

## Software quality model based on development team characteristics

Hamidreza Asfa<sup>1</sup>, Taghi Javdani Gandomani<sup>2</sup>

<sup>1</sup>Department of Software Engineering, Isfahan Branch, Islamic Azad University, Isfahan, Iran

<sup>2</sup>Department of Computer Science, Shahrekord University, Shahrekord, Iran

### Article Info

#### Article history:

Received Dec 12, 2021

Revised Jul 21, 2022

Accepted Aug 19, 2022

#### Keywords:

Characteristics of the software development team

Quality of teamwork

Software product

Software quality model

### ABSTRACT

Many factors have a significant impact on producing high-quality software products. Development team members are among the most important factors. Paying attention to the quality from this perspective will be a good innovation in the software development industry. Given that team members play a very important role in software products, this study tries to focus specifically on team characteristics in software product quality and provide a qualitative model based on this. The required data were collected through observations and interviews with project managers and development team members in several companies under study. Then, data were analyzed through hierarchical analysis. According to the results, the use of this model led to the improvement of the software development process so that the team members were satisfied with it. Also, time management was improved, and the customer expressed his satisfaction with the use of this model. Finally, data analysis showed that this model may lead to faster product delivery.

*This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.*



### Corresponding Author:

Taghi Javdani Gandomani

Department of Computer Science, Shahrekord University

Shahrekord, Iran

Email: javdani@sku.ac.ir

## 1. INTRODUCTION

Nowadays, the market for software development is growing, and software development companies are always trying to attract their customers in a competitive condition. This would be possible by providing up-to-date, simple, efficient, and convenient products. In the meantime, various standards and models have been developed to produce software that has good quality and performance [1], [2].

In addition to qualitative standards, the software development team must provide its best performance to produce a better-quality product. Therefore, the concept of quality, value, and its place in software engineering is very important. In addition to meeting the customers' needs, high-quality software should produce a software product in such a way that the conditions and costs of its development are also cost-effective for software companies.

There are several definitions of quality, including compliance with specifications and requirements [3], [4], customer satisfaction [5], [6], reliable and durable products [7], and so on. But in the meantime, there is a complete definition of quality as expressed by IEEE, software quality can be defined as the degree to which a system, component, or process meets specified requirements and the degree to which a system, component, or process meets customer or user needs or expectations [8]–[11]. Software quality assurance (SQA) is one of the most important parts of software quality. According to IEEE, software quality assurance is a means and practice of monitoring the software engineering processes and methods used in a project to ensure the proper quality of the software and can be independent of the project [12], [13].

In fact, in order to achieve quality assurance, we first seek to ensure an acceptable level of trust and performance for the software product and relevant service; after that, we seek to ensure that the software development process meets the requirements of scheduling and budgeting by launching and managing activities [14]. The product has always attracted a lot of attention to date, and less attention has been paid to the role of software development teams in high-quality product development. This study aimed to investigate the individual conditions of team members in providing product quality and to provide a software quality model that shows a significant relationship between team characteristics and the quality of the final product.

The rest of the article is organized as follows. Related research and studies in the field of software quality are reviewed in section 2. The proposed qualitative model is presented in section 3. Evaluation criteria, data set, results analysis, and environmental evaluation using the proposed model will be discussed in section 4. The limitations and threats of the research will be presented in section 5. Finally, the conclusion is presented in section 6.

## 2. RELATED STUDIES

Many studies have been done in the field of software quality, each of which addressed different aspects. This section will review the research conducted in the field of software quality, and various models and standards that have been developed and expanded in this field. In 1967, McCall *et al.* [15] and Galin [16] introduced a model for the first time that examines product evaluation criteria and the relationship between quality factors. The purpose of this model, which has been used in large-scale military and spatial projects, is to close the gap between users and developers based on the system life cycle. This model expresses three perspectives for grouping features in the software development process.

- Operation viewpoint: This view is based on qualitative factors and indicates the extent to which the specifications and features of the software are met and includes features such as correctness, reliability, efficiency, integrity, and usability.
- Revision viewpoint: This view defines the qualitative factors affecting the ability to change the software product, which includes maintainability, flexibility, and testability.
- Transition viewpoint: This perspective includes qualitative factors affecting the ability to change the software product and includes reusability, interoperability, and portability.

Then, Boehm added several features to the McCall model, emphasizing the ability to maintain software. The model also added considerations to software evaluation based on the type of application and hardware-related features. They tried to define software quality as a hierarchical model of quality characteristics, and based on this model, the basic requirements for software are divided into three categories of utility, portability, and maintainability, each of which has its subset [17].

The functionality, usability, reliability, performance, supportability (FURPS) model is another model presented for classifying software features that include two different groups of software requirements called operational requirements and non-operational requirements [18]. After providing a high-level framework for describing the quality of software products by the ISO 9126 standard, which is known as the software product quality assessment standard, Dromey *et al.* [19] presented a model based on this standard in 5 steps. However, ISO experts revised the ISO 9126 standard in 2001 and presented a newer model, which has two levels.

At the first level, the model divides the quality of software products into six main features, each of which consists of one or more sub-features. In this model, there is a one-many relationship between the features of the first level and the second level, so there is the least overlap in this model [20]–[24]. These models mainly focus on the characteristics of the output product, but in the field of software quality assessment, studies have been conducted that focus on other criteria such as individual personality such as individual and team characteristics. Schneiderman believes that "personality variables play an important role in determining the interaction between programmers and individual work style" [25].

Some researchers have examined the role of personality in software teams [26]–[33]. In the meantime, Cruz *et al.* [34] reviewed more than 19,000 articles on individual personality and extracted nine different topics, including pair programming, team effectiveness, individual performance, software process allocation, behavior and preference, education, project manager effectiveness, personality test application, and job retention.

Pocius [35], points to the relationship between individual talent and personality traits, and programmer success. The author provides evidence that some personality factors, such as introversion, help improve programming performance. Of course, it has been concluded that the ratio of people with extraversion is completely dependent on the success and performance of the team. Teams with a moderate proportion of extroverts do a better job than teams with a small or large number of extroverts [36], [37].

Weinberg believes that "the personality and identity of the programmer are very important factors in his success due to the complex nature of programming" [38]. However, so far, no official evidence has been provided to show that there is a significant relationship between the personality type of talented individuals and the success of programming. Many researchers have tried to identify the relationship between personality and performance.

The majority of research has been carried out on individual performance to five personality dimensions, including anger, extraversion, openness to experience, adaptability, and conscientiousness [39]–[42]. Of course, other criteria have also been considered. For example, Barrick and Mount [43], examined the relationship between personality and individual performance concerning three criteria of job performance, including training proficiency, job proficiency, and personnel data. Soomro *et al.* [44], during a systematic study, examined the relationship between individual personality and the performance of software teams. These studies provided a better understanding of the concept of "The relationship between individual characteristics and the outcome of the team of which the individual is a member." He also concluded that it is useful to evaluate team personality according to the classification of personality types by evaluating the useful work environment of the team, and can be effective in the success or failure of the project [44].

It should be noted that team performance cannot be due to the combination of team personality and the task assigned to them but depends on the interactive effects of team behavior. McGrath's [45] model refers to a simple but effective method for teams, in which the variables tested are people, work, team processes, and team effectiveness [46], [47]. Some studies [48]–[52] have concluded that most software projects fail due to team problems and weaknesses. There is a vast experience that productivity in the software development process depends heavily on human and social factors [51]–[53].

### 3. PROPOSED QUALITY MODEL

This study seeks to evaluate variables such as skill level, history of collaboration, degree of team participation in group decision making, the impact of work experience, product quality, and reward received and examines their growth rate and impact before and after model implementation. These factors have been selected because they have the highest impact on the final product. After completing the questionnaire, the questions were given to the interviewees, and they answered them. The obtained answers were categorized with the help of some project managers and quality factors and were divided into four categories or dimensions, which mentioned include subsets as shown in Figure 1.

- Individual dimension: a set of factors that refer to individual factors.
- Cultural and ethnic dimension: it is a set of intellectual, ethnic, and cultural beliefs.
- Team dimension: the extent of the factors involved in forming a team.
- Organizational dimension: the degree of ability of an organization to form a team and the facilities that are provided to the team.

Each of the subsets is defined as:

#### 3.1. Individual factors

An important part of the quality model includes individual factors. These factors cover almost all various aspects of the human related factors. These factors are:

- Experience: the amount of experience a person has gained from activities in different situations.
- Education: the level of literacy of individuals in both academic and non-academic forms.
- Personality: the set of educational, intellectual, environmental, behavioral, and physical factors that are formed in a person as a personality.
- Adequacy-based individual sense: the degree to which people feel worthy of doing new things.
- Individual ability in terms of workflow: competence and ability of people to have a position in the project, such as being a project manager.
- Individual skill level: ability of people other than the current specialty, such as familiarity with graphic topics (for example, a person has programming expertise but also specializes in graphic topics according to his interest).

#### 3.2. Cultural and ethnic factors

The second part of the proposed quality model include cultural and ethnic factors. This dimension of the quality model is mainly important because it focuses team atmosphere. These factors include:

- Holding special festivals and traditions: ceremonies and friendly gatherings resulting from a special event or occasion such as holding Nowruz and Christmas celebrations and so on.
- Holding competitions and recreational and technical competitions: doing sports activities to create a friendly, happy, and exciting environment in the workplace.

- Culture of cooperation: refers to holding cultural ceremonies and rituals that are specific to a nation or culture, and others (other colleagues who are not familiar with those rituals and customs) can participate in it, such as holding Iftar ceremonies, special ceremonies of Hindu tribes.
- Intra-team trust: the feeling of closeness in people and trust in each other.

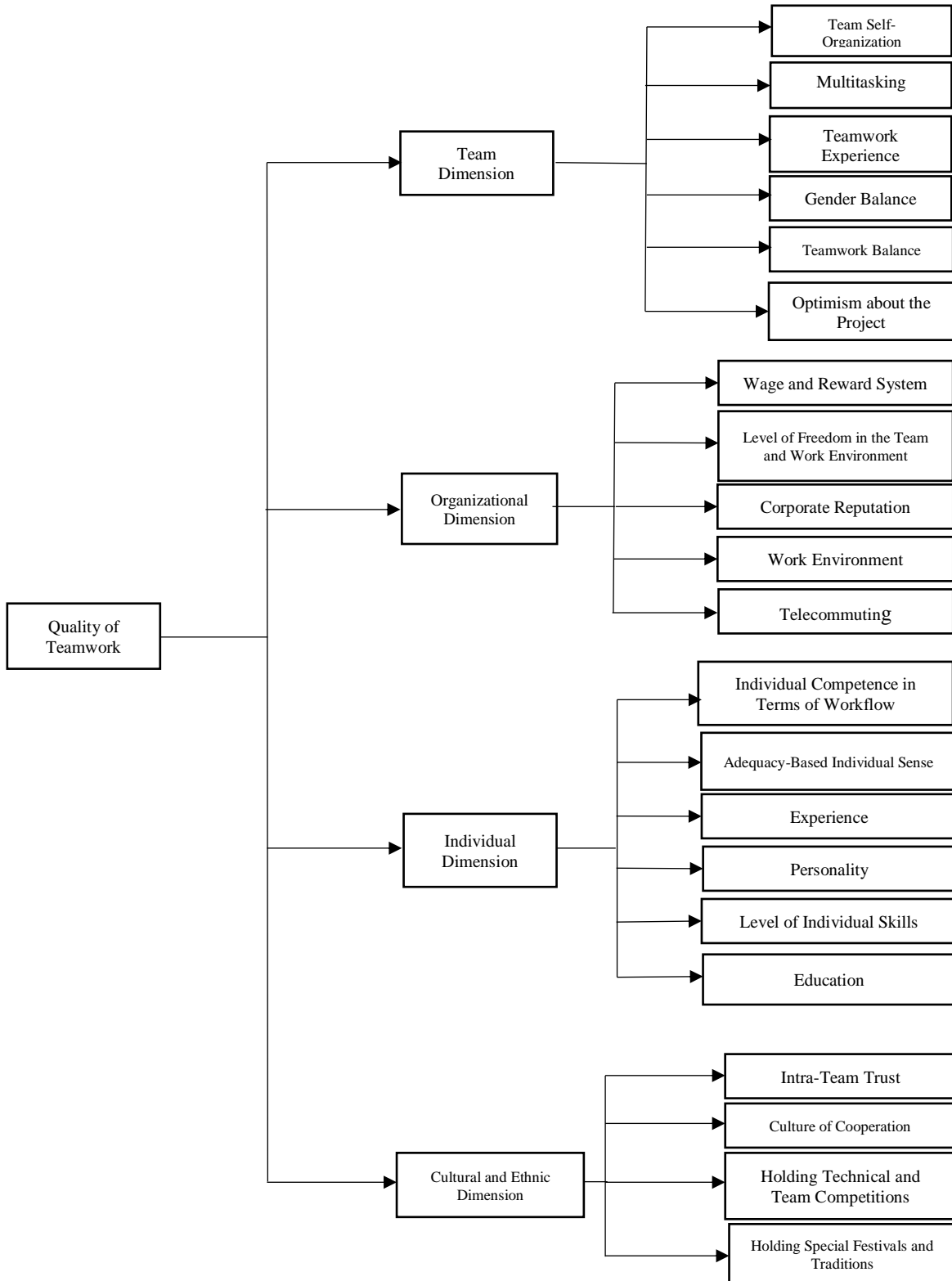


Figure 1. Different dimensions of teamwork quality

### 3.3. Team factors

Team factors include team-related factors that have a significant impact on the teamwork quality. These factors include:

- The amount of optimism to do the project: the number of people willing to do the project.
- Establishing gender balance: the gender ratio (male and female) in a project.
- Teamwork experience: the experience of individuals in a group in carrying out various projects.
- Teamwork balance: existence of work balance between different teams.
- Multitasking: each person on a team has to do several things.
- Team self-organization: the degree to which individuals are free to form a team and take on responsibilities.

### 3.4. Organizational factors

The last part of the quality model focuses on the organization factors. These factors mainly focus on the structure of software companies and their credibility and position in the market. This part includes the following factors.

- Work environment: physical workspace for team building and doing projects. (In terms of the type of decoration of the room or hall or work environment)
- Telecommuting: the freedom of individuals to carry out their responsibilities without being present at work.
- The degree of freedom of individuals in the team and work environment: freedom and authority of the individual to act without any restrictions, such as doing overtime arbitrarily.
- Corporate reputation: the background and experience of the company in carrying out projects, as well as the ability to provide the necessary facilities and tools for employees to carry out projects, such as providing the necessary and up-to-date hardware platform for heavy computing.
- Reward system: the financial ability of the company to pay the salaries and benefits of its employees on time.

## 4. EVALUATION AND ANALYSIS OF RESEARCH RESULTS

### 4.1. Evaluation criteria

In this study, a questionnaire was designed to collect the required data. The questions were then shown to several software experts, including project managers, and were finally approved after some modifications. In the reliability section, Cronbach's alpha test was used to validate and evaluate the collected data; the result of this test was higher than 0.7 in all the cases.

### 4.2. Data collection

This study has been conducted in collaboration with four companies. In this study, interviews were conducted with two companies and consulted with the experts in this field, and cooperation was conducted with two companies by sending a questionnaire and conducting interviews. Questions are asked about the role of individuals and teams in the quality of the final product. The collected questions are obtained by studying previous articles in this field.

Of course, these questions became more complete later during conducting the interviews, as the interviewees themselves helped a lot in completing the type of questions based on their work experience and their answers. The reason for choosing these companies is their field of activity and work. First, interviews were conducted with participants, and then questionnaires were distributed among participants to answer. The research, both in the form of questions and answers and in the form of questionnaires, focused more on the role of individuals in the production and promotion of the final product and how the behavior of individuals in a team affects the final product and even this impact on customer behavior. Reflected and appears in the form of satisfaction or dissatisfaction.

### 4.3. Results

In this study, the required data were collected through the study and review of working documents, field observations, and interviews with project managers and programmers of several studied organizations, and the data were analyzed through hierarchical analysis. Factors affecting the software quality model proposed in this research, along with the weight of each, are presented in this section. An analysis of the responses received from the interviewees is also provided on each of the factors.

### 4.4. Individual factors

Individual dimension includes six factors experience, education, personality, adequacy-based individual sense, individual competence in terms of workflow, and individual skill level. Table 1 shows the

priority of each of the factors. In this group, the highest weight is assigned to the individual competence factor. What is important in Figure 2 is the degree of closeness of the indicators of experience, adequacy-based individual sense, and individual competence. Individual competence refers to the individual's ability to manage and control the process of execution of work or project, which is achieved by cultivating individual skills, experience, and risk-taking in work (of course with proper knowledge and understanding and measuring all factors and shortcomings), being responsible, research and consulting.

Table 1. The priority of the individual dimension factors

Individual dimension factors	The number of factors
Individual competence in terms of workflow	0.244
Adequacy-based individual sense	0.231
Experience	0.207
Personality	0.153
The level of individual skills	0.103
Education	0.62

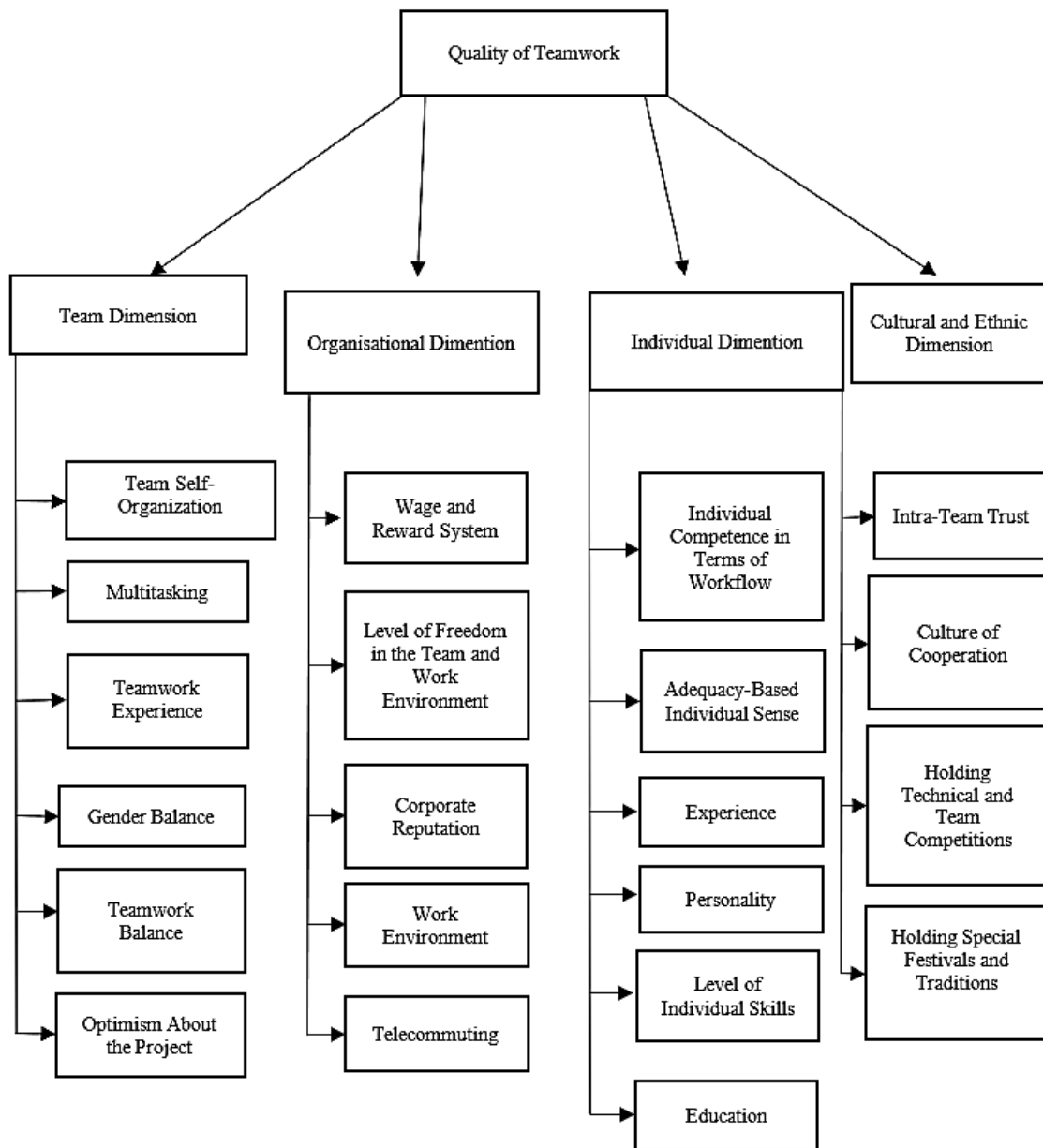


Figure 2. Overview of the model and its factors

It is very important for a person to have a full understanding of that project in different projects and not to consider all the works and activities from one perspective. This factor can even be the driving force in the team since team members for any reason are discouraged or worried about the work process or may have doubts; this factor can be an obstacle for such issues and avoid wasting time, money, motivation, and so on. All factors of the individual dimension are interdependent and complementary in some way, and one cannot be preferred over the other. For example, experience, education, and personality are interdependent, like links in a chain, and growth and sublimity in each provide the suitable context for the progress of other factors. One of the interviewees, who is a manager of several projects, believes that self-confidence is one of the main pillars of this factor.

Adequacy-based individual sense is also one of the important factors in the formation of team personality of individuals. A person who has worked with different teams on several projects tends to have the self-confidence to work in new fields as well. Experience in the team is very important. In an interview with experts, one of the project managers emphasized that the experience of experienced managers is very useful in cases where the project lags behind in terms of schedule, and these experiences have been used for new projects.

Personality, level of individual skills, and education are each valuable and important in turn. One of the project managers made an interesting point; he valued people who had just graduated. According to him, these people are dormant forces who can become worthy managers in the future if they are treated properly. Because they have just graduated from university, they are not familiar enough with the job market, so they enter the job market with an academic perspective.

#### 4.5. Factors of the cultural and ethnic dimension

Factors of cultural and ethnic dimension include holding special festivals and traditions, holding recreational and technical competitions, and the culture of cooperation and trust within the team. Table 2 shows the priority of each of the factors. As shown in the figure, team trust has a higher priority than other factors. One interviewee believes that team trust can be like a family relationship at work, where team members feel close to each other and feel part of it. According to him, sometimes this intimacy becomes so strong and close that if one of the team members arrives late for some reason, the other team members wait for him to come, and everyone starts working together.

Table 2. The priority of cultural and ethnic dimension factors

Cultural and ethnic factors	The number of factors
Intra-team trust	0.375
A culture of cooperation	0.319
Holding recreational and technical competitions	0.202
Holding special festivals and traditions	0.104

Intra-team trust also includes a common sense of work among team members so that the competitive behavior that may exist between individuals becomes a constructive interaction and relationship, and everyone does their job independently and has peace of mind. Furthermore, a sense of intra-team trust can be the driving force in dealing with obstacles that the team encounters because team members can solve problems in consultation and with the help of their abilities and overcome obstacles.

The culture of cooperation is the second factor in this dimension, which is very evident in large companies where several teams work on a project. Because there are people of different nationalities in these teams, each of them undoubtedly has their own cultural and religious beliefs, which they follow in specific situations and times. For example, during the holy month of Ramadan, a group of Muslims entertains their colleagues by holding Iftar ceremonies and introducing them to this Islamic culture.

Another thing that is done is that the members of a team suddenly and surprisingly hold a birthday party or a wedding anniversary party for each other, and the person is completely shocked, surprised, and surprised, and these simple behaviors enhance intimacy and friendship among team members. Holding recreational and technical competitions, holding special celebrations and ceremonies is another factor of the cultural dimension, which is performed in large companies for a special occasion, and people are eager to participate in it.

#### 4.6. Team factors

This dimension includes the factors of optimism about the project, gender balance, teamwork experience, team balance, multi-tasking, and team self-organization. Table 3 shows the priority of each of the factors. The highest weight of this group belongs to the team self-organization factor. In explaining this

factor, it should be noted that when intimacy prevails between people, the people themselves form the team based on their skills and expertise and do and present the work in the best way. Individuals can even share responsibilities within the team by their choice, such as selecting one person as project manager, because the selection of the person is based on the votes and opinions of individuals and not on the appointment of a senior manager.

**Table 3. The priority of team dimension factors**

The name of the team dimension factor	The number of factors
Team self-organization	0.306
Multi-tasking	0.238
Teamwork experience	0.189
Establishing gender balance	0.114
Balance of teamwork	0.80
The level of optimism to do the project	0.71

Regarding the multi-tasking of people, it can be said that a person in the team may do several things during the project at will. Unfortunately, this has become an unwelcome compulsion for individuals in two domestic companies. In a way, during the project process, a person sometimes has to do things that may not be in his field of work at all, and this is not pleasant for the person for several projects. Teamwork experience can be examined from two perspectives.

The first view is based on the view of team members, which means that people tend to work with their teammates and achieve new success for the team. The second view is based on the opinion of managers. Managers usually choose a team or teams with a brilliant and successful work experience in projects to show the customer that the result is important to them. The issue of gender balance is interesting because some people were not very satisfied with the gender ratio of people based on their reasons and preferred that the team is not gendered homogeneous.

This gender balance was important to some of the team members who have a marital relationship. The level of optimism of the team members about the project depends on the success of the team in previous projects as well as the ability of the company and the organization. When a company or organization enters the negotiation phase with the employer, based on its capabilities and its forces, team members must be aware of the agreements made with the employer so that the process of work is clear to team members from the beginning. Teamwork balance refers to the fact that the teams involved in a project are responsible for each part of the project according to the ability of the team and its members; and one team has to do several things in parallel, and the other team is only working on the part of the project.

#### **4.7. Organizational factors**

This dimension has five factors, including work environment, telecommuting, the degree of freedom of people in the team and work environment, corporate reputation, and reward system. Table 4 shows the priority of each of the factors. The appropriate wage and reward system has earned the highest score in this group. The wage and reward system are considered as one of the components of motivation and energizing employees and gaining an appropriate reputation for themselves in the labor market. Because timely payment to employees assures them of the financial dimension, they will no longer have to worry about late payment of their salaries and benefits.

Failure to pay salaries on time will delay the project and lead to feeling lack of motivation in employees and cause intra-organizational stress. The second important factor in this dimension is the degree of freedom of individuals in the team and organization or company. Happiness in teamwork is more observed in teams where people have freedom of action. This freedom of action can be in any form, as long as it is within the rules and authority of the company, such as the freedom to work overtime. Telecommuting is considered one of the company's options for supporting the activities of its employees. According to one of the project managers, this strategy is useful for both the organization and the individual. According to him, telecommuting is an effective work potential for the individual and the organization. The work environment is also one of the factors affecting the work execution process and employees. According to one of the interviewees, the team members sometimes get bored and tired early due to the prolongation of some steps of the project, which after many evaluations concluded that the change of workplace and change in the decoration of the room has a significant effect on the mood of the people and the staff has done their job with more motivation and seriousness. The company's reputation is another factor affecting the organization. Several of the interviewees of these companies believed that although the company or organization has not yet acquired the necessary qualifications, but only for economic gain, it participates in some auctions and



withdraws so after a period of time when the inability of the company or organization is identified and leaves a part-time output for the employer. Of course, in the meantime, the work pressure on the team members is also debatable.

Table 4. The priority of organizational factors

The name of organizational dimension factors	The number of factors
Wage and reward system	0.340
The degree of freedom of individuals in the team and work environment	0.272
Corporate reputation	0.153
Workplace	0.141
Telecommuting	0.94

#### 4.8. Comparison of qualitative factor category

After comparing the factors of each dimension, this section provides a general comparison of the categories. Table 5 shows the priority of each category. As shown in Figure 2, the team dimension has the highest priority in this area. Given that people are working in teams, they usually consider themselves part of the team and believe that achievements and results belong to the whole team. Another reason that the team approach has a higher priority is that team members can compensate for problems and shortcomings by thinking together and cooperating with even the most experienced, and they can support new and inexperienced people. People need to work in a company or organization that has extensive experience and support for executive work.

Table 5. Comparison of qualitative factor categories

Qualitative factor name	The amount of qualitative factor
Individual dimension	0.178
The cultural and ethnic dimension	0.118
Team dimension	0.414
Organizational dimension	0.250

As shown in Figure 2, the team dimension has the highest priority in this area; given that people are working in teams, they usually consider themselves part of the team and believe that achievements and results belong to the whole team. Another reason that the team approach has a higher priority is that team members can compensate for problems and shortcomings by thinking together and cooperating with even the most experienced, and they can support new and inexperienced people. People need to work in a company or organization that has extensive experience and support for executive work.

Of course, it is not easy to get into these companies, and they are also looking for people with successful and experienced careers. Large and reputable companies are also constantly updating their teams to provide decent work. In the individual dimension, in addition to having experience, a person can update his information and awareness by studying and passing training courses and improve his position in the team or company. In the cultural dimension, different people are working in an organization, each living with their ideas. The fact that the work environment is such that people adhere to their cultural ceremonies and customs while working can lead to a better interactive communication environment in addition to familiarity with the cultures of colleagues' nations and tribes. Figure 2 shows the general view of the model along its factors. Table 6 shows the extraction of project key information based on team characteristics factors.

#### 4.9. Empirical evaluation

A workable model was obtained after analyzing the responses, which was implemented for three months in a software company that was doing a major project for a government agency. It was very important for the employer that the contractor had to carry out the project in the employer's organization and under his supervision because of the sensitivity and importance of the work, and this made the contractor completely subordinate to the issues and conditions of the employer's work environment. Parts of the project were done daily according to the prioritization of each part, and the parts that had less priority were done in free time. The proposed model was implemented in the lower priority sectors, which resulted in the optimal use of time, increased speed in doing work, better and more accurate planning, and increasing the importance of the prioritization of activities, reducing work stress, and increasing individual and team self-confidence, timely or early delivery of part of the project that should have been done and ultimately, the satisfaction of the employer.

Table 6. Key information extraction

	Measurable criteria	Expected options for response	The time period for the question raised	How to measure	Number of responsive people
Daily preparation	How long does it take for people to start taking responsibility?	1. About 15 minutes 2. About 30 minutes 3. About 45 minutes 4. About 1 hour 5. More than 1 hour	Weekly	Direct questions from people	10 people (Team members)
Unscheduled capability	How are extra and out-of-work tasks done?	1. Priority is given to daily tasks. 2. Priority is given to immediate out-of-turn tasks. 3. Priority is given to non-urgent out-of-turn tasks. 4. Priority is given to out-of-turn tasks and then daily works 5. There is no order.	Weekly	Asking people directly	10 people (Team members)
Optimism to do the project	1. How satisfied are the people with the assigned work? 2. How optimistic are people about the project?	1. Too much 2. A lot 3. Medium 4. Low 5. It does not matter	Weekly	Asking people directly	10 people (Team members)
Reward	How to pay the bonus is desirable?	1. Timely payment 2. After each phase of the project 3. During the project 4. Together and after the completion of the project 5. Payment time does not matter	Monthly	Asking people directly	10 people (Team members)
History of joint cooperation	If you were to work on similar projects, which one would you choose?	1. I do not want to cooperate with the current team. 2. I want to work with the current team. 3. It does not matter.	Monthly	Asking people directly	10 people (Team members)
Skill level	1. Do you want to improve your work skills?  2. If your colleague asks you to share your information and learning in your field of expertise, would you be willing to do that?	1. Yes, if the conditions and situation are suitable 2.No, I do not want to 3. Yes, if it is considered as overtime. 1. Yes, I want to. 2. No, I do not want to 3. Yes, If the training fee is paid.	Monthly	Asking people directly	10 people (Team members)
Product quality	Customer satisfaction level with the product	1. Very excellent 2. Excellent 3. Good 4. Medium 5. Bad	Monthly	According to the project manager and team members before and after the implementation of the model	10 people (Team members)

In addition to the above issues, people's activities in some cases had improved and become more intimate, including the level of skills that people had in different sectors. For example, people with more experience in multiple programming languages helped other team members solve a problem in the project that they were having trouble with. People were more satisfied with the team and their group, and team members tended to work together and make decisions in other activities as well (some even offered to work out of office hours and for projects that were not related to the company).

Also, team members focused on common ground in making decisions and pursuing work. Customer satisfaction with the work done was another thing that can be mentioned. During various meetings with the employer, the employer expressed his satisfaction with the progress of the project. Also, the use of new technologies in the project pleased the employer, which led to the payment of rewards earlier than scheduled for team members.

The obvious points that were revealed during the implementation can be mentioned in this section. What trivial issues and cases have delayed the project implementation process and delayed the implementation and delivery time in only one phase, maybe up to months. Some of the most important are: i) request to do non-project-related tasks by some sectors of the organization, ii) There are restrictions on the type of clothing, iii) intrusive inspections by the security department, iv) limitations on facilities and equipment used, such as low-speed internet, v) lack of cooperation in holding meetings by the employer for the first phase of the project for various reasons, vi) existence of intense organizational competition between the people of the employer organization and its impact on the project implementation process, vii) existence of lengthy and erosive paperwork processes for required permissions, and viii) doing something like holding a meeting with a unit again due to the employer's dissatisfaction.

And many other cases are only part of the reason for the increase in time required to complete a single phase of the project. According to a survey of the project manager and others who participated in this study, the use of the proposed model has facilitated the project implementation process, and some phases of the project have progressed earlier than scheduled, and others have been done on time. Some factors during the project implementation based on before and after the implementation of the model are listed in Table 7. A few points can be explained about Table 7:

- In the column "Model effectiveness", the results are intuitively collected, and the result is a comparison of the team's performance in previous projects with the current project.
- In the column "Status before the implementation of the model", data is collected based on the recorded history of projects and statements of the project manager, and in the column "Status after the implementation of the model", data is collected according to the statements of the project manager, the software product owner, and the project scrum master.
- In the raw "Product quality", the announced titles are also expressed based on the comparison of old projects with the current project and the criteria of measurement, customer satisfaction, speed in project delivery, and product support.

Table 7. The progress of the project based on the teamwork quality model

Variable name	Status before the implementation of the model	Status after the implementation of the model	Model effectiveness
Team self-organization	Medium	High	Improvement in team self-organization
Multi-tasking of the team	Irregular and without priority	Prioritized and regular	Fix irregularities
Optimism to do the project	It did not matter much	It is important	Good
Reward	Timely payment	Early payment	Good
History of joint cooperation	Each person may have individual experience in several projects from different places	People's interest in being in a joint team and continuing to work together on other projects	Good
Skill level	It is limited to the training and experiences that the person has learned personally	Sharing the lessons learned and experiences of people together during the project and raising the knowledge and awareness of team members	Increase skills
Product quality	Good	Better	Increased quality

## 5. LIMITATION

The collected data, which are the basis of this research, were obtained from the statistical community that participates in this research voluntarily. Therefore, the results included the mentioned limitation. This study can be used in larger projects to find better results, and the current results do not confirm the completeness of the present study. Also, this study does not claim to offer a global solution but believes that the results are data-driven and avoid researcher bias.

## 6. CONCLUSION

The members of the development team are one of the influential factors in the software production process. There are different criteria for measuring teamwork quality. This study, by examining the characteristics of the team, was able to present a model based on human characteristics that can provide the best performance of the development team, which is a high-quality final product. Accordingly, a qualitative model based on team characteristics was presented, which according to the results of this model, when paying more attention to characteristics such as individual dimension, cultural dimension, organizational dimension, and team dimension will have a positive effect on the performance of the software development team. Also, time management can be improved, as a result of which the customer will be satisfied, and also this product will be provided with the highest quality.




## REFERENCES

- [1] G. Succi, A. Valerio, T. Vernazza, and G. Succi, "Compatibility, standards, and software production," *StandardView*, vol. 6, no. 4, pp. 140–146, Dec. 1998, doi: 10.1145/338183.338185.
- [2] X. Xu, M. Ghaffarinia, W. Wang, K. W. Hamlen, and Z. Lin, "CONFIRM: Evaluating compatibility and relevance of control-flow integrity protections for modern software," in *28th USENIX Security Symposium (USENIX Security 19)*, 2019, pp. 1805–1821.
- [3] P. B. Crosby, "Quality is free-if you understand it," *Winter Park Public Library History and Archive Collection*, pp. 1–4, 1979.
- [4] T. Hovorushchenko, O. Pavlova, and M. Bodnar, "Development of an intelligent agent for analysis of nonfunctional characteristics in specifications of software requirements," *Eastern-European Journal of Enterprise Technologies*, vol. 1, no. 2, pp. 6–17, Jan. 2019, doi: 10.15587/1729-4061.2019.154074.
- [5] B. Bergman and B. Klefsjö, *Quality from customer needs to customer satisfaction*. Lund: Studentlitteratur AB, 2010.
- [6] M. Gheisari et al., "An optimization model for software quality prediction with case study analysis using MATLAB," *IEEE Access*, vol. 7, pp. 85123–85138, 2019, doi: 10.1109/ACCESS.2019.2920879.
- [7] D. A. Garvin, "Product quality: An important strategic weapon," *Business Horizons*, vol. 27, no. 3, pp. 40–43, May 1984, doi: 10.1016/0007-6813(84)90024-7.
- [8] D. Galin, *Software quality: concepts and practice*. John Wiley & Sons, 2018.
- [9] P. Thongtanunam and A. E. Hassan, "Review dynamics and their impact on software quality," *IEEE Transactions on Software Engineering*, vol. 47, no. 12, pp. 2698–2712, Dec. 2021, doi: 10.1109/TSE.2020.2964660.
- [10] G. Arcos-Medina and D. Mauricio, "Aspects of software quality applied to the process of agile software development: a systematic literature review," *International Journal of System Assurance Engineering and Management*, vol. 10, no. 5, pp. 867–897, Oct. 2019, doi: 10.1007/s13198-019-00840-7.
- [11] M. Yan, X. Xia, X. Zhang, L. Xu, D. Yang, and S. Li, "Software quality assessment model: a systematic mapping study," *Science China Information Sciences*, vol. 62, no. 9, Sep. 2019, doi: 10.1007/s11432-018-9608-3.
- [12] A. Aggarwal, K. S. Dhindsa, and P. K. Suri, "Enhancing software quality assurance by using knowledge discovery and bug prediction techniques," in *Soft Computing for Intelligent Systems*, 2021, pp. 97–118.
- [13] S. D. Palma, D. Di Nucci, F. Palomba, and D. A. Tamburri, "Toward a catalog of software quality metrics for infrastructure code," *Journal of Systems and Software*, vol. 170, Dec. 2020, doi: 10.1016/j.jss.2020.110726.
- [14] F. J. Buckley and R. Poston, "Software quality assurance," *IEEE Transactions on Software Engineering*, vol. SE-10, no. 1, pp. 36–41, Jan. 1984, doi: 10.1109/TSE.1984.5010196.
- [15] J. A. McCall, P. K. Richards, and G. F. Walters, "Factors in software quality: preliminary handbook on software quality for an acquisition manager," *General Electric*, vol. 1, pp. 1–3, 1977.
- [16] D. Galin, "Software quality factors (Attributes)," in *Software Quality: Concepts and Practice*, Hoboken, NJ, USA: John Wiley & Sons, Inc., 2018, pp. 23–44.
- [17] B. W. Boehm, J. R. Brown, and M. Lipow, "Quantitative evaluation of software quality," in *ICSE '76: Proceedings of the 2nd international conference on Software engineering*, 1976, pp. 592–605.
- [18] R. B. Grady and D. L. Caswell, *Software metrics: establishing a company-wide program*. ACM Digital Library, 1987.
- [19] R. G. Dromey, "A model for software product quality," *IEEE Transactions on Software Engineering*, vol. 21, no. 2, pp. 146–162, 1995, doi: 10.1109/32.345830.
- [20] A. Abran, "Software engineering-Product quality-Part 3: Internal metrics," *ISO draft for Review*, 2000.
- [21] F. Coallier, "Software engineering-product quality-Part 1: Quality model," *International Organization for Standardization: Geneva, Switzerland*, 2001.
- [22] I. ISO and T. IEC, "9126-2: Software engineering-product quality-part 2: External metrics," International Organization for Standardization, Geneva, Switzerland, no. 2, Art. no. 86, 2003.
- [23] I. ISO and T. IEC, "9126-4: Software engineering-product quality-part 4: Quality in use metrics," International Organization for Standardization, Geneva, Switzerland, Switzerland, no. 1, Art. no. 59, 2004.
- [24] ISO Standard, "Software engineering-product quality-Part 1: Quality model," ISO Standard, pp. 9126-1, 2001.
- [25] J. M. Lee and B. Shneiderman, "Personality and programming: Time-sharing vs. batch preference," in *Proceedings of the 1978 annual conference on - ACM '78*, 1978, vol. 2, pp. 561–569, doi: 10.1145/800178.810092.
- [26] J. E. Hannay, E. Arisholm, H. Engvik, and D. I. K. Sjøberg, "Effects of personality on pair programming," *IEEE Transactions on Software Engineering*, vol. 36, no. 1, pp. 61–80, Jan. 2010, doi: 10.1109/TSE.2009.41.
- [27] S. McDonald and H. M. Edwards, "Who should test whom?," *Communications of the ACM*, vol. 50, no. 1, pp. 66–71, Jan. 2007, doi: 10.1145/1188913.1188919.
- [28] V. Pieterse, M. Leeu, and M. van Eekelen, "How personality diversity influences team performance in student software engineering teams," in *2018 Conference on Information Communications Technology and Society (ICTAS)*, Mar. 2018, pp. 1–6, doi: 10.1109/ICTAS.2018.8368749.
- [29] N. Salleh, E. Mendes, J. Grundy, and G. S. J. Burch, "An empirical study of the effects of personality in pair programming using the five-factor model," in *2009 3rd International Symposium on Empirical Software Engineering and Measurement*, Oct. 2009, pp. 214–225, doi: 10.1109/ESEM.2009.5315997.
- [30] S. D. Vishnubhotla, E. Mendes, and L. Lundberg, "Investigating the relationship between personalities and agile team climate of software professionals in a telecom company," *Information and Software Technology*, vol. 126, Oct. 2020, doi: 10.1016/j.infsof.2020.106335.
- [31] M. N. Sarpiri and T. J. Gandomani, "The impact of team climate on failure and success of scrum adoption," *International Journal of Software Engineering & Applications*, vol. 8, no. 3, pp. 33–38, May 2017, doi: 10.5121/ijsea.2017.8303.
- [32] M. Radnejad and T. J. Gandomani, "Structure and criteria defining business value in agile software development based on hierarchical analysis," in *2022 Second International Conference on Distributed Computing and High Performance Computing (DCHPC)*, Mar. 2022, pp. 117–122, doi: 10.1109/DCHPC55044.2022.9732113.
- [33] T. J. Gandomani et al., "Talent management in agile software development: The state of the art," in *2021 3rd East Indonesia Conference on Computer and Information Technology (EIConCIT)*, Apr. 2021, pp. 156–160, doi: 10.1109/EIConCIT50028.2021.9431902.
- [34] S. Cruz, F. Q. B. da Silva, and L. F. Capretz, "Forty years of research on personality in software engineering: A mapping study," *Computers in Human Behavior*, vol. 46, pp. 94–113, May 2015, doi: 10.1016/j.chb.2014.12.008.
- [35] K. E. Pocius, "Personality factors in human-computer interaction: A review of the literature," *Computers in Human Behavior*, vol. 7, no. 3, pp. 103–135, Jan. 1991, doi: 10.1016/0747-5632(91)90002-I.




- [36] S. T. Acuña, M. Gómez, and N. Juristo, "How do personality, team processes and task characteristics relate to job satisfaction and software quality?," *Information and Software Technology*, vol. 51, no. 3, pp. 627–639, 2009, doi: 10.1016/j.infsof.2008.08.006.
- [37] B. Barry and G. L. Stewart, "Composition, process, and performance in self-managed groups: The role of personality," *Journal of Applied Psychology*, vol. 82, no. 1, pp. 62–78, 1997, doi: 10.1037/0021-9010.82.1.62.
- [38] G. M. Weinberg, *The psychology of computer programming*. Van Nostrand Reinhold New York, 1971.
- [39] A. English, R. L. Griffith, and L. A. Steelman, "Team Performance: The effect of team conscientiousness and task type," *Small Group Research*, vol. 35, no. 6, pp. 643–665, Dec. 2004, doi: 10.1177/1046496404266320.
- [40] G. A. Neuman and J. Wright, "Team effectiveness: Beyond skills and cognitive ability," *Journal of Applied Psychology*, vol. 84, no. 3, pp. 376–389, 1999, doi: 10.1037/0021-9010.84.3.376.
- [41] I. Sommerville and T. Rodden, "Human, social and organisational influences on the software process," *Software Process*, vol. 4, pp. 89–100, 1996.
- [42] A. E. M. van Vianen and C. K. W. De Dreu, "Personality in teams: Its relationship to social cohesion, task cohesion, and team performance," *European Journal of Work and Organizational Psychology*, vol. 10, no. 2, pp. 97–120, Jun. 2001, doi: 10.1080/13594320143000573.
- [43] M. R. Barrick and M. K. Mount, "The big five personality dimensions and job performance: a meta-analysis," *Personnel Psychology*, vol. 44, no. 1, pp. 1–26, Mar. 1991, doi: 10.1111/j.1744-6570.1991.tb00688.x.
- [44] A. B. Soomro, N. Salleh, E. Mendes, J. Grundy, G. Burch, and A. Nordin, "The effect of software engineers' personality traits on team climate and performance: a systematic literature review," *Information and Software Technology*, vol. 73, pp. 52–65, May 2016, doi: 10.1016/j.infsof.2016.01.006.
- [45] J. E. McGrath, *Groups: Interaction and performance*. Englewood Cliffs, NJ: Prentice-Hall, 1984.
- [46] S. Martínez-Fernández *et al.*, "Continuously assessing and improving software quality with software analytics Tools: A case study," *IEEE Access*, vol. 7, pp. 68219–68239, 2019, doi: 10.1109/ACCESS.2019.2917403.
- [47] A. Poth, M. Kottke, and A. Riel, "Evaluation of agile team work quality," in *Agile Processes in Software Engineering and Extreme Programming – Workshops*, 2020, pp. 101–110.
- [48] T. DeMarco and T. Lister, *Peopleware: productive projects and teams*. 3th ed. Addison-Wesley, 2013.
- [49] H.-L. Yang and J.-H. Tang, "Team structure and team performance in IS development: a social network perspective," *Information & Management*, vol. 41, no. 3, pp. 335–349, Jan. 2004, doi: 10.1016/S0378-7206(03)00078-8.
- [50] M. Afshari and T. J. Gandomani, "A typical practical team structure and setup in agile software development," in *2021 7th International Conference on Electrical, Electronics and Information Engineering (ICEEIE)*, Oct. 2021, pp. 483–487, doi: 10.1109/ICEEIE52663.2021.9616743.
- [51] F. Tavakoli and T. J. Gandomani, "A novel team productivity model for XP teams," *Journal of Cases on Information Technology*, vol. 20, no. 4, pp. 93–109, Oct. 2018, doi: 10.4018/JCIT.2018100106.
- [52] T. J. Gandomani and M. Z. Nafchi, "Agile transition and adoption human-related challenges and issues: a grounded theory approach," *Computers in Human Behavior*, vol. 62, pp. 257–266, Sep. 2016, doi: 10.1016/j.chb.2016.04.009.
- [53] M. Afshari and T. J. Gandomani, "Quality of agile adoption in global software development: an assessment model," *Indonesian Journal of Electrical Engineering and Computer Science (IJECS)*, vol. 21, no. 1, pp. 367–376, Jan. 2021, doi: 10.11591/ijeecs.v21.i1.pp367-376.

## BIOGRAPHIES OF AUTHORS



**Hamidreza Asfa**    received the Engineer degree in Computer Science from Shahid Asharafi Isfahani University of Sepahanshahr, Isfahan in 2009. He received the master's degree in software engineering from Isfahan Branch Islamic Azad University in 2019. He can be contacted at hr.asfa@gmail.com.



**Taghi Javdani Gandomani**    Senior Member, IEEE, received the Ph.D. degree from UPM, Malaysia in 2014. He is currently an Assistant Professor of Software Engineering at Shahrekord University, Iran. His research interests include Agile software development, software process improvement, software project management, and empirical software engineering. He is also the leader of the Data Science Research Center at Shahrekord University, Iran. He can be contacted at javdani@sku.ac.ir and javdani@ieee.org.