Proposing and Design a Model to Develop the Global Virtual Team (GVT) Performance in Global Software Development (GSD)

A. R. A. Shaheen , L. M. I. Alzubaidy

²Department of Software, College of Computer Sciences and Math., University of Mosul, Mosul, Iraq

Article information	Abstract
  Correspondence: **A. R. A. Shaheen** ahmed.21csp4@student.uomosul.edu.iq	The development of Information and Communication Technology (ICT), globalization of software, search for an abundance of cost and time, and improving the quality of the developed product, these factors helped to grow the use of Global Virtual Teams (GVTs) in Global Software Development (GSD). This enabled software companies to adopt the GSD approach by using GVTs as an alternative to the centralized approach in the development process. Despite the benefits and advantages of this approach, it is affected by a set of challenges that affect the performance of GVTs which must be identified and considered. This paper aims to design a proposed model for developing the performance of (GVTs) in (GSD) by identifying the challenges affecting performance. The model will help workers in this field to work effectively by knowing all the challenges that they will face. The challenges are identified by reviewing the literature and analyzing related research content and then collecting it in the proposed model. To verify the validity of the components of the proposed model an expert questionnaire is conducted and the target group (13) experts in (GSD) using (GVTs). The results are analyzed using the statistical package for Social Sciences (spss) and came out positive in favor of the proposed model by (91.165)%.

1. Introduction

Virtual work teams are groups of geographically dispersed and culturally different individuals who can work from anywhere in the world without the need to be in offices or work face to face they communicate using ICT and through it, data is exchanged[1]. Virtualization refers to the degree to which teams rely on the use of ICT to communicate and exchange data, which eliminates time constraints and geographical dispersion and enabled access to the best expertise and employment for more than one task regardless of the location and thus reducing development costs and saved site costs and access time, which added a competitive advantage to it as well as enabled it to respond quickly to change in global markets, which gave higher results and efficiency[2]. In addition to the search for globalization and efficient human expertise and fruitful cooperation [3]. To the extent that working across geographical boundaries has become the standard used for all software developers[4]. As these companies sought to reduce the cost of the software product and increase its quality through outsourcing and benefiting from the possibility of working (24) hours a day [5]. Which reduced the delivery time of the software product to the consumer by twenty to fifty percent, in addition to reducing labor costs[6].

The presence of GVT individuals in different geographical areas and their use of ICT as a means of communication between its members resulted in a set of problems [7], such as cultural differences as a result of geographical diversity, differences in language, and related misinterpretation of concepts. The difference in time, lack of communication between team members, delays in obtaining responses on a specific topic, and problems related to trust, knowledge sharing, cooperation, and coordination within the team, in addition to many other challenges [8].Recently increased interest in GVTs and how to make these teams

successful, but few studies shed light on the factors that affect the performance of these teams [9]. This paper aims to design a proposed model for developing GVT performance in GSD to understand these factors and challenges that international software companies face in the development process to reduce their impact on projects that are developed using GVTs.

2. Background

International companies are working to change the work methodologies used by them based on factors such as keeping pace with the change in global market demand, global technological progress, searching for a way to compress development costs, obtaining skilled expertise, and commercial competition [10]. Therefore, globalization has become the criterion for companies to expand their activities and achieve commercial competition, in the nineties of the last century global software companies directed software development in countries such as Ireland and India, and then later the trend became towards Eastern Europe, Latin America, and the far east, and China and India they were the first countries[11]. The development witnessed by the world in the field of ICT created a new organizational structure called GVTs[12]. It is possible to obtain global experience with low wages by taking advantage of the expertise available in geographical areas with different economies[2]. And enabled the deployment of its employees geographically and helped in the rapid response to the change in the requirements of the global market[13], and reduce development time by exploiting the time difference between team members and adapting them to work (24) hours a day [14]. Virtual teams are characterized by high flexibility, as the same person can work in more than one team without the need to be in one place[15]. The global changes that occurred after the corona epidemic led to an increase in the use of virtual teams because of the rules of curfew and non-mixing, the feature of virtual teams has emerged and work has shifted from teamwork to the use of GVTs [4]. These factors drive global software companies to shift from the traditional or one-region approach to a GSD approach using GVTs to take advantage of the features it provides [16]. It is defined as the process of software development using teams from different geographical locations, where companies transfer all or part of their software development process to teams in other countries [8]. The software industry is a field with enormous potential since the use of software applications in the fields of life is endless [17]. Whereas the development included the economic, engineering, medical, educational, and cultural sectors, its most important pillar was software applications that facilitated work and created a competitive atmosphere between companies [18]. GVTs have been built in various sectors (industrial, commercial, educational, health, software engineering, and information technology) and all of these teams share a set of characteristics. Table 1 shows the characteristics of GVT.

Table 1. Characteristics of GVTs[19]

Seq.	Characteristics	Description
1	Temporary	There are no permanent virtual teams, but they are formed for a specific purpose and time.
2	Geographically Distributed	That is, the members of the virtual team are from different countries.
3	Cultural Diversity	As a result of the diversity of the countries of the virtual team members, cultural diversity is born.
4	Communicate Electronically	Communicate using the Internet and various communication programs.
5	Flexibility	Its members can work in more than one team and from anywhere in the world.

With these privileges, many factors and challenges are associated with the virtual work environment some of these factors are from the literature on virtual teams that resulted from managing teams remotely along with geographical diversity and cultural differences and related differences in language and culture of countries, which in turn affects communication and trust between team members or teams themselves[20]. Other challenges must be taken into account represented in the communication mechanism and information technology used and their differences from one country to another. Likewise, the difference in timing is an important and influential work due to its relationship to the communication mechanism used between individuals in the team[21]. Also, cohesion among team members is one of the factors that affected performance and created an ideal work environment, in contrast to a hectic and incoherent team negatively affecting the performance of teams[22], in addition to the size of the GVT and related matters. Among the important factors that affect the development of software projects is not using the standard terminology and concepts used in software engineering and the use of terms that differ according to the language and cultural diversity of individuals, which negatively affect the construction, documentation, and maintenance of software projects. As well as factor people, which can be considered one of the keys to the success of software teams, since each person in the team has responsibilities and a role within the team [23], as well as work efficiency, team training, context, and people problems [20]. The lack of an organizational structure leads to team frustration and results in conflict and the inability to manage skills within the team [24].

3. Related Works

In this section, a literature review is conducted that addresses the challenges affecting the performance of GVTs in GSD.

In (2017) Mohd. Shameem et al.[25] conducted a study to develop an action plan for global software companies to help them improve the building of virtual teams from the beginning. They showed a set of factors that affect the performance of GVTs in GSD, which are (trust, communication, cultural diversity, geographical distance, ICT problems, and lack of communication).

In (2018) , Yusmadi Yah Jusoh et al.[5] investigated the influence of the communication factor in GSD using GVTs and identified the factors related to it. Where a survey was conducted to verify the impact of factors such as (time distance, geographical distance, cultural differences, training, people's skills in communication, and language differences). A survey was distributed to software and information systems specialists in various sectors in Malaysia. The results of the study showed that the factors (Geographical difference, time zone difference, language difference, ICT problems, team size, technical problems, and lack of trust) all positively affected good communication in global software development.

In (2018), Brian J. Galli. [8] presented research to identify the factors and challenges that result from the use of the GSD approach and to discuss the risk management plan based on these factors. The researcher indicated that communication problems and cultural differences are behind most of the problems facing the distributed development process.

In (2019), Amna Batool et al.[26] conducted a literature review to investigate factors affecting resilience in GSD and provided a real-world scenario survey of the factors faced by a software company, Bestweb Malaysia. The research aims to help companies understand the challenges and adopt the best development options, where the following factors are identified (knowledge management, lack of trained employees, and lack of motivation).

In (2020), Vida Davidaviciene et al.[19] introduced research aimed at creating a model to assess the impact of knowledge sharing in the virtual team environment in the Middle East by selecting information technology companies in the UAE. The research showed that the following factors had a direct impact on knowledge sharing in virtual teams (motivation, culture, conflict, ICT, confidence, and leadership) and the results did not show any effect of language.

In (2021), Victor Garro-Abarca et al.[27] offered research on the factors affecting the GSD, where these factors were arranged in models based on reviewing the literature and analyzing the results amid the Corona epidemic on (317) development teams participating in virtual teams. The study concluded by identifying some factors that affect the performance of the virtual team, which are communication and trust Cohesion and empowerment, as the study helped to understand the impact of these factors on performance, and the structural equation approach with partial least squares was used to evaluate the performance model.

In (2021), Naveed Ali et al.[23] conducted a review of previous works on GSD and what are its advantages and the challenges it faces. The review showed that the challenges facing GVT in GSD were (culture, communication, language, time zone difference, collective awareness, and coordination).

In (2021) Gaye Kiely et al. [28] determined the factors that affect coordination in virtual teams when developing global software by identifying a group of factors that affect performance which is (ICT, cultural difference, geographical distance, time zone difference, team leadership, language differences, trust, participation Knowledge, subscriber identity). Among these factors, five of them were selected to study their impact on coordination between members of the GVT in GSD which is (geographical diversity, cultural difference, trust, time zone difference, and language).

In (2021), Ali Yahya Gheni et al.[29] investigated the success factors of the GVT manager when developing global software during the COVID-19 pandemic through qualitative research for these factors, which included reviewing the literature on the subject, collecting relevant information, conducting a questionnaire, and analyzing it to evaluate the results. The study showed the importance of the following factors (communication, information sharing, and cooperation). And the communication factor constituted the knot in the process of developing the performance of the GVT.

In (2022), Asim Iftikhar et al.[30] presented research that includes an analysis of risk factors in GSD projects, where the research identified (54) factors divided into three axes (cost, time, and resources). Pareto statistical analysis was conducted to discover the most important of these factors in influence, in addition to designing and implementing the (firefly) algorithm to evaluate the results obtained from the analysis, which identified the most important risks (resources, cultural differences, and poor training).

4. The Proposed Model

The following steps explain the proposed model used in this paper, Figure 1. shows the proposed model steps.

Figure 1. Proposed model steps

1. **Literature Review:** this stage includes the following steps.
   - **Search for relevant research:** conducting a literature review to search for required terms and concepts in published journals, research, conferences, and e-books in electronic databases (IEEE Xplore, Wiley Online, Springer Link, Research Gate, ACM SIGCHI, Google Scholar, Science Direct, IET Library) to obtain research within the required field. The summary and conclusion are read, and a list of available research from the year (2017 to 2022) was prepared.
   - **Analyzing research:** analyze the content of previous research to determine the concepts related to the development process as well as the factors and challenges affecting the performance of the virtual team and the connections and relationships between them. The research is carried out in four directions. The first direction includes factors related to people and their impact on performance. The second direction includes the impact of the type of projects on performance. The third direction includes the type of development process used and its impact on performance. The fourth direction includes the impact of the characteristics of the developed product on the performance.
   - **Factors extraction:** extract the challenges and factors affecting the performance of the GVTs in GSD.

   By reviewing the literature and analyzing the content of relevant research, (31) factors affecting the performance of the GVTs in GSD are identified, which are explained in Table 2.

Table 2. Explain the factors

Seq.	Factors	Explain
	GVT Performance In GSD	Performance is a vital element and one of the pillars of a successful project. It is defined as a work that focuses on determining the rate of progress in the project and the completion of the work[31].
1	Person	Human resource management is considered one of the important topics for any software development project, and for its importance, the institute of software engineering developed the people management capabilities maturity model (PM-CMM) because the human factor is the basis of software engineering and the software development process is an intensive activity for individuals [22].
2	Diversity of Skills	There is a shortage of skills required for software development using the traditional approach, which leads to a rise in costs and wages. To reduce this rise, a distributed approach is followed in software development, where work is transferred to countries such as (Russia, India, Brazil, and China) to obtain skills at low wages[2].
3	Geographical Diversity	It is considered an important factor for the behavior of individuals and works to increase their creativity in solving problems that arise during work, but at the same time, it can be a factor to reduce communication and cohesion, increase conflict, and lead to misunderstanding and lack of trust among members of the GVT[32].
4	Language Different	The geographical diversity of the members of the hypothetical team has created a diversity of languages within the team. Language is one of the factors affecting communication, knowledge sharing, and team cohesion and is reflected in performance [10][19].
5	Cultural Differences	Cultural difference is referred to as the cultural distance, which is the extent to which the team members differ in belonging to race, social behavior, culture, values, and communication mechanisms, and it increases with increasing geographical distance, despite the existence of cultural and ethnic diversity within the same countries [33].
6	ICT Different	ICT is the mechanism that brings the members of the virtual team together, allowing communication, data sharing, and collaboration among them[34]. Geographical diversity also led to a difference in ICT used as a result of different countries[16].
7	Time Zone Different	The difference in time between the countries to which the members of the GVT belong [28]. The increase in time distance is directly proportional to the geographical distance between individuals, which represents the time between

		the time of sending data and the time of receiving it, which is at its minimum using direct communication. the greater the time difference, the lower the performance of the GVT[35].
8	Project	Software engineering is concerned with the process of designing programs, writing the code, testing the code, implementing it, and performing maintenance operations on it [36].
9	Team	In GSD it is referred to as the GVT, which develops global software, which is also divided into several teams based on the work assigned to it. Each team consists of a group of people working on tasks from different geographical areas and communicating using information and communication technology [27].
10	Leadership	Management of software projects is one of the difficult projects to manage because it requires the cooperation of the team members and the difficulty increases with the increase of the team members and the complexity of the project [37].
11	Communication	It is an important element in GVTs through which the correct information is delivered to the correct person without errors, and communication is considered a key player in developing the performance of the teams since other factors depend on it in determining performance [38].
12	Cooperation	In contrast to traditional teams, cooperation in virtual teams requires greater motivation and support from the team leader to increase performance within the team due to the lack of face-to-face communication [32]. The basis for cooperation in the virtual team is to build trust and effective communication between individuals [33].
13	Coordination	It is any method used to achieve integration between members of the GVT and unite efforts among individuals in the team [39]. The reason behind the lack of coordination in the virtual teams is the difference in the time zone and the geographical and cultural diversity between the individuals. The challenge increases with the increase in the size of the project and the dispersion of the team members, which makes it difficult for the team leader to coordinate between them [40].
14	Trust	Building trust among members of the GVT is important to increase performance, cooperation, and job satisfaction [34].
15	knowledge sharing	The performance of the team is affected by the failure of individuals to share knowledge and their adherence to it as a result of their fear of losing their unique knowledge and position in the company for that. Knowledge in institutions is classified into two types: explicit knowledge and tacit knowledge [32]. The process of managing knowledge effectively is required, but it is affected by the geographical and temporal diversity factor within the team, while cultural difference leads to problems in interpreting concepts [41].
16	Motivation	It is considered one of the first factors that were found to affect the performance and productivity of the hypothetical team, as it affects individual performance and team performance, and through it, performance can be increased by giving incentive rewards or by showing gratitude [27].
17	Conflict	Conflict arises from perceived or real differences that occur between members of the virtual team and that occur as a result of teamwork in the virtual environment [20].
18	Cohesion	Cohesiveness in GVTs is defined as the attraction of team members to each other and the desire to remain united in pursuit of goals [42].
19	Lack Of Organizational Structure	Roles must be defined for each individual in the team before starting work. Also, each member of the team must be aware of the positions and tasks of other individuals, since the wrong allocation of tasks leads to a lack of performance and failure in distributed projects [24].
20	Team Size	The size of the project team is of great importance in software projects. The literature on virtual teams divided the work team into three sizes: 1)- A team

		consisting of 10 people or less, 2)- A team consisting of 11 to 25 people 3)- A team consisting of 26 or more. More. The smaller the size of the team, the easier it is to manage, the less complicated it is, and the more communication and information transfer among its members [43].
21	Training	Coaching is the process of developing the skills and knowledge of employees in GVTs to improve performance [43]. The training of new team members is important to work to increase the confidence of team members in their potential and to increase the speed and effectiveness of work [44].
22	Technical problems	The use of heterogeneous communication tools causes coordination problems, and different communication generations can lead to problems in communication speed between different sites [45].
23	Process	The development process is a description of the sequence and order of operations followed when developing the software product. Many software development models have been discovered, ranging from heavy or traditional process models such as the spiral model, the incremental model, and the waterfall model to agile process models such as scrum and xp, which are challenged depending on the goal of the developed product, the development team, the market need, and the degree of reliability of requirements [46].
24	Marketplace Demands	The software is designed based on the customer's requirements or the need of the global market, and the degree of proof of the requirements of the markets or customers has a significant impact on the cost and time of development and the amount of effort expended. It also has a relationship with determining the type of development process used, and all these factors are related to the performance of the GVT [22].
25	Product	The product is considered successful if it is completed at a specific time, at a specific cost, and within quality, with the participation of stakeholders in the project[33]. The process of reworking the developed product leads to exceeding the time and cost allocated to the product, reducing quality, and dissatisfaction with the customer, and leading to reducing team morale and performance [41].
26	Goal	Changing, blurry, or confusing goals are the most common risks associated with project managers and designers underperforming[22].
27	Scope	Changes in the scope of the project represent one of the critical reasons for the failure of software development projects because the project manager will focus most of his attention on controlling the scope changes and ignore the impact of these changes on the cost and time of the project [47].
28	Cost	The cost is the amount of money that is spent on the software project to complete it, and it is also known as the project budget, which is determined based on the paragraphs of the project and gives a clear perception of the cost spent during the work and avoiding any sudden costs [30]. Each software project has a specific cost. This cost must be accurately estimated before embarking on the project [48].
29	Time	Can say that the time factor can be considered one of the important factors that determine the success of any project, as software project managers face two types of challenges related to the time factor, which are the modifications that are made during implementation and the time spent in implementing unnecessary activities, which are dealt with by developing a project plan good and fixed schedule[49].
30	Quality	The quality looks at the operations that must be carried out to reach the desired goal and to identify problems that reduce the expected performance of the team [4].
31	Resources	The unavailability of resources is one of the problems associated with project delays and lack of performance, and the project manager must, during the planning stage, determine his needs for resources, their quantities, and the required period [47].

2. **Designing the Proposed Model**: this stage combines the extracted factors into a proposed model.

The process of developing a model to improve the performance of GVTs in GSD is complex and multi-faceted as it involves consideration of the various challenges and constraints of the development process. The following steps represent the algorithm for designing the proposed model.

Step 1: Factors selection
Select factors and challenges affecting GVT performance in GSD that is identified through a literature review.
Step 2: Determine the relationships
Determine the relationships between the selected factors based on their impact on each other and on the performance of the GVT.
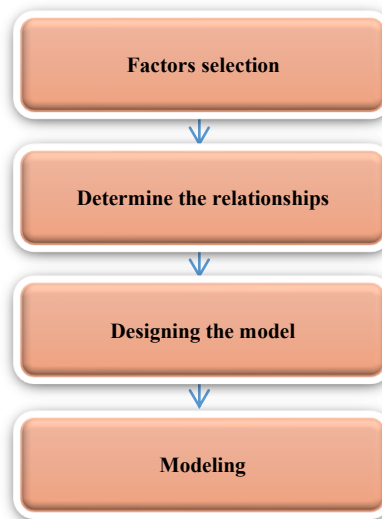**Step 3: Designing the model**
Collect the selected factors into a proposed model based on the relationships that have been identified.
Step 4: Modeling
Represent the proposed model using one of the used modeling languages such as Object-Role Modeling Language(ORM) or Unified Modeling Language(UML).
Figure 2. represents the structure of designing the proposed model.

Figure 2. Structure of designing the proposed model

And to achieve the desired goal of this research, a model is proposed to develop the performance of the GVT in GSD, the model consists of the factors identified through the literature review amounting to (31) factors. These factors are linked to each other based on their impact and the relationships that link them which are inferred by explaining the factors, as shown in Table (2).

1. The performance of the GVT in GSD is affected positively or negatively by four basic factors (people, project, process, and product).
2. Based on the characteristics of the GVT, its members are geographically distributed as a result of their presence in different countries. This geographical diversity produced a diversity of skills for team members which is reflected positively in an increase in performance.
3. In addition, geographical diversity produced (language differences, cultural differences, ICT different, and time zone different), the effect of the language difference and geographical diversity is negative on performance, while the effect of time zone differences and ICT differences had a positive or negative effect on performance.
4. Based on the flexibility characteristic of virtual teams people can be associated with more than one virtual team this team is affected by a group of factors like (Leadership, communication, cooperation, coordination, trust, knowledge sharing, motivation, conflict, cohesion, weak organizational structure, team size, training, technical problems) and all these factors can positively and negatively affect the team's performance.

5. The team is assigned a specific task from the project based on the team's type, and the team's performance is affected by the type of developed software project.
6. Each project has an appropriate software development process that is chosen depending on the type of project, the development team, the characteristics of the product, the people who requested the product, and the market need, choosing an inappropriate development process negatively affects the team's performance.
7. **Also, the team's performance is affected positively or negatively by the characteristics of the developed product, each software product has a specific goal and scope and is developed within cost, time, quality, and resources.**

Figure 3. shows the proposed model using ORM.

Figure 3. The Proposed mode

3. Model Validation

To validate the proposed model, a questionnaire of experts in GSD was conducted using GVTs. A Likert Scale is used for the questionnaire, which is used to measure topics that are not observable but have a significant impact on people's behavior and depend on responses that indicate approval or rejection of a subject. The questionnaire was presented to (13) software development experts. The questionnaire consisted of two parts:
The first section is done to verify the components of the model and the relationships between these components and the components of each part of the model. The three-point Likert scale is used (Yes=3, Yes with modification=2, No=1). The questionnaire consisted of ten questions. The experts' answers are shown in Table 3.

The second section is done to verify the impact of the factors in the model on the performance of the GVTs in GSD. The five-point Likert scale is used to determine the degree of impact which are
(Strongly Agree=5, Agree=4, Neutral=3, Disagree=2, Strongly Disagree=1). The experts' answers are shown in Table 4. which consists of twenty-six questions.

Table 3. Experts' answers to the first part of the questionnaire

question number	Yes	Yes with modification	NO	Sample volume	Arithmetic mean	standard deviation	percentage	sample orientation
1	12	1	0	13	2.92	0.27	97.33	Acceptable
2	10	3	0	13	2.77	0.42	92.33	Acceptable
3	11	2	0	13	2.85	0.36	95	Acceptable
4	12	1	0	13	2.92	0.27	97.33	Acceptable
5	8	4	1	13	2.54	0.63	84.67	Acceptable
6	13	0	0	13	3	0	100	Acceptable
7	10	3	0	13	2.77	0.42	92.33	Acceptable
8	10	3	0	13	2.77	0.42	92.33	Acceptable
9	11	2	0	13	2.85	0.36	95	Acceptable
10	8	5	0	13	2.62	0.49	87.33	Acceptable

Table 4. Experts' answers to the second part of the questionnaire

question number	Strongly Agree	Agree	Neutral	disagree	Strongly Disagree	Sample volume	Arithmetic mean	standard deviation	percentage	sample orientation
1	7	4	2	0	0	13	4.38	0.74	87.6	Strongly Agree
2	9	3	1	0	0	13	4.62	0.62	92.4	Strongly Agree
3	5	6	1	1	0	13	4.15	0.86	83	Agree
4	6	6	1	0	0	13	4.38	0.62	87.6	Strongly Agree
5	3	10	0	0	0	13	4.23	0.42	84.6	Strongly Agree
6	3	4	4	2	0	13	3.62	1	72.4	Agree
7	6	3	4	0	0	13	4.15	0.86	83	Agree
8	11	2	0	0	0	13	4.85	0.36	97	Strongly Agree
9	9	4	0	0	0	13	4.69	0.46	93.8	Strongly Agree
10	7	6	0	0	0	13	4.54	0.5	90.8	Strongly Agree
11	11	2	0	0	0	13	4.85	0.36	97	Strongly Agree
12	6	5	2	0	0	13	4.31	0.72	86.2	Strongly Agree
13	6	3	4	0	0	13	4.15	0.86	83	Agree
14	10	3	0	0	0	13	4.77	0.42	95.4	Strongly Agree
15	8	5	0	0	0	13	4.62	0.49	92.4	Strongly Agree
16	7	5	1	0	0	13	4.46	0.63	89.2	Strongly Agree
17	9	3	1	0	0	13	4.62	0.62	92.4	Strongly Agree
18	8	4	1	0	0	13	4.54	0.63	90.8	Strongly Agree

19	4	5	3	1	0	13	3.92	0.92	78.4	Agree
20	9	4	0	0	0	13	4.69	0.46	93.8	Strongly Agree
21	6	7	0	0	0	13	4.46	0.5	89.2	Strongly Agree
22	10	3	0	0	0	13	4.77	0.42	95.4	Strongly Agree
23	7	6	0	0	0	13	4.54	0.5	90.8	Strongly Agree
24	8	5	0	0	0	13	4.62	0.49	92.4	Strongly Agree
25	7	6	0	0	0	13	4.54	0.5	90.8	Strongly Agree
26	5	5	3	0	0	13	4.15	0.77	83	Agree

The questionnaire results :
The results are divided into two parts, depending on the experts' answers to the questions of each section in tables (3 and 4) which are analyzed and results calculated using (the statistical package for the Social Sciences (spss)) program.

The result of the first section is shown in Table 5.
The method of calculating the results of Table (5) was done manually.
Arithmetic mean=$\sum$(frequency* Likert score)/ sample size
 = (105(Yes)*3+24(Yes with modification)*2+1(No)*1) / 130 =364/130=2.8
Standard deviation= $\sqrt{\sum}$(frequency*Likert score^2)-(Arithmetic mean^2 *sample size)/sample size-1
$\sqrt{}$(105*9+24*4+1*1)-(2.8^2*130)/129 =$\sqrt{}$(1042-1019.2) /129 = 0.42
 Percentage= (Arithmetic mean / large Likert score) *100
=(2.8 / 3)*100= 0.9333*100 =93.33

Table 5. The acceptance rate for the first part of the questionnaire

Arithmetic mean	standard deviation	percentage	sample orientation
2.8	0.42	93.33	Agree

The result of the second section is shown in Table 6.

Table 6. Percentage of the impact of factors for the second part of the questionnaire

Arithmetic mean	standard deviation	percentage	sample orientation
4.45	0.7	89	Strongly Agree

In conclusion, the acceptance rate for the proposed model as a whole is
93.33%+89%/ 2 = 91.165%.

5.   **Compare the proposed model with previous work**
   In this section, the proposed model is compared with (Davidaviciene, Al Majzoub, and Meidute-Kavaliauskiene) and (Garro-Abarca, Palos-Sanchez, and Aguayo-Camacho) models as follow.

   1.   The knowledge-sharing model proposed by (Davidaviciene, Al Majzoub, and Meidute-Kavaliauskiene), measures the effect of factors (leadership, motivation, language, ICT, culture, conflict, trust) on knowledge sharing in GVT [19]. Figure 4. shows the proposed model.
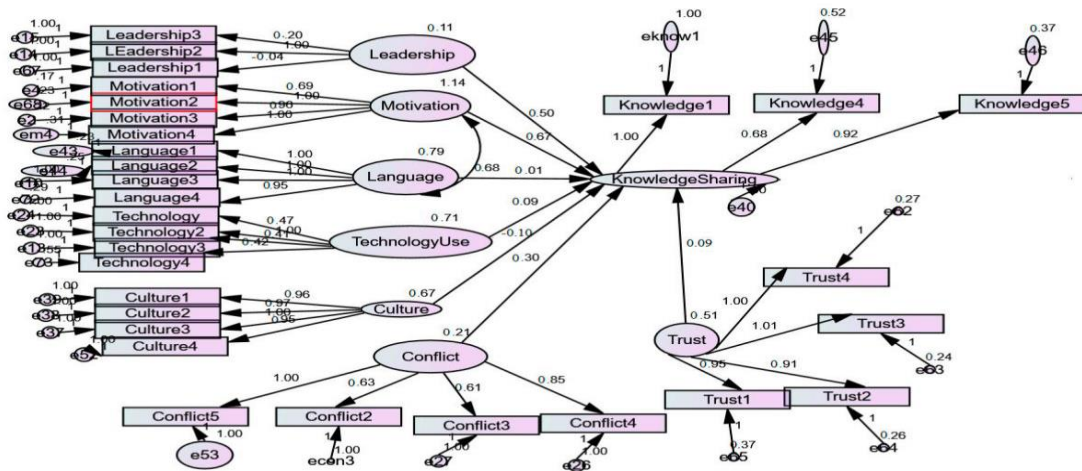
Figure 4. Knowledge sharing model [19]

2. The study model proposed by (Garro-Abarca, Palos-Sanchez, and Aguayo-Camacho), shows the impact of communication and trust factors on the performance of the GVT, and that the trust factor has an impact on the communication factor, and that the communication factor is affected by the characteristics of project tasks, and the trust factor is affected by leadership and cohesion factors and empowerment within the team [27]. Figure 5. shows the proposed model.
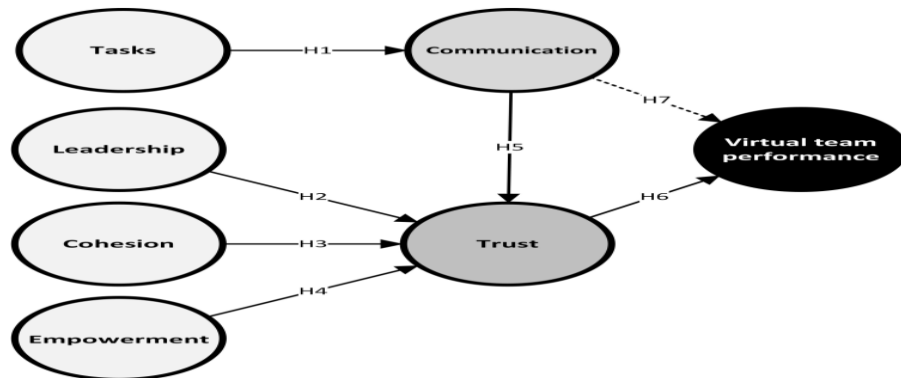

6. **Compare the method with some methods in previous work** is shown in Table 7.

Figure 5. Proposed model [27]

Table 7. Compare the methods

paper	Aim	Result and conclusion	Gaps
[19]	It aims to assess the impact of factors (language, motivation, culture, conflict, information and communication technology, trust, and leadership) on knowledge sharing in a virtual team environment in the Middle East.	The following research question was hypothesized: Do these factors affect positively or negatively on knowledge sharing? As a result of the significant impact of these factors on knowledge sharing, which was identified through a review of the literature, a model was designed that measures knowledge sharing in GVTs. The research question and the proposed model were tested by conducting a questionnaire. The results of the study showed that the factors	The study dealt with the effect of only seven factors on knowledge sharing, and it was applied to information and communication technology companies in the UAE only, and it did not address other companies and countries.

		(motivation, information, and communication technology), confidence, leadership) had a positive effect on knowledge sharing in GVTs, while factors (culture, conflict) had a negative effect, and the results did not show any effect of language on knowledge sharing.	
[27]	Analyzing the relationship between a group of factors affecting GSD during the Corona epidemic.	Influencing factors were identified by reviewing previous works. The study sample included (317) software engineers belonging to global virtual development teams that use agile methodologies in software development. Their performance was analyzed using the structural equation approach with partial least squares (PLS) through an online questionnaire. The researchers used the results of the questionnaire To test a set of hypotheses based on which the study model was built, which concluded by identifying the factors that affect the performance of the global virtual team, which are communication and its association with the characteristics of tasks, and trust as one of the factors that have a significant impact on performance and it's affected by cohesion, leadership, and empowerment factors.	There are factors identified in previous works that have a significant impact on performance, but in this study, they were not included in the proposed model, either because their influence was not high or because the sample of the selected study was not appropriate.
[5]	Study the communication factor in GSD using GVTs and the factors associated with it.	A questionnaire was conducted to verify the effect of factors such as (time distance, geographical distance, social distance, cultural distance, access to training, personal communication skills, and language differences) where the questionnaire was distributed to (150) specialists in software and information systems, in various health, education and industrial sectors in Malaysia using (Google Form). The results showed that the factors (geographical distance, time zone difference, language difference, communication with the development process, technology problems, social and cultural communication skills, and interpersonal communication skills) all affected good communication in GSD.	The study examined the effect of only seven factors on communication in GSD projects and did not address the impact of other factors such as cooperation, coordination, trust, and cohesion on good communication in GSD.
[8]	Determining the factors and challenges that arise from the use of GSD in software projects, and discussing and evaluating a risk management plan based on these factors.	By reviewing previous works, six categories of risks were identified (communication, cultural difference, geographic distance, mistrust, software quality, and human resources). These risks were analyzed and a plan was proposed to mitigate their impact on the	The sample size was small, as 45 studies related to risks were identified, which was not sufficient to identify all risks and obtain information from different directions.

		development process. The study also showed that communication problems and differences cultural are behind most of the risks facing the GSD process.	
[28]	Investigating the use of traditional coordination mechanisms in GSD projects and exploring the impact of factors (cultural difference, geographic distance, language differences, time zone differences, trust) on their effectiveness.	The study applies a part of a conceptual model taken from previous research to explore the impact of these mechanisms based on a GSD team affiliated with a global multinational telecommunications company that develops its software system. The effect of the above-mentioned factors on the effectiveness of coordination mechanisms was analyzed. Accordingly, the conceptual model was developed and modified to serve as a reference for future research to assess the effectiveness of coordination mechanisms in GSD using GVTs. The model shows, each of the coordination mechanisms was negatively affected by a group of factors that affect the GVT.	The study dealt with the effect of only five factors on the traditional coordination mechanisms in GSD projects.
[29]	Identify critical success factors for the GSD Manager in the COVID-19 pandemic.	The works related to this topic were reviewed, information was collected, and a questionnaire was conducted on the Internet in which software experts, project managers, and academics participated the aim was to classify these factors. And then the results of the questionnaire were analyzed by specialists in software development and the use of the SPSS in data analysis, twelve factors were identified in this study are (leadership skills, communication skills, teamwork skills, analytical thinking skills, decision-making skills, educational background, focus on client needs, technical skills, building confidence, optimism, understanding different cultures, personality) and leadership skills had the highest impact on these factors. This study showed the importance of factors (communication, information sharing, cooperation) in the GVT, and that the communication factor constitutes a problem for managers in developing the performance of the GVTs.	The study dealt with twelve factors only, while there are other factors affecting the success of the global software development manager.

7. Conclusion And Future Work

After completing the design and application of the proposed model, the following conclusions are reached.

1- GSD using GVTs is a popular approach to software development that has grown in popularity to take advantage of the feature it provides in terms of access to skilled resources and its diversity, reducing development costs and time through communication using ICT, and improving the quality of software and competitive ability in addition to high flexibility and understanding of the requirements of markets and customers.

2- Despite the benefits of GVTs, several factors affected the performance of the GVTs in GSD.
3- This paper provides knowledge related to the factors affecting the performance of GVTs in GSD.
4- (31) factors affecting performance were identified and discussed.
5- These factors were collected in a proposed model and the aim was to help software companies, practitioners and customers understand these factors to help reduce their impact when building virtual teams and improving project management.
6- Future research considers:

• Explore other factors affecting the performance of the GVT (Company, Staff turnover, Reliability of information, Data repositories, experience, Requirement problem, Framework activities principles,).
• Determine the correlations between the factors of the proposed model and determine their impact on performance.

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Conflict of interest

The author has no conflict of interest.

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اقتراح وتصميم نموذج لتطوير أداء الفريق الافتراضي العالمي في تطوير البرمجيات العالمية

احمد رياض عبدالله شاهين و لهيب محمد ابراهيم الزبيدي

قسم البرمجيات، كلية علوم الحاسوب والرياضيات، جامعة الموصل، الموصل، العراق

المستخلص:

تطور تكنولوجيا المعلومات والاتصالات (ICT)، وعولمة البرمجيات، والبحث عن وفرة في التكلفة والوقت، وتحسين جودة المنتج المطور ، ساعدت هذه العوامل على نمو استخدام الفرق الافتراضية العالمية (GVTs) في تطوير البرمجيات العالمية (GSD). حيث مكن شركات البرمجيات من تبني نهج (GSD) باستخدام (GVTs) كبديل للنهج المركزي في عملية التطوير. على الرغم من فوائد ومزايا هذا النهج إلا أنه يتأثر بمجموعة من التحديات التي تؤثر على أداء (GVTs) والتي يجب تحديدها والوقوف عليها. تهدف هذه الورقة إلى تصميم نموذج مقترح لتطوير أداء (GVTs) في (GSD) من خلال تحديد التحديات التي تؤثر على الأداء. سيساعد النموذج العاملين في هذا المجال على العمل بفعالية من خلال معرفة جميع التحديات التي سيواجهونها. يتم تحديد التحديات من خلال مراجعة الأدبيات وتحليل محتوى البحث ذات الصلة ثم جمعها في النموذج المقترح. للتحقق من صحة مكونات النموذج المقترح يتم إجراء استبيان الخبراء والمجموعة المستهدفة (13) خبيرًا في (GSD) باستخدام (GVTs). تم تحليل النتائج باستخدام الحزمة الإحصائية للعلوم الاجتماعية (spss) وجاءت إيجابية لصالح النموذج المقترح بنسبة (91.165)%.