Measuring Team Productivity in Agile Development: A Scrum-Based Process

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Abstract. Team productivity in agile software development (ASD) is perceived as an abstract concept that is still evolving. It works as a fundamental indicator in organizations since it provides information about how a team behaves. Recent studies have revealed that team productivity is composed of determinants, influencers and impact factors. In recent years, the widespread dominance of agile methods in organizations has led to use mainly Scrum in software industry, which is a teamwork management framework used in complex projects. In this sense, it is interesting to establish a system that allows an agile team working with Scrum to incorporate the measurement and improvement of productivity in its activities. In this project, we propose a structured process for measuring team productivity that is aligned with the Scrum framework. The construction of the process was elaborated in two phases. In the first phase, the proposed process is designed, and a representation is elaborated. In the second phase, a validation of the designed process is performed, evaluating the acceptance in a software industry context. As a result, a Scrum-aligned team productivity measurement process was designed. This process is represented by business process models using BPMN notation and supported by a set of artifacts. In addition, the proposed process is validated by 77 software industry professionals organized in 19 Scrum teams. It is possible to establish a process for measuring team productivity in ASD for the following moments: planning, execution, and evaluation. By implementing the proposed measurement process with professionals, a high level of acceptance was obtained.

Keywords: Agile Software Development · Productivity Measurement Process · Team Productivity · Team Productivity Factors

1 Introduction

When talking about productivity, the term used since centuries ago in the economic framework is evoked, relating two relevant dimensions: quantity and quality [1]. Subsequently, software engineering coined the concept in the last three decades of the 20th century, specifically in the late 1970s, reflecting a classical perspective closely aligned with the models of that time [2].

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With the advent of the Agile Software Development (ASD) manifesto, the mindset and working methods underwent a significant change [3]. The traditionalist position was left behind to adopt an approach that combines flexibility without compromising the stability of the projects and where people play a leading role in the processes [4].

Nowadays, different organizations, regardless of their context, in which they operate, are using agile methodologies to develop their operations. This is because they provide a strong organizational framework with positive aspects such as alignment with the business, greater customer satisfaction and continuous collaboration [5].

In the literature, it has been observed that the definition of team productivity in ASD is perceived as an abstract concept [6, 7], which is still evolving. This concept not only acts as a crucial indicator in organizations [8, 9] but is also shaped by determining, influential and impacting factors [6–8, 10–13].

These factors are categorized into four groups [8, 14]: ***Meaning***, factors that analyze how development team members perceive productivity, either individually or in general terms; ***Impact*****,** factors that affect the team and can negatively, positively or neutrally influence its behavior [8, 14]; ***Flexibility***, factors that affect team performance when faced with conditions that require adaptation and change [8, 14]; and ***Socio-Human***, factors that focus on the human qualities essential to achieving high levels of team performance and ensuring the success of the software development process [8, 14].

In ASD, productivity is used as an indicator [8, 9] to evaluate the team's performance and efficiency in delivering its tasks [7]. A software development team must incorporate productivity measurement and improvement in its activities [15, 16]. To achieve this goal, it is essential to understand its behavior, which is achieved through the use of metrics. These metrics allow the collection of relevant information to understand performance objectively and guide the continuous improvement of the work process [16].

The widespread use of agile methods in organizations has led them to opt for Scrum [5], a flexible, fast framework used to manage highly complex projects [17].

Scrum was conceived in the 1990s by Ken Schwaber and Jeff Sutherland [18] in response to common problems in project execution: slowness, cost overruns, delivery delays, and lack of customer satisfaction [19]. Its objective is to transform the traditional process into one that prioritizes incremental and iterative deliveries, embracing an adaptive and self-directed approach to generate value quickly [3, 19]. According to the seventeenth agile report exposed by Digital.ai [5], 63% of agile users at team level use Scrum being since 2006 the most popular framework in history.

The motivation for this paper arises, from the above description, which is to propose a productivity measurement process for Scrum teams considering the factors that affect it organized in the categories of: Meaning, Impact, Flexibility and Socio-Human; with their corresponding evaluation metrics.

The paper is organized as follows. Section 2 describes the related work, Sect. 3 presents the methodological process used, Sect. 4 the results, Sect. 5 describes the discussion, and Sect. 6 details the conclusions.

2 Related Works

The study [20] analyzed the metrics used in the evaluation of eleven factors that influence team productivity within ASD, classified into the categories of *Meaning*, *Impact* and *Flexibility*. This analysis was conducted through a systematic mapping of the literature following Petersen's protocol [21]. As a result of this process, 37 primary research available in the bibliographic databases of IEEE Xplore DL and Scopus. The findings highlight the definition of the factors analyzed, the identification of specific productivity metrics associated with each of them, and an attempt at mathematical formalization of some of these metrics.

In the research [14], they conducted a comparative analysis of productivity perceptions among ASD team members based on 63 factors identified in a preliminary Systematic Literature Mapping. Their study was guided by Kitchenham and Pfleeger's [22] protocol for survey development in Software Engineering. The collection of 82 responses from software industry professionals made it possible to establish that productivity is a crucial indicator of improvement within the team's processes and the fulfillment of the client's objectives. Furthermore, productivity can be measured through various factors. The above included a categorization of the factors in terms of Meaning, Flexibility, Impact and Socio-Human highlighting the relevance of 22 of them.

A systematic literature review focused on metrics used to assess team productivity in the context of ASD [23] identified ten main articles following a specific protocol. The results revealed the existence of 21 team productivity metrics, especially highlighting the measurement of early and frequent software delivery and the value added by tasks to the software product.

Machuca and Gasca [24] proposed a gamification-based model that seeks to impact team productivity through intervention in the Socio-Human Factors (SHF). The study presents an innovative proposal that incorporates three thematic areas in Software Engineering: gamification, SHF in software development contexts, with the objective of strengthening skills and abilities; and serving as a strategy to improve productivity.

3 Methodology

In software engineering (SE), a process is defined as a series of activities to be carried out within a specific time frame, using resources to produce work products [25]. Specific roles perform these activities and can be subdivided into tasks, each with an assigned level of responsibility, with the goal of achieving the desired results [25].

That is why, through an SE process, we intend to methodically establish a set of activities that serve as a reference for ASD teams to measure productivity. The process is emphasized in Scrum teams and consists of two phases: design and validation.

Figure 1 details the measurement process in the exposed stages.

3.1 Phase 1: Process Design

This section presents the systematic way in which the proposal of a process for measuring team productivity from the ASD approach is elaborated is presented. The activities carried out in the design of the process are described below.

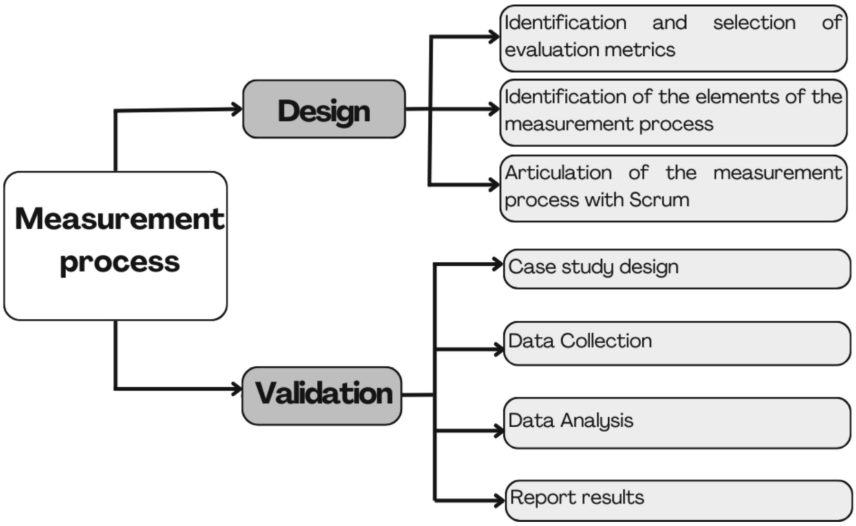

Fig. 1. Stages of the measurement process.

Note: All figures and tables are elaborated by the authors unless otherwise stated.

Identification and Selection of Evaluation Metrics. Metrics are essential in organizations [26] and must be aligned with agile principles such as frequent delivery of value, flexibility and continuous communication with the customer [26, 27]. However, defining metrics is not a trivial task because they can be categorized in different ways depending on the approach adopted [28]. This phase seeks to establish metrics for the evaluation of 22 productivity factors identified in a previous study [14].

Identification of the Elements of the Measurement Process. This part seeks to establish the elements that will be part of the process and, in turn, relate it to Scrum. The elements to be considered are described as follows.

Event. It is an event that allows the team to review its progress and adapt to changes. In Scrum, events enable the work to be visible to those who perform it as well as to those who receive it [18]. The events suggested by Scrum are: Sprint, Sprint Planning, Daily Meeting, Sprint Review and Sprint Retrospective [18].

Metrics. Indicates the way to collect and analyze data in order to produce objective information about a variable that is desired to know and that this contributes to learning, in this case, about a team [23].

Activity. Involves one or more types of work items and how to perform them [29]. An activity consumes certain resources, generates some work product and a role executes it. For the process of measuring team productivity in ASD, activities will be considered and addressed within each of the events proposed by Scrum. It should be noted that the measurement activities should be relevant to the needs of the organization. They should consume little time and effort for the ASD team to implement them [26].

Resources. These are the necessary components for the ASD team to carry out the measurement. There are two types of elements: inputs, which are necessary to start an

activity, and work products, which are the results generated once that activity has been executed [25].

Roles. An individual or a group of people who carry out a task or responsibility within a specific process. The roles established for this process follow the Scrum framework and include Product Owner, Scrum Master and Developers [3, 18]. In addition, Stakeholders are considered as an additional role.

Articulation of the Measurement Process with Scrum. This section articulates metrics, activities, resources, and roles defined with the Scrum events, in order to have a systematic way of adoption by the teams in the productivity measurement. To elaborate the representation, the Business Process Management Notation (BPMN) is used, which is a standard that allows for the detailed representation of high-level business processes. BPMN allows the processes to be represented based on central objectives [30], in this case, the measurement of team productivity. The representation is carried out in three stages of the process: planning, execution and evaluation.

3.2 Phase 2: Validation

In this section is presented the systematic approach used to validate the process proposed in Phase 1. The activities performed in the validation follow the protocol proposed by Runeson and Host [31] for the Case Study (CS).

Case Study Design. The objective of this stage is to define what the CS is intended to achieve, what is to be investigated and the context in which the information is to be obtained.

Data Collection. In this stage, the aim is to establish the technique to be used for data collection. According to Lethbridge [31] the techniques to achieve this purpose can be direct methods, indirect methods and independent analysis of work artifacts. For this case study, the survey is taken into consideration as a direct method.

Five important moments were considered when constructing the validation instrument. First, the objective of the instrument was defined. Secondly, the population to which the validation instrument will be applied is established. Next, the duration of the validation is estimated. As a next step, the resources for the application of the instrument are established. Finally, the activities to be developed are selected.

On the other hand, it describes how the implementation of the designed instrument was carried out. Details are included on: execution of planned activities, resource management and interaction with participants.

Data Analysis. Once the data have been collected, the analysis is performed by identifying the most relevant findings. The analysis can be qualitative or quantitative. This case study performs a quantitative analysis considering the participants' perceptions on the productivity measurement process established.

Report Results. To finalize the validation, a results report was prepared based on the participants' perceptions. With the descriptive analysis of the data, positive aspects and aspects to be improved for the process were established.

4 Results

The results obtained are presented in accordance with the methodological design established in Sect. 3.

4.1 Phase 1: Process Design

Establishment of Team Productivity Metrics in ASD. Identifying productivity metrics is a crucial step in the measurement process. To carry out this task, productivity factors were grouped into the following categories: Meaning, Impact, Flexibility and Socio-Human (22 factors in total). The productivity factors are set out in Fig. 2.

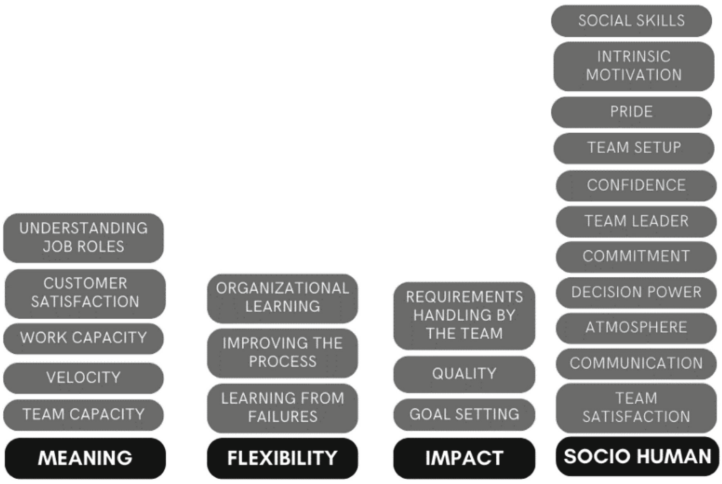

Fig. 2. Productivity factors considered in the study.

For the factors Meaning, Impact, and Flexibility, the metrics identified in [20] were selected, which are determined through a systematic mapping of literature using the IEEE Xplore and Scopus bibliographic databases.

Regarding the factors belonging to the Socio-Human category, the metrics identified in previous works carried out in [32–36] were selected.

Identification of Measurement Process Activities and Alignment with the Scrum Framework.

Currently, the Scrum framework does not provide concrete guidelines for measurement. Therefore, this study proposes a prescriptive process as a contribution to the framework, specifically focused on improving productivity measurement.

Table 1 shows the identified activities and the role that would develop them to plan, execute, and evaluate the measurement of team productivity in ASD considering the Scrum events.

The following presents the different stages of the process, each illustrated with diagrams detailing the activities and resources involved. Each of these figures uses BPMN

Table 1. Measurement process activities linked to Scrum.

Phase	Activity	Scrum Event	Scrum Role
Planning	Introduce factors for measuring productivity	Sprint Planning Meeting	Scrum Master
	Select Productivity Factors	Sprint Planning Meeting	Scrum Master
	Identify the metric(s) or evaluation indicators for each selected factor	Sprint Planning Meeting	Scrum Master
	Establish the form and measure in which a metric can be evaluated	Sprint Planning Meeting	Scrum Master
	Determine the type of rating scale to be used and the set of values that comprise it	Sprint Planning Meeting	Scrum Master
	Identify the resources or tools that will support the process of measuring factors	Sprint Planning Meeting	Scrum Master
	Establish the period the team will be subjected to the measurement process	Sprint Planning Meeting	Scrum Master
Execution	Coordinate data recording for measurement	Sprint	Scrum Master
	Select metric	Sprint	Scrum Team
	Record the data required for measurement of the metric	Sprint	Scrum Team
	Calculate the value of the metric from the collected data	Sprint	Scrum Master
Evaluation	Elaborate a graphical representation of the behavior of the results of the metric	Sprint Retrospective	Scrum Master
	Interpret the results of the graphical representation of the behavior of the metrics	Sprint Retrospective	Scrum Master
	Establish regulation and improvement actions	Sprint Retrospective	Scrum Team
	Synthesize regulatory and improvement actions	Sprint Retrospective	Scrum Master
	Specify action plan	Sprint Retrospective	Scrum Master

(Business Process Model and Notation), employed in the **Bizagi Modeler** tool, to clearly and visually represent the key elements in each phase of the process. Through this representation, the flow and interaction between activities throughout the cycle are made easier to understand.

Figure 3 shows the Planning stage, outlining the key activities and resources required to set the foundation for the process.

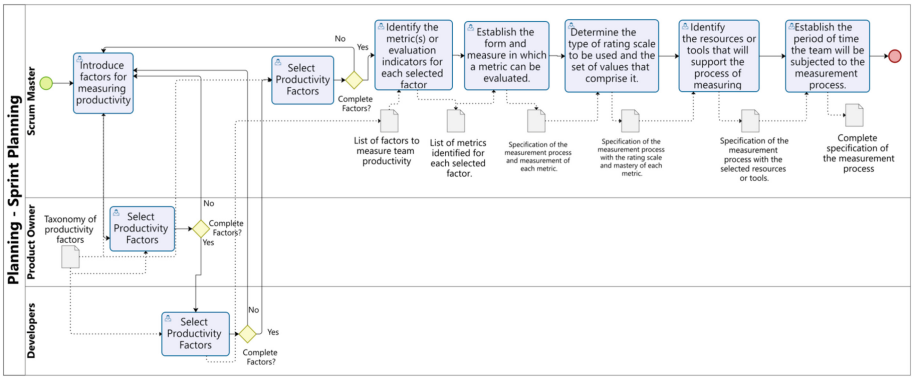

Fig. 3. Planning phase of the productivity measurement process.

To support the Planning stage, artifacts were developed to support the process. Figure 4 details the artifact created for the Planning stage.

Category							
Factor							
Attribute (Metric)	Measurement	Form	Type of Measurement Scale	Measurement Scale	Resource Type	Resource	Period

Fig. 4. Artifact to specify planning.

The ***category*** corresponds to one of the four classification categories to which a productivity factor could belong (Meaning, Impact, Flexibility, Socio-Human). The ***factor*** is associated with one of the 22 team productivity factors in ASD. The ***attribute*** represents the evaluation metrics or indicators according to the productivity factor. The measure is the value or symbol that is assigned to the attribute. The ***form*** is the formula used so that an attribute can be measured. The ***type of measurement scale*** is the subjective assessment scheme selected to classify the measure; according to the proposal [23, 28], these can be Likert Scale, Forced Classification, Verbal Frequency Scale, Ordinal Scale, Comparative Scale, Numerical Scale, etc. The ***measurement scale*** represents the set of values that are part of the subjective assessment scale according to the type selected. On a Likert scale, for example, the values could be Very high, High, Medium, Low, Very Low [23, 28]. The ***resource type*** is the one used for the measurement process (Physical, Computational Tool, Human, etc.). The ***resource*** refers to the resource that will support the measurement process. The ***period***, which refers to the period of time in which the metric must be calculated.

Figure 5 illustrates the **Execution** process using BPMN. This figure visually represents the activities and flow involved in the Execution stage, providing a clear understanding of how the process unfolds and the interactions between its key elements.

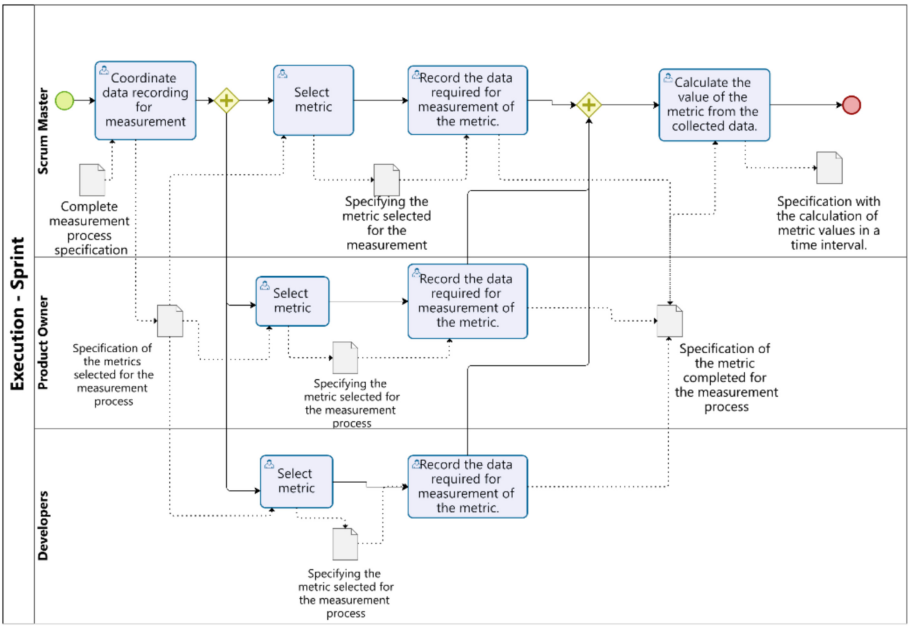

Fig. 5. Execution phase of the productivity measurement process.

As a support resource for the execution stage, the artifact presented in Fig. 6. Was created.

Category				
Factor				
Attribute				
Form				
Period	Variables			
	Variable 1	Variable 2	…	Variable m
Period 1 value				
Period 2 value				
…				
Period value n				

Fig. 6. Artifact to specify execution.

Category, Factor, Attribute, Form, and Period represent the same data displayed in the planning artifact. The ***Variables*** refer to the values that are captured to obtain the measurement in a specific period.

Finally, to support the **Evaluation** stage, the process is represented (see Fig. 7), and an artifact is created to specify the evaluation (see Fig. 8), along with another to specify the recommendations resulting from the analysis of the metrics (see Fig. 9).

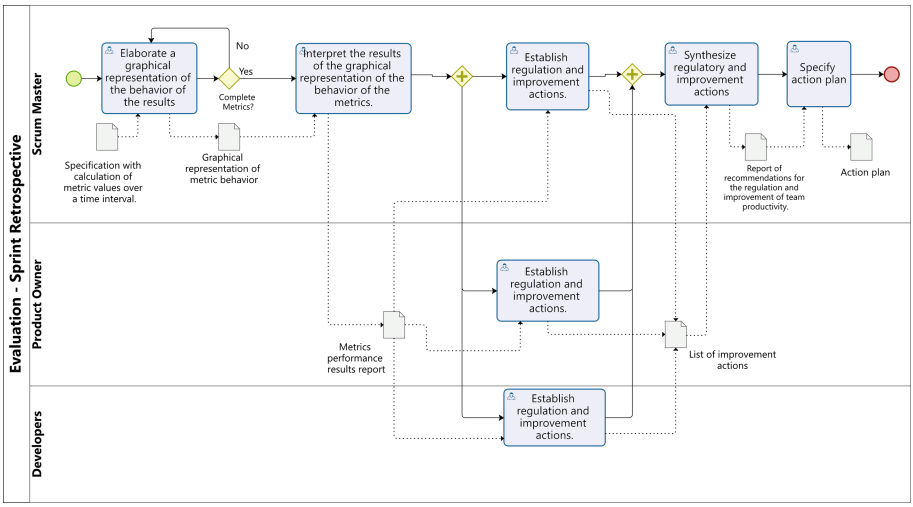

Fig. 7. Evaluation phase of the productivity measurement process.

Category	
Factor	
Attribute	
Form	

Graphical representation of the measurement	**Report of results of the behavior of the metric**
Sprint 1 Sprint 2 Sprint 3 ... Sprint N	Date Observations

Fig. 8. Artifact to specify evaluation.

Category, Factor, Attribute, Form represent the same data displayed in the planning artifact. The ***Variables*** refer to the values that are captured to obtain the measurement in a specific period.

This report details the regulation and improvement actions that the team must implement.

4.2 Phase 2: Validation

Below are the results of the phases of the protocol proposed by Runeson and Host [31] for the Case Study (CS).

Recommendations report	
Date	
ID	Recommendations

Fig. 9. Artifact to specify the recommendations report.

Case Study Design. The purpose of the CS was to validate the process proposed in Phase 1 in order to measure team productivity in the development of a software product of medium complexity using Scrum. This was applied in a real operational scenario with software industry professionals during 6 weeks.

Data Collection. During April and May 2024, CS was held to validate the process of measuring team productivity in ASD with professionals from the software industry. A total of 77 professionals participated, organized in 19 teams.

The teams worked on a project using the Scrum guidelines as a framework for work management, developing two sprints of 3 weeks each. The development of the CS was carried out in three moments.

The first moment corresponded to the planning phase of the process. Prior to the application of the CS, the teams were made aware of the importance of measuring team productivity in ASD. In addition, the productivity measurement process proposal was socialized, including the identification of factors and metrics, together with the activities to be carried out and some artifacts that were created for the collection of information.

In the second moment, the participants were guided in data collection during the development of each Sprint using the artifacts designed to support the process.

In the third moment, at the end of each Sprint, the results were analyzed and interpreted. In this space, participants reflected on the productivity measurements generated in each of the iterations and made a report of results and recommendations.

Data Analysis and Report Results. To collect the participants' perceptions about the proposed process for measuring team productivity in ASD, a survey was developed and administered to the 77 participants. The variables analyzed were: the level of acceptance of the proposal, the difficulties encountered, positive aspects, aspects to include and aspects to improve.

The following section presents the sociodemographic characteristics of the survey participants. These characteristics include gender, age, and professional experience, which provide context for the analysis of the survey results.

The results obtained from the survey revealed that 79.2% of the respondents are male (61), while the remaining 20.8% are female (16).

Regarding the age of the respondents, it was observed that 37.7% of the participants are between 24 and 31 years old, 24.7% are in the 32 to 39 age range, 20.8% are between 40 and 47 years old, and 16.9% are between 48 and 55 years old.

Concerning the amount of time the professionals have been working in software development projects, it is evident that 39% have more than twelve years of experience

in the field, 26% have between 1 and 4 years, 20.8% have between 5 and 8 years, and 14.3% have between 9 and 12 years.

Figure 10 shows that the proposal obtained an acceptance level of 97.4% at the High and Very High levels, representing 75 professionals. The above means that the process of measuring team productivity in Scrum has been relevant to evaluating a team performance by proposing a set of activities and artifacts that contribute to the achievement of this objective.

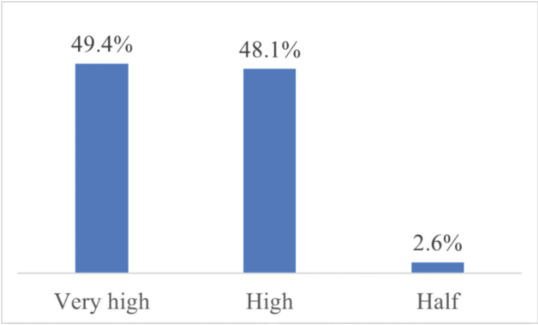

Fig. 10. Level of acceptance of the proposal by professionals.

When investigating the positive aspects, in Fig. 11, it can be seen that the participants fundamentally highlight that the proposal provides artifacts to measure productivity in an organized and systematic way. In addition, there is a systematic process that guides the measurement of productivity from planning to evaluation. Finally, the proposal adapts to the Scrum framework.

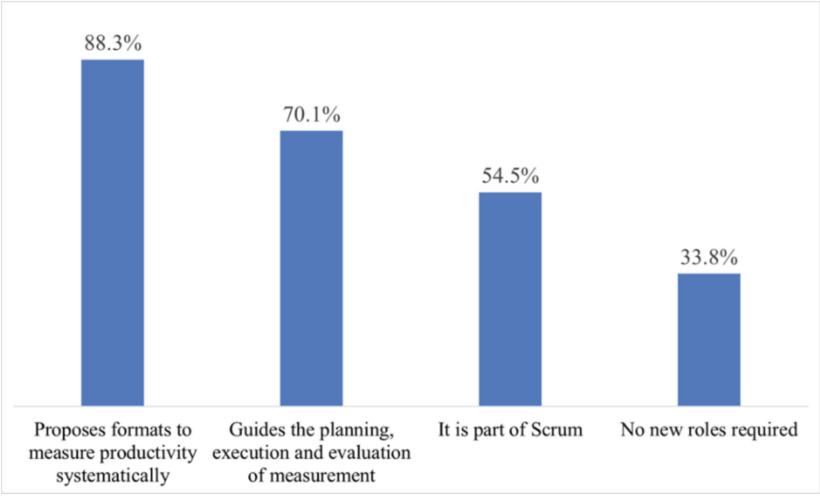

Fig. 11. Positive aspects of the proposal according to the professionals.

Regarding the difficulties expressed by the population object of the validation, when measuring team productivity, it is highlighted that 11.7% (9 professionals) stated that they had had problems when recording the data in the measurement devices, 7.8% (6 professionals) in understanding some factors such as work capacity; and 3.9% (3 professionals) in defining the assessment scales.

According to the data collected, the participants mentioned that one aspect they would like to include in the proposal is the automation of the measurement process through the use of a software tool.

Regarding aspects that could be improved, 74% consider that no additional contribution is required. 16.9% suggest creating a computer tool to automate the measurement process. Finally, 9.1% of participants suggest providing an instruction manual to facilitate the understanding of the factors and the recording of data in the templates that support the process.

After reviewing the measurement process results, one suggestion providing an instruction manual for using the proposal was implemented. A software product that supports the measurement process during all stages is considered a future work line.

5 Discussion

The measurement process consists of several components and is divided into three stages. It began with the definition of specific metrics for the 22 relevant productivity factors, selected through a systematic literature mapping (SMS) and significant studies in the field. The objective of this review was to establish precise definitions for each factor and their measurement indicators using various metrics.

Subsequently, we established the activities, resources and roles to be considered in the evaluation process, dividing them into three key moments: Planning, Execution and Evaluation. For each of these moments, artifacts were designed to specify the results of the tasks. These artifacts provide a clear and defined structure to guide the implementation of the process, ensuring its coherence and effectiveness.

Finally, the defined components were integrated and adapted to the framework and dynamics of the agile Scrum method, taking advantage of its existing structures and ceremonies to facilitate the effective implementation of the process. The process is represented using the business process model proposed by [30] using the BPMN notation.

In this way, the agile Scrum approach and the objective of measuring and improving productivity in a specific software development context synergized [37].

During the validation stage of the measurement process, both the positive aspects of the proposal and those to be improved were identified, as well as the difficulties encountered. It was observed that the proposal obtained a high degree of acceptance, exceeding 90%, which indicates that, in this population, the established measurement process is effective for evaluating productivity in ASD teams. The idea of providing greater support to the measurement process through the creation of an instruction manual to guide the steps to be followed, as well as the automation of the process through a computer tool, is proposed.

6 Conclusions

The research contributed to establishing a team productivity measurement process in ASD for the moments Planning, Execution and Evaluation, which is integrated to the Scrum framework. The measurement process through previous studies, manages to consolidate a set of 22 productivity factors classified into the categories: Meaning, Impact, Flexibility and Socio Human.

Implementing the proposed measurement process with software industry professionals achieved a high level of acceptance. The main difficulty encountered was in capturing the necessary data to carry out the measurement. In addition, the participants suggested the creation of a resource to guide the adoption of the proposal and the development of a computer tool to support the proposed process.

The level of abstraction required to plan the productivity measurement process allowing the identification of a high level of complexity generated in the professionals. In this sense, it is proposed, as future work, to use strategies such as gamification to reduce the level of complexity.

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