A Review on the Critical Success Factors of Agile Software Development

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**Abstract.** Given the evolution and increasing usage of agile methods and practices, the successful adoption of agile is crucial. During the last decade, the critical success factors (CSFs) of agile development research developed rapidly. This paper aims to review the research on CSFs of agile software development in the last ten years (2006-2016) which used empirical methodologies to identify the success factors. In this paper, eight factors are selected as critical success factors for agile software development. A taxonomy which maps these eight CSFs into Technical, Organizational, People, Process categories is introduced in this research.

**Keywords:** Success Factors, Agile Development, Software Development, Agile success.

1. Introduction

The success of implementing agile development practices has been investigated by many researchers over the last decade. According to Sjoberg, Dyba, & Jorgensen [1], in the future software engineering research should focus more on empirical studies. Such empirical research will likely lead to established scientific knowledge regarding how the different software engineering methods, tools, and techniques are being used. In the case of agile development, empirical studies should enable a better understanding regarding how agile principles and practices are adopted and their impact on project success. Important factors associated with agility, such as people, process, and organizational culture, are unlikely to be addressed without solid empirical research. Kitchenham et.al [2] did a systematic review about the status of systematic literature review (SLR) in software engineering and 20 SLRs have been selected. There are some SLRs covering aspects of agile development such as requirement engineering [3]. However, there was no SLR focused on the success factors of agile software development. In light of this, there is a need for more SLRs to study the status of the success in agile development.

This paper is aiming to review the literature on the critical success factors (CSFs) of agile software development over the past ten years. The focus in this paper will be only on the studies which use empirical methodologies to identify the success factors of agile software development in the last decade. Eight papers have been selected which investigated the CSFs of agile development dated from 2006 to 2016. We then include all the success factors which were mentioned in at least two of these eight papers.

The success factors identified by this process are Delivery strategy, Team capability and training, Agile development techniques, Customer involvement, Project management process, Organizational culture, Communication, and Top management support. This paper also introduces a taxonomy which maps these eight CSFs into Technical, Organizational, People, Process categories.

This paper is organized as follows: Section 1 is an introduction, and Section 2 is a background. Section 3 shows the research methodology, Section 4 presents the findings and gives more details about each success factor. Section 5 provides conclusion and suggestions for future work some of which is on-going.

1. Background

Agile practices have been developing since the late 1990s. The agile momentum in the software industry started with the Agile Manifesto [4]. In 2001, a group of software practitioners introduced the Agile Software Development Manifesto. According to Conboy [5], agility denotes “the continual readiness of an information system development (ISD) method to rapidly or inherently create change, proactively or reactively embrace change”. According to agile principles, the focus should be on adding value rather than following the plan. Delivering working software to the users frequently and in a short period of time can add a value for the users [6]. Agile development expects the software development team to deliver early and then gain feedback early, meaning it can make changes more easily, improve quality, and conduct constant testing.

The agile mindset supports changes during the development rather than discouraging them. It also encourages feedback from the users as early as possible. Agile practices address two of the toughest challenges facing business and technology nowadays: firstly, the need for an innovative approach in developing software and, secondly, the need for a work environment which is dynamic in responding to frequent changes [7].

The agile encourages the overlapping of roles and tasks within the development team. Such overlapping will likely lead to skills improvement among the team members. This overlapping of roles and redundancy of skills will probably enhance the team’s ability to respond to changing requirements throughout the development project [8].

Cockburn & Highsmith [9] claimed that the agile philosophy places more emphasis on the people factor than traditional software development approaches. A skilled team is crucial, and so each individual team member adds more value to the agility of the development process. Thus, agility not only reduces the documentation effort in a development project, but also focuses on building a highly-skilled team capable of using any technique or tool to achieve its objectives.

In addition to this, Boehm & Turner [10] identified several barriers preventing the implementation of agile practices in a legacy organization. They divided the barriers into three categories, the first of which is software development conflicts, which are linked to the process of developing the software itself. Since the agile methods and the traditional methods differ, the process of requirement gathering, designing, implementation... etc. will require new approaches which will, in turn, require new techniques, tools, and skills to develop software. The second category is related to business process conflicts. Because agile development is evolutionary or iterative, there will be tremendous changes in the way business processes are built or managed. The third category is people conflicts. People conflicts constitute the most critical barrier standing in the way of development. The people factor is a vital aspect of agile movement, since agile relates to motivated individuals and flexibility in a supportive environment [10].

Gandomani et al. [11] claimed that the obstacles in agile transformation originate from the organizational culture and structure. It is suggested that organizations attempting to move to agility should pay attention to the efforts involved in moving from a process-centric model to a people-centric model.

Begel & Nagappan [12] from Microsoft Research, conducted a survey with 487 respondents, all of whom were asked what they felt were the top benefits and problems associated with agile development. The top three benefits were the improvement of communication and coordination among the development team, faster delivery and release, and quicker response to changes/design flexibility. On the other hand, the top three problems were the difficulties with large-scale projects, many required meetings, and management buy-in, the latter of which means being strict with dates.

According to Leidecker & Bruno [13], the critical success factors are those factors, conditions, variables and attributes that, when properly addressed, managed and sustained, have a huge impact on the success of the work. Kloppenborg, Manolis, & Tesch [14] stated that a project is considered successful if it meets the traditional success measures of cost, time and scope constraints. However, Bytheway [15] claimed that unless a software project addresses organizational needs, it cannot be deemed successful. Shenhar, Dvir, Levy, & Maltz [16] introduced a multidimensional concept of project success. This concept introduced four measures of project success: project efficiency (meeting time, cost and scope constraints), customer satisfaction, business or organizational success, and future preparation.

1. Research Methodology

According to Kitchenham [17], one of the reasons for undertaking a systematic review is to summarize the existing evidence about a technology or a phenomenon. In this paper, the reason for undertake a study review is to summarize the empirical evidence of the critical success factors of agile software development during the last ten years. The literature reveals a large number of studies which have examined the success factors of implementing agile practices in an organization. We did a review to search for the studies of agile CSFs in the last ten years (2006-2016) which used empirical methodologies to identify the success factors of agile development. Previous empirical studies ([18]; [19]; [20]; [21]; [22]; [23]; [24]; [25]) have been selected to review in this paper. Indeed, a number of success factors in agile development have been proven as a result of these studies. The selected journals and conferences which are the ones recognized for publishing high quality papers on agile development are shown in Table 1.

**Table 1.** Selected Journals and Conferences Proceedings

|  |  |
| --- | --- |
| Source | Number of selected studies |
| Journal of Systems and Software | 3 |
| Journal of Software Engineering and Applications | 1 |
| European Conference on Software Process Improvement | 1 |
| International Journal of Project Management | 1 |
| the Eighth International Workshop on Cooperative and Human Aspects of Software Engineering | 1 |
| SoutheastCon, 2007. Proceedings. IEEE | 1 |
| Empirical Software Engineering Journal | 0 |

1. Findings

The criteria for selecting the critical success factors in this study are: i) to be validated by an empirical study; ii) to be mentioned in at least two different studies. The selected critical success factors for agile development and the corresponding literature are listed in Table 2. There are other success factors which we did not include in this paper because they were mentioned only in one study. For example, Livermore [25] indicated that the organization size is a success factor for agile development. Another example, Stelzmann et al. [19] claimed that the change response strategy is a success factor for agile development. A taxonomy of the critical success factors is shown in Fig. 1.

This taxonomy of the success factors is driven by the classical approaches of project management and ISO21500 were the success factors classified into technical, process, and organizational categories. According to [26], projects success factors could be classified into four categories as follows:

* Project initiation and pre-contract activities
* Project preparations, design policy, technological infrastructure, design methods
* Planning and control processes
* Organizational and management environment

In light of this, these categories proposed by [26] could be labeled as Process, Technical, and Organizational categories. With categories I and III to be merged as Process. And category II could be labeled as Technical and category IV could be viewed as organizational category.

In the case of agile projects success factors. With the concentration of the agile manifesto values [4] on individuals and the people role in agile software development. There is a need to add a new category of the success factors of agile development which is people category. Therefore, this paper categorized the eight identified success factors of agile development from the literature into Technical, Process, People, and Organizational categories Fig. 1.

**Table 2.** CSFs of Agile Software Development

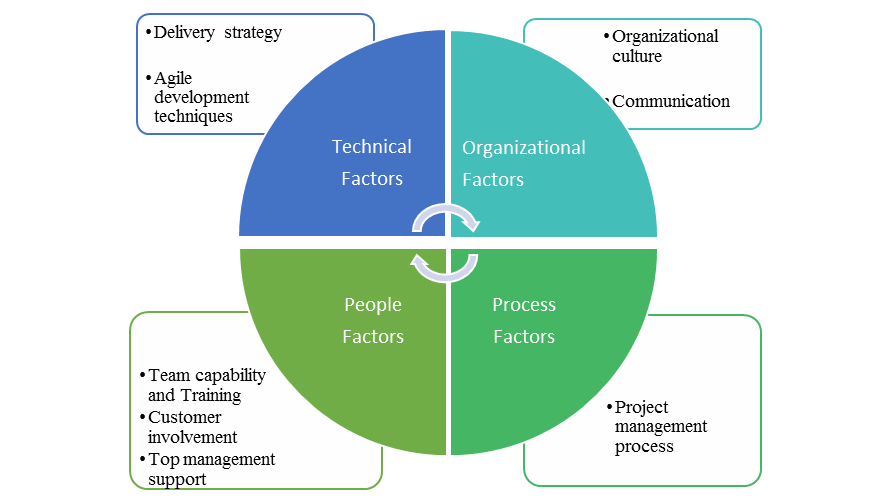
|  |  |
| --- | --- |
| Success Factors | Literature |
| Delivery Strategy | **[18], [19]** |
| Team Capability and Training | **[25], [18], [20], [22], [21]** |
| Agile Development Techniques | **[18], [22], [19]** |
| Customer Involvement | **[18], [20], [19]** |
| Project Management Process | **[18], [19], [23]** |
| Organizational Culture | **[20], [22], [21], [24]** |
| Communication | **[19], [24]** |
| Top Management Support | **[25], [24]** |

* 1. Delivery Strategy

In order to have an effective delivery strategy in agile development projects, two points must be assured. Indeed, there must be frequent delivery of working software and the most important features should be delivered first [18]. The delivery strategy should be clear within the project team, and each member should know his/her role in the strategy.

* 1. Team Capability and Training

Agile development should be built on motivated individuals. Having the right people is essential for any project, and in agile projects it is even more important, since agile projects depend on the individuals’ competency. There should be an emphasis on training and continuous learning during the agile development project [20]. In order to maximize the benefits of the team capability factor, agile development should be built on a talented team. Moreover, all necessary steps should be taken to ensure that the team has the training needed and that all members are empowered; this will lead to high levels of trust, and will ultimately result in success on the agility journey. According to Livermore [25], there is a significant relationship between successful agile implementation and receiving training on the implemented agile methods or practices.



**Fig. 1.** Agile Development Success Factors Taxonomy

* 1. Agile Development Techniques

Before using an agile method or technique, it is essential that the project members are familiar with the selected method or technique. The tools, ideas, and terminologies used by the selected agile method or practice must be clear to all agile development project team members [19].

* 1. Customer Involvement

Customer involvement is crucial during agile software development. Delivering frequent releases of working software and welcoming the changes in the requirements depend heavily on the involvement of customers. The more involved customers are, the more satisfied they will be with the agile development. Customer collaboration and commitment are believed to have an impact on the successful implementation of agile software [20].

* 1. Project Management Process

During the early stages of the agile development project, it is essential to launch the project plan, which must be correctly sized. The selection of an appropriate project management process contributes to the success of agile development projects in term of developing quality software [18]. According to Sheffield & Lemétayer [21], the project factor is considered to be an indicator of the agility in software development. The selected project management process should empower the project team and address the talents of the development team. The nature of agile projects which embrace changes and deliver many iterations requires a flexible project management approach.

* 1. Organizational Culture

Organizational culture can be defined as a set of organization’s factors or variables which may influence the development of agile software in an organization. Organizational culture factor is a vital factor in the transition into agility. The organization should have a dynamic culture to respond to the frequent changes during the agile development life cycle [20]. According to Wan & Wang [22], three aspects of organizational culture may affect agile development, the first of which is the overtime culture. This is followed by the culture of no trust in an organization, and finally the lack of mutual collaboration culture.

* 1. Communication

Communication is essential to the success of any project. In agile development, communication factor is playing a vital role to the success of agile projects. The nature of agile project which includes involvement of the customers, frequent feedback, dynamic changing and self-organizing teams will require an efficient communication between the project’s members and with the customers. Stelzmann et al. [19] stated that in agile development it is necessary that the communication being as direct as possible. Since direct communication will eventually lead to foster the communication process in agile development projects.

* 1. Top Management Support

According to Livermore [25] study, there was a significant relation between the support of top management and the success of agile projects. The management involvement and support is crucial to the success of agile projects.

1. Conclusion and Future Work

The last decade has produced a great deal of research focused on identifying the factors that influence the success of agile software development. This paper aims to do a review of the critical success factors of agile software development research in the last decade (2006-2016). Eight previous studies have been selected because they used empirical methodologies to validate the CSFs. The selected studies identified many success factors for agile software development. Of which eight factors have been selected in this paper because they were identified by more than one study. The eight factors are delivery strategy, team capability and training, agile development techniques, customer involvement, project management process, organizational culture, communication, and top management support. The selected factors have been classified into a taxonomy of factors which include Technical, Organizational, Process and People categories.

Future research might work on the proposed taxonomy and explore how those success factors are related to each other. Future work may study the importance of these CSFs and the weight for each factor. There is an on-going survey to collect data from agile practitioners around the world to explore the importance of the eight identified success factors. We received responses from 131 agile practitioner. The relation between the number of completed iterations in the agile project and the importance of the success factors will be investigated. The role of individual’s experience and organizational experience with agile in the perception of the identified success factors will be explored. Using factor analysis, we will investigate the relationships among the identified eight success factors.

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