

# Factors that Influence the Productivity of Software Developers in a Developer View

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**Abstract-** To measure and improve the productivity of software developers is one of the greatest challenges faced by software development companies. Therefore, aiming to help these companies to identify possible causes that interfere in the productivity of their teams, we present in this paper a list of 32 factors, extracted from the literature, that influence the productivity of developers. To obtain the ranking of these factors, we have applied a questionnaire with developers. In this work, we present the results: the factors that have the greatest positive and negative influence on productivity, the factors with no influence and the most important factors and what influences them. To finish, we present a comparison of the results obtained from the literature.

## I. INTRODUCTION

One of the fundamental issues facing the software engineering industry is programmer productivity. Over the past several years, many studies have demonstrated a wide disparity in the productivity of similarly experienced programmers [1].

According to [1], if a company is able to identify the most productive programmers and eliminate or further train the least productive, the resulting productivity increases would be a competitive advantage.

With software development viewed more as an art than a science, it has been difficult to study the productivity factors, which affect software projects, and to accurately predict software development costs. The lack of understanding of software productivity and productivity measurement methods has caused confusion in software cost estimation. In order to improve the quality of a software product, and the productivity of the development process, accurate measurements of development costs and productivity factors are required [2].

In the software industry, productivity and quality are primordial and must be considered simultaneously because the fact that a professional is able to perform his/her task fast, but without quality, does not mean that he/she is productive. The most important, for the issue of productivity, is to perform a task with quality in the shortest time possible.

For a matter of competitiveness, companies need to increasingly improve the productivity of their development teams and, for that, acknowledge the factors that influence such productivity. However, it is observed that companies usually do not know these factors and, furthermore, cannot measure the influence of such factors.

According to [3], basically there are three major stages in the process of software productivity improvement: measuring, analyzing, and improving software productivity.

There are several articles that aim to identify the factors that have influence on the productivity of developers, but no article was found that lists a ranking of these factors. Our work aims to identify the factors that influence the productivity of developers and to define a ranking.

This article is organized as follows: The second section presents studies about productivity in the software industry. The third section presents the survey performed. In the fourth section, we present the result obtained from applying the questionnaires. The fifth section presents a comparison of the result of our survey with existing works. Finally, we finish by presenting the conclusion.

## II. RELATED WORKS ON PRODUCTIVITY IN THE SOFTWARE INDUSTRY

### A. Systematic Review

Since a systematic review aims to reach a higher level of scientific rigor, we have decided not to do a conventional literature review, but to do a systematic review [4]. Unlike conventional literature reviews, in which the researcher does not follow a defined process, a systematic review is done in a formal manner, following a pre-defined protocol. This way, the result tends to be more reliable since it uses a methodology that is rigorous and capable of being audited and repeated.

According to [4], a systematic literature review is defined as a way to identify, evaluate and interpret the available research that is relevant to an issue or discipline, or phenomenon of interest of a specific research domain.

The activities of a systematic review should include: formulate a research question; identify the need to conduct a systematic review; exhaustive and thorough search, including primary studies; evaluate the quality of the selected studies; extract data; summarize the results of the study; interpret the results to determine its applicability; and write the report [5].

This systematic review aims to identify relevant publications that comment on factors that influence the productivity of developers. The search for articles was done in the ACM (Association for Computing Machinery) and the IEEE (Institute of Electrical and Electronics Engineers) digital libraries, using the term “software productivity” and “factors”.

We have not limited the date to search on the libraries and the articles have been selected from inclusion and exclusion criteria.

We have excluded articles that do not present factors that influence the productivity and included articles that presented factors that influence the productivity.

In the first search, we have found 28 articles in the IEEE digital library and 5 articles in the ACM digital library. From these articles, we have selected 10 articles from IEEE and one article from ACM. Therefore, a total of 33 articles were analyzed, but only 11 articles were selected for this review.

There are several factors that influence the productivity of developers; however, each author lists distinct factors. Therefore, aiming to include the factors in a questionnaire, it was necessary to unify some of them, since it is one of the goals of this work to define a ranking of the factors.

### B. Main Identified Factors

In the researched studies, we have identified several factors that influence the productivity in the software development because according to [6], productivity is impacted by a great number of factors.

In this systematic review, the most frequently mentioned factors were: experience of the team, programming language used, code reuse, size of the project and consistent requirements.

In the next section, we will detail the factors used in our survey.

Peck and Callahan [1] affirm that the difference in the productivity in certain situations is higher, with a ratio of 28:1 from the most productive to the least productive. Even though this is an extreme scenario, many studies show a ratio of 10:1. Besides, other researchers have also showed that the most productive programmers also produce the best code.

## III. SURVEY

The survey of the factors that influence the productivity of software developers was composed of several steps.

In the first survey step, for the systematic review, we have selected articles that are relevant to the topic of productivity in software development, and from these articles, we have listed the previously mentioned factors and grouped the ones with the same meaning, resulting in 32 factors, as presented in Table 1.

TABLE 1  
FINAL LIST OF FACTORS

Factor	Description
Agile Methodology	Adoption of a methodology that uses agile processes and/or practices (XP, SCRUM).
Architecture	A software architecture that is clear and adequate.
Benefits	The company offers additional benefits, such as health insurance, food stamps and participation in profits.
Code Reuse	Existence of a code library for reuse and policies for code reuse.
Commitment	Professional is devoted and committed with his/her work.
Communication	Appropriate communication in projects, frequent meetings to review the status, etc.
Consistent Requirements	The requirements given by the analyst are clear, complete and stable.

Factor	Description
Development Tool	Use adequate tools for software development. Example: Visual Studio, Eclipse, etc.
Documentation	Updated documentation for all phases of the software development lifecycle.
Domain of the Application	Knowledge on the domain of the application that is being developed. Example: Medical Systems.
Experience	Knowledge and experience on processes, methodology, technology and tools used in the work.
Home Office	Work in the "home-office" format.
Internet Access	Free access to the Internet, including chats, YouTube, social networks, etc.
Interpersonal Relationship	Have a good relationship with colleagues and customers.
Knowledge Management	Have an environment and policies for knowledge management.
Maturity Level	The company has a specific level of process maturity (e.g. MPSBR, ISO or CMMI).
Methodology	The company has a formal software development methodology.
Modernity	Always use the new technologies available in the market.
Motivation	Be motivated with the work.
Physical Location	Easy access to the workspace (e.g. no traffic, availability of public transportation).
Programming Language	Programming language is part of the latest generation.
Project Management	Have an adequate project management.
Project Size	The size of the project (effort) is very high.
Prototyping	Project has used software prototyping
Salary	Have a salary according to the market.
Team Size	The project has a large number of people in the team (more than 20).
Technological Gap	Use of obsolete tools / software versions. Example: Fortran.
Test	The project has policies for tests (the test is done before the code is sent to the customer).
Training	Adequate training prior to performing specific activities.
Type of Project	The project is for development or maintenance.
Work Environment	A pleasant work environment, with a nice, silent and comfortable space.
Workstation	Use of an appropriate workstation (physical infrastructure) to perform activities.

After selecting the factors, a questionnaire was created for developers to assess the type and level of influence that each factor has in the productivity during software development. The questionnaire was administered as a pilot-study with five developers and one university professor, who could give their

opinions and criticisms, aiming to assemble the final version of the questionnaire.

After the application in the pilot-study, the necessary adjustments were made and the final questionnaire to be applied was created, containing three sections: contextualization of the company, profile of the respondent and evaluation of the factors.

The section for the contextualization of the company collected data related to the companies, such as: sector in which the company is active (public or private), quantity of employees, for how long it has been in operation and if it applies evaluation methods (e.g. CMMI [7], MPS.BR [8] or ISO 9001[9]).

The section for the profile of the respondent identified some characteristics of the respondents, such as: time of experience in this job, if they have any certification (PMI, Microsoft, IBM, Sun or others) and the level of education.

These two sections were useful to group the collected data, to identify patterns related to the level of maturity of the companies and of the respondents and to identify whether this data influences the way they see the productivity in software development.

For the section about the evaluation of the factors, each factor was explained with a brief description to facilitate understanding. Each factor was classified according to the following options: High positive influence (HPI), Low positive influence (LPI), No influence (NI), Low negative influence (LNI), High negative influence (HNI) and No comment (NC).

At the end of the questionnaire, we requested the respondents to list five factors that have more positive influence on the productivity in software development and the factors that influenced these five factors the most.

We have applied the questionnaire in 11 (eleven) companies in Ceará, a state in the Northeast of Brazil. The sample size was 77 (seventy seven) respondents.

#### IV. RESULTS

In this section, we will present the results obtained from the data analysis of the questionnaires. Since we have used different scales to measure the influence of productivity (HPI, LPI, NI, LNI, HNI, NC), for this study, in which we aim to identify the factors that have a greater influence on the productivity of developers, it is relevant only to present the results that have High positive influence (HPI), No influence (NI) and High negative influence (HNI), excluding the results from

Low positive influence (LPI) and Low negative influence (LNI).

The factors Home Office, Knowledge Management and Agile Methodology were the ones that had the highest response rates of NO. We concluded that the respondents, possibly, do not have experience in working in the home-office format and in using knowledge management and agile methodologies.

##### A. Profile of Surveyed Companies

The questionnaire was applied in 11 (eleven) companies, being 1 (one) public and 10 (ten) private companies.

The greatest part of the companies (72,73%) has more than 9 (nine) years of existence and only one company has less than 3 years of existence, which we concluded that the surveyed companies have a certain level of maturity. From the surveyed companies, only 27,27% was evaluated by CMMI [7] or MPS.BR [8], and 36,36% have ISO 9001 certificate [9], therefore most of the surveyed companies do not have a formal process that is well defined and evaluated.

##### B. Profile of Surveyed Professionals

Only 6,49% of the respondents has more than 9 (nine) years of experience and 11,69% of the respondents has up to 6 years of experience in the job. It is apparent then, that in the profile of developers, there are many people who do not have much experience.

From the surveyed professionals, 38,96% has an official certificate of a manufacturer and 54,55% has not yet finished college. Therefore, besides not having experience in the job, most of the developers are still attending the university.

##### C. Factors that have High Positive Influence (HPI)

According to our survey, as depicted in Table 2, the factors that have highest positive influence on productivity are: Commitment and Motivation. We understand that this result is related with the fact that these factors are the basis for any professional who wants to productively perform their activities.

For the developers, the fact that requirements are consistent increases the productivity because not understanding requirements leads to doubts and, consequently, reduces productivity.

TABLE 2  
FACTORS THAT HAVE HIGH POSITIVE INFLUENCE (HPI) ON PRODUCTIVITY

POSITION	FACTOR	QTY	%
1	Commitment	67	87,0%
2	Motivation	67	87,0%
3	Consistent requirements	65	84,4%
4	Work Environment	64	83,1%
5	Salary	63	81,8%
6	Workstation	61	79,2%
7	Development Tool	60	77,9%
8	Project Management	58	75,3%
9	Experience	56	72,7%
10	Interpersonal Relationship	56	72,7%

The work environment and a good workstation have also been considered as important. Simple actions, such as replacing the equipment of the developer or adding extra memory and maybe even changing to a more comfortable chair can positively influence the productivity.

Development tools have also been considered as important and, indeed, tools that facilitate editing the code, debugging and other aspects, provide better productivity.

The salary is also among the ones with highest influence on productivity. Developers are the lowest paid professionals involved in the project, therefore, they end up having financial problems that influence the productivity.

Interpersonal relationship has also been considered as an important factor, mainly because, in software projects, there is a great need to interact with the team members of a project.

Considered by most of the articles as a very important factor, the Experience factor was 15% below the factor that was considered the most important. Possibly, the majority of the respondents consider that they have a level of experience appropriate to perform their activities and do not consider that they would produce more if they were more experienced.

Project management, which is a key success factor for any software project, was also considered as important by the respondents.

#### D. Factors with No Influence on Productivity (NI)

For factors that do not influence the productivity (Table 3), the main factor is the “Home Office” factor, possibly the majority of the respondents is not used to work in this format, therefore, they believe that this factor has no influence on productivity.

TABLE 3  
FACTORS THAT HAVE NO INFLUENCE ON PRODUCTIVITY (NI)

POSITION	FACTOR	QTY	%
1	Home Office	12	15,6%
2	Knowledge Management	12	15,6%
3	Agile Methodology	10	13,0%
4	Type of Project	7	9,1%
5	Architecture	5	6,5%
6	Maturity Level	5	6,5%
7	Team Size	5	6,5%
8	Project Size	5	6,5%
9	Prototyping	5	6,5%
10	Technological Gap	4	5,2%

The knowledge management, the type of project (development or maintenance) and the project size (when the effort is very high) were evaluated as not having influence on productivity. This makes sense since the survey was conducted directly with developers, who, possibly, receive an artifact to be developed and it makes no difference if the artifact is for development or maintenance. Usually, they also not use knowledge management tool and it does not make any difference whether the team is large or not because each developer will perform the activities assigned to him/her.

The “Agile Methodology” factor was considered to have no influence, which is justifiable because most respondents do not work with agile methods. The fact that maturity level was also considered with no influence may have been for the same reason.

#### E. Factors that have High Negative Influence (HNI) on Productivity

According to Table 4, the Technological Gap (Use of obsolete tools / software versions. Example: Fortran) was

considered to have the Highest Negative Influence on Productivity. Because of that, it is important for the development team to work with recent technologies (not obsolete).

TABLE 4  
FACTORS THAT HAVE HIGH NEGATIVE INFLUENCE (HNI) ON PRODUCTIVITY

POSITION	FACTOR	QTY	%
1	Technological Gap	46	59,7%
2	Methodology	38	49,4%
3	Home Office	11	14,3%
4	Team Size	10	13,0%
5	Internet Access	6	7,8%
6	Project Size	3	3,9%
7	Maturity Level	2	2,6%
8	Modernity	1	1,3%
9	Documentation	1	1,3%
10	Workstation	1	1,3%

The fact that the company does not have a formal software development methodology (“Methodology” factor) was also considered as a high negative influence on productivity. We have, therefore, considered as highly important for companies to have a formal software development methodology.

Some of the respondents considered negative the fact of working at home, which is a tendency in some corporations. We believe that this result is related to the greater difficulty to interact with the other participants of the project.

The fact that the team is large (“Team Size” factor) has also been considered as a negative influence on productivity. This makes perfect sense especially because in a project with a large team, the management effort is much higher and it becomes necessary to interact with more people.

Even though it has been mentioned as a factor that has no influence on productivity (NI), Internet Access has also been considered negative, since some people disperse with free Internet access, they browse for long hours and, consequently, their productivity decreases.

The other factors did not have great quantitative relevance and, therefore, they will not be mentioned.

#### F. Most Important Factors and What Influences Them

At the end of the survey, we asked what were the 5 (five) most important factors from the list of High Positive Influence. We have also asked which factors influenced these items. The result is depicted in Table 5.

The factors considered as most important were: Motivation, Salary, Work environment, Commitment and Experience.

Among the factors that were considered as MORE IMPORTANT (Table 5) and the factors that were selected as HIGH POSITIVE INFLUENCE ON PRODUCTIVITY (Table 2), we have concluded that, from 10 (ten) factors most voted as HPI, 9 (nine) were considered as the most important ones and there are only changes in order of position from Table 2 and Table 5.

TABLE 5  
FACTORS WITH HIGHEST DEGREE OF IMPORTANCE AMONG THE FACTORS WITH HIGH POSITIVE INFLUENCE

POS.	FACTOR	QTY.	INFLUENCE 1	INFLUENCE 2	INFLUENCE 3
1	Motivation	47	Salary	Work Environment	Benefits
2	Salary	37	Benefits	Experience	Commitment
3	Work Environment	32	Workstation	Interpersonal Relationship	Physical Location
4	Commitment	25	Motivation	Work Environment	Salary
5	Experience	25	Training	Commitment	Motivation
6	Interpersonal Relationship	18	Communication	Team Size	Work Environment
7	Consistent Requirements	18	Documentation	Communication	Domain of the Application
8	Project Management	17	Experience	Methodology	Communication
9	Workstation	15	Work Environment	Development Tool	Architecture
10	Domain of the Application	14	Training	Experience	Communication

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Among the factors that were considered as MORE IMPORTANT (Table 5) and the factors that were selected as HIGH POSITIVE INFLUENCE ON PRODUCTIVITY (Table 2), we have concluded that, from 10 (ten) factors most voted as HPI, 7 (seven) were considered as the most important ones.

#### V. COMPARISON OF THE SURVEY WITH THE LITERATURE

In Table 6, we compare our ranking with the most important factors that were indicated in the literature.

The “Experience” and “Consistent Requirements” factors were the only ones that were considered as very important in both studies.

In the literature, it is also presented as important factors the following: Programming Language, Code Reuse and Project Size. In our survey, these factors appear in the last positions.

According to [6], the “Project Size” factor is the most basic factor in the analysis of productivity. There is a tendency to increase the productivity as the project size increases. In the survey, this factor was not considered as important since, for developers, the productivity of developers is the same whether the project is large or small.

According to [10], the “Communication” factor has a great influence on productivity. In large projects, many of the problems, if not most of them, are the result of the lack of communication. In the survey, communication is also considered important (14<sup>th</sup> position).

Enthusiasm can be contagious and people tend to produce more in an optimistic environment than in an environment that is “negative towards work” [11]. The “Work Environment”

factor proves this, besides having influence on the motivation of the developer.

Reuse of previously tested code improves productivity and, consequently, decreases the development time because it reduces the need to create new code [12]. Code reuse was not considered important in our survey, possibly because the interviewed developers do not practice reuse in their companies.

TABLE 6  
COMPARISON OF THE SURVEY AND THE LITERATURE

POS.	MOST IMPORTANT FACTOR	QTY.	FACTORS FROM THE LITERATURE
1	Motivation	47	Experience
2	Salary	37	Programming Language
3	Work Environment	32	Consistent Requirements
4	Commitment	25	Code Reuse
5	Experience	25	Project Size
6	Interpersonal Relationship	18	
7	Consistent Requirements	18	
8	Project Management	17	
9	Workstation	15	
10	Domain of Application	14	
24	Programming Language	3	
26	Code Reuse	3	
32	Project Size	0	

The time spent learning what the customer wants or needs at the beginning of the project should reduce the frequency of future changes in the specification [12]. Indeed, the “Consistent Requirements” factor is very important for the productivity of developers since re-work is discouraging for any professional.

Finally, contracting the best people and supporting them with training increases productivity and speed [12]. There is no doubt that the “Experience” factor is primordial to increase productivity.

## VI. CONCLUSION AND FUTURE WORKS

Several factors influence the productivity of software developers. For a company to become more competitive, it is necessary to measure, analyze and improve the main factors that influence the productivity of developers.

For instance, in a company where it is identified that a workstation has a high influence on the productivity of the developer, the investment in new workstations (low cost in comparison to the developer salary) could bring a high gain in productivity for the company.

We have had some divergences between the survey and the literature. This is due to the fact that the survey is subjective and expresses the opinion of developers, while some articles in the literature make a real measurement of projects and come to more objective conclusions. However, in this work, it is extremely relevant to understand the factors that influence the productivity of developers from their own opinion.

According to the item *C.Factors that have High Positive Influence (HPI)*, the “Motivation” and “Commitment” factors are the basis for any professional to productively perform their activities. Since they are in the literature, these factors were included in our survey, however for future surveys in other regions, it would be important not to consider them since they will always be mentioned as HPI.

We consider important for future works to perform a survey in other regions in Brazil because we understand that some factors can be relevant in one region and not so relevant in another one.

After identifying the factors that have highest influence on the productivity, we will also seek to define a model capable of measuring each factor individually (developer) and organizationally. This model could be used as a basis for developer productivity improvement programs in companies.

Another future work is to perform a bibliographical study to identify what can be done to minimize the effect of factors that have HPI on the developer. For instance: how to improve communication in projects? What must be done to improve the developer work environment?

Last, but not least, since software development is done by people and it is considered more an “art” than a “science”, it is

necessary to have continuous investment on what is more important so companies have more productivity and quality: the People.

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