

# Enhancing Virtual Team Performance Through a Quantitative-Based Management Model (VTPM)

Sathya A/L Nantha Kumar, Zulkefli Mansor  
Faculty of Information Science and Technology,  
Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia

**Abstract**—The rapid growth of globalization, digital transformation, and remote working practices has significantly increased the reliance on virtual teams within modern organizations. Despite their advantages, virtual teams continue to face challenges such as communication barriers, inadequate technology management, unclear role allocation, ineffective strategic planning, and excessive documentation practices, all of which negatively affect team performance. This study aims to identify the key factors affecting virtual team performance and to develop a structured Virtual Team Performance Management (VTPM) model to improve the effectiveness of virtual collaboration. A quantitative research approach was adopted, involving questionnaire-based data collection with 110 respondents who had worked in virtual teams (instrument reliability testing was conducted using Cronbach’s Alpha analysis). The findings indicate that role clarity, effective communication, effective strategic planning, task allocation, and appropriate management of technology are important in the determination of the performance of virtual teams. Specifically, 39.1% of respondents rated communication as “needs improvement,” 63.6% agreed that excessive documentation reduces efficiency, and 56.4% strongly agreed that strategic planning is effective. On this premise, the Virtual Team Performance Management Model (VTPM) has been constituted and validated by three academic and industry experts through expert evaluation. The model received positive evaluations from academic and industry experts regarding its practicality and relevance in virtual team environments. This study provides a comprehensive and empirically informed model that organizations can apply to improve the work of virtual teams.

**Keyword**—Virtual teams; team performance; remote work; VTPM model; communication; quantitative study

## I. INTRODUCTION

The latest dramatic shifts to digital technology and overwhelming effects of globalization have created and triggered the enormous application of virtual teams, groups of people that are physically separated and communicate using digital media. This change was also triggered by the onset of the COVID-19 pandemic [7], [32]. Among these advantages, virtual teams introduce the following, which include flexibility, access to global talent, and reduced cost of operation [32]. Nevertheless, they suffer significant performance challenges, which consist of communication barriers, leadership challenges, and the overuse of digital and asynchronous tools [5], [19], [32], the ambiguity of the roles that lead to the

undermining of accountability [11], [43], which is determined by the absence of technology use or insufficient training [42]. Other than this, the absence of systematic strategic planning can lead to long delays in the processes and ineffective communication [22].

Scope boundary of the VTPM model: The VTPM model is empirically informed for technology-mediated, task-oriented virtual teams operating in corporate, public, and academic sectors. It assumes stable internet connectivity, basic digital literacy among team members, and the use of standard collaboration tools (e.g., Microsoft Teams, Zoom, Slack). The model may not be directly applicable to purely social virtual communities, emergency response teams, highly creative design teams where unstructured communication is critical, or teams in low-connectivity environments without adaptation. Fig. 1 illustrates the key challenges affecting virtual team performance identified from the literature review and empirical observations.



Fig. 1. Key challenges affecting virtual team performance.

Despite the numerous models of performance, a large part of performance models has not been empirically informed and has no implication to be applied practically to virtual teams in the actual real-life context [22], [27]. In one of the attempts to fill this knowledge gap, the suggested research offers the Virtual Team Performance Management Model (VTPM). The model is aimed at fulfilling three clear objectives, namely, to recognize the issues of virtual teams, to recognize the key factors that influence their performance, and to develop a management framework supported by empirical findings, based on the received results.

## II. LITERATURE REVIEW

Virtual teams operate across geographical and cultural boundaries using digital tools [4]. Their outcomes depend on interconnected factors including communication, technology,

leadership, and trust. This review synthesizes existing literature to establish a theoretical foundation for the Virtual Team Performance Management (VTPM) model, identifying key performance determinants, challenges, and limitations of existing frameworks.

### A. Key Determinants of Virtual Team Performance

Communication drives coordination and trust in virtual teams through message clarity, appropriate frequency, open dialogue, and responsive leadership [1], [16], [20], [48]. Mismatches between message medium and task type create problems because complex issues require real-time discussion [38]. Effective communication demands both technical access and relational competence across diverse team backgrounds [18].

Technology management directly impacts performance through tool adequacy, availability, reliability, and user competence [12]. High-performing teams integrate communication, collaboration, and project management systems [25]. Post-deployment training gaps remain common [23], and inadequate tools and information-sharing practices generate both delays and psychological burden in agile virtual teams [24], [32].

Role clarity is essential where informal cues are absent. Ambiguity causes duplicated work, missed tasks, and interpersonal conflict [43]. Defined positions enhance coordination, productivity, and confidence [43], requiring leaders to articulate and revisit responsibilities regularly, particularly in agile software development contexts [15].

Strategic planning in distributed work demands explicit task breakdowns, visible priorities, and established deadlines [22]. Strategic planning encompasses goal setting, activity prioritization, and ensuring members understand their role in the broader project context [47]. Effective planning reduces communication waste; excessive messaging often signals poor planning rather than active collaboration [31].

Documentation preserves organizational memory, retaining decisions and enabling continuity [45]. Quality records enhance transparency and accountability [46], while poor recordkeeping creates operational failures. Performance monitoring, when oriented toward process improvement rather than surveillance, enables early problem identification and works most effectively when integrated with documentation practices [41].

Trust develops through demonstrated reliability and competence [13], requiring structured and consistent management practices in virtual settings where face-to-face interaction is limited [43].

### B. Existing Models and Their Limitations

Several models have attempted to address virtual team management, as summarized in Table I.

Despite their contributions, existing models suffer from three common limitations: they lack empirical support, cannot be readily operationalized into actionable management practices [39], or fail to integrate multiple performance determinants simultaneously [22], [27]. Recent studies also

highlighted that agile transformation and knowledge management practices influence collaboration, project values, and team coordination within virtual project environments [33], [34].

TABLE I. COMPARATIVE ANALYSIS OF EXISTING VIRTUAL TEAM MANAGEMENT MODELS

Model	Weakness	Comparison / Contribution
Kauffmann & Carmi [23]	Limited attention to collaboration tools and cultural diversity	Emphasizes communication and team integration
Iyamu & Adelakun [22]	Limited practitioner involvement	Focuses more on collaboration than overall team performance
Lumseyfai [27]	Based on a single organizational context	Integrates human interaction, technology, and governance
Holtz [21]	Lacks feedback and leadership communication elements	Highlights engagement and emotional management
Wei [42]	Limited focus on collaboration technologies	Emphasizes team diversity and communication processes
Garro-Abarca [19]	Limited attention to tools and technology management	Highlights communication and trust in team performance

### C. Research Gap and Study Contribution

The literature establishes that virtual team performance depends not on geographical distance but on coordinated management practices. Performance is a multidimensional phenomenon requiring integrated attention to communication, technology, planning, documentation, and role clarity. However, no existing model provides an empirically informed, practically operationalizable framework that addresses all these dimensions together.

This study fills this gap by developing the Virtual Team Performance Management (VTPM) model, a systematic, empirically supported framework designed to enhance virtual team performance through integrated management of communication, technology, strategic planning, documentation, and role clarity.

## III. METHODOLOGY

This study employs a quantitative research methodology to investigate factors influencing virtual team performance and to develop a structured management model. The methodology is structured into four main phases: theoretical study, empirical study, model development, and model validation.

### A. Research Design

A quantitative research design was adopted to allow the organized collection of data and statistical analysis [2]. The four-phase approach consists of: 1) a literature review to determine the issues of interest, 2) an empirical investigation (through a questionnaire- Appendix), 3) the development of the Virtual Team Performance Management Model (VTPM), and 4) expert validation of the model. Fig. 2 illustrates the four-phase research methodology adopted in this study. This is done to make sure that the model is conceptually grounded and quantitatively supported.

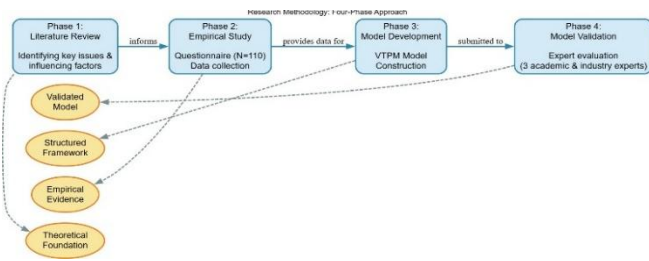


Fig. 2. Four-phase research methodology.

### A. Population and Sampling

People with experience in virtual teamwork in different industries were the target population. With the purposive sampling technique, 110 respondents were sampled in the study, and this was considered sufficient to provide a statistical description and a valuable understanding of virtual team practices [43]. The study involved 110 respondents selected using purposive sampling techniques. The sample size was considered sufficient to identify patterns, trends, and perceptions related to factors affecting virtual team performance.

### B. Data Collection Instrument

Data were collected via a structured questionnaire developed from the literature review, covering demographics, communication effectiveness, technology management, strategic task planning, role clarity, and documentation

TABLE II. RELIABILITY TEST RESULTS OF PILOT STUDY

Section	Construct	Number of Items	Sample Size	Cronbach's Alpha
A	Demographic Information	13	33	-
B	Communication Management in Virtual Teams	15	33	0.829
C	Technology Management in Virtual Teams	14	33	0.704
D	Strategic Planning and Effective Task Allocation	5	33	0.726
E	Documentation	3	33	0.775
F	Role Clarity	4	33	0.773

### E. Model Development

VTPM model was constructed out of the identification of the key factors found in the literature and empirical evidence as core components: communication management, technology management, role clarity, strategic task planning, and documentation. The interdependence of these elements is what constitutes the model structure.

### F. Model Validation

Three academic and industry professionals evaluated the relevance, effectiveness, and applicability of the proposed model through expert evaluation. The analysis indicated that the model is realistic and applicable in the practical management of virtual teams.

### G. Ethical Considerations

Participation was voluntary, and none had to engage in the research without their consent; they were made aware of the purpose of the research, and all information was kept

practices. All items were measured on a five-point Likert scale to quantify perceptions and support analysis.

### C. Instrument Validation and Reliability

The questionnaire was subjected to content validation to ensure that the constructs were measured appropriately and to support reliable statistical analysis of questionnaire data [2], [44]. A pilot study involving 33 respondents was conducted to evaluate the reliability of the research instrument using Cronbach's Alpha analysis through SPSS. The reliability analysis demonstrated acceptable internal consistency across all constructs. The Communication Management construct recorded a Cronbach's Alpha value of 0.829; Technology Management recorded 0.704; Strategic Planning and Effective Task Allocation recorded 0.726; Documentation recorded 0.775; and Role Clarity recorded 0.773. These values exceeded the acceptable threshold of 0.70, indicating satisfactory reliability and suitability of the instrument for quantitative data collection and analysis. Table II presents the reliability analysis results obtained from the pilot study using Cronbach's Alpha.

### D. Data Analysis Techniques

The frequency distribution, percentage analysis, and mean score analysis of the virtual team were employed as descriptive statistical tools to identify patterns and examine factors affecting virtual team performance. The analysis focused on identifying patterns, respondent perceptions, and commonly observed factors influencing virtual team performance.

confidential and was to be used in an academic context only.

### H. Summary of Methodology

The methodology offers a systematic and trustworthy way of exploring the performance of a virtual team. The study provides empirical support for the proposed VTPM model since it will be combined with a quantitative analysis and validated with respect to experts.

## IV. RESULTS AND DISCUSSION

This section presents the empirical results provided by the questionnaire survey that was conducted among the virtual team practice people. The data are analyzed based on descriptive statistics, which encompass the frequencies, percentages, and means of the data. Table III presents the gender distribution of the respondents involved in the study. The results are organized in the form of major elements that affect Virtual Team Performance Management (VTPM). Table IV summarizes the educational background of the respondents.

TABLE III. GENDER DISTRIBUTION

Gender	Frequency	Percentage (%)
Male	62	56.4
Female	48	43.6
<b>Total</b>	<b>110</b>	<b>100.0</b>

TABLE IV. EDUCATION LEVEL

Education	Frequency	Percentage (%)
SPM/STPM	2	1.8
Diploma	12	10.9
Bachelor's degree	66	60.0
Postgraduate	29	26.4
PhD	1	0.9
<b>Total</b>	<b>110</b>	<b>100.0</b>

A. Descriptive Analysis

1) *Respondent demographics*: A total of 110 respondents participated in this study. Table V presents the types of organizations represented by the respondents.

B. Communication Analysis

The findings reveal that communication is a sensitive issue that influences the performance of virtual teams [19]. Most of the respondents (39.1%) reported the necessity of communication being improved, and the assessment of communication effectiveness has a great discrepancy. The survey indicated that there was inconsistency in leadership communication practices, as 46.4 percent of the surveyed revealed that leaders only communicate on a part-time basis about tasks and roles [15]. Besides, 39.1% of respondents said that they hardly get constructive feedback, implying a significant deficiency in leadership engagement. Table VI summarizes respondent perceptions regarding communication effectiveness in virtual teams.

C. Technology Management Analysis

Most respondents (48.2%) experienced issues occasionally, indicating moderate reliability challenges [42]. Only 35.5% reported sufficient training frequently, indicating a need for improved training strategies [50]. Table VII presents the frequency of technology-related issues experienced in virtual teams.

D. Strategic Planning and Task Allocation

Most respondents agreed that effective strategic planning and task allocation positively influence virtual team performance. Specifically, 56.4% of respondents strongly agreed that strategic planning with effective communication improves productivity within virtual teams, while another 56.4% strongly agreed that poor task allocation and lack of strategic planning result in repetitive and unnecessary communication. Table VIII summarizes respondent perceptions regarding strategic planning and task allocation effectiveness. These findings indicate that structured planning, clear communication, and proper task allocation are essential for improving coordination and overall effectiveness in virtual teams [47].

E. Documentation Analysis

63.6% of respondents agreed that excessive documentation exists, which may reduce efficiency [45].

F. Role Clarity Analysis

Although most respondents agreed that roles are clear, over 50% also reported difficulties when roles are not defined [43].

TABLE V. TYPE OF ORGANIZATION

Organization	Frequency	Percentage (%)
Academic	10	9.1
Public	22	20.0
Corporate	73	66.4
Others	5	4.5
<b>Total</b>	<b>110</b>	<b>100.0</b>

TABLE VI. COMMUNICATION LEVEL IN VIRTUAL TEAMS

Level	Frequency	Percentage (%)
Very Poor	8	7.3
Poor	10	9.1
Needs Improvement	43	39.1
Satisfactory	39	35.5
Effective	10	9.1
<b>Total</b>	<b>110</b>	<b>100.0</b>

G. Discussion

The results show that the most important factors in the performance of a virtual team are communication, technology management, and clarity of roles [3], [39]. The issue of communication issues, especially in feedback regarding leadership and clarity of leadership, affects team effectiveness a lot [1], [6]. The issues associated with technology are another cause of inefficiency in that there is a lack of training and problems associated with the tool [12]. Strategic planning enhances productivity when it is correctly applied, but failure to maintain consistent task allocation compromises team performance [29], [47], [49]. Furthermore, too much documentation and role ambiguity create team inefficiencies and confusion [46]. Fig. 3 summarizes the key quantitative findings obtained from the survey respondents.

Key Quantitative Findings (N=110)	
Communication Needs Improvement	39.1%
Technology Issues (Sometimes/Often)	64.6%
Insufficient Training Reported	35.5%
Effective Planning Improves Productivity	56.4%
Task Allocation Poorly Executed	42.7%
Excessive Documentation	63.6%
Difficulties When Roles Unclear	>50%

Key Quantitative Results

Fig. 3. Key quantitative findings (N=110).

TABLE VII. ISSUES WITH COLLABORATIVE TOOLS

Frequency of Issue	Frequency	Percentage (%)
Never	1	0.9
Rarely	29	26.4
Sometimes	53	48.2
Often	18	16.4
Always	9	8.2
<b>Total</b>	<b>110</b>	<b>100.0</b>

TABLE VIII. STRATEGIC PLANNING EFFECTIVENESS

Response	Frequency	Percentage (%)
Strongly Disagree	2	1.8
Disagree	8	7.3
Slightly Agree	15	13.6
Agree	23	20.9
Strongly Agree	62	56.4
<b>Total</b>	<b>110</b>	<b>100.0</b>

In general, the findings can be utilized to work on a structured VTPM model with communication, technology, planning, documentation, and role clarity as the primary aspects of it.

#### V. VIRTUAL TEAM PERFORMANCE MANAGEMENT (VTPM) MODEL DEVELOPMENT

In this part, the framework of Virtual Team Performance Management (VTPM) is developed. This step is aimed at transforming the findings made during the literature review and the conducted empirical research into a model structure that could be employed to enhance the management and performance of virtual teams. The section covers the logic of this model, the types of factors of the model, a suggested framework, functions of each aspect, and the method of professional validation that is applied to determine the value and applicability of the model. The model was developed following the necessity to offer a practical and holistic structure of organizations and team leaders who work with virtual teams [37]. As the results of the last chapter revealed, various factors constantly recur, as they affect the performance of a virtual team, and the most frequent are the management of communication, the use of technology, planning of the tasks, documenting, and clarity of role in a virtual team. Table IX presents respondent perceptions regarding documentation practices in virtual teams. The findings that were made served as the keystone to determining the key elements of the model and arranging them into a logical framework that helps in performance management in distributed team setups. The influencing factors mentioned above had to be sorted out into categories to build the model beforehand. Table X summarizes the responses related to role clarity within virtual teams. Such a classification narrows down the scope of comprehending the contribution of the various approaches applied by management to the success of virtual teams. The section, accordingly, starts by talking of the classification of

the factors and then goes on to describe the proposed model and its validation.

TABLE IX. DOCUMENTATION VOLUME

Response	Frequency	Percentage (%)
Strongly Disagree	3	2.7
Disagree	13	11.8
Slightly Agree	24	21.8
Agree	48	43.6
Strongly Agree	22	20.0
<b>Total</b>	<b>110</b>	<b>100.0</b>

TABLE X. ROLE CLARITY

Response	Frequency	Percentage (%)
Strongly Disagree	1	0.9
Disagree	12	10.9
Slightly Agree	27	24.5
Agree	44	40.0
Strongly Agree	26	23.6
<b>Total</b>	<b>110</b>	<b>100.0</b>

#### A. Categorization of Key Influencing Factors in Virtual Team Performance Management

Classification of the management-related components or elements, based on the empirical findings, was the next step in the model development process. Judging by the questionnaire answers and the discussion in the last section, the most important aspects that influenced the performance of virtual teams were summarized into five major categories:

- Effective Communication Management
- Adequate Technology Management
- Effective Strategic Planning and Task Allocation
- Documentation
- Role Clarity

These five categories were chosen due to their reiteration as the most pertinent and pertinent areas that were relevant in the literature review as well as in the empirical investigation. Their combination constitutes the management aspects that are necessary to coordinate successfully, monitor, and enhance virtual team performance [28]. Mapping the forty-questionnaire metrics into these five categories was also done during the classification process. Most metrics can be found in the communication category since communication was ranked as the most central activity in the operations of a virtual team [1]. Such areas that are covered by technology management are collaboration tools, training, availability of tools, and successful utilization of digital platforms. Strategic planning and task allocation involve the aspects that are related to clear planning, task allocation, and work coordination. Documentation is the process of documenting and maintaining the information regarding the project. The factors addressed by

role clarity are those pertaining to clarity of expectations and responsibility, as well as accountability. The importance of this categorization is that a substantial number of individual survey measures are reduced to a manageable and meaningful structure through this categorization. The model does not consider metrics independently but clumps the related practices into fundamental managerial units. This aids in interpretation as well as practice since the organizations can adopt the model by paying attention to these five big areas rather than solitary concerns.

### B. Proposed Virtual Team Performance Management (VTPM) Model

The results of the empirical study conducted in this study were the foundation for the development of the Virtual Team Performance Management (VTPM) model. The suggested model was created to assist organizations and team leaders in controlling their virtual teams more efficiently and enhancing the performance of their teams. The model is grounded on the five most important elements realized in empirical research: Effective Communication Management, Adequate Technology Management, Effective Strategic Planning and Task Allocation, Documentation, and Role Clarity. The components mentioned were based on the results of the surveys and are regarded as crucial in managing virtual teams [30]. Effective Communication Management has been utilized as the go-to mechanism in virtual teams in an effort to ensure easy communication and effective work among team members [20]. Another essential consideration is Adequate Technology Management, which focuses on the utilization of technological resources and platforms, as well as on their oversight and maintenance to support communication and collaboration [42]. In the VTPM model, Effective Strategic Planning and Task Allocation become one of the attributes that are needed to attain alignment with the project objectives, as well as to allocate work efficiently [22]. Documentation is also considered necessary to ensure transparency and that other information and project developments are well recorded and communicated [45]. Role Clarity is another important factor in virtual teams since it makes every team member understand their tasks, role, and the role they have in relation to others in the project as a unified team [43]. The suggested VTPM is a framework of management for enhancing the performance of virtual teams. Fig. 4 presents the proposed Virtual Team Performance Management (VTPM) model developed from the empirical findings. Through taking into account and applying all five primary aspects, organizations and team leaders can better manage the distributed work and have a higher chance of successful completion of the projects.

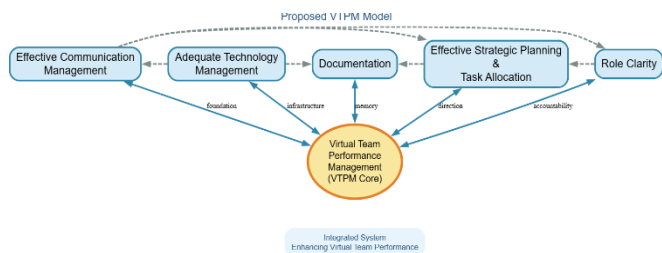


Fig. 4. Proposed Virtual Team Performance Management (VTPM) model.

Fig. 4 above represents the overall structure of the VTPM model. Although the components are presented individually, in practice they are interrelated. Communication influences planning and role clarity, technology supports communication and coordination, documentation reinforces shared understanding, and role clarity improves accountability and productivity. Therefore, the model should be understood as an integrated system rather than a set of isolated management activities.

### C. Components of the Virtual Team Performance Management (VTPM) Model

VTPM model includes five components interacting with each other. Effective Communication Management [1], [20] defines ongoing communication as the likeness to collaboration based on the understanding of expectations, active listening, and feedback systems, which should be carried out through the right channels [38]. Teams need appropriate tools and training, so Adequate Technology Management [12], [42] makes sure the teams have the right tools and training in a certain context [25], [32]. Good Strategic Planning and Task Assignment [22], [47] gears project goals and well-defined responsibilities, and frequent reviews of development. One of the ways organizational memory is preserved and transparency is ensured is documentation [45], [46]; however, it has been found to have to be balanced to ensure that it is not inefficient. Lastly, Role Clarity [43] provides both parties, each member, with knowledge of their duties through clear communication of the leadership and continuous support [15]. These elements do not exist in isolation since they are a system. Fig. 5 illustrates the integrated VTPM system and the relationships between its core components.

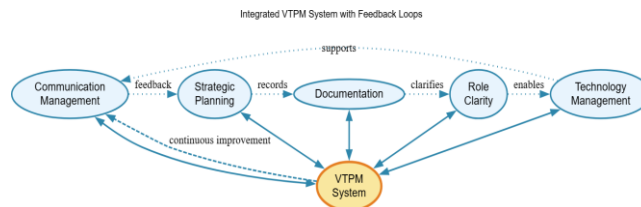


Fig. 5. Integrated VTPM system with feedback loops.

### D. Model Validation

1) *Introduction:* Expert validation is a significant measure that needs to be taken to verify the accuracy, usefulness, and credibility of the VTPM model [2]. This was done through the model being exposed to expert scrutiny and juxtaposition to real-world and hypothetical expectations within the field of virtual team performance management. The validation stage was aimed at the validation of the usability and appropriateness of the VTPM model in the real setting of virtual teams. Validation is significant as a model should not be theoretically sound only, but practical. Domain experts can benefit by providing valuable information about experience and conceptual information. Their analysis allows judging whether the model is reflective of the conditions of real-world virtual teams, whether the model is composed of relevant components, and whether or not enhancements are necessary.

2) *Experts involved in the process of validation:* The VTPM model was found to be evaluated by academic and industry experts. The academic experts assessed the correspondence of the model to the theoretical and scientific assumptions, and the professionals serving industry assessed the correspondence of the model to the real conditions of work and management in virtual teams [8]. The combination was a balanced and holistic evaluation of the model. The involvement of academic and industrial professionals allowed for defining strengths, weaknesses, and potential changes. This shaped and multi-perspective validation procedure contributed to the strengthening of the credibility of the model and boosted confidence in its applicability in research and practice.

3) *Expert validation:* The expert validation procedure concentrated on the sub-componential as well as key constituents of the VTPM model. For the Effective Communication Management component, specialists approved the appropriateness of several subcomponents, such as effective communication of the leadership on the task functions and project responsibilities, team-in-the-loop feedback, effective verbal and written communication, strong leadership communication, and the ability to share information using appropriate communication [15]. Further decision making by academic experts regarded these sub-components as adequate, whereas industry experts were broadly in agreement, but were found in a manner the information sharing is practiced.

For the Adequate Technology Management component, the experts confirmed the significance of team leaders working to identify and resolve problems, the necessity of training and education in using collaboration tools, the most efficient utilization of multiple communication and collaboration tools, and better access to these tools [42]. The industry input showed that the use of the tools was proper, but awareness and accessibility could be expanded beyond the scope of tools that were widely used.

For the Role Clarity component, the professionals affirmed that role and responsibility articulation is required and appropriate in the model [43]. They also emphasized cross-functional teamwork and communication, along with mentioning that this process might need additional polishing in large or complicated teams where it is not easy to coordinate interdepartmental work.

For the Effective Strategic Planning and Task Allocation sub-component, academic and industry professionals found the sub-elements appropriate [22]. These involve the implementation of the strategic planning by team leaders through effective communication, task allocation through clear communication, and strategy establishment by the team leaders at the first stage of assigning tasks and responsibilities. Scholars admitted that this element is a powerful contributor to the effectiveness of virtual teams and their fit to the project goals.

For the Documentation component, the specialists ensured the appropriateness of correct documentation goals and

document review procedures [45]. These results imply that documentation may be helpful and compatible with the agile or efficient working practices, provided that it is meaningful and controlled properly.

Besides rating sub-components, there was also the rating of the significance of big components by experts. By rating Effective Communication Management, Technology Management, and Documentation as very important, Strategic Planning and Task Allocation as important, and Role Clarity as moderately important, the academic experts rated them accordingly. Technology Management, Strategic Planning and Task Allocation, and Documentation were rated as very important by industry experts, Effective Communication Management important and Role Clarity moderately important by the industry experts. These scores demonstrate that there is high support for the primary structure of the VTPM model.

Professionals also gave recommendations on how it could be improved. Research scholars suggested refinements of the technology management factor in the IT-oriented settings, specialized communication technology to enhance cooperation, and application of the model to teams other than software teams. Experts in the industry recommended smaller, more focused meetings with the help of collaborative tools, more extensive applications of numerous tools in managing time and tasks, improved communication around objectives and key performance indicators, improved evaluation of the status of the existing technology, and organized performance assessment and improvement strategies. These suggestions make the model more useful and flexible. Fig. 6 compares the validation ratings provided by academic and industry experts.

Expert Validation Ratings Comparison		
Component	Academic Experts	Industry Experts
Communication Management	Very Important	Important
Technology Management	Very Important	Very Important
Strategic Planning	Important	Very Important
Documentation	Very Important	Very Important
Role Clarity	Moderately Important	Moderately Important

Fig. 6. Comparison of academic and industry expert ratings.

## VI. CONCLUSION

This is the concluding section of the study that provides a comprehensive overview of the research done on virtual team performance management, specifically on the communication as well as the technology management strategy employed to manage performance in the virtual project team. This study has synthesized the research objectives, methodology, highlights, and overall findings related to virtual teams operating in the digital age [40]. The research was based on finding a multifocused explanation of how the proposed Virtual Team Performance Management (VTPM) model can solve the challenges determined in the virtual team setting. This study used both theoretical models combined with the empirical evidence presented in real-life situations to create a strong model of virtual team performance optimization in different situations. This section emphasizes that the study not only enhances the theoretical base of virtual team management but

also offers practical guidance on how it can be applied. The importance of these findings does not support just academic discourse, but provides useful information to virtual team leaders, team members, and the organization that deals with the management of virtual projects. This study is able to present actionable suggestions and strategic considerations to serve as guidance to stakeholders to resolve the problem of virtual collaboration. In general, the section is a valuable source in relation to the future of the developing virtual team's scenario.

### A. Analysis of the Research Results

This part is a summary of the study progress according to the three research objectives. The initial goal, which was to determine problems and difficulties encountered by virtual teams in performance management, was realized in terms of the literature review and questionnaire results. As it was found, the key challenges are communication ambiguity, poor application of technology, documentation weaknesses, deficient strategic planning, poor allocation of tasks, as well as role ambiguity [22]. These problems formed a good background for the realization of the necessity to have a structured and efficient management strategy. Fig. 7 summarizes the research objectives and the corresponding achievements of the study.

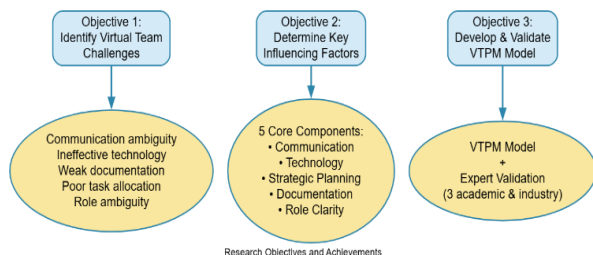


Fig. 7. Research objectives and key achievements.

The second goal, aimed at defining the main factors that affect the virtual team performance, was fulfilled in selecting five fundamental elements consisting of communication management, technology management, strategic planning, task allocation, role clarity, and documentation. All these aspects were based on empirical evidence and attested by the existing literature [3], [39]. They constitute the foundation for defining major performance criteria that should be dealt with by organizations and team leaders to enhance the performance of virtual teams. The third goal that attempted to formulate the Virtual Team Performance Management (VTPM) model was met with great success through the use of empirical evidence combined with theoretical methodologies and expert guidance [28], [37]. The VTPM model developed not only solves the major problems discussed but also offers an opportunity to have a practical design with the best practices, evidence-based management approaches, and feedback systems. The model was further refined through expert evaluation in order to make sure that it matches the project management requirements in the real world [8]. As a whole, this development of the study fits well within the three research objectives. The research identifies and evaluates the factors affecting virtual team performance and develops a practical management model.

### B. Significance of the Study

The research on the Virtual Team Performance Management (VTPM) model makes a great contribution to

both theoretical, practical, and social levels. Fig. 8 illustrates the theoretical, practical, and societal contributions of the proposed VTPM model.

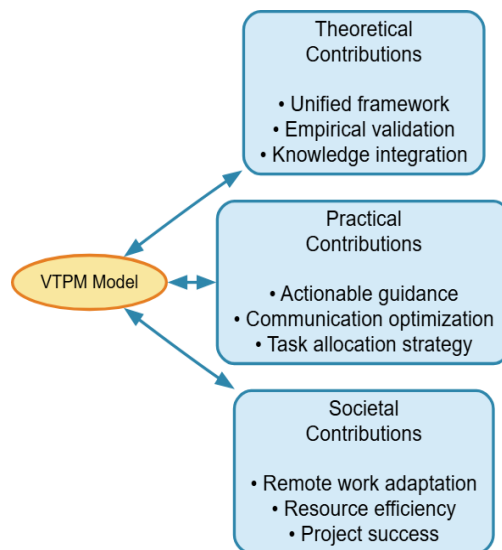


Fig. 8. VTPM model contributions: theoretical, practical, and societal.

1) *Theoretical contributions*: The study contributes to the theoretical knowledge on the issue of virtual teams by uniting the main factors that include management of communication, management of technology, strategic planning, task division, clarity of tasks, and documentation. VTPM model is an overall framework that integrates all these aspects in a single framework for managing virtual teams [26], [30]. Moreover, the empirical findings obtained through surveys and experts' evaluation give rather good evidence on the effectiveness of the model. This helps in closing the gap between theory and practice as it provides a validated framework to be used in further research.

2) *Practical contributions*: In practical terms, the VTPM model has implications for the practical understanding of team leaders and organizations. It provides systematic leadership in ensuring effectiveness in communication and technology use, as well as a better strategy and delegation of tasks [14], [47]. The model can also greatly enhance the performance and the productivity of the team in a virtual environment because some typical challenges, including barriers to communication, knowledge deficits, and poor management of technology, have been solved.

3) *Societal contributions*: The analysis aids the organizations in readjusting to the growing trends of a remote and distributed workplace setting [9]. The VTPM model helps enhance more fruitful and fulfilling remote working circumstances by enhancing the management of virtual teams. Moreover, the study should minimize instances of project failure as a result of communication and technology problems, which helps to ensure a higher level of efficiency in the use of resources and a better result of the project at the organizational level.

### C. Critical Limitations and Threats to Validity

This study has several limitations that qualify its conclusions:

1) *Cross-sectional design*: Data were collected at one point; causal relationships cannot be inferred. Longitudinal studies are needed.

2) *Self-report bias*: All measures are perceptual. Objective performance metrics (e.g., project completion time, deliverable quality) were not collected.

3) *Sample size and generalizability*: N=110 is moderate. The sample is predominantly Malaysian corporate employees (66.4%); findings may not generalize to other cultural contexts, very small teams (<5 members), or very large teams (>20 members).

4) *Lack of objective performance data*: Perceived team performance may not align with actual outcomes.

5) *Expert validation sample*: Only three experts; a larger panel would increase confidence.

6) *No structural equation modeling (SEM)*: Mediation pathways (e.g., whether communication effects are mediated by trust) were not tested.

7) *Scope constraints*: The VTPM model is validated only for technology-mediated, task-oriented teams in stable connectivity environments. It may not apply to emergency-response, creative, or purely social virtual teams.

### D. Future Research Recommendations

It is suggested that future studies be done to enhance the VTPM model, especially as regards virtual and agile teams. These are the recommendations that fall into three broad regions.

1) *Virtual team performance measurement*: Information shedding in case of future research needs to involve detailed case research in an organization where virtual teams are significantly applied. This would give more detailed information on how the performance of teams is assessed in a real-life setting [10]. The most effective way to gather data on the effectiveness of the VTPM model is by means of documenting the project, interactions between the team, and interviews with the team members and managers. Longitudinal studies can also be performed in order to monitor the change in performance over time.

2) *Formulation of performance measurement metrics*: the future study must be on how to come up with developed performance measures in a well-structured, objective manner. Suggested metrics include: Sprint burndown, cycle time to assess productivity [41]. Division of high-quality deliverables to determine the output quality. Minutes during which meetings were undertaken to assess the efficiency of communication [38]. The metrics can be used to complement the current performance assessment models and offer more extensive information applicable to the management of virtual teams.

3) *Pay attention to agile virtual teams*: Future studies should address the implications of the VTPM model to Agile

Virtual Teams and software development environments within the digital economy [35], [17], [36]. The research established that performance appraisal among agile virtual teams has not been extensively studied, and mostly it is based on subjective appraisals [47]. The way VTPM elements can accommodate agile methodologies like Scrum and Kanban should be studied in the future [50]. Moreover, innovative analytics and machine learning methods can be considered to forecast the performance of the team and suggest changes based on the information in real time.

Summing it up, the presented study produces a holistic approach to enhancing the performance of virtual teams using the Virtual Team Performance Management (VTPM) model. The model touches upon such essential issues as communication management, technology management, strategic planning, task distribution, role clarity, and documentation. The model may incorporate potential performance evaluation metrics such as cycle time, burndown charts of sprints, and quality indicators, among others, which makes it a solid framework and tool that can assess and enhance team effectiveness. Time tracking of the meetings is also helpful in communication and cooperation. VTPM model provides a bridge between theory and practice because it provides practical recommendations on how to manage virtual teams. It allows ongoing improvement, decision-making, and resource allocation, which will increase the success of a particular project. Further studies on the model should be done in the future by incorporating detailed performance measurement models and sophisticated methods of analysis. It will help to shed more light on virtual team dynamics and facilitate decision-making based on the facts. On balance, the improved VTPM model could help to advance the practice of virtual team management considerably and enhance the sphere of virtual project management, in general.

### ACKNOWLEDGMENT

The authors would like to express their gratitude to Universiti Kebangsaan Malaysia for supporting this research.

### REFERENCES

- [1] S. Agarwal, S. Ferdousi, T. Stahl, M. John, and A. Nalven, "Effective leadership in virtual teams during the COVID-19 pandemic," *Engineering and Technology Management Student Projects*, 2020.
- [2] I. Ahmed and S. Ishtiaq, "Reliability and validity: Importance in medical research," *Journal of the Pakistan Medical Association*, vol. 71, no. 10, pp. 2401–2406, 2021.
- [3] H. M. A. Al Kaabi, S. Sidek, and N. A. Mosali, "Mediation model of factors affecting virtual team performance in UAE organisations," *International Journal of Sustainable Construction Engineering and Technology*, vol. 13, no. 2, pp. 268–284, 2022.
- [4] A. Alaiad, Y. Alnsour, and M. Alsharo, "Virtual teams: Thematic taxonomy, constructs model, and future research directions," *IEEE Transactions on Professional Communication*, vol. 62, no. 3, pp. 211–238, 2019.
- [5] A. B. Anoye and J. S. Kouamé, "Leadership challenges in virtual team environment," *International Journal of Scientific and Technology Research*, vol. 7, no. 7, pp. 160–167, 2018.
- [6] C. C. S. de Araújo, C. D. Pedron, and F. Q. P. de O. e Silva, "IT project manager competencies and team commitment: A new scale proposal," *Revista de Gestão e Projetos*, vol. 9, no. 1, pp. 39–57, 2018.
- [7] P. Barry and B. Kane, "Global virtual team working during the COVID-19 pandemic," *Interacting with Computers*, vol. 35, no. 5, pp. 681–690, 2023.

- [8] C. J. Behling, "Project success in virtual projects: A qualitative study of leadership behaviors," Ph.D. dissertation, 2019.
- [9] S. K. Bhat, N. Pande, and V. Ahuja, "Virtual team effectiveness: An empirical study using SEM," *Procedia Computer Science*, vol. 122, pp. 33–41, 2017.
- [10] M. S. Bissaliyev, "The effectiveness of collaboration tools on virtual project management," *International Journal of Applied Engineering Research*, vol. 12, no. 21, pp. 10747–10755, 2017.
- [11] C. Breuer, J. Hüffmeier, F. Hibben, and G. Hertel, "Trust in teams: A taxonomy of perceived trustworthiness factors and risk-taking behaviors in face-to-face and virtual teams," *Human Relations*, vol. 73, no. 1, pp. 3–34, 2020.
- [12] V. Casey, "Virtual software team project management," *Journal of the Brazilian Computer Society*, vol. 16, no. 2, pp. 83–96, 2010.
- [13] P. Chamakiotis, N. Panteli, and R. M. Davison, "Reimagining e-leadership for reconfigured virtual teams due to COVID-19," *International Journal of Information Management*, vol. 60, p. 102381, 2021.
- [14] D. Ciric, B. Lalic, D. Gracanin, I. Palcic, and N. Zivlak, "Agile project management in new product development and innovation processes: Challenges and benefits beyond software domain," in *TEMSISIE 2018 – 1st Annual International Symposium on Innovation and Entrepreneurship of the IEEE Technology and Engineering Management Society*, pp. 1–9, 2018.
- [15] K. A. Crowne, "Does national culture influence peer evaluations on global virtual teams?" *Journal of Teaching in International Business*, vol. 31, no. 3, pp. 191–213, 2020.
- [16] I. Dumitras,cu-Ba`lda`u and D. D. Dumitras,cu, "Intercultural communication and its challenges within the international virtual project team," *MATEC Web of Conferences*, vol. 290, 2019.
- [17] I. Dumitras,cu-Ba`lda`u and O. Dumitras,cu, "Research on the behavior of factors that influence the international virtual project team performance, using data modeling techniques," *Sustainability*, vol. 11, no. 3, 2019.
- [18] J. S. Gallego, I. Ortiz-Marcos, and J. Romero Ruiz, "Main challenges during project planning when working with virtual teams," *Technological Forecasting and Social Change*, vol. 162, p. 120353, 2021.
- [19] V. Garro-Abarca, P. Palos-Sanchez, and M. Aguayo-Camacho, "Virtual teams in times of pandemic: Factors that influence performance," *Frontiers in Psychology*, vol. 12, pp. 1–14, 2021.
- [20] C. Hargreaves, A. P. Clarke, and K. R. Lester, "Microsoft Teams and team performance in the COVID-19 pandemic within an NHS trust community service in North-West England," *Team Performance Management*, vol. 28, no. 1–2, pp. 79–94, 2022.
- [21] K. Holtz, V. O. Castella, A. Z. Abad, and B. Gonza`lez-Anta, "Virtual team functioning: Modeling the affective and cognitive effects of an emotional management intervention," *Group Dynamics*, vol. 24, no. 3, pp. 153–167, 2020.
- [22] T. Iyamu and O. Adelakun, "A global virtual team model to improve software development collaboration project," *Information Systems and e-Business Management*, vol. 19, no. 3, pp. 937–956, 2021.
- [23] D. Kauffmann and G. Carmi, "A comparative study of temporary and ongoing teams on e-environment," *IEEE Transactions on Professional Communication*, vol. 62, no. 2, pp. 148–164, 2019.
- [24] F. Kortum, J. Klunder, O. Karras, W. Brunotte, and K. Schneider, "Which information help agile teams the most? An experience report on the problems and needs," in *46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*, pp. 306–313, 2020.
- [25] C. T. Kuah and K. Y. Wong, "Evaluating team performance using slack based data envelopment analysis," in *International Conference on Advanced Communication Technology (ICACT)*, pp. 1152–1157, 2014.
- [26] P. Lous, P. Tell, C. B. Michelsen, Y. Dittrich, and A. Ebdrup, "From scrum to agile: A journey to tackle the challenges of distributed development in an agile team," in *ACM International Conference Proceeding Series*, pp. 11–20, 2018.
- [27] J. Lumseyfai, "A four-pillared holistic model for improving performance in engineering virtual project teams," *Engineering Management Journal*, vol. 32, no. 2, pp. 107–119, 2020.
- [28] J. Malmqvist, K. Hellberg, G. Möllås, R. Rose, and M. Shevlin, "Conducting the pilot study: A neglected part of the research process? Methodological findings supporting the importance of piloting in qualitative research studies," *International Journal of Qualitative Methods*, vol. 18, pp. 1–11, 2019.
- [29] A. Mashmool, S. Khosravi, J. H. Joloudari, I. Inayat, T. J. Gandomani, and A. Mosavi, "A statistical model to assess the team's productivity in agile software teams," in *CANDO-EPE 2021 – IEEE 4th International Conference and Workshop in Obuda on Electrical and Power Engineering*, pp. 11–18, 2021.
- [30] C. Mayer, S. Mutze-Niewo`hner, and V. Nitsch, "Empirical classification of advanced information technology towards their support of leadership behaviors in virtual project management settings," in *IEEE International Conference on Industrial Engineering and Engineering Management*, pp. 275–279, 2020.
- [31] K. Mehtab, A. ur Rehman, S. Ishfaq, and R. A. Jamil, "Virtual leadership: A review paper," *Mediterranean Journal of Social Sciences*, vol. 8, no. 4–1, pp. 183–193, 2018.
- [32] S. Morrison-Smith and J. Ruiz, "Challenges and barriers in virtual teams: A literature review," *SN Applied Sciences*, vol. 2, no. 6, pp. 1–33, 2020.
- [33] P. Paterek, "Agile transformation in project organization: Knowledge management aspects and challenges," in *Proceedings of the European Conference on Knowledge Management (ECKM)*, vol. 2, pp. 1170–1179, 2017.
- [34] P. Paterek, "Agile transformation changes from the perspective of project team values," in *8th International Scientific Conference on Project Management in the Baltic Countries: Project Management Development – Practice and Perspectives*, pp. 162–174, 2019.
- [35] K. Saeedi and A. Visvizi, "Software development methodologies, HEIs, and the digital economy," *Education Sciences*, vol. 11, no. 2, pp. 1–22, 2021.
- [36] B. Seerat, M. Samad, and M. Abbas, "Software project management in virtual teams," in *Proceedings of the Science and Information Conference (SAIL)*, pp. 139–143, 2013.
- [37] D. Simpson, "Advantages and disadvantages of international virtual project teams," *International Business and Global Economy*, vol. 36, no. 1, 2017.
- [38] V. Stray, N. B. Moe, and M. Noroozi, "Slack me if you can! Using enterprise social networking tools in virtual agile teams," in *2019 ACM/IEEE 14th International Conference on Global Software Engineering (ICGSE)*, pp. 111–121, 2019.
- [39] C. K. Tan, T. Ramayah, A. P. Teoh, and J. H. Cheah, "Factors influencing virtual team performance in Malaysia," *Kybernetes*, vol. 48, no. 9, pp. 2065–2092, 2019.
- [40] N. U. Thuong, "Virtual teams in the digital age," *Hue University Journal of Science: Economics and Development*, vol. 128, no. 5C, pp. 67–80, 2019.
- [41] M. Topaloglu and A. S. Anac, "Exploring major factors affecting virtual team performance," *European Journal of Business and Management Research*, vol. 6, no. 5, pp. 107–114, 2021.
- [42] L. H. Wei, R. Thurasamy, and S. Popa, "Managing virtual teams for open innovation in Global Business Services industry," *Management Decision*, vol. 56, no. 3, pp. 570–590, 2018.
- [43] S. I. Wong and S. van Gils, "Initiated and received task interdependence and distributed team performance: The mediating roles of different forms of role clarity," *AI and Society*, 2021.
- [44] K. Y. Yigzaw, A. Michalás, and J. G. Bellika, "Secure and scalable statistical computation of questionnaire data in R," *IEEE Access*, vol. 4, pp. 4635–4645, 2016.
- [45] K. Yoon and Y. Zhu, "Social media affordances and transactive memory systems in virtual teams," *Management Communication Quarterly*, vol. 36, no. 2, pp. 235–260, 2021.
- [46] W. Yu, K. Cormican, Q. Wu, and S. Sampaio, "In whom do we trust? Critical success factors impacting intercultural communication in multicultural project teams," *International Journal of Information Systems and Project Management*, 2021.
- [47] A. M. Younus and H. Younis, "Conceptual framework of agile project management affecting project performance: Key requirements and challenges," *International Journal of Innovative Research in Engineering & Management*, vol. 8, no. 4, pp. 10–14, 2021.
- [48] J. H. Yahaya, M. M. Basir, and A. Deraman, "Unified communication and collaboration model for virtual distributed teamwork: A study in Malaysia," *International Journal of Software Engineering and Its Applications*, vol. 9, no. 2, pp. 125–142, 2015.
- [49] Z. Ahmed, Z. Mansor, K. Ahmad, and M. Zafarullah, "Enhancing team-related knowledge sharing in agile virtual teams: Social, psychological and trust enablers for distributed collaboration – KSAVT framework," *TPM – Testing, Psychometrics, Methodology in Applied Psychology*, vol. 32, no. S9, pp. 680–683, 2025.
- [50] L. Moradi, Y. Yahya, and I. Mohamed, "Relationship between E-training in virtual team and IT project performance with the mediation role of organizational commitment in E-tourism," in *Proc. IEEE*, 2017, pp. 1–5.

APPENDIX

Table XI provides the mapping between each construct, the corresponding questionnaire items, and their sources. All items were measured on a 5-point Likert scale (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree).

The full questionnaire consisted of 22 items across the five independent constructs and multiple items for the dependent variable (team performance). The complete instrument is available from the corresponding author upon request. Table XI presents the mapping of constructs, questionnaire items, and supporting references used in the study.

TABLE XI. CONSTRUCT MAPPING AND QUESTIONNAIRE ITEMS

Construct	Sample Item	Source
Communication	“Leadership clearly communicates task expectations”	[1], [20]
Technology Management	“Collaboration tools are reliable and accessible”	[12], [42]
Strategic Planning	“Project goals are clearly defined at the outset”	[22], [47]
Role Clarity	“My responsibilities are well-defined”	[43], [15]
Documentation	“Documentation is excessive and reduces efficiency” (reverse coded)	[45], [46]
Team Performance (DV)	“Overall, my virtual team performs effectively”	[10]