insight into the impact that collocation of teams has on them. These factors are Feedback, Performance Targets, Trust / Mutual Accountability, Team Identity, and Conflict Management. The findings therefore show that, similarly to what was mentioned in literature, each of these factors is positively impacted by collocation in the South African context. According to the results, the Role factor was also found to confirm literature, whereby collocation does not have a significant impact on the definition of the roles of team members in the South African context.

However, collocation of agile software developers in South Africa appears to also leverage inter-team communication, leads to softer boundaries of individual roles, yields faster progress due to transparency of work processes, and promotes individual recognition by team members.

The study demonstrates that, the close proximity of the team members in a collocated working environment promotes the adoption of a common work process by team members, and assists the team members in establishing common ground. However, no mention was made about the influence of the use of shared artefacts within a team on work approach, or of the influence of face-to-face communication and interaction.

Results pertaining to four of the fifteen team effectiveness factors namely Goal, Commitment, Resources and Morale, agreed with, as well as provided additional insight into the

literature. In essence, these factors are all positively impacted by the collocation of software development teams.

The literature with regards to the Goal factor found that the use of shared artefacts, which is encouraged in a collocated environment, lead to the increased awareness of a common goal within a collocated team. The research confirmed this view and added that the close proximity of team members in a collocated environment, the increased existence of a common process within a collocated team, and the generally small team size of collocated teams increase the existence and awareness of a common goal within a collocated team.

Findings surrounding the Communication factor agreed with the literature with regards to the impact of collocation on communication within a team. In essence, due to the close proximity of team members, collocation promotes direct and open communication as well as increases the level of osmotic communication. The study also found that by working in an environment in which a number of teams are collocated in the same area, communication and knowledge transfer between the teams is improved. This further increases the effectiveness of a collocated team as the team members are easily able to discuss inter-team issues with and get support from people that may not necessarily be part of their team.

The findings surrounding the impact of collocation on the Resources factor suggest that collocation does not only improve the use of shared artefacts, and thus team effectiveness within a team. Collocation was also found to improve the awareness and availability of the resources within a team. These resources include people, time, shared artefacts, software and information. However, although the research provided additional insights into the impact of collocation on the Resources factor, it was found that, while collocation does influence this factor positively, this influence is very minor.

The findings of the research surrounding the Morale factor confirmed the literature, which suggested that collocation leads to increased team morale and satisfaction. This was largely attributed to the close proximity of the collocated team members. The research also found that collocation of team members with the team leader or manager leads to decreased stress levels within the team, as team members are easily able to communicate with these authority figures whenever necessary, and thus increase morale.

Due to the lack of literature surrounding the impact of collocation on the Commitment and Fun factors, these were not included in the literature review. Both of these factors were, however, believed to be positively influenced by collocation and so were investigated in the research. From the findings, collocation was found to have a significant positive impact on the Commitment factor. Increased commitment level in a collocated working environment was attributed to the increased team identity and trust also found in a collocated environment. In addition it was suggested that the close proximity of the team members leads to the development of good relationships between the team members, and increases the overall transparency within a team. As a result, team members tend to be more committed to performing to the best of their ability.

The research findings with regards to the Fun factor indicated that this factor is positively impacted by the collocation of software development team members. It was suggested that, collocated team members are more able to become familiar with each other and develop good relationships, as well as communicate and interact with each other. This ease and frequency of communication and interaction also results in team members developing social relationships with each other. Consequently, collocated team members were found to have more fun.

These findings show that the collocation of agile software development teams has a positive impact on a majority of the team effectiveness factors investigated, and thus increases overall team effectiveness. These finding thus fulfil the primary objective of the research, which was to determine the impact of collocation on each of the team effectiveness factors investigated.

7. CONCLUSION

The main purpose of this research was to determine the impact of collocation on a number of factors that influence the effectiveness of teams. The research was conducted using a sample of collocated agile software development teams that were all adopting the Scrum approach to software development. From the analysis and findings of the questionnaire and interview data, the following conclusions can be drawn.

Collocation has a positive impact on all but one of the team effectiveness factors discussed in the literature, namely Role. The Commitment and Fun factors, two team effectiveness factors which were not discussed in the literature, are positively impacted by collocation.

The following recommendations can be made taking into account the findings and conclusions of the research. Even though the research was conducted in South Africa we believe that the results of this research are likely to be applicable to other contexts. Companies should consider collocating their agile software development teams in order to increase the overall effectiveness of the teams. This is recommended as collocation has been found to have a positive impact on fourteen team effectiveness factors, which indicates that the collocation of agile software development teams would increase overall team effectiveness. However, some negative aspects of collocation which emerged from the study are worth noting. For instance, team members reported that in a collocated environment, roles are less emphasised and some team members complained that they did tasks that were not part of their job specification. Also, the morale of the whole group is often influenced by individuals. For instance, if one team member is feeling down, the whole team is more likely to feel down as well. Collocation was also considered as invasive, reduced the level of privacy and increased frequency of interruptions. In addition, noise factor was considered as disruptive and at times reduced the level of concentration.

A possible area for future research could be to take a quantitative approach to determining the difference in the level of effectiveness of distributed and collocated teams (possibly with the inclusion of control groups for increased reliability of the findings) or conducting similar studies in other contexts to assess the generalisability of our findings.

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