



Measuring the Performance of the Virtual Teams in Global Software Development Projects

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Abstract

The development teams who are geographically spread, culturally mixed and mainly depend on information and communication technology (ICT) for communication is defined as a global virtual teams (GVTs). Despite the advancement of technologies, achieving the efficient performance of GVTs remains a challenge. The reviewed literature has highlighted the importance of training and development, organizational commitment and motivation in enhancing the performance of GVTs. This study aims to identify the key performance indicators (KPIs), measures, and variables for assisting the GVT performance in global software development projects (GSD). In addition, this study aims to measure the GVTs performance involving online training and development, organizational commitment, and motivation in GSD projects. A survey was conducted among 103 respondents. Then, the performance measurement model (PMM) for GVTs in GSD projects was proposed based on the result of the survey. Finally, the project managers validated the study model. The proposed PMM includes four major components, namely performance measurement processes, mapping strategy for performance evaluation, measurements and performance analysis. The results showed the validity of the proposed model and confirmed that the PMM can assist project managers in measuring the performance of GVTs in GSD Projects.

Keywords: Global software development (GSD); Global virtual teams (GVTs); Information and communication technology (ICT); Performance measurement model (PMM).

Introduction

Companies have become increasingly dependent on complex Information Technology (IT) systems. Large amounts of money are invested in IT projects aimed at developing, improving, and maintaining these systems (Von et al., 2011). Essentially, GVTs are teams that are distributed in different countries using advanced IT systems such as email, instant messaging, and video conferencing to communicate between them (Wildman & Griffith, 2015). The research on GVTs is important in the information system (IS) field because GVTs are using information communication technologies as well as consists of people from different cultures (Yusof & Zakaria, 2012).

In measuring the performance of individual and team outcomes, many organizations develop a system. Some organizations concentrate on the team outcomes because they believe that the team bond would be threatened by individual performance. However, most organizations select team and individual outcomes. Therefore, GVT measures must include an explicit determination of individual contributions (Gibson & Cohen, 2003). Despite the technological advancement, GVTs still face many challenges in achieving their performance. The reviewed literature in GVT

performance has shown that many studies on this subject have been conducted. These studies highlight the importance of online training and development to the GVTs and its effect on its performance. The existing works present certain variables such as online training and development as well as GVT performance. However, measuring these combined studies are still insufficient to achieve a high level of GVT performance and therefore there is a need to include additional related variables to achieve high GVT performance.

Materials and Related Work

Related Works for Key Performance Indicators (KPIs), Variables, and Measures

Past studies have revealed that project success is greatly influenced by efficient and effective communication among members of virtual teams. The result of lack of communication in sharing knowledge leads to poor performance of team (Lee, 2013). Therefore, there is a need for members of virtual teams to attend training for the purpose of gaining the skills required by the project and to also learn the act of information sharing (Brent Booth Prescott Valley, 2011).

Hill (2013) suggested that training should be conducted at the inception of a team and when other members join. Just like other teams, virtual teams need to be trained from time to time so that their skills will be sharpened. Virtual team members need to be trained in the areas of professional disciplines, competency and skills training, training in practices, products and processes as well as trainings related to the introduction and use of new technology and tools.

Increasing popularity of virtual teams and the challenges which they face makes it important for researchers to find ways through which new training strategies will help management address these challenges (Kulesza, 2015). While research on GVTs is increasing, many questions remain regarding what is needed to ensure their effectiveness. The face-to-face meetings and socialization can serve to strengthen the bond between team members, whereas socialization in GVTs is difficult to achieve because of lack of face-to-face meetings. So, commitment should be considered as an important factor in GVTs environment (Powell et al., 2004).

For many years the subject of commitment has been widely covered in the literature of organizational behavior (Meyer & Allen, 1997). Attitudinal and behavioral commitment are the two basic kinds of commitment (Mowday et al., 1979). The process through which people have a reflection on their relationship with the organization is covered by attitudinal commitment. It can also be described as the “mind set” which individuals possess in relation to the degree to which their goals and values correspond with that of the organization. There are three types of attitudinal commitment that have been defined and widely accepted and they include affective, normative and continuance commitment (Cotton & Tuttle, 1986).

Definition related to the nature of commitment which has continued to be the focus of organizational commitment has been defined by different elements. Three elements of

commitment which have been defined by Meyer and Allen (1991) include: affective commitment (emotional attachment, identification and involvement with organization); continuance (awareness of costs which could be incurred by leaving the organization); and normative (feeling of obligation to remain with the organization) or, simply put by O'Reilly and Chatman (1986) "want to, need to, ought to". To achieve successful GVTs, the organization must develop a commitment among its members (Batarseh et al., 2017).

Motivation is very important to drive work in a virtual team project (Lurey & Raisinighani, 2001). The major factor that contributes to the success of GVTs is motivation (Richardson et al., 2012). It has been found that numerous problems that affect the performance of GVTs are caused by distance which affects members of GVTs adversely.

A research done by Geister et al., (2006) demonstrated that information and feedback about the situation of a team plays an important role in improving the satisfaction and motivation of members in virtual teams. The satisfaction and motivation of teams can be positively affected by increasing feedback; this can enhance teams' performance (Geister et al., 2006). Finally, the results of the study conducted by Sridhar et al., (2007) indicate that motivation is one of the factors that affect the performance of GVTs.

Efficiency is related to the time and cost to finish the software project. Effectiveness is related to the satisfaction of user (Sundqvist, Backlund, & Chron er, 2014). Saxena and Burmann (2014) measured the performance of global virtual teams' performance with effectiveness and efficiency. In this research; the measurement scale was originally used by Henderson & Lee (1992) whereas team performance is often evaluated on the basis of acceptance of a specified output (such as product or service) by a customer (Weimann, Pollock, & Scott, 2013). Access to online training was measured by the item scale developed by Bartlett (2001), Mahdi Almodarresi, Hajmalek, and Professor (2015), also used by Dhar (2015). Support for online training and development refers to the employees who get supports from their organizations to solve the problems. The item scale was adopted from Bulut & Culha (2010) based on scale adopted from Klein (2001), Noe and Wilk (1993), Almodarresi et al. (2015), also used by Dhar (2015).

Training program benefits can be observed from three different perspectives: (a) personal benefits, (b) job related benefits, and (c) career benefits Noe and Wilk (1993). It was measured using the item scale adopted from study by Bulut and Culha (2010), which was initially adopted from a study by Noe and Wilk (1993), Almodarresi et al. (2015), also used by Dhar (2015). Affective commitment, normative commitment, and continued commitment are used to measure organizational commitment. The scale developed by Meyer & Allen (1991), Sani (2013), and also used by Naqvi and Bashir (2015) was adapted to measure the items.

Motivation refers to the level of excitement and the drive to work in a global virtual team

project (Richardson et al., 2012). It was measured using item scale adopted from Noe and Schmitt (1986), also used by Bulut and Culha (2010) as well as Yanson et al., (2016). Team performance measures depend on the basis of acceptance of a specified output (such as product or service) by a customer (Weimann et al., 2013) (Table 1).

Table 1. Summarization of the research background Key performance indicators (KPIs), variables, and measures

Key Performance Indicators (KPIs)	Variables	Measures	Sources
Online Training and Development	Access to online training	The opportunity for the developers to attend the online training 24/7 from any device.	(Bartlett, 2001), (Almodarresi et al., 2015), and (Dhar, 2015).
	Benefits from online training	Grouped developer training benefits into three categories: personal benefits, career benefits and job related benefits. Personal benefits represent the extent to which developers believe that participation in training activities help to improve their job performance and make progress towards their personal development. Career benefits result from participation in training activities that lead to identifying career objectives, reaching career objectives and creating opportunity to pursue new career paths. Job-related benefits lead to better relationships between peers and Project Managers, and provide a necessary break from the job.	(Bulut and Culha, 2010) which was originally taken from a study by Noe and Wilk (1993) , (Almodarresi et al., 2015), also used by Dhar (2015)
	Support for online training	Organization supports upgrading and skills development to find better solution to work related problems	Bulut and Culha (2010) based on scale adopted from Klein (2001) and Noe and Wilk (1993) , Almodarresi et al. (2015), also used by Dhar (2015)
Organizational commitment	Organizational commitment	Developer's emotional attachment to organization, awareness of the costs associated with leaving the organization, and feeling of obligation to continue employment.	(Meyer and Allen (1991), Sani (2013), also used by Naqvi and Bashir (2015)
Motivation	Motivation	The degree to which developers are willing to make efforts to improve themselves and their task and job performance by training	Noe and Schmitt (1986), also used by Bulut and Culha (2010) and Yanson et al., (2016)
GVTs performance in GSD Projects	GVTs performance in GSD Projects (Project Efficiency and Project Effectiveness)	Strong management and internal organizational structures (time, cost, and specification) and user satisfaction.	Sundqvist et al. (2014), Saxena and Burmann (2014) which represent the efficiency and effectiveness for this study which was originally used by Henderson and Lee (1992), (Weimann et al., 2013)

Existing Training and Development Approaches and Hypothesis Development

According to Dhar (2015) and Almodarresi et al., (2015) the relationship between perceived access to training and organizational commitment is positive. Dhar (2015) and Almodarresi et al., (2015) found that there is a positive relationship between perceived support for training and organizational commitment. All employees who perceived support from their organizations feels committed to them (Brunetto et al., 2012). According to Facticeau et al., 1995, employees are more interested in participating in trainings if it is useful for them. It has also been observed by Phillips and Stone (2002) that the intangible outcomes of beneficial training programs are organizational commitment. There is therefore a positive relation between perceived benefits from training and organizational commitment Dhar (2015) and Almodarresi et al. (2015).

The performance of employees increased through trainings (Colbert, 2004). It is very important in improving their performance. Through training, the employees are encouraged to increase their commitment to the organization (Elmadağ et al., 2014). Perception of the employee about the importance of the training as well as the worth of the specific training is improved based on the way in which the supervisor frames the assignment of the training (Tai, 2006).

Olomolaiye et al., (1998) asserts that higher productivity can be enhanced through a properly designed system of reward and additional pay to gain the efforts of employees. Noe and Wilk (1993) found that an employee's participation in training courses is influenced by the benefits which the employee feels he/she can obtain from the training. The training motivation of the trainee increases if they sense the importance of the training (Cohen, 1990). List of the hypotheses from this study is as shown in Table 2.

Materials and Methods

This study undertakes two research methodologies, the first one is a systematic literature review based on original guidelines as proposed by Kitchenham (2004) and the second one is a survey.

1. Systematic Literature Review (SLR)

The SLR begins with planning the review, research identification, papers selection, extracting the data and finally, synthesizing the data (Figure 1). Systematic literature review was conducted to answer this research question (RQ) below:

RQ: What are the key performance indicators (KPIs), measures, and variables for assisting the GVT performance in GSD projects?

1.1. Planning the review

We start this research by providing a strategy for the systematic literature review. We start our searching for specific terms and resources from specific databases, specific journals, electronic books and conferences.

1.2. Research identification

We start this research by identifying the keywords and specific terms related to the topic of our research. General keywords are used to search for many various relevant papers regarding the key performance indicators (KPIs), measures, and variables for assisting the GVT performance in GSD projects. The search strategy for the review was directed towards finding published papers in archival journals, conferences and electronic books from nine electronic database, IEEE Explore, Science Direct, Research Gate, Springer Link, ACM, IOP, Wiley Online, IET Library, Scholar Space.

1.3. Papers selection

We used two techniques to select the papers and archival journals and conferences. The initial list based on reading the abstract and conclusion of the papers and the final list based on reading the full paper with details. Only 47 papers were considered in the final list. Our findings are based on papers published in archival journals, conferences and electronic books from nine electronic database, IEEE Explore, Science Direct, ResearchGate, Springer Link, ACM, IOP, Wiley Online, IET Library, Scholar Space. The selected source of the research papers used are published from 2013-2019. The shortlisted studies were published all year long, with their distribution over public venues and presentations were made. A total of 47 articles were used for this study.

1.4. Extracting the data

The researchers extracted the information from the selected papers about the key performance indicators (KPIs), measures, and variables for assisting the GVT performance in GSD projects.

1.5. Synthesizing the data

We divided the work into two main parts, the first one focused on collecting the information about the concepts of global virtual teams by going through the definitions of global virtual teams, and its performance, and the second one focused on the key performance indicators (KPIs), measures, and variables for assisting the GVT performance in GSD projects.

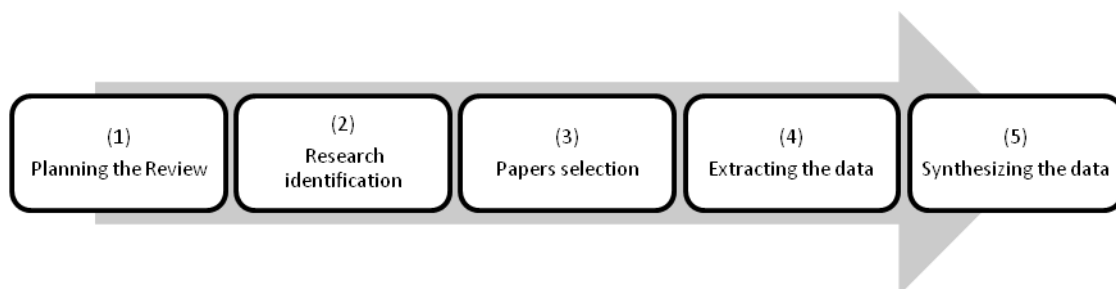


Figure1. Systematic Literature Review

2. The survey

The survey respondents were randomly selected from different IT companies based in Technology Park Malaysia (TPM) using snowball sampling technique. These companies have several staff members working virtually with other companies and individuals in countries like Iraq, Ukraine, and Syria. Among 40 respondents, 25 accomplished the survey for the pilot study which was recommended by Sekaran and Bougie (2011). For the empirical study, only 103 survey respondents were from these companies. Thus,

the total number of respondents was 140. The sample size is supported by Krejcie and Morgan Table (1970), (Guthrie, 2010), and also recommended by Components and Variables (2014) while the data was analyzed using PLS- SEM as supported by Lurey and Raising Hani (2001).

3. Model validation

Next, a usability test of the system was conducted in three IT companies at TPM. These companies were randomly selected and have staff members working virtually. Eleven project managers were asked to fill out the system usability scale (SUS) questionnaire (Salvendy, 2010; Albert & Tullis, 2013). The questionnaires asked for the respondents' opinion about ease of use when performing different tasks on the prototype, which was adopted from Harrati et al., (2016) and originally from Brook et al., (1996). The subjective assessment of usability from the questionnaires is based on a Likert scale. The instrument is intended to measure the key variables of the study using a five-point Likert-type rating scale (ranging from "strongly disagree" to "strongly agree") with 10 questions related to satisfaction, efficiency, and effectiveness.

Results and Discussions

1. The survey

According to the analysis, access to online training on global virtual teams' performance and global IT projects success was positive and significant which had the highest effect ($B=0.282$, $p=0.001$) followed by supervisory support for online training ($B=0.263$, $p=0.008$). Perceived benefits of online training also had positive influence on global virtual teams' performance and global IT projects success ($B=0.240$, $p=0.009$).

Results of boot strapping method after introducing mediator variables (organizational commitment) in the model showed the effect of all three independent variables including access to online training ($B=0.158$, $p=0.014$), supervisory support for online training ($B=0.228$, $p=0.003$) and perceived benefits of online training ($B=0.123$, $p=0.047$) were not statistically significant on global virtual teams' performance and global IT project success while all these IVs significantly influenced organizational commitment as a mediator. These results indicated that supervisory support for online training ($B=0.405$, $p=0.027$) followed by access to online training ($B=0.281$, $p=0.002$) had the highest effect on organizational commitment and the lowest effect belonged to perceived benefits of online training ($B=0.235$, $p=0.000$). According to these results organizational commitment showed a significant and positive effect on global virtual teams' performance and global IT projects success ($B=0.562$, $p=0.000$).

The results found that motivation was able to moderate positively the relationship between access to online training global virtual teams' performance and global IT projects success ($B=0.191$, $p=0.031$) while the moderating effect of motivation for perceived benefits of online training ($B=0.080$, $p=0.098$) and supervisory support for online training ($B=-0.079$, $p=0.336$) was not statistically significant. According to the results, it was found that motivation was able to moderate positively the relationship between access to online training global virtual teams'

performance and global IT projects success. The moderating effect of motivation for perceived benefits of online training and supervisory support for online training was not statistically significant (Table 2).

Table 2. List of hypotheses and relative paths

Hypothesis	Path	B	T value	p value	Result
H1 (a): Access to training is related positively to GVTs performance in Global Software Development (GSD) Projects.	AOT -> GPF	0.282	3.497	0.001	Supported
H1 (b): Developers' perceived degree of support for online training positively affects GVTs performance in Global Software Development (GSD) Projects.	SSOT -> GPF	0.263	2.672	0.008	Supported
H1 (c): Developers' perceived degree of benefits from online training positively affects GVTs performance in Global Software Development (GSD) Projects.	PBOT -> GPF	0.240	2.726	0.009	Supported
H2 (a): Access to training is related positively to organizational commitment.	AOT -> OC	0.281	3.183	0.002	Supported
H2 (b): Developers' perceived degree of support for online training positively affects their commitment level.	SSOT -> OC	0.405	4.568	0.027	Supported
H2 (c): Developers' perceived degree of benefits from online training positively affects their commitment level.	PBOT -> OC	0.235	2.244	0.000	Supported
H3: Organizational commitment has a positive relationship with GVTs performance in Global Software Development (GSD) Projects.	OC -> GPF	0.562	4.607	0.000	Supported
H4 (a): Organizational commitment mediate the relationship between accessibility to online training and GVTs performance in Global Software Development (GSD) Projects.	AOT -> OC -> GPF	0.158	2.499	0.014	Supported
H4 (b): Organizational commitment mediate the relationship between perceived support for online training and GVTs performance in Global Software Development (GSD) Projects.	SSOT -> OC -> GPF	0.228	3.045	0.003	Supported
H4 (c): Organizational commitment mediate the relationship between perceived benefits from online training and GVTs performance in Global Software Development (GSD) Projects.	PBOT -> OC -> GPF	0.132	2.012	0.047	Supported
H5 (a): Motivation moderate the relationship between accessibility to online training and GVTs performance in Global Software Development (GSD) Projects.	AOT * MOT -> GPF	0.191	2.184	0.031	Supported
H5 (b): Motivation moderate the relationship between perceived support for online training and GVTs performance in Global Software Development (GSD) Projects.	SSOT * MOT -> GPF	-0.079	0.966	0.336	Not Supported
H5 (c): Motivation moderate the relationship between perceived benefits from online training and GVTs performance in Global Software Development (GSD) Projects.	PBOT * MOT -> GPF	0.080	1.225	0.098	Not Supported

2. The validation of PMM

The results of this study are presented in the form of interpretive structural modeling steps. A usability test of the system was conducted in three IT companies at TPM. These companies have several staff members working virtually and they were randomly selected using snowball sampling technique. A total of 11 Project Managers were asked to complete an online survey.

The results were analyzed by using SPSS 22 as presented in Table 3. Results show that most of the respondents strongly agree that the system is easy to use and usable (40.90% for “strongly agree” and 27.20% for “agree”). According to users’ responses to item, 90.91% said that they would like to use the system often. For item 19 (“I found the system unnecessarily complex”), 72.73% of the respondents agreed. However, users’ responses are high on “agree” (81.82%) and “disagree” (18.18%) because this item is a negative one.

The respondents also disagree with item 23 (“I thought there was too much inconsistency in this system”) with a total of 100%. Additionally, responses to item 25 (“I found the system cumbersome to use”) shows that the users found the system easy and not cumbersome. Item 24 proves that the system is easy to learn, as shown 90.91% of the respondents “strongly agree”. Finally, the results obtained from the 10 items related to the system usability show that the system usability is high, and the users were very satisfied (Table 3).

Table 3. Frequency distribution for responses related to usability

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
18	0	0	0	1 (9.09%)	10 (90.91%)
19	0	0	0	8 (72.73%)	3 (27.27%)
20	0	0	0	5 (45.45%)	6 (54.45%)
21	2 (18.18%)	9 (81.82%)	0	0	0
22	0	0	0	3 (27.27%)	8 (72.73%)
23	4 (36.36%)	7 (63.64%)	0	0	0
24	0	0	0	1 (9.09%)	10 (90.91%)
25	1 (9.09%)	10 (90.91%)	0	0	0
26	0	0	0	3 (27.27%)	8 (72.73%)
27	6 (54.55%)	5 (45.45%)	0	0	0
Total	11.82%	28.20%	0	27.20%	40.90%

3. Contribution of research (The Performance Measurement Model (PMM))

The main contribution of this research is to develop PMM. This model consists of four steps to be followed by the Project Manager in measuring the GVT performance. These steps are data and information gathering, mind-mapping strategy, measuring the GVT performance, and comparing the results (Figure 2).

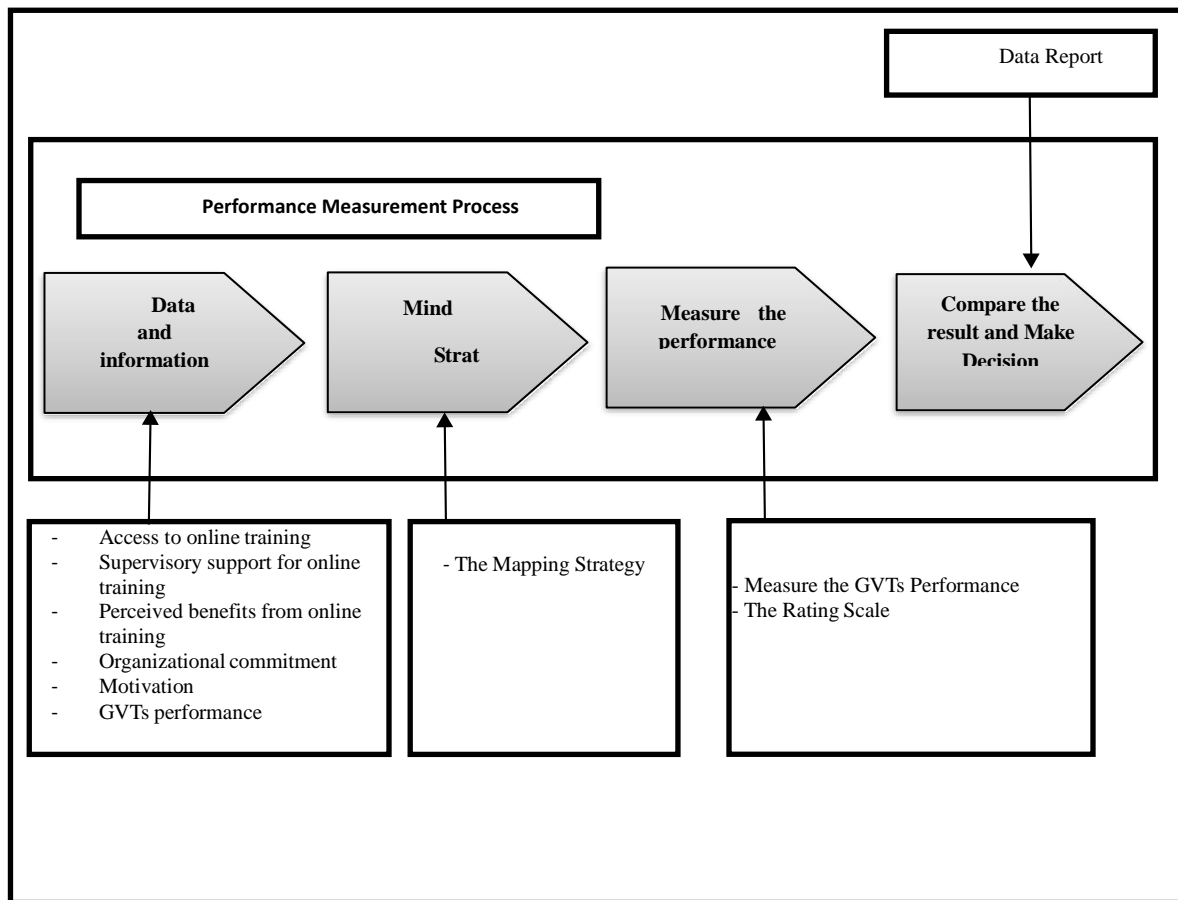


Figure 2. The performance measurement model (PMM) for GVTs in global software development (GSD) Projects

The process of performance measurement includes four steps. Performance measurement is a sequential approach, and each step is based on an input and a produced output. Each step consists of several related activities, with each activity requiring a related input to ensure that an outcome is generated. Mind mapping is a technique used in visually representing the processes that contain ideas and concepts about a problem (Buzan et al., 2010).

The first step in the process of mind mapping is to place a thought in the middle of the map. The issue or problem to be addressed is positioned in the middle of the map. Afterwards, groups of related concepts are linked to the central focus using arrows that show the associations among them. Therefore, it can be said that through mind mapping a process of addressing an issue can be holistically viewed; evidence has shown that both left brain and right brain thinking can be enhanced through the use of mind mapping as a learning tool (Wycoff & Trade, 1991) (Figure 3).

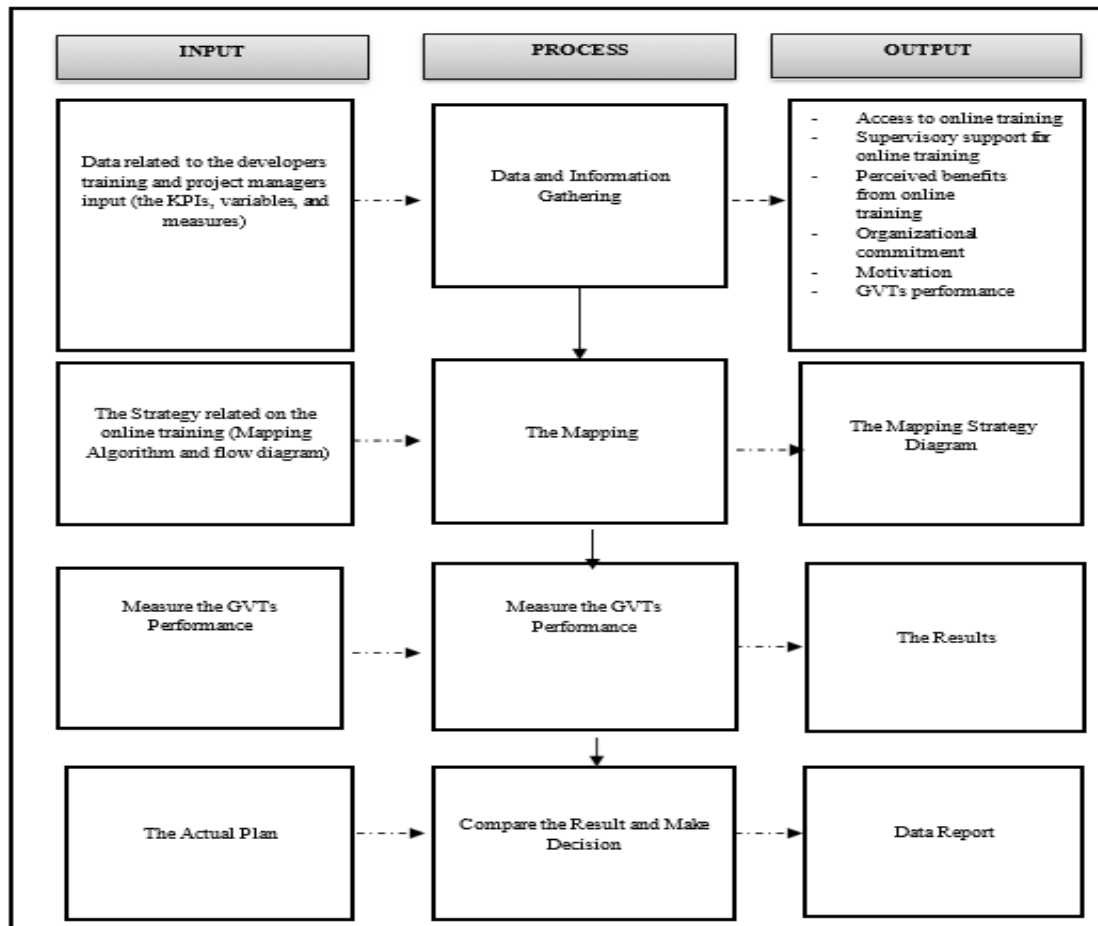


Figure 3. Input, process, and output of the performance measurement process

The Project Manager measure the GVTs performance based on the Key Performance Indicators (KPIs), Variables, and Measures. The data and information gathered are calculated to get the mean value and average score value using the following formula below:

$$\text{Feedback score, } FSQ = \sum (\text{score value} \times \text{number of developer})$$

$$\text{The Mean Value, } MQ = FSQ / D$$

$$\text{The Average Score Value} = \sum FSQ / E$$

Where:

FSQ = Feedback Score for each Feedback (question)

D = total number of developers

E = Total number of Questions for each feedback evaluation AVS = Average Score Value

The developers' perception to online training program is easy to access. Accessibility to online training is positively related to employees' commitment. There is a positive relationship

between perceived support for online training and commitment level of developers towards their organization. The commitment level of employees will increase if they get the expected support from their organizations. Perceived benefits from attending the online training program have a positive relationship with their commitment level. This suggests that those developers who expect that attending training programs will be beneficial are likely to develop a higher level of commitment towards their organization.

The organizational commitment has a positive relationship with GVTs performance. According to the findings, we suggest that when developers develop a higher-level commitment towards their organization, they tend to perform well by providing high performance in terms of efficiency and effectiveness. Online training (perceived access to training, perceived support for training, and perceived benefits from training) and GVTs performance is mediated by organizational commitment. This signifies that the commitment level of developers towards their organization influence the GVTs performance they offered when they perceived training programs are positive step taken by management for their development. On the other hand, access to online training and GVTs performance is moderated by motivation. Rating scales are as shown in Table 4.

Table 4. Rating scales

Score	Rating Scale
0-0.99	Unacceptable
1.0-2.49	Below Average
2.5-2.99	Average
3.0-4.49	Good
4.5 -5.0	Excellent

From the discussion above, the Project Manager is able to make a clear view on the relationship among the variables. The Project Manager is also able to draw the ideas on how to measure the GVTs performance according to these relationships among variables by using the mind mapping strategy (Figure 4).

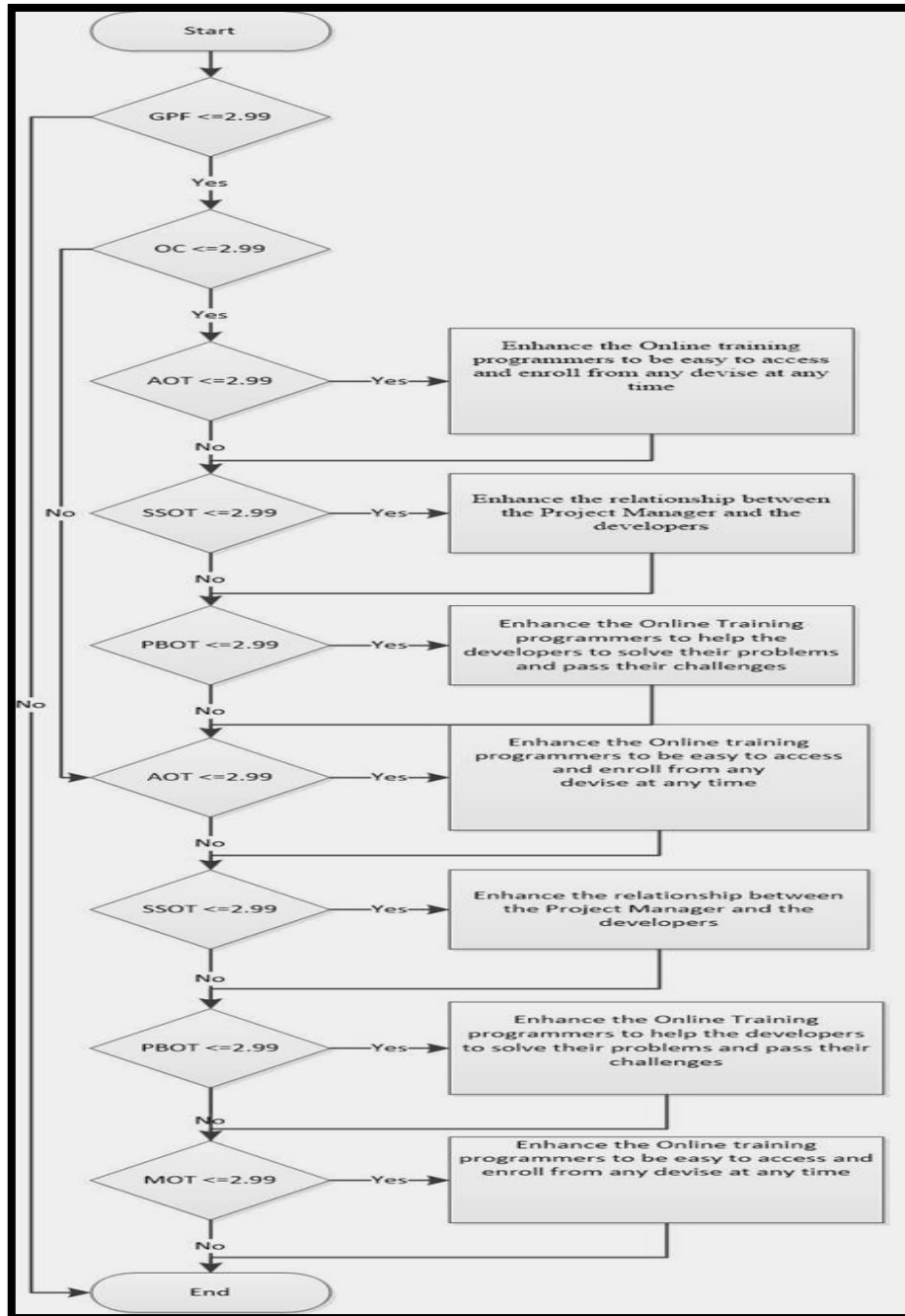


Figure 4. Project manager decision making flow diagram

Conclusion and future work

The model provides the project manager a clear representation of ideas that can be used in measuring and improving the performance of GVTs. These ideas are derived from the relationships among the variables. The model provides a mind map of ideas, which are the variables that are essential for the GVT performance.

A project manager is able to measure the performance through the level of organizational commitment, motivation, and access to online training and development because performance is influenced by these variables. In fact, if a project manager finds out that the level of motivation is low among virtual workers, then he/she can know that the performance level will also be affected (it may be low). With this knowledge, the project manager will be able to take the necessary steps towards improving motivation, which will in turn increase the performance level. The results showed that access to online training and performance of GVTs in GSD is positively moderated by motivation. This finding was also observed by Tai (2006). Further research should be conducted to identify those factors responsible for the negative relationships found by previous studies and how these relationships can be enhanced in the future.

Notes

GPF: global virtual teams performance, AOT: access to online training, PBOT: perceived benefits from online training SSOT: supervisory support for online training, OC: Organizational Commitment, MOT: Motivation

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Bibliographic information of this paper for citing:

Gheni, Ali Yahya; Jusoh, Yusmadi Yah; Jabbar, Marzanah A.; Ali, Norhayati Mohd; Shanmugam, Mohana, & Adel Yousif, Hiba (2019). Measuring the performance of the virtual teams in global software development projects. *Journal of Information Technology Management, 11*(1), 42-59.

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