**University of Bahrain**
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# Enhancing Project Management Performance through Optimal Human-Artificial Intelligence Collaboration

**Ph.D. Thesis Submitted in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

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# Thesis Abstract

The emergence of collaboration between humans and artificial intelligence (AI) is a promising approach to enhancing team performance. This study bridges the gap in literature by developing a Human-Generative AI Collaboration Model for project teams in project management and determining criteria for measuring the performance of human-generative AI project teams.

The study was conducted in 3 Phases. In Phase 1, the study adopted mixed methods, starting with conducting a systematic literature review to explore collaboration theories. The study then employed several quantitative techniques by developing and following a text-mining framework to identify and prioritize the main factors of team formation, solving the team formation problem for traditional teams. Moreover, the study explored generative AI capabilities that support project teams through a qualitative method and determined the main capabilities through a quantitative method by employing Machine Learning clustering algorithms. By considering how the team formation problem for traditional teams is solved and the main capabilities of generative AI, the study solves the human-generative AI team formation problem and hence builds a Human-Generative AI Project Team Formation Model. In Phase 2, by adopting mixed methods, the study first explored models for stages of team development to determine the behaviors and attitudes of humans when working in teams and studied how the main characteristics and abilities of generative AI support humans and compensate for their drawbacks in performance in each of the stages. The study builds the Stages of Human- Generative AI Project Team Development Model and compares it with the stages of the team development models for traditional teams. By quantifying the human behaviors and attitudes as well as the generative AI characteristics and abilities according to their positive or negative influence on the performance of project teams, the study confirms that the performance of teams consisting of humans and generative AI supersedes traditional human teams when working on projects.

By combining the two proposed models of Phase 1 and Phase 2, the study develops the Human-Generative AI Collaboration Model for project teams to enhance the collaboration between humans and generative AI when working in project management by improving the team's performance, and hence attaining project success.

Finally, in Phase 3, qualitative data was collected to establish key performance indicators for measuring the performance of human-generative AI project teams in terms of efficiency and effectiveness.

The study's main contribution lies in the development of the Human-Generative AI Collaboration Model, which serves as an extensive framework for supporting the teamwork between humans and generative AI in projects, from team formation through the stages of team development, and the establishment of the Key Performance Indicators for assessing the performance of humans-generative AI project teams.

# Dedication

I dedicate this thesis to my beloved husband, Mohamed, my son, Talal, and my daughter, Nouf.

Your constant encouragement, tolerance, and support have been my guiding light throughout this journey. Without your unconditional love and faith in me, this accomplishment would not have been achieved.

With heartfelt gratitude and love,

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# List of Content

Thesis Abstract
Dedication ..... A
Acknowledgment ..... B
List of Content ..... C
List of Tables ..... 1
List of Figures ..... 4
List of Abbreviations ..... 7
**Chapter One** ..... 8
Introduction to the Study ..... 8
1.1 Introduction ..... 8
1.2 Research Background ..... 8
1.3 Research Problem ..... 10
1.4 Research Questions ..... 13
1.5 Research Objectives ..... 16
1.6 Research Significance ..... 17
1.7 Research Setting ..... 20
1.8 Research Terminology ..... 23
**Chapter Two** ..... 29
Theoretical Framework and Literature Review ..... 29
2.1 Introduction ..... 29
2.2 Project Management ..... 30
2.3 Team Dynamics ..... 33
2.3.1 Team Formation Problem ..... 35
2.3.2 Factors Affecting Team Formation ..... 36
2.3.3 Stages of Team Development ..... 42
2.3.3.1 Tuckman's Model ..... 44
2.3.3.2 Woodcock's Model ..... 47
2.4 AI & Generative AI: From Tools to Teammates ..... 49
2.4.1 Human-AI Collaboration ..... 56
2.4.2 AI & Generative AI in Project Management ..... 58
2.5 Factors Supporting H-AI Collaboration ..... 60
2.6 Performance Indicators for H-AI Project Teams ..... 66
2.7 Model Development ..... 68

**Chapter Three** ..... 83
Methods and Procedures ..... 83
3.1 Introduction ..... 83
3.2 Research Design ..... 87
3.2.1 Philosophical Assumptions and Worldviews ..... 88
3.2.2 Strategies of Inquiry ..... 93
3.2.3 Qualitative, Quantitative, & Mixed-Methods Research Approaches ..... 94
3.3 The Research Methods of the Study ..... 95
3.3.1 Phase 1 Part 1: Systematic Literature Review ..... 95
3.3.2 Phase 1 Part 2: Quantitative Approach ..... 102
3.3.2.1 Text Mining Framework ..... 103
3.3.2.1.1 Stage 1: Data Preprocessing ..... 105
3.3.2.1.2 Stage 2: Data Processing ..... 105
3.3.2.1.2.1 Term Frequency-Inverse Document Frequency ..... 106
3.3.2.1.2.2 Machine Learning Clustering Algorithms ..... 107
3.3.2.1.2.3 Latent Dirichlet Allocation ..... 111
3.3.2.1.3 Stage 3: Data Post-processing ..... 112
3.3.2.1.3.1 Data Source, Sampling Procedures, & Instruments of Data Collection ..... 114
3.3.2.1.3.2 Structured Interviews Representatives ..... 115
3.3.2.1.3.3 Multi-Criteria Decision-Making Approaches: Weights Allocation Methods ..... 116
3.3.2.1.3.3.1 Best-Worst Method ..... 119
3.3.3 Phase 1 Part 3: Mixed Methods Approach ..... 125
3.3.3.1 First Phase: Qualitative Approach ..... 126
3.3.3.1.1 The Research Method: Semi-structured Interviews ..... 126
3.3.3.1.2 Qualitative Data Source & Sampling Procedures ..... 127
3.3.3.1.3 Interview Protocol ..... 128
3.3.3.1.4 Semi-structured Interviews Representatives ..... 130
3.3.3.1.5 Conducting the Interviews ..... 131
3.3.3.1.6 Qualitative Data Analysis ..... 132
3.3.3.1.7 Validity and Reliability ..... 134
3.3.3.2 Second Phase: Quantitative Approach ..... 135
3.3.3.3 Third Phase: Quantitative Approach ..... 138
3.3.4 Phase 1 Part 4: Qualitative Approach ..... 138
3.3.5 Phase 2 Part 1: Mixed Methods Approach ..... 139
3.3.6 Phase 2 Part 2: Mixed Methods Approach ..... 140
3.3.7 Phase 3: Qualitative Approach ..... 141
3.4 Conclusion ..... 142

**Chapter Four** ..... 143
Results & Discussion ..... 143
4.1 Introduction ..... 143
4.2 Results ..... 143
4.2.1 Phase 1: H-GenAI Project Team Formation ..... 143
4.2.1.1 Phase 1 Part 1: SLR on Team Formation Theories ..... 144
4.2.1.2 Phase 1 Part 2: Solving H-H Team Formation Problem ..... 155
4.2.1.2.1 Stage 1: Data Preprocessing ..... 155
4.2.1.2.2 Stage 2: Data Processing ..... 161
4.2.1.2.2.1 Text Transformation using TF-IDF ..... 161
4.2.1.2.2.2 Text Clustering using ML: Partitional Clustering: K-Means ..... 163
4.2.1.2.2.3 Text Clustering using ML: Hierarchical Clustering: Agglomerative ..... 164
4.2.1.2.2.4 Text Clustering using ML Algorithms: Silhouette Index ..... 168
4.2.1.2.2.5 Latent Dirichlet Allocation ..... 169
4.2.1.2.3 Stage 3: Data Post-processing ..... 172
4.2.1.3 Phase 1 Part 3: H-GenAI in Project Teams ..... 185
4.2.1.3.1 First Phase: Generative AI Capabilities ..... 186
4.2.1.3.2 Second Phase: Clustering Generative AI Capabilities ..... 189
4.2.1.3.2.1 Clusters of Generative AI Characteristics ..... 189
4.2.1.3.2.1.1 Themes of Generative AI Main Characteristics ..... 194
4.2.1.3.2.2 Clusters of Generative AI Abilities ..... 203
4.2.1.3.2.2.1 Themes of Generative AI Main Abilities ..... 209
4.2.1.3.3 Third Phase: Solving H-GenAI Team Formation Problem ..... 229
4.2.1.4 Phase 1 Part 4: GenAI Enablers & Factors Supporting H-GenAI Collaboration 235
4.2.1.4.1 GenAI Enablers ..... 235
4.2.1.4.2 Factors Supporting H-GenAI Collaboration ..... 240
4.2.1.5 Summary of Phase 1 ..... 261
4.2.2 Phase 2: Stages of H-GenAI Project Team Development ..... 264
4.2.2.1 Phase 2 Part 1: Building & Evaluating the H-H STD ..... 265
4.2.2.1.1 Tuckman's Model ..... 267
4.2.2.1.2 Woodcock's Model ..... 268
4.2.2.1.3 Tuckman's & Woodcock's Models Combined ..... 269
4.2.2.2 Phase 2 Part 2: Building & Evaluating the H-GenAI SPTD ..... 270
4.2.2.2.1 Tuckman's Model ..... 273
4.2.2.2.2 Woodcock's Model ..... 275
4.2.2.2.3 Tuckman's & Woodcock's Models Combined ..... 278
4.2.2.3 Summary of Phase 2 ..... 280

4.2.3 Phase 3: KPIs for H-GenAI Project Teams ..... 290
4.2.3.1 Efficiency ..... 290
4.2.3.2 Effectiveness ..... 296
4.2.3.3 Summary of Phase 3 ..... 298
4.2.4 Summary of Results: All 3 Phases ..... 300
4.3 Discussion ..... 303
4.3.1 H-GenAI Project Team Formation ..... 303
4.3.2 Stages of H-GenAI Project Team Development ..... 308
4.4 Further Findings of the Study ..... 309
4.4.1 Generative AI Supporting Project Management ..... 309
4.4.2 A Hybrid Setup for Successful Project Management ..... 313
**Chapter Five** ..... 317
Conclusion ..... 317
5.1 Introduction ..... 317
5.2 Addressing Research Questions ..... 317
5.3 Study Contribution to Research & Practice ..... 327
5.4 Limitations of the Study ..... 329
5.5 Recommendations & Directions for Future Research ..... 331
References
Appendices
Thesis Abstract (Arabic)
Title (Arabic)

# List of Tables


| Table No. | Table Title | Page No. |
|---|---|---|
| **Table 1** | Mapping Study's Objectives with Research Questions | 15 |
| **Table 2** | Main Terminologies of the Study | 23 |
| **Table 3** | Models and Stages Synopsis | 43 |
| **Table 4** | Tuckman's Stages of Group Development | 45 |
| **Table 5** | A Summary of the AI Capabilities | 53 |
| **Table 6** | A Summary of the Influential Factors for Human-AI Collaboration | 64 |
| **Table 7** | Model Terms and Definitions | 81 |
| **Table 8** | Four Worldviews | 89 |
| **Table 9** | Worldviews Elements and Implications for Practice | 92 |
| **Table 10** | PICOC-Based Study Criteria | 97 |
| **Table 11** | Criteria for Inclusion & Exclusion | 99 |
| **Table 12** | Previous Studies Search | 100 |
| **Table 13** | Selected Previous Studies | 100 |
| **Table 14** | Outcomes of Study Quality Assessment | 101 |
| **Table 15** | Structured Interviews Representative Information | 115 |
| **Table 16** | The Pairwise Comparison Scale | 121 |
| **Table 17** | Consistency Index Table | 124 |
| **Table 18** | Interview Protocol Agenda | 128 |
| **Table 19** | Semi-structured Interviews Representative Information | 130 |
| **Table 20** | Summary of SLR Study Findings | 144 |
| **Table 21** | Theories in Team Formation | 145 |
| **Table 22** | Theories in Team Formation for H-AI Collaboration | 151 |
| **Table 23** | Future Research Aspects for H-AI Collaboration | 154 |
| **Table 24** | Factors for Project Team Formation | 156 |
| **Table 25** | TF-IDF & Pareto Results of the Most Used Factors for Project Team Formation | 162 |
| **Table 26** | Clustering Factors Under Themes | 165 |
| **Table 27** | Latent Dirichlet Allocation Clustering Results | 169 |
| **Table 28** | Comparison between Latent Dirichlet Allocation & Agglomerative Hierarchical Clustering Results | 170 |
| **Table 29** | Financial Sector: Pairwise Comparison Vector for Best Criterion | 173 |

| | | |
|---|---|---|
| **Table 30** | Financial Sector: Pairwise Comparison Vector for Worst Criterion | 174 |
| **Table 31** | Financial Sector: PMs Criteria Weights | 174 |
| **Table 32** | Financial Sector: Factors Rank | 175 |
| **Table 33** | Telecommunication Sector: Pairwise Comparison Vector for Best Criterion | 175 |
| **Table 34** | Telecommunication Sector: Pairwise Comparison Vector for Worst Criterion | 176 |
| **Table 35** | Telecommunication Sector: PMs Criteria Weights | 176 |
| **Table 36** | Telecommunication Sector: Factors Rank | 177 |
| **Table 37** | Real Estate Sector: Pairwise Comparison Vector for Best Criterion | 177 |
| **Table 38** | Real Estate Sector: Pairwise Comparison Vector for Worst Criterion | 178 |
| **Table 39** | Real Estate Sector: PMs Criteria Weights | 178 |
| **Table 40** | Real Estate Sector: Factors Rank | 179 |
| **Table 41** | Energy Sector: Pairwise Comparison Vector for Best Criterion | 179 |
| **Table 42** | Energy Sector: Pairwise Comparison Vector for Worst Criterion | 180 |
| **Table 43** | Energy Sector: PMs Criteria Weights | 180 |
| **Table 44** | Energy Sector: Factors Rank | 181 |
| **Table 45** | Governmental Sector: Pairwise Comparison Vector for Best Criterion | 181 |
| **Table 46** | Governmental Sector: Pairwise Comparison Vector for Worst Criterion | 182 |
| **Table 47** | Governmental Sector: PMs Criteria Weights | 182 |
| **Table 48** | Governmental Sector: Factors Rank | 183 |
| **Table 49** | Average Criterion Weights from All Sectors | 183 |
| **Table 50** | Service Industry Factors Rank | 183 |
| **Table 51** | Generative AI Capabilities: Semi-structured Interview Results | 187 |
| **Table 52** | Generative AI Characteristics | 188 |
| **Table 53** | Generative AI Abilities | 188 |
| **Table 54** | Generative AI Main Characteristics | 195 |
| **Table 55** | Generative AI Main Abilities | 210 |
| **Table 56** | Service Industry: Pairwise Comparison Vector for Best Criterion | 231 |
| **Table 57** | Service Industry: Pairwise Comparison Vector for Worst Criterion | 232 |
| **Table 58** | Average Criterion Weights from All Project Managers of the Five Sectors within the Service Industry | 232 |
| **Table 59** | Service Industry: Factors Rank | 233 |

| | | |
|---|---|---|
| **Table 60** | Interview Results: List of Generative AI Enablers | 236 |
| **Table 61** | List of Influential Factors for Human-AI Collaboration | 240 |
| **Table 62** | Human Behaviors and Attitudes in Tuckman's and Woodcock's Models | 265 |
| **Table 63** | Performance of H-H Teams in Tuckman's Models | 268 |
| **Table 64** | Performance of H-H Teams in Woodcock's Models | 269 |
| **Table 65** | Performance of H-H Teams in Tuckman's & Woodcock's Models | 270 |
| **Table 66** | Humans & Generative AI Attributes | 271 |
| **Table 67** | Performance of Human-Generative AI Teams According to Tuckman's Models | 273 |
| **Table 68** | Performance Comparison Between H-H & H-GenAI Teams According to Tuckman's Models | 274 |
| **Table 69** | Performance of H-GenAI Teams According to Woodcock's Models | 276 |
| **Table 70** | Performance Comparison Between H-H & H-GenAI Teams According to Woodcock's Models | 277 |
| **Table 71** | Performance of Human-Generative AI Teams according to Tuckman's & Woodcock's Models | 278 |
| **Table 72** | Performance Comparison Between H-H & H-GenAI Teams According to Tuckman's and Woodcock's Models Combined | 279 |
| **Table 73** | Generative AI Characteristics & Abilities for SPTD | 281 |
| **Table 74** | Human Behaviors & Attitudes (B&A) & GenAI Characteristics & Abilities (C&A) throughout STD According to Tuckman's Model | 284 |
| **Table 75** | Human Behaviors & Attitudes (B&A) & GenAI Characteristics & Abilities (C&A) throughout STD According to Woodcock's Model | 286 |
| **Table 76** | H-GenAI SPTD Model | 288 |

# List of Figures


| Figure No. | Figure Title | Page No. |
|---|---|---|
| **Figure 1** | Agile Software Development Team Formation Conceptual Model | 38 |
| **Figure 2** | Two Unanswered Questions in Stage Models of Team Development, Based on Bruce Tuckman's Model | 46 |
| **Figure 3** | A Revised Model of Team Development Introducing a Weak Barrier to Standard Performance and a Strong Barrier to Exceptional or Creative Performance | 46 |
| **Figure 4** | Phases of Team Development Based on Group Dynamics Model by Bruce Tuckman | 47 |
| **Figure 5** | Mike Woodcock's Model: Characteristics of Stages of Team Development | 48 |
| **Figure 6** | Model Segment: H-H Project Team Formation | 69 |
| **Figure 7** | Model Segment: H-GenAI Project Team Formation | 71 |
| **Figure 8** | H-GenAI Project Team Formation Model | 72 |
| **Figure 9** | Model Segment: Stages of H-H Team Development | 74 |
| **Figure 10** | Model Segment: Stages of H-GenAI Project Team Development | 76 |
| **Figure 11** | Stages of H-GenAI Project Team Development Model | 77 |
| **Figure 12** | H-GenAI Project Team Key Performance Indicators | 78 |
| **Figure 13** | Human-Generative Artificial Intelligence Collaboration Model (H-GenAI Collab) | 80 |
| **Figure 14** | Segments of H-GenAI Collab | 85 |
| **Figure 15** | Segments of H-GenAI PTs KPIs | 86 |
| **Figure 16** | Interconnection Between Worldviews, Strategies of Inquiry, & Research Methods | 87 |
| **Figure 17** | The Interrelationship Between the Building Blocks of Research | 93 |
| **Figure 18** | Systematic Methodology of Literature Review | 96 |
| **Figure 19** | Text Mining Process Flowchart | 103 |
| **Figure 20** | Proposed Text Mining Framework (TMF) | 104 |
| **Figure 21** | Classification of Different Clustering Techniques | 108 |
| **Figure 22** | Analysis Procedure in Qualitative Research | 132 |
| **Figure 23** | Clustering Framework | 135 |
| **Figure 24** | H-GenAI PTF section (Phase 1) | 144 |
| **Figure 25** | K-Means Clustering: Elbow Method for Optimal k | 163 |

| | | |
|---|---|---|
| **Figure 26** | K-Means Clustering of Factors | 163 |
| **Figure 27** | Three Clusters of Factors in Hierarchical Clustering: Human-related Factors (C1), Project-related Factors (C2), and Team-related Factors (C3) | 166 |
| **Figure 28** | Eight Main Clusters of Factors in Hierarchical Clustering | 167 |
| **Figure 29** | Comparison of Clustering Methods using Silhouette | 168 |
| **Figure 30** | Latent Dirichlet Allocation Clustering Results | 169 |
| **Figure 31** | Factors Affecting Traditional H-H Team Formation in the Service Industry | 184 |
| **Figure 32** | Pareto Principle: Factors Affecting Traditional H-H Team Formation in the Service Industry | 185 |
| **Figure 33** | Clusters of Generative AI Characteristics Using Hierarchical Clustering Algorithms | 190 |
| **Figure 34** | Silhouette plot for Hierarchical Clustering Results (12 clusters): clustering 27 GenAI Characteristics | 191 |
| **Figure 35** | Silhouette plot for Hierarchical Clustering Results (overall): GenAI Characteristics | 192 |
| **Figure 36** | t-SNE: Preserving Global Structure | 193 |
| **Figure 37** | t-SNE: Preserving Local Structure | 194 |
| **Figure 38** | Clusters of Generative AI Abilities Using Hierarchical Clustering Algorithm | 204 |
| **Figure 39** | Silhouette plot for Hierarchical Clustering Results (12 clusters): clustering 37 GenAI Abilities | 205 |
| **Figure 40** | Silhouette plot for Hierarchical Clustering Results (overall): GenAI Abilities | 206 |
| **Figure 41** | Silhouette plot for Hierarchical Clustering Results (12 clusters): clustering 34 GenAI Abilities (amended plot) | 207 |
| **Figure 42** | t-SNE: Preserving Global Structure | 208 |
| **Figure 43** | t-SNE: Preserving Local Structure | 209 |
| **Figure 44** | Factors Affecting H-GenAI Team Formation in the Service Industry | 233 |
| **Figure 45** | Pareto Principle: Factors Affecting H-GenAI Team Formation in the Service Industry | 234 |
| **Figure 46** | A Comparison Between the Factors that Influence Project Team Formation for Traditional H-H Project Teams & H-GenAI Project Teams in the Service Industry | 235 |
| **Figure 47** | H-GenAI PTF Model | 262 |
| **Figure 48** | H-GenAI SPTD section (Phase 2) | 264 |
| **Figure 49** | H-H Team Performance in Tuckman's Model for Stages of Team Development | 268 |

| | | |
|---|---|---|
| **Figure 50** | H-H Team Performance in Woodcock's Model for Stages of Team Development | 269 |
| **Figure 51** | H-H Team Performance in Both Tuckman's & Woodcock's Models for Stages of Team Development | 270 |
| **Figure 52** | H-GenAI Team Performance through Stages of Team Development According to Tuckman's Model | 274 |
| **Figure 53** | The Difference in Performance of H-H & H-GenAI Teams According to Tuckman's Model | 275 |
| **Figure 54** | H-GenAI Team Performance through Stages of Team Development According to Woodcock's Model | 276 |
| **Figure 55** | The Difference in Performance of H-H & H-GenAI Teams According to Woodcock's Model | 277 |
| **Figure 56** | H-GenAI Team Performance through Stages of Team Development | 279 |
| **Figure 57** | The Difference in Performance of H-H & H-GenAI Teams | 280 |
| **Figure 58** | Tuckman's H-H STD Model | 283 |
| **Figure 59** | H-GenAI SPTD Model (According to Tuckman's Model) | 283 |
| **Figure 60** | Woodcock's H-H STD Model | 285 |
| **Figure 61** | H-GenAI SPTD Model (According to Woodcock's Model) | 285 |
| **Figure 62** | H-H STD Combined Model | 287 |
| **Figure 63** | H-GenAI SPTD Model (According to Tuckman's & Woodcock's STD Models Combined | 287 |
| **Figure 64** | H-GenAI PT KPIs section (Phase 3) | 290 |
| **Figure 65** | Key Performance Indicators for Human-Generative AI Collaboration | 299 |

# List of Abbreviations

| | |
|---|---|
| **AI** | Artificial Intelligence |
| **AIR** | Artificial Intelligence Representative |
| **BWM** | Best-Worst Method |
| **BC** | Best Criterion |
| **ES** | Energy Sector |
| **FS** | Financial Sector |
| **GenAI** | Generative Artificial Intelligence |
| **GS** | Governmental Sector |
| **H-AI** | Human-Artificial Intelligence |
| **H-GenAI** | Human-Generative Artificial Intelligence |
| **H-H** | Human-Human |
| **H-GenAI Collab** | Human-Generative Artificial Intelligence Collaboration Model |
| **MCDM** | Multi-Criteria Decision-Making |
| **ML** | Machine Learning |
| **MOB** | Main Objective |
| **MRQ** | Main Research Question |
| **NLP** | Natural Language Processing |
| **PM** | Project Manager |
| **PT** | Project Team |
| **PTF** | Project Team Formation |
| **RQ** | Research Question |
| **RS** | Real Estate Sector |
| **SOB** | Sub-Objective |
| **SPTD** | Stages of Project Team Development |
| **SRQ** | Sub-Research Question |
| **STD** | Stages of Team Development |
| **TF** | Team Formation |
| **TFP** | Team Formation Problem |
| **TF-IDF** | Term Frequency Inverse Document Frequency |
| **TP** | Team Performance |
| **TS** | Telecommunication Sector |
| **WC** | Worst Criterion |

# Chapter One

# Introduction to the Study

## 1.1 Introduction

This chapter provides an outline of the study's context, presenting an overview of the subject and highlighting the importance and usefulness of the research. It consists of seven main sections. After this introductory section, the following section provides a brief overview and background to the research topic, followed by an outline of the research's problems, questions, objectives, significance and contribution, setting, and terminologies.

## 1.2 Research Background

As patterns of work started to change, the collaboration between humans and artificial intelligence (AI), currently humans and various forms of AI, is becoming increasingly important (Boni, 2021). With the significance of collaboration between humans and AI, it is more acceptable to regard AI as team members rather than as merely tools (Ma et al., 2022a). A research agenda on human-agent teaming and the roles and effects of AI agents in contemporary teamwork is emerging as a result of the more recent technological convergence of AI and teamwork (Schelble et al., 2022), (O'Neill et al., 2022a). In complementing human-AI (H-AI) teams, team performance (TP) is expected to be greater than if the human and AI operated alone (Inkpen et al., 2023). However, when AI agents are employed in teams, how well humans and AI work together typically determines the collaboration's outcomes (Munyaka et al., 2023). This intersection revolves around the integration and development of AI teammates (Schelble et al., 2022). To make a significant contribution, these

AI technologies must be capable of assisting human teammates with a task without interfering with the sensitive interpersonal states and team dynamics that underpin productive collaboration (Eloy et al., 2023). Therefore, it is important to investigate the optimization and dynamics of H-AI collaboration in projects (Nenni et al., 2024).

Effective teamwork is the key to high TP (Zajac et al., 2021) and a critical factor that determines the success of projects (Pollack & Matous, 2019). In the case of project management, finding the right team members is essential to attaining project goals, managing risks, overcoming uncertainties, and ultimately succeeding with the project (BALCIOĞLU et al., 2022). Yet, selecting a team to execute a project is not simple (Kalayathankal et al., 2021). Besides, although teams of humans and AI can be considered as those that collaborate to achieve a common goal (Ma et al., 2022a), these new ways of collaborating between humans and AI have benefits and some concerns (Boni, 2021). Therefore, future research must focus on developing tailored AI methodologies for certain industries to consider as a solid framework that can be applied and replicated across other sectors (Nenni et al., 2024).

The proliferation of technology that facilitates teamwork presents an opportunity to investigate how systems assist individuals in teams (Gómez-Zará, DeChurch, et al., 2020). Although generative AI (GenAI) can significantly improve the outcomes of project teams (PTs), there is limited research on the integration of GenAI into PTs and the prospects of GenAI in various sectors (AbuAlfateh et al., 2024). This necessitates a suitable regulatory framework, one that is future-proof, predicts the growth of AI, adopts a risk-based strategy, and uses ex-ante evaluation as a tool to prevent unforeseen outcomes while ensuring ethical and accountable behaviors when using AI technologies (Boni, 2021).

## 1.3 Research Problem

Many of the jobs we do are best completed in teams (Bachrach et al., 2020), and the engineering and management structures are largely influenced by teamwork (Kalayathankal et al., 2021). The process of forming a team requires finding a group of people who are very likely to work well together, employing their own skills to meet a set of necessary competencies (Rad et al., 2023) while assuring that team members' skills match the requirements of the project that is being considered (Stavrou et al., 2023). Nevertheless, team success may not always be assured, and forming an inappropriate type of team can be discouraging and hence impede learning (Stavrou et al., 2023). To tackle this problem, researchers have developed several team formation (TF) techniques that are influenced by Multi-Criteria Decision-Making methods (MCDM), which score team members and rank teams according to how closely they match the project's ideal profile (Ribeiro et al., 2023).

The appropriate allocation of human resources is vital for every type of business and organization (D'Aniello et al., 2021), yet the challenge of forming teams out of the members of a particular population arises in a variety of domains (Bahargam et al., 2019a). Methods and procedures employed in the formation of a team tend to vary depending on many factors, including the tasks, context, personalities, and characteristics and traits of the team members (Stavrou et al., 2023). As employee pools increase, it is no longer possible to create nearly ideal teams through manual implementation (Josue-Miguel Flores-Parra et al., 2018). Even when researchers across various disciplines with diverse data sets are investigating a variety of clustering models and techniques, employing best practices, and striving to create tools, strategies, and different approaches to enhance and streamline the process of assembling productive teams

(Stavrou et al., 2023), more comprehensive and detailed models must be taken into consideration to effectively convey the various factors influencing team performance (TP) (Andrejczuk et al., 2019) and hence, enhance the process of TF by addressing these issues.

As the service industry is progressively embracing AI solutions (Lokhande, 2022), H-AI collaborations are becoming more and more common in numerous domains (Munyaka et al., 2023). Besides, in the era of GenAI, Chatbots, which are a form of cutting-edge technology referred to as automated systems that mimic human conversations using Natural Language Processing (NLP) algorithms to offer humans immediate assistance and support (Raj et al., 2023), are becoming increasingly common among industries worldwide (Raj et al., 2023). In addition, advancements in large language models (LLMs) have transformed perceptions of AI and its applications, allowing GenAI to offer a variety of potential applications in the management domain (Haase et al., 2023). Therefore, it is important to establish new methods for H-AI TF (Ali et al., 2023).

Nowadays, the growing dependence of teams on technologies for task completion has resulted in the adaptation of team processes and dynamics to the social structures and interaction opportunities offered by socio-technical systems (Gómez-Zará, DeChurch, et al., 2020). Yet, with the emergence of AI and its presence as a fundamental aspect of society, it is becoming a growing necessity to gain insight into how people collaborate with AI systems to accomplish jobs (Munyaka et al., 2023). Therefore, researchers must comprehend the various avenues for H-AI collaboration since it will transform the way tasks are performed and, as a result, impact the scope of work in general in the future (Abedin et al., 2022).

The collaboration of humans with AI in PTs will ultimately result in remarkable improvements not only in the abilities of humans and the way challenging problems are solved (Rawas, 2024) but also in enhancing PT performance and, hence, project success (Ali et al., 2023). Although GenAI tools, such as GPT, Bard, and CoPilot, have become more widespread (Bahi et al., 2024), there is an inadequate understanding of the capabilities of GenAI and their impact on the collaboration with humans in PTs (AbuAlfateh et al., 2024). Besides, there is a lack of empirical data on GenAI's effectiveness in improving team performance and attaining project success (AbuAlfateh et al., 2024). Thus, future research must urgently focus on determining clear pathways and optimal techniques for integrating AI into the processes of project management (Nenni et al., 2024), specifically GenAI.

Individuals are not required to be professionals in AI to apply AI approaches, rather, they must be professionals in their particular fields (Haase et al., 2023). However, the collaboration between humans and AI demands careful consideration, not only given its challenging design but also for its associated management challenges (Abedin et al., 2022). Although there is growing recognition of AI's potential to enhance and elevate teams' performance (Ali et al., 2023), it is unclear how the processes of project management executed by PTs in the scenario of H-AI collaboration will be evaluated, even when the terms efficiency and effectiveness are frequently applied to evaluate various processes in project management (Sundqvist et al., 2014). Besides, developing suitable measures that may be applied to evaluate it is essential (Ali et al., 2023). Therefore, it is important to explore the key performance indicators (KPIs) to assess a PT’s performance when GenAI and humans collaborate in PTs within the service industry.

## 1.4 Research Questions

To address the research gaps, this study develops 2 main research questions (MRQs) for its 2 main objectives (MOBs) as follows:

**MRQ1: How to develop a H-GenAI collaboration model for PTs in project management within the service industry?** *(MOB1: To develop a H-GenAI collaboration model for PTs in project management within the service industry.)*

**MRQ2: What are the KPIs that can be utilized to measure the performance of H-GenAI PTs?** *(MOB2: To determine KPIs for measuring the performance of H-GenAI PTs.)*

To address the MRQ1 and better understand the topic under consideration, the study develops 3 sub-research questions (SRQs):

***SRQ1: How to build a model for H-GenAI PTF?***

First, the study explores the theories of TF, discovers the factors that influence the formation of a PT from existing models, and determines the techniques used to allocate weights to the main factors influencing TF to prioritize their impact on achieving optimal teams to solve the TFP for traditional human teams. Then, the study explores the capabilities of GenAI -which consist of characteristics and abilities- for PTs to better comprehend the advantages of GenAI for PTs and solve the H-GenAI TFP. After that, the study investigates how GenAI is capable of functioning and the factors that support H-GenAI collaboration to better understand how H-GenAI PTs work.

***SRQ2: How to build a model for H-GenAI stages of project team development?***

The study explores models for the STD for traditional human teams and determines the behaviors and attitudes of humans working in teams throughout the STD to better comprehend the progress of humans throughout the STD during projects. Then, the study reflects the H-GenAI PTs' progress throughout the STD during projects using existing models of the STD for traditional teams by mapping the characteristics and abilities of GenAI with those behaviors and attitudes of humans to determine what capabilities of GenAI aid humans in elevating the behaviors and attitudes of humans throughout the STD when working in PTs.

***SRQ3: To what extent do the capabilities of GenAI enhance the performance of humans in H-GenAI PTs compared to H-H PTs throughout the STD?***

To measure the extent to which GenAI capabilities enhance human performance in H-GenAI PTs throughout the STD during projects, the study first examines the progress of humans throughout the STD during projects by measuring H-H PT's level of development. In doing so, the study quantifies the human behaviors and attitudes into "+1" or "-1" according to their influence on PTs, whether positively or negatively, and calculates the positive ones to evaluate the performance of H-H PTs throughout the STD. To compare between H-H team's progress throughout the STD with H-GenAI team's progress throughout the STD, the study quantifies the capabilities of GenAI -the characteristics and abilities of GenAI- into "+1" or "-1" according to their influence on PTs, whether positive or negative, and calculates the positives ones. Finally, the study evaluates the performance of H-GenAI PTs level of development throughout the STD to assess the extent to which GenAI compensates via its capabilities for the drawbacks in human performance due to the behaviors and attitudes of humans that arise while working on projects

throughout the STD by comparing the results of the different PTs; H-H and H-GenAI PTs.

To address the MRQ2 and better understand the topic under consideration, the study develops 2 SRQs:

***SRQ4: How can we measure the efficiency of H-GenAI PTs?***

***SRQ5: How can we measure the effectiveness of H-GenAI PTs?***

The study determines criteria to assess the performance of PTs consisting of humans and GenAI in terms of how efficient and effective H-GenAI PT can be.

Table 1 presents the mapping of the study's objectives (MOBs and SOBs) and research questions (MRQs and SRQs).

Table (1): Mapping Study's Objectives with Research Questions

<table>
<tr><th colspan="4">Mapping of Research Objectives & Questions</th></tr>
<tr><td rowspan="2">Main Objectives (MOBs) & Sub-objectives (SOBs)</td><td colspan="2">MOB1: To develop a H-GenAI collaboration model for PTs in project management within the service industry.<br>(Addressed in Phase 1 & Phase 2 of the study)</td><td rowspan="2">MOB2: To determine KPIs for measuring the performance of H- GenAI PTs.<br>(Addressed in Phase 3 of the study)</td></tr>
<tr><td>SOB1: To build a model for H- GenAI PTF.<br>(Phase 1)</td><td>SOB2: To build a model for H- GenAI stages of project team development and determine the extent to which the capabilities of GenAI enhance the performance of H-GenAI PTs compared to H-H PTs throughout the STD.<br>(Phase 2)</td></tr>
<tr><td>Main Research Questions (MRQs)</td><td colspan="2">MRQ1: How to develop a H-GenAI collaboration model for PTs in project management within the service industry?</td><td>MRQ2: What are the KPIs that can be utilized to measure the performance of H- GenAI PTs?</td></tr>
<tr><td>Sub-Research Questions (SRQs)</td><td>SRQ1: How to build a model for H-GenAI PTF?</td><td>SRQ2: How to build a model for H-GenAI stages of project team development?<br>SRQ3: To what extent do the capabilities of GenAI enhance the performance of humans in H- GenAI PTs compared to H-H PTs throughout the STD?</td><td>SRQ4: How can we measure the efficiency of H- GenAI PTs?<br>SRQ5: How can we measure the effectiveness of H- GenAI PTs?</td></tr>
</table>

## 1.5 Research Objectives

The roles and consequences of AI and its developments in contemporary teamwork, as well as H-AI teaming, are the subject of a developing research topic in computer-supported cooperative work (Schelble et al., 2022). The need to comprehend how team dynamics are found in H-AI teams is expanding as collaborative technologies go from helpful tools to interactive teammates (Eloy et al., 2023). The increasing prevalence of AI in our regular interactions and communication demands the development of new conceptual models and theories of H-AI collaboration (Joksimovic et al., 2023). Besides, examining similarities and differences in the collaboration between H-H and H-AI is one field of study for H-AI collaboration (Munyaka et al., 2023). In addition, incorporating the "efficiency" and "effectiveness" concepts in project management may assist academics and practitioners in structuring initiatives to enhance the work in project-based organizations (Sundqvist et al., 2014). For these reasons, this study aims to address these issues and bridge the gap in the literature by developing a model for H-GenAI collaboration for PTs in project management within the service industry and determining KPIs for measuring the performance of H-GenAI PTs.

The study contributes to the concept of TF and the STD by, first, investigating effective ways for forming H-H and H-GenAI PTs and, then, examining how H-H and H-GenAI PTs develop throughout the STD. The results shed light on how techniques are utilized to improve the strategies of TF for better teamwork performance and, hence, project outcomes.

The explanation of how humans and GenAI PTs are formed and then developed throughout the STD during their collaboration builds a general understanding of the use of GenAI capabilities in project management for

better PT performance. Besides, determining KPIs for evaluating the performance of H-GenAI PTs helps project managers within the service industry establish criteria for measuring the performance of their PTs.

## 1.6 Research Significance

TF is a crucial area for investigation (Schelble et al., 2022) as every organization is constantly searching for ways to form an ideal team (Kalayathankal et al., 2021). Teams must be formed for collaborative tasks, depending on the project at hand (Stavrou et al., 2023). Problems concerning the formation of teams occur frequently in numerous fields such as industries, sports, education, and general business (Josue-Miguel Flores-Parra et al., 2018). Thus, the TFP has drawn the attention of numerous researchers since it is crucial to the accomplishment of every project within an organization (Rahmanniyay et al., 2019a).

Although numerous methods based on knowledge modeling have been developed for TF (D'Aniello et al., 2021), there are no techniques in the literature on organizational psychology that offer a comprehensive set of instructions for forming teams. Besides, even when numerous fields have focused a great deal of research on the TFP (Rahmanniyay et al., 2019a), there hasn't been much research in the project management literature on the formation and development of successful PTs (Pollack & Matous, 2019). Therefore, this study highlights the importance of forming PTs in project management by exploring the factors that affect the formation of PTs in project management within the service industry for better PTs' performance.

Throughout the previous studies in this area, it has been acknowledged that the formation of the PT is a complex MCDM problem (Kalayathankal et al., 2021), and by using the MCDM methods, an organization can assemble

an ideal team with confidence (Kalayathankal et al., 2021). While research offers insightful information on TF in general, the precise effect of technology on TF has not yet been thoroughly examined (Gómez-Zará, DeChurch, et al., 2020). Therefore, this study proposes a combination approach consisting of AI technologies with an MCDM method for forming PTs and ensuring better selection of PT members for better PT performance and, hence, project success.

Although companies are organizing their work in increasing amounts into teams in an attempt to succeed and effectively navigate the constantly changing conditions (Ulfert & Georganta, 2020), it is unusual for a project to succeed if the team of individuals in charge of completing it cannot collaborate well (Pollack & Matous, 2019). Researchers in this discipline examine how individual traits impact team performance (Andrejczuk et al., 2019). Even though a significant amount of research has been done on the behavioral characteristics of team members that may impact the project's seamless operation, there is still a lack of talent-based (quantitative) studies in this area (Kalayathankal et al., 2021). Therefore, this study explores models for the stages of team development and determines the human behaviors and attitudes that arise when working in teams throughout the STD to better comprehend how teams collaborate and develop.

Even when workplace relationships may experience severe stress as a result of the pressure put on PTs, projects require teams of individuals to work together effectively despite pressures (Pollack & Matous, 2019). Besides, given the importance of human-AI collaboration (Ma et al., 2022a) and its promising approach to improving team performance (Ali et al., 2023), it becomes essential to introduce H-GenAI teams in an attempt to elevate the PT performance and avoid many of the undesired behaviors and attitudes of human teammates that arise during the project from the

complex nature of humans, which hinders effective collaboration between the team members and hence negatively affects the project.

Designing and assessing H-AI teams requires not just an awareness of how humans and AI behave differently, but also -and perhaps more importantly- how they collaborate to accomplish tasks (Ma et al., 2022b). Therefore, this study investigates the extent to which the STD for traditional human teams apply to H-GenAI collaboration and builds the stages of H-GenAI project team development model while examining the extent to which GenAI compensates for the drawbacks in the behaviors and attitudes of humans throughout the STD and determines KPIs to measure the performance of H-GenAI PTs.

The number of empirical studies on human-agent teams has been steadily rising since the beginning of the twenty-first century, yet many important concerns about the dynamics of teamwork in these types of teams are still unsolved (Schelble et al., 2022), (O'Neill et al., 2022a). Research on H-AI collaboration explores how people engage with AI systems, and understanding how people think AI systems work is part of this matter (Munyaka et al., 2023). While the topic of H-AI interaction is not new, academic research has only been able to examine human interaction with intelligent agents for the last decade or so (Larson & Dechurch, 2019). This is because AI agents are a relatively new development in intelligent technology, making them "intelligent." (Larson & Dechurch, 2019).

Considering all aspects, this study examines an issue that is both relevant and current and mixes innovative technology, project management, and the growing demand for productive cooperation between humans and AI systems, particularly GenAI. It investigates a comprehensive strategy to enhance H-GenAI collaboration in project management within the service industry by, first, forming PTs via an innovative hybrid technique that

includes NLP, ML, and an MCDM method for TF, then, determining GenAI capabilities to solve H-GenAI PTF. The study then explores the models for STD for traditional teams to build the H-GenAI stages of project team development (SPTD) and evaluates the extent to which the capabilities of GenAI compensate for human behaviors and attitudes during the H-GenAI collaboration. The study, finally, determines KPIs to measure the performance of H-GenAI PTs.

The study exhibits an in-depth knowledge of H-GenAI collaboration and how it can be used in business. Moreover, professionals in the service industry can benefit from the focus on the project management process because it directly addresses concerns specific to this industry. Besides, the conclusions and suggestions of the study should be helpful to businesses seeking to utilize GenAI in PTs as teammates to improve their PTs' performance and, hence, project management outcomes.

## 1.7 Research Setting

The study is conducted throughout 3 successive Phases: (1) H-GenAI Project Team Formation, (2) Stages of H-GenAI Project Team Development, and (3) Key Performance Indicators for Measuring H-GenAI Project Team Performance. Phases 1 and 2 combined results in developing a model for H-GenAI Collaboration, while Phase 3 results in the establishment of KPIs for evaluating the performance of H-GenAI PTs.

In Phase 1, the study starts with showcasing the different theories in TF as well as exploring the factors that contribute to forming PTs from different models that were developed to solve the TFP, addressing the effectiveness of using MCDM weighing methods in solving the TFP by assigning weights to these factors, specifically the human attributes, according to previous studies in this field, and introducing the use of the Best-Wort

Method (BWM) of the MCDM methods in particular to serve this purpose. The study explores the capabilities of GenAI and identifies the human attributes that best influence TF when GenAI is integrated into PTs to solve H-GenAI TFP. Besides, the study reveals the factors that support the collaboration of humans with GenAI in PTs, as well as the enablers of GenAI that cause GenAI to function. The study proposes a model for H-GenAI PTF.

Moving on to Phase 2, the study explores models for the STD, mainly investigating the two models of Bruce Tuckman's and Mike Woodcock's, and implements the progress or development of H-GenAI PTs throughout these stages of H-H team development, drawing the line for H-GenAI PTs in enhancing PT performance by considering the main characteristics and abilities of GenAI, and evaluates the extent to which these characteristics and abilities of GenAI compensate for the behaviors and attitudes of humans, that are driven from the two models of Tuckman's and Woodcock's, which arise when working on projects in teams. The study proposes a model for the stages of H-GenAI project team development (H-GenAI SPTD).

By combining the 2 built models of H-GenAI PTF (the output of Phase 1) with H-GenAI SPTD (the output of Phase 2), the study develops the H-GenAI Collaboration Model (H-GenAI Collab) for PTs in project management within the service industry.

In Phase 3, the study explores how the performance of H-GenAI PTs is assessed, determining KPIs to measure the performance of H-GenAI PTs, considering both efficiency and effectiveness.

This study consists of 5 Chapters, including this introductory chapter, which collectively report the study's process, findings, and contributions,

as follows: Chapter 1: Introductory to the Study, Chapter 2: Theoretical Framework and Literature Review, Chapter 3: Methods and Procedures, Chapter 4: Results and Discussion, and Chapter 5: Conclusion.

As previously indicated, Chapter 1 introduces the research by establishing the context of the study, providing an overview of the topic, and explaining the significance and value of the study. Section 1 presents a short introduction. Section 2 presents the study's background. Section 3 presents the research problem. Section 4 presents the research questions, followed by the research objectives in Section 5. Section 6 states the significance of the study. Section 7 displays the study's setting. Finally, Section 8 lists the terminologies that are used for this study.

Chapter 2 reviews the literature to ascertain the current state of knowledge on the main research questions and demonstrates the gaps in the literature that were identified in the introductory chapter, leading to the development of a model for the study. Section 1 provides an introduction. Section 2 highlights the importance of project management in the service industry, highlighting the key success and failure factors of project management and the influence of PTs on project success. Section 3 provides an overview of the team dynamics, presenting the TFP, the factors that affect TF, as well as the STD. Section 4 explains how AI applications change businesses, highlighting AI advancements and how businesses embrace GenAI and consider its integration into PTs for project management within the service industry. Section 5 explores the factors that support the collaboration between H-GenAI. Section 6 identifies the means of evaluating the performance of PTs. Section 7 presents the study's model development.

The research methods and procedures are discussed in Chapter 3, justifying the adopted research design. Section 1 provides an introduction. Section 2 presents the research design, explaining the philosophical worldview and

the strategy of inquiry. Section 3 presents the research methods used for data collection for the 3 Phases of the study. Finally, Section 4 sums up the chapter.

Chapter 4 of the study presents the results and discussion of the main findings of the research. Section 1 presents an introduction. Section 2 reveals the results of the 3 Phases of the study, followed by a summary of each Phase and ending with a summary for all the 3 Phases combined. Section 3 presents the discussion of the study. Finally, Section 4 presents further findings of the study.

Finally, Chapter 5 concludes the study. Section 1 is an introduction. Section 2 shows how the study addresses the research questions and meets its objectives. Section 3 determines the study's contribution to research and practice. Section 4 presents the study's limitations, and finally, Section 5 provides the study's recommendations and directions for future research.

## 1.8 Research Terminology

This section presents the main terminologies of the study in alphabetical order, as shown in Table 2.

Table (2): Main Terminologies of the Study

| Terms | Definitions |
|---|---|
| **Artificial Intelligence** | According to the authors Svenningsson & Faraon (2019), researchers have different definitions for artificial intelligence. It is called *"the science and engineering of making intelligent machines"*. Later definitions of AI include *"intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and other animals. AI implements human cognitive functions such as perceiving, processing input from the environment and learning"*. AI is also referred to as "*machines that exhibit aspects of human intelligence"* and *"a rational agent* |

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| | *that acts so as to achieve the best outcome or, when there is uncertainty, the best-expected outcome"*. (Svenningsson & Faraon, 2019) |
| **Autonomous Agent** | According to O'Neill et al. (2022), an autonomous agent is defined as *"a computer- based entity that is individually recognized as occupying a distinct team member role".* (O'Neill et al., 2022b) |
| **Chatbot** | According to the authors Svenningsson & Faraon (2019), a chatbot is defined as *"a social AI that has been designed to carry out conversations with humans using natural language processing".* (Svenningsson & Faraon, 2019) |
| | According to Belk et al. (2023), it is a *"type of conversational agent, often text-based, that is designed with the purpose of providing users with a specific service".* (Belk et al., 2023) |
| **Chat Generative Pre-Trained Transformer** | According to Michel et al. (2023), a Chat Generative Pre-Trained Transformer (ChatGPT) is described as *"a large language model trained to generate humanlike text based on a given prompt or context. It can be used for a variety of natural language processing tasks, such as text completion, conversation generation, and language translation".* (Michel-Villarreal et al., 2023) |
| **Generative Artificial Intelligence** | According to Lim et. Al. (2023), Generative Artificial Intelligence can be defined as *"a technology that leverages deep learning models to generate human-like content (e.g., images, words) in response to complex and varied prompts (e.g., languages, instructions, questions".*<br>(Lim et al., 2023) |
| | According to Sætra (2023), Generative Artificial Intelligence is *"an umbrella term to describe machine learning solutions trained on massive amounts of data in order to produce output based on user prompts (input in the form of commands)".* (Sætra, 2023) |

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| | According to Zhang et al. (2023), Generative Artificial Intelligence *"refers to algorithms and models, such as OpenAI's ChatGPT, that can be prompted to generate various types of content".* (P. Zhang & Kamel Boulos, 2023) |
| | According to the authors Ye et. Al. (2024), Generative Artificial Intelligence is *"a type of AI technology that empowers the generation of synthetic content and data by learning from existing man-made samples".* (Ye et al., 2024) |
| | According to Feuerriegel et al. (2024), the term Generative Artificial Intelligence refers to *"computational techniques that are capable of generating seemingly new, meaningful content such as text, images, or audio from training data"*. (Feuerriegel et al., 2024) |
| **Generative Artificial Intelligence Model** | According to Feuerriegel et al. (2024), a Generative Artificial Intelligence Model refers to *"generative modeling that is instantiated with a machine learning architecture (e.g., a deep neural network) and, therefore, can create new data samples based on learned patterns"*. (Feuerriegel et al., 2024) |
| **Group** | Lewin defines a group as *"a dynamic whole based on interdependence rather than similarity"*. (Lewin, 1948) |
| | According to Miller (2003), *"Groups are systems, often changing in social and work processes throughout the time of their existence".* (Miller, 2003) |
| **Group or Team Development** | According to Miller (2003), *"the periods of time during which an identifiable set of activities occurs are categorized as stages or phases of group development"*. (Miller, 2003) |
| | Bushe & Coetzer (2007) describe group development as "*a process that only some groups go through and that helps to explain why those groups are more effective than others."* The authors state that *"group development is associated with team effectiveness,"* and emphasize that *"development is not something all groups achieve over time but is instead a journey* |

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| | *toward optimal functioning only some groups attain".* (Bushe & Coetzer, 2007) |
| **Human-Agent Teams** | According to Schelble (2022), the authors O'Neill and colleagues *"define HAT as: 1) teams where agents are viewed as "agentic" by their human teammates (agents have a significant degree of independent decision making); 2) the agents must have a role interdependent with the roles of their human teammates; and 3) there must be one or more humans and one or more autonomous agents working towards a common goal". "Therefore, when using the term "agent," "AI," or "HAT," the current paper is referring to these definitions laid out by O'Neill and colleagues."* (Schelble et al., 2022), (O'Neill et al., 2022a) |
| | According to the authors Ulfert & Georganta (2020), Human-agent teams *"can be defined as (a) a collection of human individuals and one or more agents as autonomous team members, "who (b) socially interact (face-to-face or, increasingly, virtually); (c) possess one or more common goals; (d) are brought together to perform (organizationally) relevant tasks; (e) exhibit interdependencies with respect to workflow, goals, and outcomes; (f) have different roles and responsibilities; and (g) are together embedded in an encompassing organizational system, with boundaries and linkages to the broader system context and task environment".* (Ulfert & Georganta, 2020) |
| **Human-AI Teams** | Larson & Denchurch (2019 and 2020) clarify the meaning of human-AI teams and what it refers to by stating that *"Human-AI teams are composed of humans and disembodied intelligent agents working interdependently in pursuit of a common goal."* The authors clarify that they *"use the term agent in human-agent teams to refer to cases where a technology serves as a team member broadly. This umbrella term then captures two types of human-agent teams: human-robot teams and human-AI teams. The primary distinction between the two being the physical* |

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| | *embodiment of the robot. Both are computerized, employ computational algorithms, and occupy a role on the team. However, the robot is physically embodied while the AI teammate is not. The distinction is useful because prior work on robot embodiment is important for leading human-robot teams, but not for leading human-AI teams."* (Larson & Dechurch, 2019), (Larson & DeChurch, 2020) |
| **Human–Autonomy Teaming** | According to O'Neill (2022), it is defined as *"interdependence in activity and outcomes involving one or more humans and one or more autonomous agents, wherein each human and autonomous agent is recognized as a unique team member occupying a distinct role on the team, and in which the members strive to achieve a common goal as a collective. The "autonomy" aspect of human–autonomy teaming refers to the autonomous agent."* (O'Neill et al., 2022b) |
| **Intelligent Agents** | Kopecka (2024) defined intelligent agents as *"AI systems operating with different degrees of autonomy within their environments to achieve their objectives".* (Kopecka et al., 2024) |
| **Large Language Model** | According to Sætra (2023), it is *"a machine learning model that is trained to generate text that is similar to human language. It is called 'large' because it is trained on a large dataset and is able to generate highly realistic and coherent text."* (Sætra, 2023) |
| **Natural Language Processing** | According to the authors Svenningsson & Faraon (2019), Natural Language Processing is described as the *"combination of techniques that allow for the analysis of text or language on one or several levels".* (Svenningsson & Faraon, 2019) |
| | According to Zhang et al. (2023), Natural Language Processing is *"a pivotal subfield of artificial intelligence that focuses on the interaction between computers and human language. Its primary objective is to enable machines to comprehend, interpret, and generate human language in a meaningful and contextually relevant manner".* (P. Zhang & Kamel Boulos, 2023) |

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| **Project Team** | According to Nordahl-Pedersen et al. (2023), a project team is *"a group of people with a common goal and understanding of what is expected of them".* (Nordahl-Pedersen & Heggholmen, 2023) |
| **Team** | According to the authors Stavrou et al. (2018), a team is *"the primary component of the social structure, which refers to a set of people, who are very close together, for a short or long time, in order to meet basic common goals."* (Stavrou et al., 2018) |
| | Omar (2015) states that a *"Team often refers to members that have common goals for enhancing organizational performance".* (Omar et al., 2015) |
| **Team Dynamics** | According to the authors Nunkoo & Sungkur (2021), Team dynamics is understood as *"how team member's distinct roles and behaviours impact other team members and the team as a whole".* (Nunkoo & Sungkur, 2021) |
| **Team Formation** | According to Barambones (2021), *"Team formation represents the problem of assembling an agent team to accomplish a set of tasks with the minimum cost".* (Barambones et al., 2021) |
| | According to Sanchez-Segura (2018), Team formation is *"a complex task necessary in any project or activity in which several people are required to work together and share objectives and responsibilities".* (Sanchez-Segura et al., 2018) |
| **Team Formation Problem** | According to Ashenagar (2015), a team formation problem *"consists of formation of a team out of a large set of experts so that the outcome is most appropriate team for implementing the given project".* (Ashenagar et al., 2015) |
| | According to Yu (2017), the team formation problem *"is defined as finding a group of individuals to accomplish a job (project) requiring a set of skills for completion".* (Yu et al., 2017) |
| | According to Baghel & Bhavani (2018), a team formation problem is *"to find the allocation of people/experts for a project based on the project requirements".* (Baghel & Bhavani, 2018) |

# Chapter Two

# Theoretical Framework and Literature Review

## 2.1 Introduction

As mentioned in Chapter 1, this study aims to (1) develop a H-GenAI collaboration model for PTs in project management within the service industry and (2) determine KPIs for measuring the performance of H-GenAI PTs. Therefore, the aim of Chapter 2 is to review literature related to PTs for project management in the service industry and H-AI collaboration in project management, focusing on the integration of GenAI in PTs to support humans in projects by GenAI's unique capabilities and, hence, enhance H-GenAI PTs' performance.

This literature review is essential to build up the current research and to know where previous research has reached regarding the inquiry of this current study. For this study, the researcher executed an extensive literature search to provide a foundation for the literature review process based on scientific papers from databases such as ScienceDirect, ACM, IEEE, SAGE, ProQuest, and SpringerLink, and a more general search via Google Scholar. The literature review was divided into five main themes covering the areas of concern in this study, such as project management, team dynamics, AI and GenAI in PTs, factors supporting H-AI collaboration, and performance indicators for H-GenAI collaboration.

This Chapter finally presents the study's model and its segments, explaining the model development of the study.

## 2.2 Project Management

Project management has evolved into an indispensable discipline in many different industries (Nenni et al., 2024). In the past, project management has primarily been linked to industries such as construction and engineering (Aga et al., 2016). Nowadays, project management has become widespread across various sectors within different industries, including the service industry (Aga et al., 2016).

The implementation of efficient project management has played a role in achieving success in operations and process management (Kanski & Pizon, 2023). To ensure the accomplishment of an organization's strategic and performance goals in the context of an evolving information technology landscape, project management practices are required (Mishra et al., 2022).

Project management is supported by a variety of tools, procedures, and guidelines that constantly develop to accommodate the demands of contemporary businesses (Nenni et al., 2024).

Project management has always faced tremendous challenges at different levels in its attempt to achieve project success. The extent to which a project gets completed within budget and on schedule are two important criteria for project success that are normally assessed by the performance management system (Park, 2021). Yet every PM has experienced times when a well-thought-out strategy deteriorated into chaos as a result of scheduling delays, resource shortages, poor communication, or other logistical issues (Odeh, 2023), and as a matter of fact, schedule delays and cost overruns are two of the most frequent causes of project failure (Park, 2021).

The schedule is one of the iron triangle's three components, and any modifications to its original form will affect the other two components which are the project's cost and scope (Park, 2021). According to Park

(2021), schedules tend to be more complicated than cost, being restricted not only by the resources available but also by the interdependencies among the tasks at hand (Park, 2021).

Project failure is defined as not achieving a desired or intended goal or failing to complete a task that is expected, necessary, or due (Herz & Krezdorn, 2022). The causes of project failure can be divided into two categories: (1) people factors (continuous principal-agent problems and poor relationships) and (2) planning factors (unclear goals and insufficient planning) (Herz & Krezdorn, 2022). Inadequate project planning raises the risk of unforeseen, unfavorable situations that increase the possibility of project failure (Herz & Krezdorn, 2022). As for the "people factors" cause of project failure, it is important to mention that interactions between the individuals involved in a project become crucial in deciding its success or failure when multiple people are involved (Herz & Krezdorn, 2022). Besides, as a highly skilled and specialized profession, project management necessitates that PMs pursue learning opportunities to accomplish successful projects (Odeh, 2023). Thus, to deliver successful projects, PMs need to adapt to the evolving expectations of stakeholders by adopting new techniques and tools (Odeh, 2023). In addition, the insufficient maturity level of the technologies available for project management is another reason for the poor success rate concerning projects (Nenni et al., 2024). Therefore, new techniques and approaches must be implemented not only to enhance schedule estimates (Park, 2021) but also to address any other challenges that projects may encounter.

Project management is a tremendously significant practice that requires making decisions at various phases in a variety of uncertain circumstances (Mishra et al., 2022). The project management phases, also called project lifecycle, consist of five phases namely: (1) Initiating, (2) Planning,

(3) Implementing or Executing, (4) Monitoring and Controlling, and (5) Closing (Kalayathankal et al., 2021), (Auth et al., 2019), and all of the activities involved in each phase aim to accomplish specific objectives within the specified time frame (Kalayathankal et al., 2021). However, this cannot be achieved without a PT. Thus, it is crucial to recognize the value of teamwork in project management (Pollack & Matous, 2019), as interactions at the team level bring in a distinct dynamic (Lopes Barakat et al., 2021).

Nowadays, more focus has been placed on processes for project management to forecast and enhance product quality (Kalayathankal et al., 2021). Since projects usually involve time, financial, and staffing constraints, which affect the quality of the projects' deliverables (Kalayathankal et al., 2021), developing and implementing an approach that ensures an optimal TF to some extent is crucial (Stavrou et al., 2023). Therefore, TF, which occurs in the initiating stage of the project lifecycle, becomes one of the most important phases of the project management (Rahmanniyay et al., 2019a), and TF aims to assemble the most qualified team members available who can significantly impact the project (Kalayathankal et al., 2021).

During the project's team members selection process, we need to determine the requirements for every position and pair positions with available human resources (Kalayathankal et al., 2021). Consequently, it is fundamental to appoint the most capable individuals to each team working on a project (D'Aniello et al., 2021), place highly qualified individuals in the most suitable positions (Kalayathankal et al., 2021), and assign candidates with the appropriate duties as a result of the selection process (Rahmanniyay et al., 2019a) to ensure the project's success (Kalayathankal et al., 2021).

In general, a firm depends heavily on the competencies and skills of its workforce, and new projects usually provide opportunities for team members to gather new abilities, in terms of knowledge, attitudes, and skills, to successfully finish the work at hand (D'Aniello et al., 2021).

Since successful projects depend on factors including excellent management, specific objectives, and engaged teams (Land, 2019), the potential for a project to succeed or fail is not only closely related to the caliber of the individuals chosen to perform it but also to the hierarchical structure chosen (Kalayathankal et al., 2021). Even when a team is composed of appropriate workers, undesirable outcomes occur when the leader lacks the necessary skills to lead the team or has poor project management attitudes (D'Aniello et al., 2021). Therefore, appropriately qualified individuals positioned correctly give any company a competitive edge (Kalayathankal et al., 2021).

## 2.3 Team Dynamics

Finding a group of individuals who are extremely likely to get along well together and use the abilities they possess to fulfill a set of required competencies is a vital step in the process of forming a team (Rad et al., 2023). A team is a set of all abilities, and each member can be thought of as a set with a subset of abilities (Ali et al., 2023). The recommended solution to the TF dilemma is to identify the smallest sub-collection of expertise whose union includes the necessary set of competencies (Rad et al., 2023).

The principle of teamwork is complex and dynamic, and gaining an in-depth comprehension of teamwork should make it easier to build an effective team, including selecting team members, allocating authority and responsibility, and organizing team interactions (Ma et al., 2022b). These

variables of team composition, task characteristics, team member qualities, and work domain context, all together produce a complicated web of interdependencies that can lead to a variety of cooperation requirements that are challenging to anticipate without a full grasp of the characteristics of the current task (Ma et al., 2022b).

Teams often reflect the dynamics and advancement of the people who serve as the members of the group because they are formed out of people (Fairley et al., 2020). Team members must possess the fundamental abilities to carry out tasks that generally involve interdependencies (Lopes Barakat et al., 2021). Due to their distinctive competencies or abilities, each team member typically becomes distinguished and is essential to the success of the task as a whole (Ma et al., 2022b). Let alone the fact that a team frequently outperforms the aggregate ability of its individual members (Lopes Barakat et al., 2021). This happens when people with different technical and business backgrounds work together, giving the team complementary skills that result in a collective capacity higher than the sum of the individual skills of the members. The same idea holds true for team motivation and opportunity when the focus is on team member complementarity and variety rather than just individual contributions (Lopes Barakat et al., 2021).

The ongoing dedication of a team's members is a major factor in the success of the team (Judeh, 2023). In this context, it is important to keep in mind that teams are created precisely because the synergy generated by bringing people together results in beneficial outcomes (Lopes Barakat et al., 2021) and leadership has the challenging responsibility of evaluating each professional's talents and competencies and combining them into a cohesive team that meets the needs and characteristics of the current task (Ribeiro et al., 2023). Besides, in real-life situations, teams are urged to

perform better, yet they constantly encounter obstacles that prevent them from properly completing their goals (Judeh, 2023). Therefore, it is necessary to have an in-depth knowledge of teamwork, look at how teamwork may be described, and come up with appropriate metrics that can be utilized to evaluate it (Ma et al., 2022b).

### 2.3.1 Team Formation Problem

TF is becoming a growing problem as a result of the substantial effects it has on organizational performance (La Torre et al., 2023). TF is a vital process that guarantees the presence of effective team members, which is essential for fostering efficient teamwork (Omar et al., 2015). Ineffective TF can lead to poor performance, which can ultimately result in project failure (Aryanee et al., 2020). According to Aryanee (2020), teams can become ineffective for a variety of reasons, including members who do not complement one another, incompetent team members, conflicts brought on by incompatible personalities, a lack of skill sets within the team, and an imbalance in the positions within the team. These problems seem to shape the idea of inadequate TF (Aryanee et al., 2020).

To better comprehend the TFP, some fundamental definitions should be provided (Samie & Rajabzadeh, 2023). The authors define the TFP as the task of finding the right people or specialists for a project considering its specifications (Baghel & Bhavani, 2018). Assembling a team from a vast pool of experts to create the best team possible for executing the assigned task also defines the TFP (Ashenagar et al., 2015). A TFP is the difficulty of assembling a team of people to complete a task or project that requires a certain set of skills (Yu et al., 2017).

The TFP is frequently discussed in research and project environments, and considerable efforts were undertaken to choose the most qualified team of

specialists for projects (Samie & Rajabzadeh, 2023). For any business starting a new project, deciding how to form a team is crucial (Guo et al., 2023), as project success or failure is strongly associated with the individual skills of team members and how tasks and responsibilities are assigned to them (Gutiérrez et al., 2016). Thus, solving the TFP requires determining the best configuration to enable a team to successfully perform tasks and adhere to the project's constraints (Costa et al., 2020), (Cunha et al., 2022).

When forming a team, decision-makers need to consider multiple factors or criteria and determine which ones suit each team best (Omar et al., 2015). The decision-maker should evaluate each project's scope as well as the skills and expertise of the human resources that are available to form the teams (Costa et al., 2022). When making that decision, several factors need to be considered (Guo et al., 2023). Thus, TF in this situation can be viewed as an MCDM problem, wherein a variety of factors must be considered during the process of decision-making (Omar et al., 2015).

### 2.3.2 Factors Affecting Team Formation

Different scholars emphasized various criteria that must be utilized during the process of TF (La Torre et al., 2023). For instance, a systematic mapping study on TF explores the main characteristics of teams by identifying influential attributes of TF (Costa et al., 2020). By analyzing 51 papers from different publication types during the period 2001-2018, the study reveals five types of attributes that are utilized during the process of TF, namely: (1) Technical (including programming experience, network techniques, software design, quality control, database, and other attributes), (2) Individual cost (salary per hour), (3) Personality traits (attributes derived from Psychometric instruments such as Belbin’s Team Roles and Myers-Briggs Type Indicator), (4) Interpersonal (positive criticism,

communication, creativity, leadership, emotional intelligence, and other attributes), and (5) Social attributes (measures that can connect members, such as how many projects and how long they worked together, how close they are to one another, how many coworker friends in common, and so on). According to the systematic mapping study, the technical factor is the most used attribute to addressing the TFP as it is used in 80% of the 51 selected papers, followed by the Individual Cost (35%), Personality Traits (27.5%), Interpersonal (25%), and Social (17.5%), which is the least used attribute in comparison with the others.

Moreover, a study develops a model for TF with three main factors: the skills of experts, their collaboration network, and their reliability (Fathian et al., 2017), while another study uses the attributes of skills, personality, and the preference of agents over tasks (Georgara et al., 2022).

The study of Aryanee (2020) (Aryanee et al., 2020) identifies the attributes of Agile Software Development teams that appear under the two key components: the characteristics of the project and Agile team composition. The attributes of the project characteristics, which may influence the Agile team composition characteristics, are project size and project criticality, while the attributes of the Agile team composition characteristics are as follows: (1) Knowledge: education background, technical, domain/business, and project management, (2) Skill: interpersonal, technical, domain/business, and project management), (3) Ability: learnability and adaptability, (4) Experience: quantity of similar past projects, (5) Personality traits (HEXACO): honesty-humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience, and (6) Commitment: level of commitment. The conceptual model for Agile Software Development TF is presented in Figure 1.

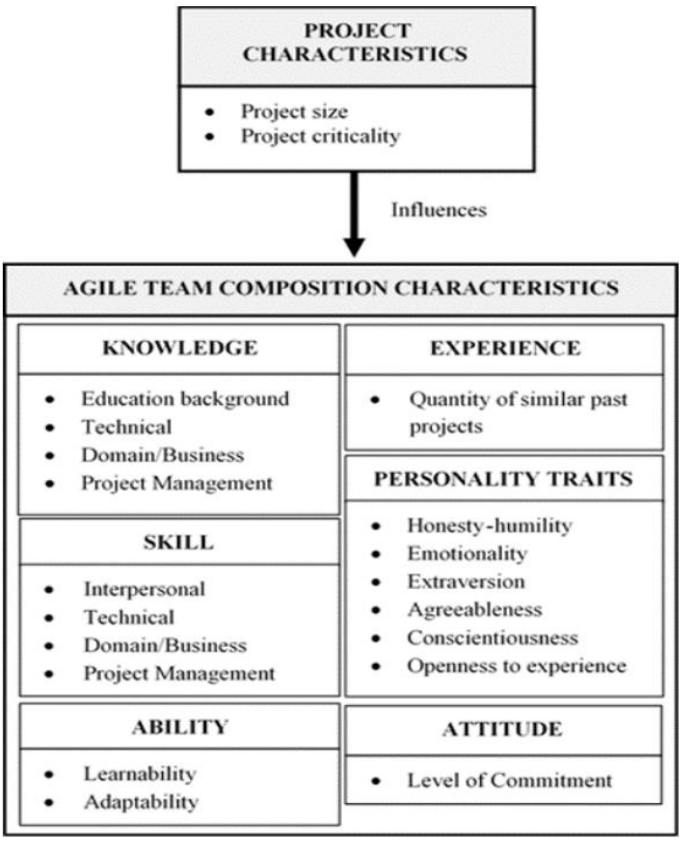



Fig. 1: Agile Software Development Team Formation Conceptual Model (Aryanee et al., 2020)

However, in an attempt to develop a comprehensive model and validate it, since the characteristics and attributes of this model were gathered only from previous studies, some authors (Zainal et al., 2024) have chosen the crowdsourcing-based data collection approach to confirm the model's factors (characteristics and attributes) and discover more. According to the respondents, the study validates the factors except for the project management attribute of Skills and Knowledge characteristics.

In the context of software development, the authors (Prashandi & Kirupananda, 2019) present a summary of the results of the factors that influence the effectiveness of TF as follows: (1) Skills and Soft Skills: (a) Skills (skills, capabilities, experience, technical knowledge) and (b) soft skills (analytic, problem-solving, commitment, responsibility, eagerness to learn, motivation, and teamwork), (2) Personality: (a) human

characteristics (personality, team work, coordination, conflict and cohesion) and (b) social psychology factors (introversion, extraversion, sensing, thinking, feeling, perceiving and judging), (3) Team Collaboration: team communication, specifications, and configuration management, Time zone differences, technical difficulties, language problems, time spent for training, (4) Project features and organizational needs: team size, required roles, technologies used, maximum team monthly cost and estimated development time, and (5) Other general factors: salary, education, working conditions, job satisfaction, age, 360-degree feedback score, overtime, absenteeism rate, environment satisfaction, hourly rate, gender, distance from home, job satisfaction, hourly rate, performance rating, total working years, training times last year, years since last promotion, business travel and job role, peer indication, availability and task preference.

In a study that aims to help managers form software teams (Cunha et al., 2022), the study mentions some factors that support TF as follows: social characteristics, technical characteristics, level of technology (programming language), tool's project-level focus, adaptability to changing technology requirements and team members after launching the project, and the projects and professionals' reliable/consistent information.

In addition, in a study that aims to form a model for software TF and team leader selection (Omar et al., 2015), the study summarizes the criteria for forming team members that can support decision-makers in forming effective teams for educational group projects as follows: Skills (including technical skills, management skills, and communication skills), aptitudes, interests, age, gender, race, ethnic background, country of origin, intelligence, training, experience (including work experience, teamwork experience), personality, personality characteristics, personal profile,

knowledge, unique knowledge, flexibility in job assignments, Grade Point Average, class schedule, student housing location. However, the study recommends evaluating its proposed model in the industrial setting.

Moreover, a study (Hosseini & Akhavan, 2017) considers the characteristics of PT candidates (Expertise level, Knowledge-absorption ability, Knowledge-sharing ability, Knowledge-sharing willingness, Knowledge-sharing motivation, and Knowledge absorption/ sharing opportunity) and project requirements (Expertise requirement, Cost of performing the task by an individual with an average expertise level and the workload of MAXWL, Duration of performing the task by an individual with an average expertise level and the workload of MAXWL, Task delivery time, and Project budget) for the development of a model that serves the purpose of project team members selection.

Furthermore, to address the TFP in the context of business processes, the study (Yu et al., 2017) considers individual expertise and handover relations to propose its method.

A study addresses the multiple TFP by considering the set of projects, skills, people/experts, and sociometric matrix in terms of members' happiness to work with one another (Baghel & Bhavani, 2018). Another study proposes an optimization model for addressing the multiple TFP that considers the set of projects, people available, skills/areas of expertise, people's allowed time allocation, project requirement matrix, sociometric matrix, and weight/priority of project (Gutiérrez et al., 2016). In addition, to aid PMs in forming multiple scrum PTs, the study proposes solutions based on allocating available developers of the organization into multiple software projects, providing recommendations for teams whose members possess competencies that align with the requirements of the projects (Costa et al., 2022).

Since the aim of the study was to construct a team of experts who are capable of performing the project tasks and communicating at a reduced cost of both personal and communication (Samie & Rajabzadeh, 2023), the study considers skills, experts, nature of task, field of work, wages or personal cost, along with communication cost. One study considers experts, skills, personnel costs, and communication costs (Ashenagar et al., 2015), while another study considers the factors of skills, positions, tasks, and communication costs to create a template-driven TF for PTs (Apostolou et al., 2020).

Considering person-job fit to address the TFP, the study (Guo et al., 2023) utilizes the factors of skills, required number of members, positions within teams, and personnel relationship (the willingness to communicate).

Although identifying the factors that aid in TF is an important phase of the process, deciding on how to assign values to each team member's abilities or attributes is also considered an important phase when forming a team (Costa et al., 2020). Thus, the authors of the systematic mapping study on TF investigate the means by which values are assigned to attributes (Costa et al., 2020) and find the following six ways in sequential order according to the most frequently used: (1) Historical data, (2) Expert judgment, (3) Psychometric instruments, (4) Self-assessment, (5) Teammate assessment, and (6) Curriculum data, in addition to other means as some studies did not mention how values were allocated, according to the authors. According to other research (Cunha et al., 2022), recent methods proposed software tools that enable the automatic retrieving of attributes from past project histories and source code platforms, while others offer distinct features like altering the team after the appointment and displaying the history of modifications.

Various approaches have been used in numerous research to quantify skill scores, such as the intuitionistic fuzzy number, probability variables, precise number score, etc. (Guo et al., 2023). Quantifying factors is a challenging approach, yet it is essential in ensuring a project's success (Prashandi & Kirupananda, 2019). While it is important in the TF process to assign a value for each attribute (Guo et al., 2023), (Costa et al., 2020), (Patil, 2020), this stage has the potential to increase or decrease the degree of subjectivity in the TF process, which could lead to more biased or fairer judgments (Costa et al., 2020). Therefore, it is necessary to establish a "gold standard" for the "attributes, metrics, and techniques" utilized in the formation of teams (Costa et al., 2020).

### 2.3.3 Stages of Team Development

A team demonstrates many developmental stages (Fairley et al., 2020), and its development can enhance TP in measurable positive and long-lasting ways (Dempsey et al., 2022). Numerous academics have investigated the STD and developed different models (Tuckman, 1965), (Tuckman & Jensen, 1977), (Mike Woodcock, 1979), (Mike Woodcock, 1989), (Graffius, 2023). To acquire a better understanding of the STD and its dynamics, the authors (Vaida & Șerban, 2021) provide detailed information and analysis on nine models, namely Bass & Ryterband (1979), Tubb (1978), Cog (1972), Homan (1950), Woodcock (1979), Fisher (1994), Jones (1975), Tuckman (1965), and Wheelan (1996), through investigating and explaining the concept of STD, drawing emphasis on traits, strengths, and weaknesses of each of their stages. Table 3 presents an overview of these 9 models. Yet, according to Miller (2003), Tuckman's sequential stage model is the most commonly referred to and generally acknowledged in organizational literature (Miller, 2003).

Table (3): Models and Stages Synopsis (Vaida & Șerban, 2021)

| Model Name/ Stage | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Stage 5 (Bonus Phase) |
|---|---|---|---|---|---|
| Bass & Ryterband | Acceptance | Communication and Decisions Making | Group Solidarity | Group Control | - |
| Tubb | Orientation | Conflicts | Consensus | Closure | - |
| Cog | The Polite Phase | "Why are we here?" Phase | The Power Phase | Cooperation Phase | The Esprit de Corps Phase |
| Homan | Needed states and behaviors | Emergent states and behaviors | Results of collective actions | - | - |
| Woodcock | Infant Team | Exploratory Team | Under Consoli-dation Team | Mature Team | - |
| Fisher | Orientation | Conflict | Emergence | Reinforcement | - |
| Jones | Immature Group | Fragmented Group | Sharing Group | Effective Team | Team Synergy |
| Tuckman | Forming | Storming | Norming | Performing | Adjourning |
| Wheelan | Dependency/ Inclusion | Counter dependency / Conflict | Trust / Structure | Work / Productivity | - |

Nevertheless, according to the authors (Vaida & Șerban, 2021), no model surpasses or is superior to others, as one model may be favored over the other depending on the requirements of the team, the leadership experience and skill, and the available resources, whether financial or time-limited (Vaida & Șerban, 2021). For instance, when focusing on a more traditional perspective of group formation, the two models put forth by Tuckman (1965) and Woodcock (1979) are the ideal options (Vaida & Șerban, 2021). Besides, they each take a four- or five-stage approach, which enables a fair assessment of the stage that each team is at or progresses up to (Vaida & Șerban, 2021).

Due to the similarity of the models of Tuckman and Woodcock in terms of their stages and suitability for a more traditional perspective on group formation, this study will focus on these two models for a better understanding of the STD and the characteristics of team members, in terms of behaviors and attitudes, throughout each of their stages.

#### 2.3.3.1 Tuckman's Model

Several models have been proposed for group development (Miller, 2003), yet the most known and extensively utilized model of the STD was produced by Bruce Tuckman (Jones, 2019), (Miller, 2003). In his original model (Tuckman, 1965), group development occurs in four stages: (1) Forming, (2) Storming, (3) Norming, and (4) Performing. These four stages were developed as a result of Tuckman's study, which aimed to examine the literature on the developmental stages in small groups, assess the stages, and draw out general principles regarding group development (Tuckman, 1965). In doing so, Tuckman looked at the studies of (1) therapy groups, (2) human relations training or T-groups, and (3) natural and laboratory-task groups, in the context of the two realms of "task activity" and "interpersonal relationships"- also referred to as group structure- to produce a summarized generalizable model of the four stages. This model was designed to serve a conceptual function in addition to an organizational and holistic one. However, Tuckman suggested areas for further investigation (Tuckman, 1965) and hence added a fifth stage "(5) Adjourning" to the model as the final stage, after reviewing the literature to see if his model had been empirically tested (Tuckman & Jensen, 1977).

Tuckman's concept suggests that group members focus on addressing interpersonal relationships and task activities as they advance through the stages (Miller, 2003). According to Tuckman (Tuckman, 1965), the forming stage is comprised of orientation, testing, and dependency. The storming stage is characterized by conflict and division over interpersonal concerns along with simultaneous emotional responses and resistance against group pressure and job demands. The norming stage overcomes resistance, during which new norms develop, new roles are adopted, ingroup emotion and cohesion develop, and intimate, personal opinions are

expressed. The group reaches the performance stage when roles are flexible and beneficial and collective energy is directed toward the task, as a result of the structural concerns being fixed which can finally support task performance. The adjourning stage was added to the original model to act as a termination stage and a separation of the group, as a result of the literature findings that advised the existence of a final noticeable and substantial stage of group development (Tuckman & Jensen, 1977).

Many scholars overlooked Tuckman's model with an agreement to its stages and presented similar interpretations and minor developments (Graffius, 2023), (Rossi, 2021). The author (Rossi, 2021) presents an elaboration of the stages of Tuckman's, integrated with many other models. Table 4 presents a description of each of the five stages (Maples, 1988).

Table (4): Tuckman's Stages of Group Development (source:(Maples, 1988) )

| Stage | Major processes | Characteristics |
|---|---|---|
| Forming | Development of attraction bonds, exchange of information, and orientation toward others and the situation | Tenative interactions, polite discourse, concern over ambiguity, and silences |
| Storming | Dissatisfaction with others, competition among members, disagreement over procedures, conflict | Criticism of ideas, interruption of speakers, poor attendance, and hostility |
| Norming | Development of group structure, increased cohesiveness and harmony, and establishment of roles and relationships | Agreement on rules, consensus-seeking, increased supportiveness, and we-feeling |
| Performing | Focus on achievement, high task orientation, and emphasis on performance and productivity | Decision making, problem solving, increased cooperation, and decreased emotionality |
| Adjourning | Termination of duties, reduction of dependency, and task completion | Regret, increased emotionality, and disintegration |

Tuckman's stage model suggests that team development occurs through specific activities and behaviors throughout a team's lifespan (Miller, 2003). According to the authors Tuckman & Jensen (1977), teams must go through all five stages to develop, address issues, discover solutions, plan work, and produce outcomes (Tuckman & Jensen, 1977). According to this viewpoint, forming a team is viewed as the first step in creating a cohesive unit since members need to get to know one another, comprehend the objectives of the assigned tasks, and adjust to their surroundings (Gómez-Zará, DeChurch, et al., 2020). Nevertheless, in Tuckman's model, the team

is pre-formed and known (Gómez-Zará, DeChurch, et al., 2020). Moreover, the stages of group development model of Tuckman's indicates that TP varies as teams progress through the stages. Although stages can be an efficient general sequence on the surface, empirical observations of particular teams show complex dynamics that oppose straightforward stage-by-stage explanations (Rickards & Moger, 2000). Teams might never reach a performance threshold or might regress to an earlier stage, and hence raising queries about the use of the Tuckman model, as illustrated in Figure 2 (Rickards & Moger, 2000).

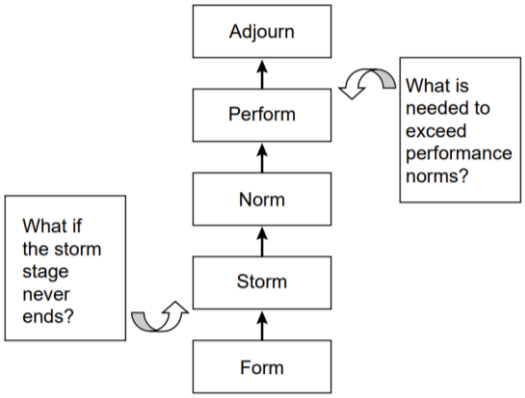



Fig. 2: Two Unanswered Questions in Stage Models of Team Development, Based on Bruce Tuckman's Model (Rickards & Moger, 2000)

Due to these considerations, a proposed framework of a two-barrier model for team creativity was developed by the authors, shown in Figure 3, which reworks the traditional team development approach (Rickards & Moger, 2000).

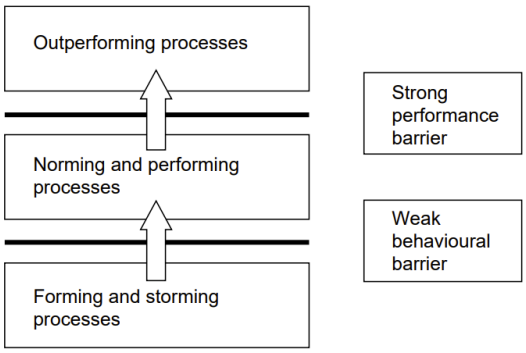



Fig. 3: A Revised Model of Team Development Introducing a Weak Barrier to Standard Performance and a Strong Barrier to Exceptional or Creative Performance (Rickards & Moger, 2000)

Since performance varies as teams advance through the stages of Tuckman's model (Rickards & Moger, 2000), it was necessary to establish effective strategies to aid teams in growing and moving forward as each stage comes to an end by looking at the factors that affect teams' performance at each stage. This is evident in Graffius' work which shows Graffius' modifications on the phases of team development, highlighting the characteristics of Tuckman's stages and presenting strategies to overcome their challenges (Graffius, 2023), as presented in Figure 4.

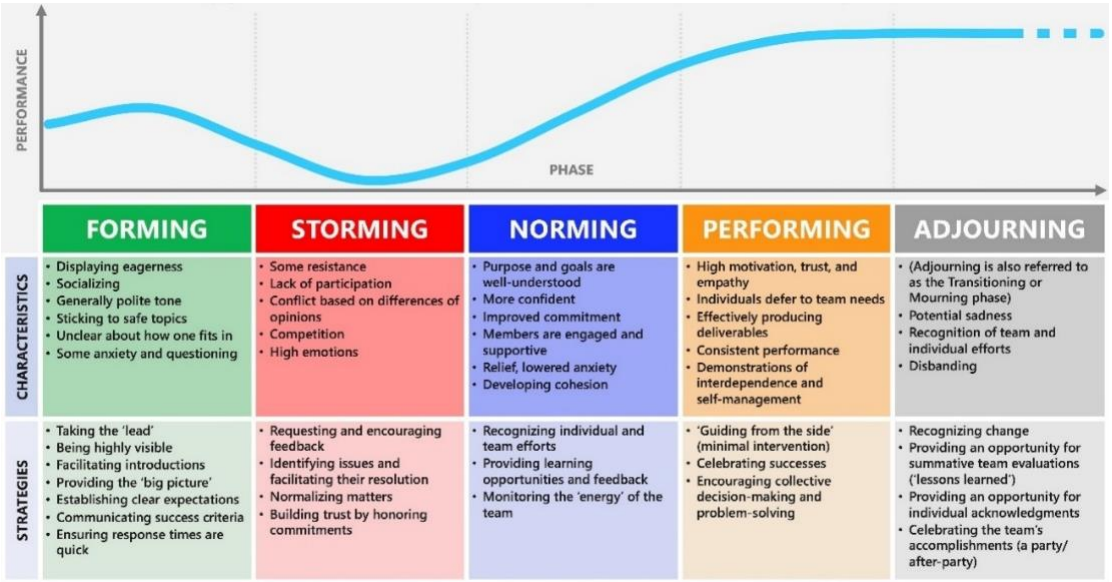



Fig. 4: Phases of Team Development Based on Group Dynamics Model by Bruce Tuckman (Graffius, 2022)

### 2.3.3.2 Woodcock's Model

The four-stage team development model of Woodcock has many overlapping elements with Tuckman's own logic because of how similar the two are (Vaida & Șerban, 2021). It is common for a team to go through numerous stages of development, each of which will bring out distinct characteristics (Mike Woodcock, 1979, 1989). According to Woodcock, teams may comprehend team development and determine their current stage of development with the use of a straightforward model based on the four fundamental stages of development, namely: (1) The Undeveloped

Team, (2) The Experimenting Team, (3) The Consolidating Team, and (4) The Mature Team. Figure 5 presents the characteristics of each stage (Mike Woodcock, 1979),(Mike Woodcock, 1989).

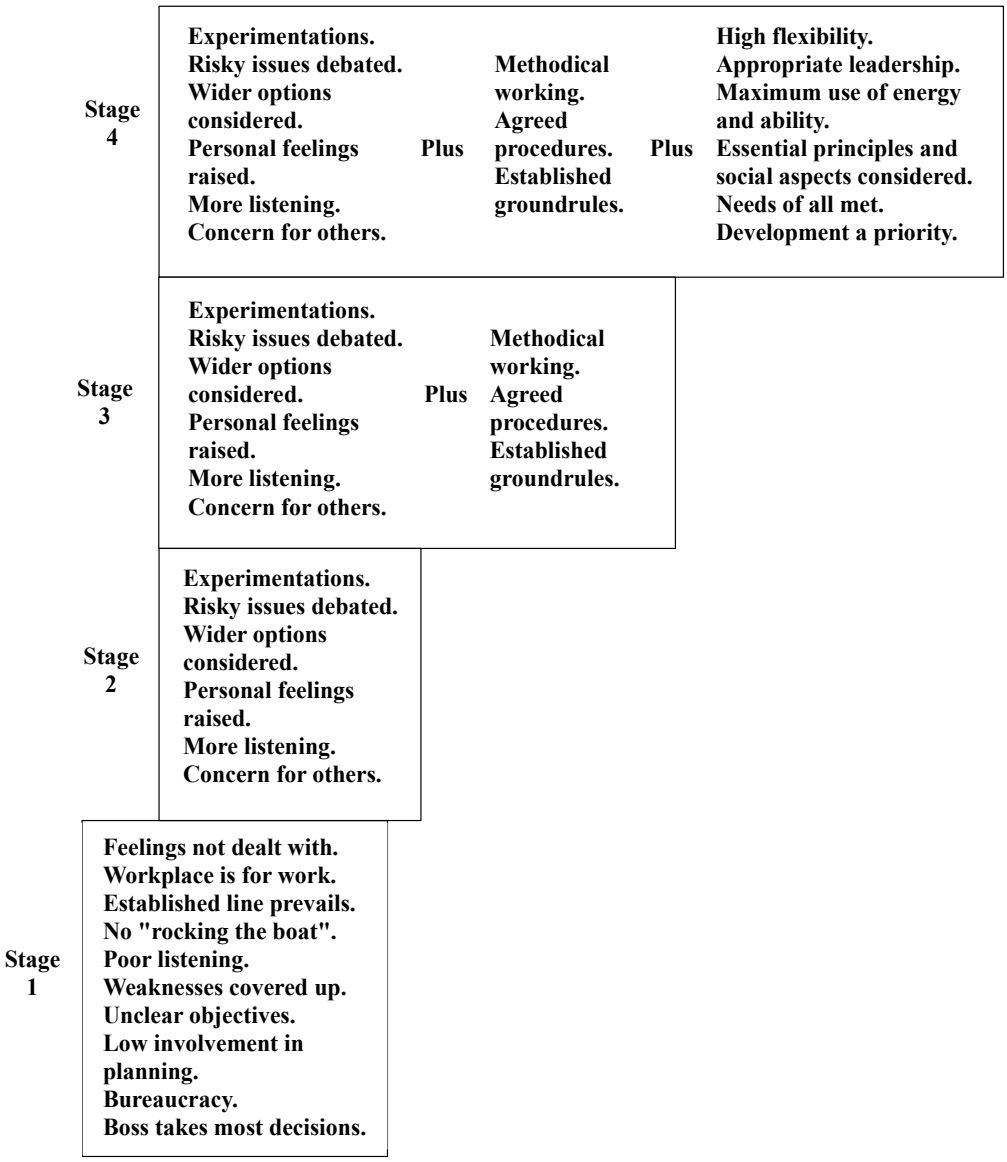



Fig. 5: Mike Woodcock's Model: Characteristics of Stages of Team Development (source: (Mike Woodcock, 1979),(Mike Woodcock, 1989))

Yet no team ever exclusively displays the characteristics of a given stage; rather, it depends on what characteristics are most obvious. Even though it is simplistic, classifications do aid in a team's understanding of where it is in the development process and where it intends to be (Mike Woodcock, 1979, 1989).

While the way forward may not always be predictable, team leaders and trainers must assist their teams as they proceed through different stages of team development (Mike Woodcock, 1989). Therefore, Woodcock suggests actions that can be taken to help teams speed up progress at each stage (Mike Woodcock, 1989).

## 2.4 AI & Generative AI: From Tools to Teammates

AI is known as the study and creation of intelligent systems possessing human-like reasoning, understanding, decision-making, and problem-solving abilities (Datta et al., 2024), while ML, being a subfield of AI, focuses on developing models and algorithms that enable machines to automatically learn from data, leading to improved machine performance over time (Datta et al., 2024). AI in computer science refers to intelligence displayed by machines as opposed to natural intelligence expressed by humans (Haesevoets et al., 2021). AI-based solutions are described as intelligent systems that can accurately interpret external data, act intelligently, and utilize such objectives in performing specific tasks in a flexible configuration, as well as replicating human behaviors with social, cognitive, and emotional intelligence (Cooper, 2024), (Johnson et al., 2022).

In this context, it is worth mentioning that AI comes in a variety of forms (Odeh, 2023). Some are categorized as non-sentient or non-emotional; rather, they are mainly concerned with generating information intelligence for users to consume and apply effectively (Odeh, 2023). Others have grown more advanced and sophisticated, possessing sentience and emotions, focusing on machines that employ human-like interactions along with cognitive computing (Odeh, 2023).

AI has numerous applications, for it is a generic term that encompasses a broad range of cognitive technologies (Haesevoets et al., 2021). Intelligent agents, for instance, are considered AI systems that function in their environments with different levels of autonomy to achieve their goals (Kopecka et al., 2024). Intelligent agents either appear as embodied agents, such as robots, or software agents (Kopecka et al., 2024).

AI and ML technologies have various capabilities (Abonamah & Abdelhamid, 2024). Unlike other technologies, AI has unique characteristics (Gabriel et al., 2023). The authors (Wang et al., 2022) mention some of the social characteristics of AI that determine the social skills of agents, such as acting human-like or being empathetic during interactions, reciprocal self-disclosure, being proactive when initiating conversations, and positive attitudes, as agents are more successful in lessening people's tension and depressing mood. Other studies mention the human-like characteristics of AI voice assistants and the decision-making processes (Zhan et al., 2024) and the robotic characteristics embodiment (Jorge et al., 2022).

One of the key factors driving the promotion of AI in the management field relies on the fact that human beings possess limited cognitive abilities, and AI can compensate for these shortcomings (Revilla et al., 2023). AI is mainly utilized to support human abilities; AI systems can process and analyze big datasets instantly and accurately and find trends or patterns that may assist collaborative problem-solving, human decision-making, or task completion (Joksimovic et al., 2023), (Kunal et al., 2023). AI can comprehend human language and produce text and images (Kunal et al., 2023). Besides, AI can evolve into more than just a technical tool; it can plan as well as execute actions autonomously (Gabriel et al., 2023), (Kunal et al., 2023). In addition, researchers found that some additional

characteristics of AI include opacity (Zercher et al., 2023), inherent non-determinism that results in some level of uncertainty (Steidl et al., 2023), power and anthropomorphism, human-like characteristics (Shuqair et al., 2024), as well as robotic characteristics, like embodiment (Jorge et al., 2022).

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Since human beings have always aimed to improve TP, integrating modern technology with them has been an ongoing endeavor (Flathmann et al., 2021). With AI becoming more accessible and widely used, technologies have advanced significantly (Flathmann et al., 2021). AI technologies can support and enhance tasks currently performed by humans (Svenningsson & Faraon, 2019). AI systems can analyze data, interpret human language, and produce both written and visual content using Machine Learning (ML)

algorithms and NLP (Kunal et al., 2023). Many people have already recognized the advantages AI can bring to teams—not just as a useful tool or assistant but as an integral part of a team (Flathmann et al., 2021). As a tool, AI makes it possible to analyze situations by processing vast amounts of data rapidly and precisely, which facilitates quicker and more effective decision-making (Kunal et al., 2023), (Kunal et al., 2023), (Revilla et al., 2023), (Zercher et al., 2023). They are also capable of identifying trends and ideas that humans might miss, which can result in new innovations and novel discoveries (Kunal et al., 2023), (Kunal et al., 2023), (Joksimovic et al., 2023), as well as offering supplementary abilities, such as the ability to coordinate and communicate (Zercher et al., 2023). However, nowadays, AI is interacting with humans as a partner rather than functioning as a tool, and this collaboration, which has both a technological actor which is the AI, and a social actor which is the human, is also known as collaborative intelligence or hybrid intelligence (Gabriel et al., 2023). Studies have indicated that humans working with AI are capable of performing better than either humans or AI working alone (Hemmer et al., 2021; Zercher et al., 2023). AI can support human capabilities (Joksimovic et al., 2023), enhance tasks (Svenningsson & Faraon, 2019), and increase performance through objectified, quicker, and far more accurate execution of tasks; humans, on the other hand, offer supplementary abilities such as contextual knowledge (Zercher et al., 2023). Besides, AI partners augment the contributions of humans while having the potential to influence the decisions made by humans (Joksimovic et al., 2023). Based on reliable information, AI can predict situations, mitigating human biases during decision-making (Revilla et al., 2023), and increase transparency and response accuracy (Guha et al., 2021), (Kumari et al., 2023), becoming a more trustworthy and reliable source of information (Correia et al., 2021), (Flathmann et al., 2021).

In the form of chatbots, AI is becoming a growing phenomenon in service-oriented firms (Svenningsson & Faraon, 2019). Other examples of AI-driven technologies include robotics, autonomous cars, face recognition, NLP, virtual assistants, and AI-powered bots, to name a few (Haesevoets et al., 2021), (Guha et al., 2021). While AI-powered bots, or chatbots, have become a common AI application, bots will soon play a bigger part in customer support (Guha et al., 2021). As for GenAI, it generates new versions of text, images, or forecasted data as per the user's request by utilizing a massive corpus of labeled data, which can include photos, text, or other types of labeled data (Cooper, 2024), (Euchner, 2023). Examples of GenAI are ChatGPT and Bard, which generate new information, data, or artifacts that resemble human creations (Cooper, 2024). Besides, ChatGPT is capable of performing a PESTEL analysis (Cooper, 2024). Moreover, in a recent study on ChatGPT (Kabir et al., 2024), the study reveals that ChatGPT surpasses the other LLMs in terms of user popularity for its usability, effectiveness, politeness, and positive sentiment, which makes it a conversational chatbot that gives feedback.

Table 5 lists some of the AI capabilities stated in the literature.

Table (5): A Summary of the AI Capabilities

| # | Publication | Capabilities | Reference |
|---|---|---|---|
| 1 | *"When powerful artificial intelligence backfires"* (Shuqair et al., 2024) | Anthropomorphism, human-like, powerful | (Shuqair et al., 2024) |
| 2 | *"Healthcare Voice AI Assistants: Factors Influencing Trust and Intention to Use"* Zhan, X., Abdi, N., Seymour, W., & Such, J. (2024) | Human-like; voice assistant and decision-maker | (Zhan et al., 2024) |
| 3 | *"Is Stack Overflow Obsolete? An Empirical Study of the Characteristics of ChatGPT Answers to Stack Overflow Questions"* | Usable, effective, polite, positive, prone to hallucination (providing conceptual errors, code errors, and terminology errors), fabricate facts, generate low-quality or misleading information | (Kabir et al., 2024) |

| | | | |
|---|---|---|---|
| | Kabir, S., Udo-Imeh, D. N., Kou, B., & Zhang, T. (2024, May) | | |
| 4 | *"Human–Artificial Intelligence Collaboration in Prediction: A Field Experiment in the Retail Industry"*<br>E. Revilla, M. J. Saenz, M. Seifert, and Y. Ma (2023) | Prediction generation, fast and scalable decision-making, mitigate human biases, information processing, produce discoveries | (Revilla et al., 2023) |
| 5 | *"The Future of OpenAI Tools: Opportunities and Challenges for Human-AI Collaboration"*<br>Rana, M., & Bansal, J. (2023, November) | Analyze data, understanding of human language, generator of text and images, assists humans in decision-making, assists human collaborators in task completion, processes large amounts of data quickly and accurately, automates tasks, faster and more efficient decision-making, Clear communication and expectations, transparent | (Kunal et al., 2023) |
| 6 | *"Artificial Intelligence's Effects on Corporate Decision-Making Processes"*<br>Kumari, N., Gangwar, K., Gaur, V., Singh, K. R., Vijay, S. A. A., & Tamkhade, J. (2023, September) | Quick, accurate, cheap, maintainable, as intelligent as a human, accuracy and transparency | (Kumari et al., 2023) |
| 7 | *"When AI joins the Team: A Literature Review on Intragroup Processes and their Effect on Team Performance in Team-AI Collaboration"*<br>Zercher, D., Jussupow, E., & Heinzl, A. (2023) | Opacity, quick and accurate task execution, planning, situation analysis, decision-making, offer supplementary abilities, coordination, communication | (Zercher et al., 2023) |
| 8 | *"Optimizing human-AI collaboration: Effects of motivation and accuracy information in AI-supported decision-making"*<br>Eisbach, S., Langer, M., & Hertel, G. (2023) | Trust, accuracy information | (Eisbach et al., 2023) |
| 9 | *"Strategic planning of the collaboration between humans and artificial intelligence in production"*<br>Gabriel, S., Kühn, A., & Dumitrescu, R. (2023) | Plan and execute actions | (Gabriel et al., 2023) |
| 10 | *"Opportunities of artificial intelligence for supporting complex problem-solving: Findings from a scoping review"* | Support human capabilities, analyze datasets instantly, find trends/ patterns, problem-solver, decision-maker, influence human decisions | (Joksimovic et al., 2023) |

| | | | |
|---|---|---|---|
| | Joksimovic, S., Ifenthaler, D., Marrone, R., De Laat, M., & Siemens, G. (2023) | | |
| 11 | *"The pipeline for the continuous development of artificial intelligence models—Current state of research and practice"*<br>Steidl, M., Felderer, M., & Ramler, R. (2023) | Non-determiner, uncertain | (Steidl et al., 2023) |
| 12 | *"Co-Designing AI Agents to Support Social Connectedness Among Online Learners: Functionalities, Social Characteristics, and Ethical Challenges"*<br>Wang, Q., Jing, S., & Goel, A. K. (2022, June) | Empathetic, human-like, self-disclosure, proactive, positive personalities/ attitude | (Wang et al., 2022) |
| 13 | *"Artificial Trust as a Tool in Human-AI Teams"*<br>Jorge, C. C., Tielman, M. L., & Jonker, C. M. (2022, March) | Robotic characteristics (embodiment), trust | (Jorge et al., 2022) |
| 14 | *"Determinants and Predictors of Intentionality and Perceived Reliability in Human-AI Interaction as a Means for Innovative Scientific Discovery"*<br>Correia, A., Fonseca, B., Paredes, H., Chaves, R., Schneider, D., & Jameel, S. (2021, December) | reliable | (Correia et al., 2021) |
| 15 | *"Modeling and Guiding the Creation of Ethical Human-AI Teams"*<br>Flathmann, C., Schelble, B. G., Zhang, R., & McNeese, N. J. (2021, July) | Trust, creativity | (Flathmann et al., 2021) |
| 16 | *"How artificial intelligence will affect the future of retailing"*<br>A. Guha et al (2021) | Speed up responses, increase response accuracy | (Guha et al., 2021) |
| 17 | *"Artificial Intelligence in Conversational Agents: A Study of Factors Related to Perceived Humanness in Chatbots"*<br>Svenningsson, N., & Faraon, M. (2019, December) | Support and enhance tasks, immediacy | (Svenningsson & Faraon, 2019) |

Innovation is driven by advancements in cutting-edge technologies, particularly AI (Odeh, 2023). There are various factors that influence businesses' decisions to invest in technology, such as the need to reduce expenses, boost efficiency, or enhance the quality of their offerings (La Torre et al., 2023). Although AI technologies can automate tedious and routine tasks which can liberate human employees to concentrate on more complicated and creative ones (Kunal et al., 2023), AI is criticized when used haphazardly, especially when supporting knowledge-based tasks, since some tasks are still difficult for machines to perform (Revilla et al., 2023). Thus, scientific research on bots has become a significant area of study (Guha et al., 2021), and researchers urge consulting AI professionals to determine the characteristics and strengths of GenAI (AbuAlfateh et al., 2024).

### 2.4.1 Human-AI Collaboration

While traditional teams consist of a relatively stable group of individuals working together toward a particular goal, contextual pressures have brought about a transformation in how teams function (Webber et al., 2019). Organizations are forming more teams with complex challenges for improving teamwork as a result of having tighter business deadlines (Webber et al., 2019), and it is evident that H-AI collaboration can lead to superior decision-making in a range of circumstances, including those with high risk and limited time (Caldwell et al., 2022a). Besides, during times of rapid expansion, the ability of an organization to promote and adopt emerging technologies, especially those linked to Industry 4.0, is crucial to its success (Kanski & Pizon, 2023).

As AI capabilities continue to advance, AI is being used in complex H-AI cooperation in a wide variety of fields (Ma et al., 2022b). AI is showing its potential in the workplace for enhancing and advancing teams that struggle

with priorities and difficult deadlines (Webber et al., 2019). Besides, the potential of AI to improve and elevate teams at work is becoming more widely acknowledged (Webber et al., 2019). Since humans and AI have complementary skills (Caldwell et al., 2022a), successful H-AI collaboration has tremendous potential and the capability to produce remarkable outcomes (Ulfert et al., 2023). With the unique competencies of both humans and AI, each team member can significantly influence the collective operation and boost the overall performance of the team (Ulfert et al., 2023), (Caldwell et al., 2022a).

Yet, even as we work to comprehend the value of hybrid teams, we are getting closer to implementing them, showcasing the evolving nature of H-AI collaboration (Caldwell et al., 2022a). And as with any other team, a hybrid team cannot simply "plug and play" its way to improved performance (Caldwell et al., 2022a). There are numerous preliminary steps that must be taken, each with its own difficulties, and Tuckman's STD model, which divides the process of creating a high-performing team into five stages, is a traditional framework that can be effectively customized to examine these steps (Caldwell et al., 2022a). The use of this model in collaborative H-H teams is well-known, and it is pertinent to some parts of teaming that represent H-AI hybridity in teaming, including virtual teams and short-term technical teams (Caldwell et al., 2022a). However, even in an experimental setting, the development process of H-AI teaming includes a wide range of traits, from shared situational awareness to sophisticated decision-making and decision-enacting procedures, from conception to high-performing teams (Caldwell et al., 2022a). Moreover, developing and evaluating H-AI teams requires more than simply understanding the differences between human behavior and that of AI (Ma et al., 2022b). It is important to comprehend how they work together to achieve tasks as a

team, and it takes more work to get this level of understanding than to merely rely on the results of teams made up of only humans (Ma et al., 2022b). Therefore, testing existing team development models in actual scenarios and customizing them for a unique team and setting is recommended (Vaida & Șerban, 2021).

### 2.4.2 AI & Generative AI in Project Management

Over the decades, project management has changed and grown from its historical beginnings (Nenni et al., 2024). The planning, management, and execution of projects have started to change drastically in recent years with the development of AI (Nenni et al., 2024). PMs may now utilize AI applications for particular tasks in project management to increase the success rates of their projects (Odeh, 2023). According to the Project Management Institute (PMI), PMs need to embrace the way that game-changing tools and AI may empower them in the future to benefit from all the advantages of disruptive technologies fully (PMI, 2020). AI will continue to expand and facilitate increasingly complicated operations across industries and enterprises (Georgiev et al., 2024). Hence, AI ought to be recognized for the value that it brings to the project (Odeh, 2023).

The application of AI to project management is growing and has several facets (Nenni et al., 2024). In particular, in businesses with high levels of complexity and quick technological development, its capacity to manage massive datasets, offer insightful analysis, and facilitate challenging decision-making processes considerably improves project management's effectiveness (Nenni et al., 2024). Besides, AI-supported tools provide better meeting planning, alerts, reminders, and many other administrative responsibilities (Odeh, 2023). AI can accurately assist, for instance, with tasks or project duration, risk mitigation, integration of the resource calendar for scheduling, and budget estimation (Odeh, 2023). In this

context, the PMI reports in the Pulse of the Profession 2020 that “In the future, AI will be doing a lot of the reporting and administrative work,” (PMI, 2020). However, practitioners need to choose AI tools that are appropriate for their particular project requirements, type of industry, size of the team, and complexity of the task (Nenni et al., 2024), since utilizing these technologies to improve efficiency, decision-making, risk management, and overall success of projects is the ultimate objective (Nenni et al., 2024).

It is expected that as AI develops further, it will be more deeply integrated into project management procedures, posing both challenges and new opportunities for businesses and PMs (Nenni et al., 2024). Moving away from traditional project management techniques, PMs must adopt a new mindset to support project management by embracing the use of AI tools and utilizing the appropriate skills to reap their benefits (Odeh, 2023). In this context, the PMI’s 15$^{th}$ annual Pulse of the Profession Report 2024 mentions, “In today’s evolving world, project professionals need the right skills and support to continually adapt to new ways of working. They need the technical skills to use AI to manage projects more effectively” (PMI, 2024). A study by Nenni (2024) reveals an extensive overview of recommendations that focus on the future of AI in the domain of project management, highlighting H-AI collaboration as one of its agendas (Nenni et al., 2024).

The collaboration with AI has a bright future ahead of it, with many prospects for continued development and implementation (Kunal et al., 2023). As far as equal effort is invested in developing AI solutions and forming productive teams that utilize them, AI may be considered an agent for innovative endeavors (La Torre et al., 2023). Given the appropriate prompts, GenAI can provide ideas for new goods directly for a particular

industry or product category (Cooper, 2024). This ensures that cutting-edge technology is not only applied but also used optimally to meet organizational goals (La Torre et al., 2023). Besides, considering the capabilities of AI, AI technologies have the potential to revolutionize a wide range of sectors and applications, including business and education, resulting in cost savings and enhanced efficiency (Kunal et al., 2023). Therefore, businesses must encourage project managers and executives to acquire innovative tools to increase the possibility of completing projects successfully (Odeh, 2023).

## 2.5 Factors Supporting H-AI Collaboration

AI has penetrated nearly all aspects of our lives over the past ten years (Haesevoets et al., 2021). AI is different from conventional information technologies in the sense that it can learn autonomously and is growing proficient at making decisions independently without assistance from humans (Revilla et al., 2023). However, businesses often fail to manage the relationship between humans and AI because they oversimplify the complicated interactions between people and technology, hence failing to realize the possible outcomes of modern AI (Revilla et al., 2023), (Metcalfe et al., 2021). Besides, society needs to realize that intelligent technologies are developing to the point where they are becoming more than just tools for human usage; they can function as collaborative partners (Metcalfe et al., 2021). Although it is necessary to regard the AI application as a technological actor of the same level as the social actor, which is the human, it must be highlighted that this equality of status is limited to certain task areas (Gabriel et al., 2023). Thus, it is vital to underline the importance of understanding the inflections caused by technology, especially AI technologies (Noble et al., 2022), (Guha et al., 2021).

Effective H-AI collaboration has great potential and the ability to achieve outstanding outcomes (Ulfert et al., 2023). Scientific studies on agents have concentrated on human-agent collaboration, and from the perspective of human-computer interaction, a fundamental driver of such collaboration between humans and AI relies on the capability of agents to be self-explanatory (Kopecka et al., 2024). AI must consider a variety of factors, including cognitive, social, and psychological factors, for it to imitate human intelligence (Svenningsson & Faraon, 2019). Besides, factors such as team cognition, coordination, and communication are also necessary for successful AI integration with human teams (Zercher et al., 2023), especially when characteristics that drive rapid development have been dedicated to tasks that are quick, accurate, cheap, maintainable, and nearly as intelligent as a human (Kumari et al., 2023). In addition, the achievement of the great performance of H-AI teams is based on multiple factors (Zercher et al., 2023), such as trust (Zercher et al., 2023), (Gabriel et al., 2023), (Flathmann et al., 2021), (Zhan et al., 2024), (Eisbach et al., 2023), (Gabriel et al., 2023), ethics (Flathmann et al., 2021), acceptance or AI acceptability (Zercher et al., 2023), (Gabriel et al., 2023), AI explainability (Gabriel et al., 2023), attitudes toward AI, and AI agent's functionalities (Wang et al., 2022). The social characteristics (Zercher et al., 2023), (Wang et al., 2022) and technical factors are also essential for successful outcomes, as well as their dynamic interaction (Zercher et al., 2023).

Researchers examined the effects of accurate information and motivation on the collaborative decision-making performance of H-AI collaboration, and the influence of those factors on trust among humans towards AI recommendations accompanied by justifications (Eisbach et al., 2023). The findings of their study suggest that in an experimental cooperative decision-making task, performance can be enhanced by both accurate

information and motivation. The study additionally examined the relationship between the two factors and trust and revealed that although neither factor affected self-reported trust, both did affect trusting behavior diverting from the recommendations of AI systems. In other words, better trust calibration and, thus, better utilization of higher quality AI recommendations and clarifications are made possible by the motivation to perform well, while providing accurate information helps to facilitate the calibration of trust (Eisbach et al., 2023).

Another study acknowledges that trust is a crucial factor in H-AI collaboration and outlines three primary types of factors that impact trust: (1) functional: which refers to the characteristics of technologies, (2) personal: which refers to the individual, their social network, and experiences, and (3) risk: which refers to the potential negative effects of the technology (Zhan et al., 2024).

According to Kunal and other authors (2023), there are several main factors for successful H-AI collaboration. Effective H-AI collaboration requires (1) clear communication and expectations: establishing precise responsibilities and roles and defined expectations for the use of the AI tool and the sorts of decisions it is expected to be engaged in, (2) transparency and trust in the process of collaboration: having faith that the decisions made by the AI tools are on the basis of reliable and objective facts and that the AI tool is in line with human values and objectives, (3) sufficient training and education for human colleagues: training on the proper usage of the AI technology in addition to knowledge about its drawbacks and possible biases, and (4) AI tools alignment with human values and objectives: ensuring AI consistency with human ethical principles and goals to prevent biases or unanticipated results from entering the collaborative process (Kunal et al., 2023).

Some of the main factors to be considered in businesses when implementing AI-based decision-making are the need for efficient AI algorithm management to prevent biases and hostile attacks, as well as to develop new procedures and laws for the supervision of AI heuristics (Kumari et al., 2023). The study (Kumari et al., 2023) also emphasizes the importance of transparency and accuracy in decision outcomes. Besides, a study presents an initial exploration into a set of factors that may serve as acceptance and reliability predictors in H-AI collaboration (Correia et al., 2021). In addition, human factors are essential to the interaction with AI, which include factors like trust in AI algorithms and data (Jorge et al., 2022), (Lindner & Reiner, 2023), in addition to acceptance of the generated decisions and outcomes (Lindner & Reiner, 2023), as well as creativity (Flathmann et al., 2021). A study (Nimmo et al., 2024) examines user's characteristics, which usually encompass a wide range of factors, such as gender, age, personality, and experience, among others (Nimmo et al., 2024). Another study (Kopecka et al., 2024) also investigates user's characteristics in terms of socio-cultural factors and cognitive styles. However, other characteristics of the user that are pertinent to the various aspects of the collaboration between humans and AI may also include the attitude of the user toward risk, self-efficacy with computers, motivations, learning style, information processing style, cognitive biases, proficiency of reading, conscientiousness, and the need for cognition, as suggested by the study (Kopecka et al., 2024). Furthermore, previous research has shown that the user values complicated language, sophisticated and diverse vocabulary, and well-constructed sentences when communicating with a chatbot (Svenningsson & Faraon, 2019). These factors were linked to immediacy and were viewed as a sign of concern when combined with lengthy conversations (Svenningsson & Faraon, 2019). In addition, successful interaction with AI can be attributed to providing relevant

responses that are clear, straightforward, and uncomplicated and that are neither too long nor too short (Svenningsson & Faraon, 2019). Besides, having shared mental models is also favorable (Joksimovic et al., 2023).

Table 6 summarizes the influential factors that may enhance H-AI collaboration, as stated in the literature.

Table (6): A Summary of the Influential Factors for Human-AI Collaboration

| # | Publication | Supporting Factors | Reference |
|---|---|---|---|
| 1 | Shuqair, S., Pinto, D. C., Miltgen, C. L., & Viglia, G. (2024) | Anthropomorphism, human-like, powerful | (Shuqair et al., 2024) |
| 2 | Zhan, X., Abdi, N., Seymour, W., & Such, J. (2024) | Trust, human-like; voice assistant | (Zhan et al., 2024) |
| 3 | Kopecka, H., Such, J., & Luck, M. (2024) | Self-explanatory agents capability - user's characteristics (socio-cultural factors and cognitive styles) | (Kopecka et al., 2024) |
| 4 | Nimmo, R., Constantinides, M., Zhou, K., Quercia, D., & Stumpf, S. (2024, May) | User's characteristics (gender, age, personality, and experience) | (Nimmo et al., 2024) |
| 5 | Kabir, S., Udo-Imeh, D. N., Kou, B., & Zhang, T. (2024, May) | Usable, effective | (Kabir et al., 2024) |
| 6 | E. Revilla, M. J. Saenz, M. Seifert, and Y. Ma (2023) | AI can compensate for human shortcomings. mitigate human biases, | (Revilla et al., 2023) |
| 7 | Rana, M., & Bansal, J. (2023, November) | Clear communication and expectations - Trust and transparency in the collaboration process - Appropriate training and education for human collaborators- Ensuring AI tools align with human values and goals, understanding of human language, process large amounts of data quickly and accurately | (Kunal et al., 2023) |
| 8 | Lindner, F., & Reiner, G. (2023, May) | Trust in the data and AI algorithms, acceptance of resulting decisions and outcomes. | (Lindner & Reiner, 2023) |
| 9 | Kumari, N., Gangwar, K., Gaur, V., Singh, K. R., Vijay, S. A. A., & Tamkhade, J. (2023, September) | Demand for efficient AI algorithm management, development of new laws and procedures for AI heuristics supervision, accuracy and transparency in decision results | (Kumari et al., 2023) |

| | | | |
|---|---|---|---|
| 10 | Zercher, D., Jussupow, E., & Heinzl, A. (2023) | Trust, acceptance, social characteristics, technical factors, dynamic interaction, team cognition, coordination, communication | (Zercher et al., 2023) |
| 11 | Eisbach, S., Langer, M., & Hertel, G. (2023) | Trust, motivation, accuracy information | (Eisbach et al., 2023) |
| 12 | Gabriel, S., Kühn, A., & Dumitrescu, R. (2023) | Trust in AI, acceptance of AI, explainability of AI | (Gabriel et al., 2023) |
| 13 | Joksimovic, S., Ifenthaler, D., Marrone, R., De Laat, M., & Siemens, G. (2023) | Support human capabilities, shared mental models | (Joksimovic et al., 2023) |
| 14 | Wang, Q., Jing, S., & Goel, A. K. (2022, June) | Attitudes toward AI, AI agent's functionalities, social characteristics, human-like, self-disclosure, proactive, positive personalities/ attitude | (Wang et al., 2022) |
| 15 | Jorge, C. C., Tielman, M. L., & Jonker, C. M. (2022, March) | Robotic characteristics (embodiment), trust | (Jorge et al., 2022) |
| 16 | Correia, A., Fonseca, B., Paredes, H., Chaves, R., Schneider, D., & Jameel, S. (2021, December) | Reliability, acceptability | (Correia et al., 2021) |
| 17 | Flathmann, C., Schelble, B. G., Zhang, R., & McNeese, N. J. (2021, July) | Ethics, trust, creativity | (Flathmann et al., 2021) |
| 18 | Svenningsson, N., & Faraon, M. (2019, December) | Cognitive, social, and psychological factors - immediacy | (Svenningsson & Faraon, 2019) |

Many studies in H-AI collaboration determine the factors that, when using AI, help or hinder team performance. The combination of human skills and the abilities of AI technology promises to yield strong intelligence that will probably surpass the performance of each party acting alone (Revilla et al., 2023), (Fügener et al., 2022). However, the development of AI demands a new human-machine dynamic relationship that indicates a shifting distribution of work between the two (Jarrahi, 2018). With augmented intelligence, human beings may focus on their strengths in creating,

imagining, and working together as best they can, whilst AI assists in providing quantitative rule-based prediction generation and fast and scalable decision-making (Revilla et al., 2023). Besides, AI technology has the potential to mitigate some of the human biases related to information processing and to produce discoveries that could not have been thought of otherwise (Revilla et al., 2023). Therefore, since H-AI collaboration may harness the benefits of humans as well as AI systems (Zercher et al., 2023), it is reasonable to expect that humans and AI will collaborate to arrive at managerial decisions at some point in the future (Haesevoets et al., 2021). Besides, it is widely acknowledged in both the business sector and academic literature that the future work environment will involve a collaborative framework where humans and AI work synergistically (Haesevoets et al., 2021; Jarrahi, 2018), (Ali et al., 2023).

## 2.6 Performance Indicators for H-AI Project Teams

TP is defined by the degree to which the team achieves its objectives (Zercher et al., 2023). The objectives of TP encompass efficiency, including time, cost, and resources, as well as effectiveness, which pertains to the ability to achieve desired outcomes and accuracy, in addition to psychological factors like team satisfaction (Zercher et al., 2023). According to Kharachenko (2022), effectiveness is described as "the ability of the AI platform, which is determined by the degree of achievement of the planned results, considering the number of resources spent" (Kharchenko et al., 2022).

Meanwhile, the terms efficiency and effectiveness also appear in the literature on project management and are frequently applied to evaluate the different types of processes in project management and are typically utilized to characterize project management (Sundqvist et al., 2014). The

practice of measuring an action's efficiency and effectiveness is known as performance measurement (Kamble et al., 2020). However, these two terms have few definitions and are typically used ambiguously (Sundqvist et al., 2014).

Since the operation of modern businesses depends heavily on teams (Levasseur, 2017), it is important not only to comply with the modern business trends of H-AI teams but also to investigate how such teams can be evaluated (Ali et al., 2023). Despite the hype and extensive trials of the popular GenAI tools and applications, such as OpenAI's chatbot application of ChatGPT (Bilgram & Laarmann, 2023), Google's DeepMind Gemini (Imran & Almusharraf, 2024), and others, there is still a dearth of research on the application of GenAI in the business sector (Bilgram & Laarmann, 2023) and the way of measuring its performance when integrated into PTs with its human counterparts in the project management domain (AbuAlfateh et al., 2025). Therefore, empirical research is required to gather practitioners' opinions on the suitability and relevance of performance indicators (Kamble et al., 2020) and to establish suitable measures for H-AI teams that may be utilized to evaluate them (Ali et al., 2023).

## 2.7 Model Development

To meet the objectives of this research, the study first investigates how traditional H-H PTs are formed, as understanding the formation of traditional teams builds a solid foundation for how to form H-GenAI PTs, how the formed H-GenAI PTs develop throughout the STD, and how H-GenAI PTs' performance is measured. Based on previous literature on TF in the project management domain, researchers have advocated the importance of determining the factors that influence the formation of PTs and assigning weights for the determined factors according to the nature of the project before selecting the team members (Costa et al., 2020), (Patil, 2020), (Stavrou et al., 2021), (Guo et al., 2023). This will ensure the formation of the best possible team for that specific project for a better performance of PTs and, ultimately, project completion and success.

For this study, TF theories (which are related to and support forming teams that consist of human members) are explored and the TF factors (which can be defined as a collection of data consisting of factors that are related to and influence the formation or the construction of teams) are derived from models of TF. To solve the TFP (which is defined as the problem of forming teams consisting of humans), the study categorizes the determined factors of TF into two main categories: Project Attributes and Human Attributes. Project Attributes are defined as the characteristics and attributes of factors related to projects, while Human Attributes are defined as the characteristics and attributes of factors related to humans.

In this study, Project Attributes influence Human Attributes, as indicated in the conceptual model of Aryanee (2020) and illustrated in Figure 1 (Aryanee et al., 2020).

Figure 6 illustrates how this study forms traditional H-H PTs.

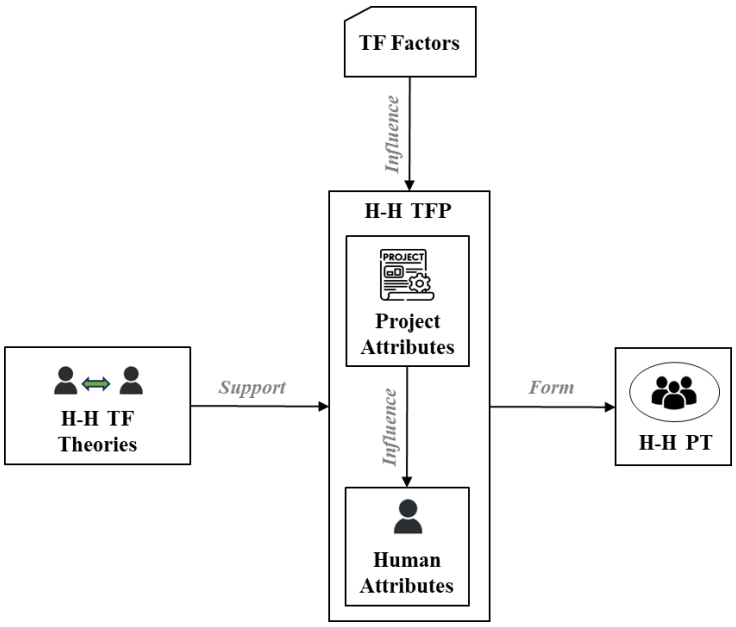



Fig. 6: Model Segment: H-H Project Team Formation

The study explains the terms that appear in Figure 6 as follows:

**H-H TF Theories:** Theories related to and supporting forming teams that consist of human members.

**TF Factors:** A collection of data consisting of factors that are related to and influence the formation or the construction of teams.

**H-H TFP:** The problem of forming teams consisting of humans.

**Project Attributes:** The characteristics and attributes of factors related to projects.

**Human Attributes:** The characteristics and attributes of factors related to humans.

**H-H PT:** The formed project team consists of human members.

After investigating how traditional H-H PTs are formed, the study then investigates how H-GenAI PTs are formed.

Teams are performing more and more work in the modern workplace, and individuals as well as organizations need to overcome obstacles to create productive teams (Gómez-Zará, DeChurch, et al., 2020). However, it is unfortunate that dealing with AI agents as full team members along with treating them with the same respect level that humans deserve is not as simple as it might appear, and previous research on computer-supported cooperative work addresses this matter (Schelble et al., 2022). Besides, businesses often fail to manage the relationship between humans and AI because they oversimplify the complicated interactions between people and technology, hence failing to realize the possible outcomes of modern AI (Revilla et al., 2023), (Metcalfe et al., 2021), such as GenAI. Thus, it is important to highlight the significance of comprehending inflections generated by technology, particularly AI technologies (Noble et al., 2022), (Guha et al., 2021). Accordingly, the study aims to investigate how H- GenAI teams are formed and how their collaboration is supported.

For this study, and to form H-GenAI PTs, H-AI TF theories (which are related to and support forming teams that consist of humans and artificial intelligent agents) are explored, and the TF factors are derived from models of TF. It is important to mention that the H-AI TF theories are derived from H-H TF theories and apply to H-AI collaboration. To solve the H-GenAI TFP (which is defined as the problem of forming teams consisting of humans and GenAI agents), the study considers the Project Attributes and Human Attributes as well as the capabilities of GenAI (which are the characteristics and abilities of GenAI). Besides, the study highlights the reasons behind the functionalities of GenAI, which are referred to as "GenAI Enablers", and what supports the H-GenAI collaboration, which is referred to as "H-GenAI Collaboration Factors". GenAI Enablers are defined as the infrastructure of GenAI agents and all supporting methods

that control the functionality of GenAI agents and enable them to perform the way they do, while the H-GenAI Collaboration Factors are defined as the factors that support the collaboration between humans and GenAI agents. Figure 7 illustrates how this study forms H-GenAI PTs.

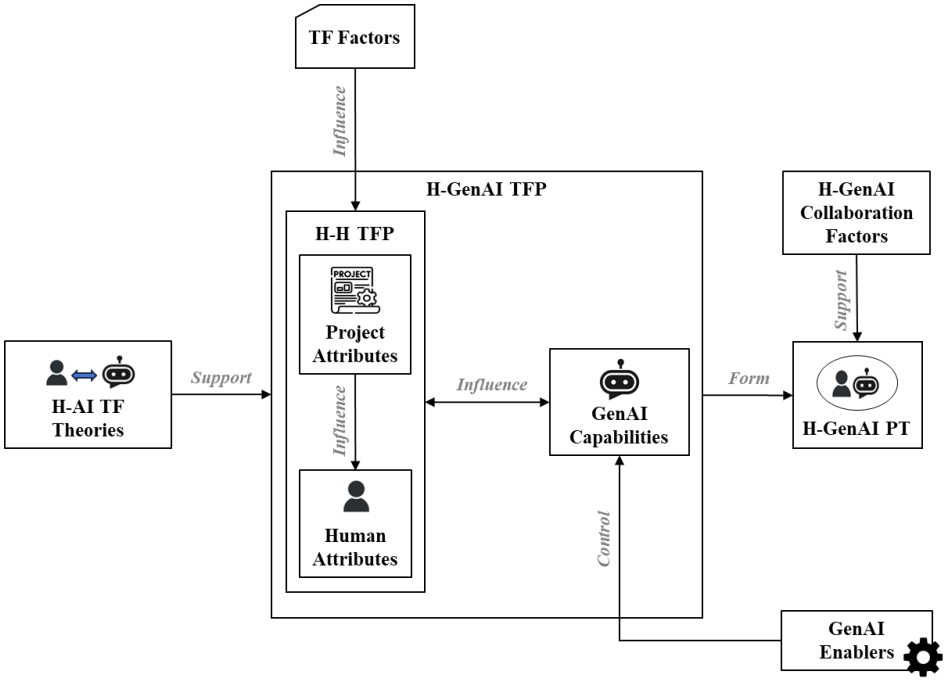



Fig. 7: Model Segment: H-GenAI Project Team Formation

The study explains the terms that appear in Figure 7 as follows:

**H-AI TF Theories:** Theories related to and supporting forming teams that consist of humans and artificial intelligent agents.

**TF Factors:** A collection of data consisting of factors that are related to and influence the formation or the construction of teams.

**H-GenAI TFP:** The problem of forming teams consisting of humans and generative artificial intelligent agents.

**H-H TFP:** The problem of forming teams consisting of humans.

**Project Attributes:** The characteristics and attributes of factors related to projects.

**Human Attributes:** The characteristics and attributes of factors related to humans.

**GenAI Capabilities:** The characteristics and abilities of generative artificial intelligent agents.

**H-GenAI Collaboration Factors:** The factors that support the collaboration between humans and generative artificial intelligent agents.

**GenAI Enablers:** The infrastructure, methodologies, and technologies of generative artificial intelligent agents that control the functionality of generative artificial intelligent agents and enable them to perform the way they do.

**H-GenAI PT:** The formed project team consists of humans and generative artificial intelligent agents.

Considering Figure 6 and Figure 7, this study presents a complete overview of the model for H-GenAI PTF as illustrated in Figure 8.

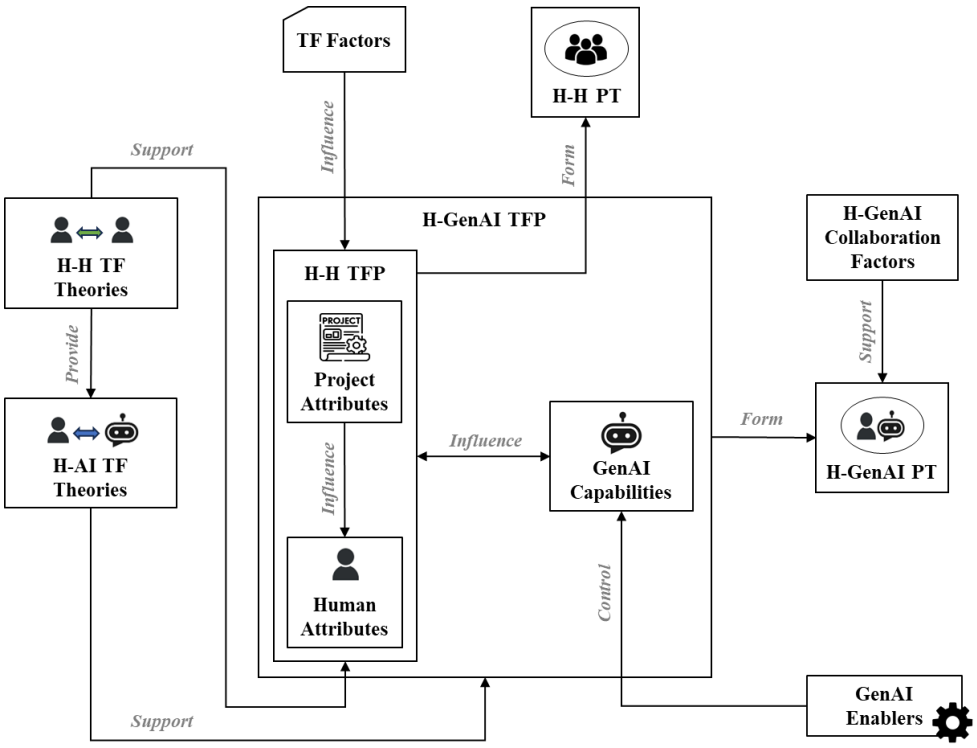



Fig. 8: H-GenAI Project Team Formation Model

Moving forward to fulfilling the objectives of the study, the study investigates how teams of H-GenAI develop once formed throughout the STD, as every team goes through the STD after being formed. Therefore, this study first investigates how traditional PTs develop when working on projects to better comprehend the basis on which H-GenAI PTs develop throughout STD when GenAI works alongside humans in PTs.

According to the authors Nunkoo & Sungkur (2021), the process of Tuckman's team development becomes engaged after establishing the team (Nunkoo & Sungkur, 2021). The Tuckman model is a helpful framework for understanding team development, but requires it to be adjusted to account for the dynamics and complexities of H-AI interactions (Ali et al., 2023). According to Gómez-Zará and DeChurch (2020), Tuckman's concept of team development was centered on fostering ties among members of the team who had already been placed together and was never referring to developing a team in the sense of constructing a team, so as with the other presented models which followed the same concept of Tuckman's. Yet, no empirical metrics are offered to evaluate members' interactions within a team. Besides, examining how a member's characteristics may impact team processes after they officially join the team and confirm their team affiliation is a challenge (Gómez-Zará, DeChurch, et al., 2020).

Even while H-GenAI teams are currently being used in the workplace, their effectiveness will be extremely restricted if the human aspect of teamwork is overlooked (Schelble et al., 2022). Besides, based on the social interaction between humans and AI agents, the formation of the team directly influences the characteristics of H-AI teaming (Schelble et al., 2022). Therefore, this study aims to examine how team dynamics in terms of human interaction in teams influence team performance throughout the

STD, as illustrated in Figure 9, and then discover the extent to which the capabilities of GenAI compensate for the drawbacks in human behaviors and attitudes to enhance PT performance, as illustrated in Figure 10.

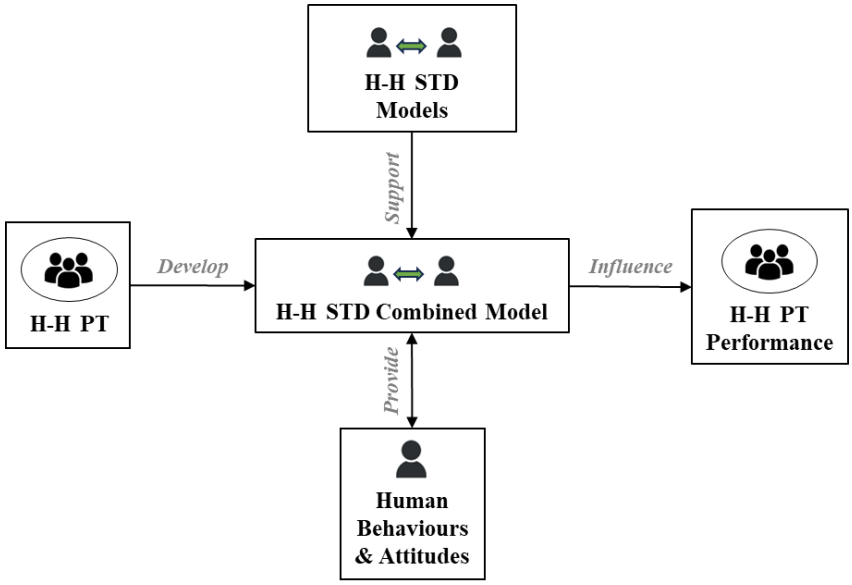



Fig. 9: Model Segment: Stages of H-H Team Development

For this study, in order to examine how humans interact in project teams (H-H PT) and influence team performance throughout the STD, the study investigates several existing models of the stages of group development for human groups or teams (H-H STD Models), which consist of different human characteristics in terms of behaviors and attitudes for each stage.

Then, the study combines two models for STD, the model of Tuckman and Woodcock, and combines all the human behaviors and attitudes that appear in the two models in all their stages (H-H STD Combined Model), and, finally, evaluates the combined model of H-H STD and measures H-H PT performance. The study explains the terms that appear in Figure 9 as follows:

**H-H PT:** The formed project team consists of human members.

**H-H STD Models:** The existing models of the stages of group development for human groups or teams, which consist of different human characteristics in terms of behaviors and attitudes for each stage.

**H-H STD Combined Model:** The combination of two existing models of Bruce Tuckman and Mike Woodcock of the stages of group development for human groups or teams, which consist of different human characteristics in terms of behaviors and attitudes for each stage.

**Human Behaviors & Attitudes:** The actions and reactions as well as the feelings and emotions of human beings that arise throughout the stages of group or team development when working in groups or teams, also called the characteristics of humans.

**H-H PT Performance:** The performance of project teams consisting of human members.

Then, to discover the extent to which GenAI capabilities support human behaviors and attitudes and compensate for the drawbacks in human behaviors and attitudes, which contribute to enhancing PT performance, the study assesses the human behaviors and attitudes throughout the stages of team development in the combined model of H-H STD and maps the human behaviors and attitudes with the characteristics and abilities of GenAI (GenAI Capabilities). The study finally evaluates the H-GenAI SPTD (after considering GenAI Capabilities and adding them with human behaviors and attitudes to the combined model of H-H STD) and measures H-GenAI PT performance. Figure 10 illustrates the abovementioned steps.

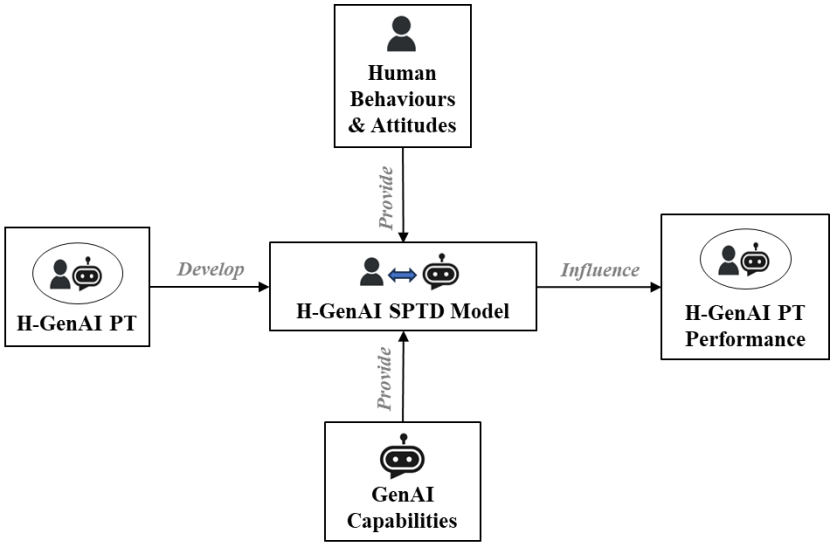



Fig. 10: Model Segment: Stages of H-GenAI Project Team Development

The study explains the terms that appear in Figure 10 as follows:

**H-GenAI PT:** The formed project team consists of humans and generative artificial intelligent agents.

**H-GenAI SPTD Model:** The replication of the combined model of Bruce Tuckman and Mike Woodcock of the stages of group development for human groups or teams -which consist of different human characteristics in terms of behaviors and attitudes for each stage- for project teams that integrate generative artificial intelligent agents as teammates, considering their capabilities in terms of characteristics and abilities of generative artificial intelligent agents.

**Human Behaviors & Attitudes:** The actions and reactions as well as the feelings and emotions of human beings that arise throughout the stages of group or team development when working in groups or teams, also called the characteristics of humans.

**GenAI Capabilities:** The characteristics and abilities of generative artificial intelligent agents.

**H-GenAI PT Performance:** The performance of project teams consisting of humans and generative artificial intelligent agents.

Considering Figure 9 and Figure 10, this study shows a complete H-GenAI SPTD Model overview, as illustrated in Figure 11.

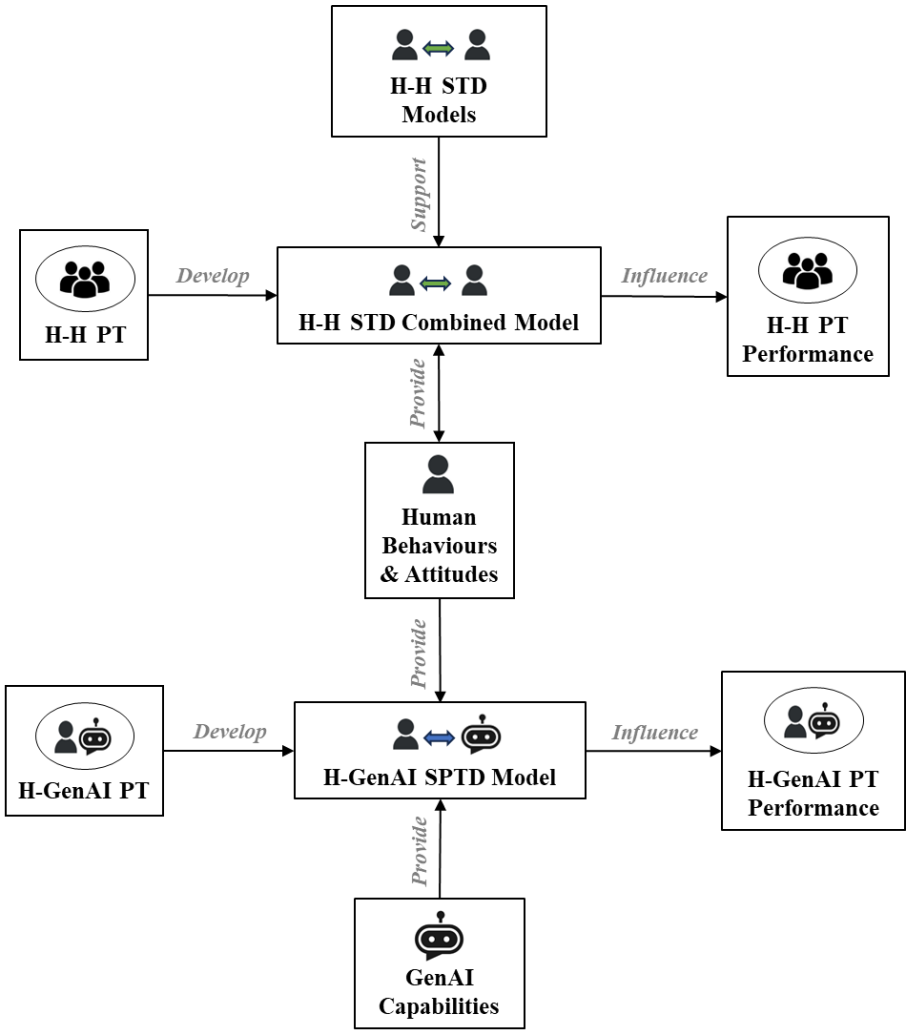



Fig. 11: Stages of H-GenAI Project Team Development Model

Moving forward to fulfilling the objectives of the study, the study studies how to establish criteria for measuring the performance of H-GenAI PTs.

Scholars have emphasized the necessity of conducting research on performance evaluation in the evolving setting of Industry 4.0, for it not only encourages better organizational performance but also fosters

a positive work atmosphere (Kamble et al., 2020). Therefore, to provide empirical results of H-GenAI PT performance, the study aims to determine KPIs for measuring the performance of H-GenAI PTs in the service industry, as illustrated in Figure 12.

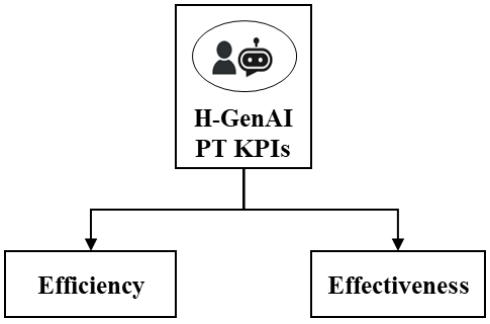



Fig. 12: H-GenAI Project Team Key Performance Indicators

The study explains the terms that appear in Figure 12 as follows:

**H-GenAI PT KPIs:** The key performance indicators for measuring the performance of project teams that consider humans and generative artificial intelligent agents as teammates.

**Efficiency:** The ability of a project team consisting of humans and generative artificial intelligent agents to perform tasks in a timely manner, to be cost-effective, and optimize resources.

**Effectiveness:** The ability of a project team consisting of humans and generative artificial intelligent agents to perform tasks with high accuracy and quality, and transparently and clearly.

The study meets its objectives by developing the following: (1) the Model for H-GenAI Project Team Formation (Figure 8), (2) the Model for H-GenAI SPTD (Figure 11), and (3) the H-GenAI Project Team Key Performance Indicators (Figure 12). Considering all components of the H-GenAI Project Team Formation Model (Figure 8) and H-GenAI SPTD

Model (Figure 11), the study meets MOB1, its first objective, by developing the H-GenAI Collaboration Model (H-GenAI Collab), which is illustrated in Figure 13. Thus, this study bridges the gap in the literature by developing a model for H-GenAI collaboration for PTs in project management within the service industry through:

a. building a model for H-GenAI Project Team Formation (H-GenAI PTF), and
b. building a model for the Stages of H-GenAI Project Team Development (H-GenAI SPTD).

In addition, the study meets MOB2, its second objective, by establishing KPIs for H-GenAI PTs (Figure 12).

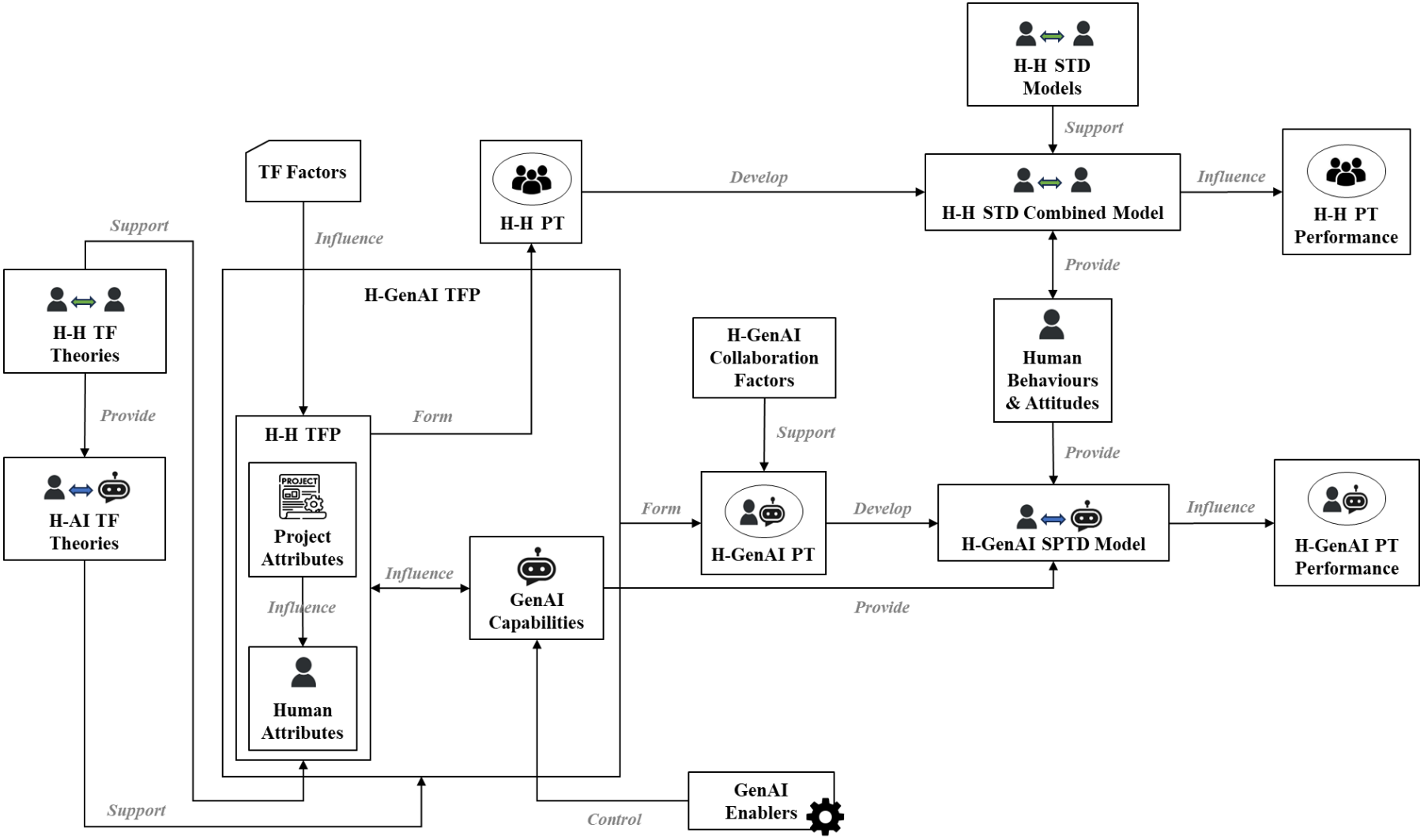



Fig. 13: Human-Generative Artificial Intelligence Collaboration Model (H-GenAI Collab)

Table 7 presents the terms and definitions of the study's model.

Table (7): Model Terms and Definitions

| Terms | Definitions |
|---|---|
| **H-H TF Theories** | Theories related to and supporting the formation of teams that consist of human members. |
| **H-AI TF Theories** | Theories related to and supporting the formation of teams that consist of humans and artificial intelligent agents. |
| **TF Factors** | A collection of data consisting of factors that are related to and influence the formation or the construction of teams. |
| **H-H TFP** | The problem of forming teams consisting of humans. |
| **Project Attributes** | The characteristics and attributes of factors related to projects. |
| **Human Attributes** | The characteristics and attributes of factors related to humans. |
| **H-GenAI TFP** | The problem of forming teams consisting of humans and generative artificial intelligent agents. |
| **GenAI Capabilities** | The characteristics and abilities of generative artificial intelligent agents. |
| **H-H PT** | The formed project team consists of human members. |
| **H-GenAI PT** | The formed project team consists of humans and generative artificial intelligent agents. |
| **H-GenAI Collaboration Factors** | The factors that support the collaboration between humans and generative artificial intelligent agents. |
| **GenAI Enablers** | The infrastructure, methodologies, and technologies of generative artificial intelligent agents that control the functionality of generative artificial intelligent agents and enable them to perform the way they do. |
| **H-H STD Models** | The existing models of the stages of group development for human groups or teams, which consist of different human characteristics in terms of behaviors and attitudes for each stage. |

| | |
|---|---|
| **H-H STD Combined Model** | The combination of two existing models of Bruce Tuckman and Mike Woodcock of the stages of group development for human groups or teams, which consist of different human characteristics in terms of behaviors and attitudes for each stage. |
| **H-GenAI SPTD Model** | The replication of the combined model of Bruce Tuckman and Mike Woodcock of the stages of group development for human groups or teams -which consist of different human characteristics in terms of behaviors and attitudes for each stage- for project teams that integrate generative artificial intelligent agents as teammates, considering their capabilities in terms of characteristics and abilities of generative artificial intelligent agents. |
| **Human Behaviors & Attitudes** | The actions and reactions as well as the feelings and emotions of human beings that arise throughout the stages of group or team development when working in groups or teams, also called the characteristics of humans. |
| **H-H PT Performance** | The performance of project teams consisting of human members. |
| **H-GenAI PT Performance** | The performance of project teams consisting of humans and generative artificial intelligent agents. |
| **H-GenAI PT KPIs** | The key performance indicators for measuring the performance of project teams that consider humans and generative artificial intelligent agents as teammates. |
| **Efficiency** | The ability of a project team consisting of humans and generative artificial intelligent agents to perform tasks in a timely manner, to be cost-effective, and optimize resources. |
| **Effectiveness** | The ability of a project team consisting of humans and generative artificial intelligent agents to perform tasks with high accuracy and quality, and transparently and clearly. |

# Chapter Three

# Methods and Procedures

## 3.1 Introduction

This Chapter explains the methodology employed in the study and its research design, along with the reasoning behind the adoption of a mixed-method research approach to answer the research questions.

According to Clough and Nutbrown, a methodology demonstrates how research questions are formulated concerning field inquiries and the reasons behind choosing appropriate methods for the study to address the research questions (Clough & Nutbrown, 2012). Furthermore, Clough and Nutbrown clear the confusion between the two terms “method” and “methodology” by considering “methods” as the ingredients of research, and “methodology” as the reasoning behind utilizing a specific research “recipe” (Clough & Nutbrown, 2012).

According to Kothari, research methodology is defined as “a way to systematically solve the research problem, while research design is “the conceptual structure within which research is conducted” (Kothari, 2004). Therefore, the research design is the way the study methodology is put into practice.

Creswell (2013) discusses the three different kinds of research approaches: qualitative, quantitative, and mixed methods (Creswell, 2013). According to Creswell (2013), the choice of approach to take when conducting the study can be influenced by the research problem or subject under investigation (Creswell, 2013). As a result, to achieve the research objectives and address its questions, intending to develop a H-GenAI

collaboration model to enhance the performance of H-GenAI PTs in project management and to examine the extent to which the GenAI capabilities enhance the performance of H-GenAI PTs compared to H-H PTs, a mixed-method approach was required for obtaining the results of the model, which serves as the strategy of this study.

The structure of the study is divided into 3 Phases, and each Phase has its own parts. Phase 1 represents the H-GenAI PTF Model, Phase 2 represents the H-GenAI SPTD Model, and Phase 3 represents the KPIs of H-GenAI PTs. Figure 14 illustrates Phases 1 and 2, while Figure 15 illustrates Phase 3 of the study.

In Phase 1 and 2, the study employs qualitative, quantitative, and mixed methods approaches, and in Phase 3, the study uses a qualitative approach.

The study is under the pragmatism philosophical paradigm. This will allow us to, first, explore ways of solving the TFP by identifying factors of TF in several companies of different sectors within the service industry, and then, examine the extent to which the capabilities of GenAI enhance the performance of H-GenAI PTs compared to H-H PTs after forming the H-GenAI PT and working on projects.

Following this introductory section of the Chapter, the research design is demonstrated in Section 2 by emphasizing the philosophical assumption and worldview, or paradigm, that the study employed as well as the chosen strategy of inquiry. Section 3 demonstrates the research method of the study, in terms of data collection methods and analysis of each Part of the 3 Phases of the study. Finally, Section 4 provides the conclusion of Chapter 3.

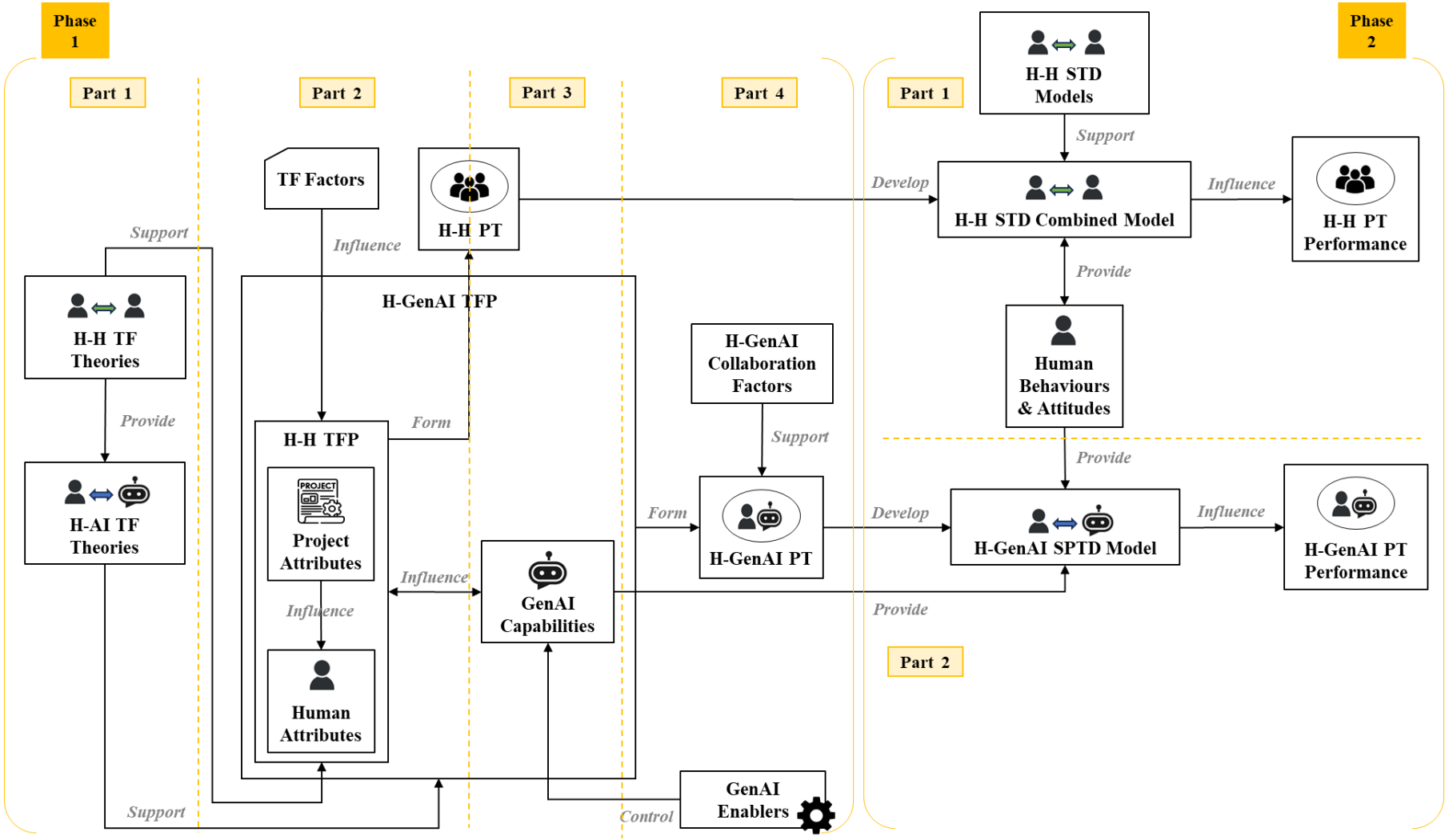



Fig. 14: Segments of H-GenAI Collab

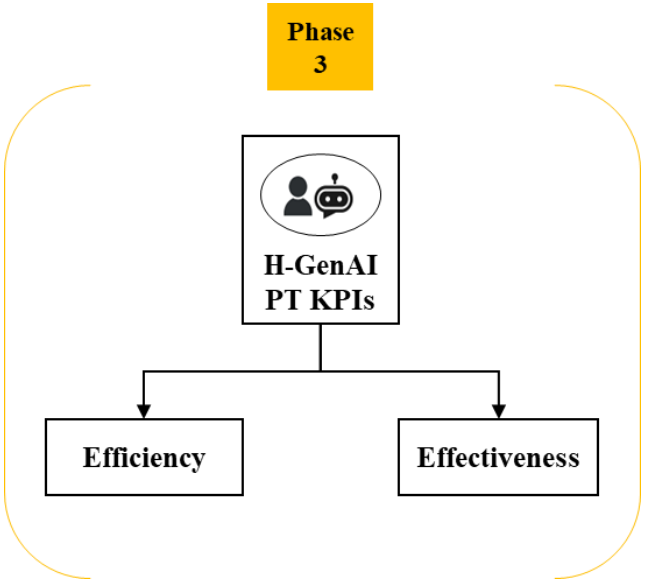



Fig. 15: Segments of H-GenAI PTs KPIs

## 3.2 Research Design

Creswell and Plano Clark define research designs as the "procedures for collecting, analyzing, interpreting, and reporting data in research studies," (Creswell & Plano Clark, 2018). A research design is a flexible collection of guidelines that provides a connection between theoretical paradigms with inquiry strategies and methods for gathering empirical data (Denzin & Lincoln, 2018). Creswell (2009) refers to the research design as "the plan or proposal to conduct research," which involves the intersection of philosophical worldviews, inquiry strategies, and research methods (Creswell, 2009).

Within qualitative, quantitative, and mixed-method approaches, come strategies of inquiry that offer particular guidance for the procedures in a study design (Creswell, 2013). Figure 16 is a framework for design that explains how Worldviews, Strategies of Inquiry, and Research Methods interconnect (Creswell, 2009).

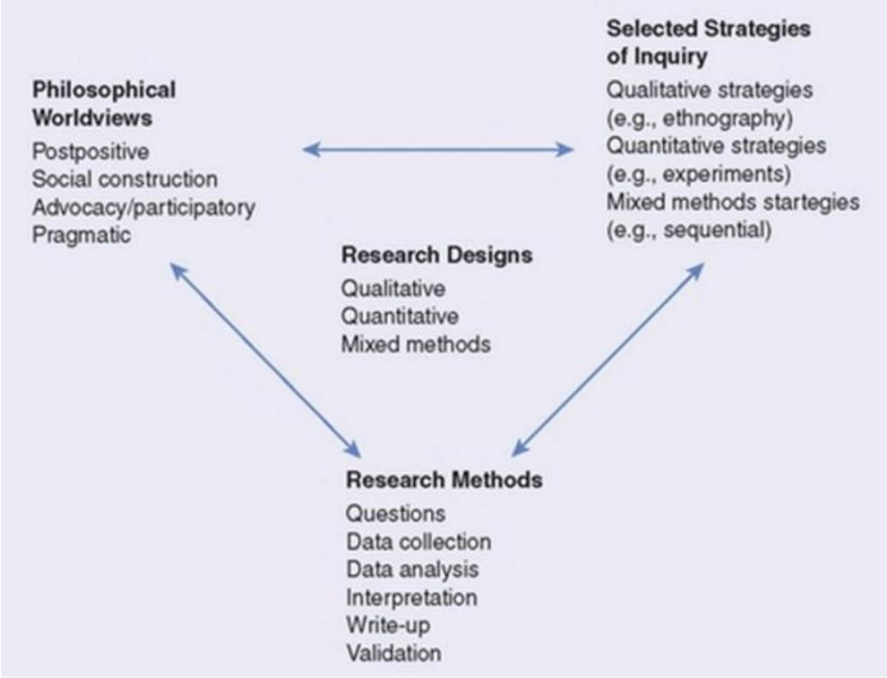



Fig. 16: Interconnection Between Worldviews, Strategies of Inquiry, & Research Methods (Source: adapted from Creswell (2009) (Creswell, 2009))

Broadly defined, the research design entails a precise focus on the study's objectives, the research topic, and what information best addresses particular research questions, and which methods are most suitable for gathering it (Denzin & Lincoln, 2018). To better comprehend the concept of research design, research designs are referred to as the mechanism of accomplishing the objectives of the research (Flick, 2009). The methods and resources employed for accomplishing objectives are linked with theoretical frameworks, questions, research, generalization, and presentational purposes. Their realization is the result of decisions reached in the research process (Flick, 2009). Thus, this section will cover the structure of the study that is designed to collect the data needed for answering the research questions using mixed methods.

### 3.2.1 Philosophical Assumptions and Worldviews

Mixed methods research is surrounded by philosophical assumptions that function on a wide, abstract scale (Creswell & Plano Clark, 2018). Philosophical assumptions, in mixed methods research, involve “a basic set of beliefs or assumptions that guide inquiries”, according to Creswell and Plano Clark (2018) who refer to assumptions as the term “worldviews” (Creswell & Plano Clark, 2018). However, paradigm is a term that is frequently used interchangeably with worldview (Creswell & Plano Clark, 2018). According to Creswell (2009), the term “worldview” refers to “a basic set of beliefs that guide action” (Creswell, 2009), while Guba and Lincoln (1994) view paradigms as “a set of basic beliefs (or metaphysics) that deals with ultimates or first principles (Guba & Lincoln, 1994). It represents a worldview that defines, for its holder, the nature of the “world,” the individual’s place in it, and the range of possible relationships to the world and its parts, as, for example, cosmologies and theologies do” (Guba & Lincoln, 1994).

Creswell (2009) finds worldviews as a researcher's overall perspectives on the world and the nature of the study, which is influenced by the student's discipline, the opinions of professors in that field, and prior research experiences (Creswell, 2009). According to Guba and Lincoln (1994), beliefs tend to be basic in that, despite being persuasively stated, they could only be accepted purely based on faith (Guba & Lincoln, 1994), and the type of researcher's beliefs generally influence whether they choose to use a quantitative, qualitative, or mixed methods approach in their work (Creswell, 2009).

Four different types of worldviews appear in social sciences studies, namely: postpositivism, constructivism, transformative (also called advocacy or participatory), and pragmatism (Creswell, 2009), (Creswell & Plano Clark, 2018). Table 8 lists the essential components of each type (Creswell, 2009).

Table (8): Four Worldviews (Source: adapted from Creswell and Plano Clark (Creswell & Plano Clark, 2018)

| Postpositivist Worldview | Constructivist Worldview | Transformative Worldview | Pragmatist Worldview |
|---|---|---|---|
| Determination | Understanding | Political and activist | Consequences of actions |
| Reductionism | Multiple participant meanings | Empowerment, human rights, social justice oriented | Problem centered |
| Empirical observation and measurement | Social and historical construction | Collaborative | Pluralistic |
| Theory verification | Theory generation | Change, emancipatory oriented | Real-world practice oriented |

The traditional research methodology has been embodied by postpositivist assumptions, which are more applicable to quantitative than qualitative research (Creswell, 2009). The postpositivist worldview is also called the scientific method or doing science research, positivist/postpositivist research, empirical science, and postpositivism (Creswell, 2009). According to Creswell (2009), postpositivists embrace a deterministic

worldview in which causes are expected to affect consequences or results. They place a strong emphasis on identifying and evaluating these causes, commonly via experiments. This reductionistic method seeks to condense concepts into variables that may be tested through research questions and hypotheses. Knowledge is created by measuring and closely observing the external world, giving numerical measurements priority, and researching individual behaviors. They think that hypotheses or laws governing the world should be put to the test and improved. Postpositivists begin with a theory, develop a hypothesis, gather evidence to support or contradict it, and then modify the theory as necessary to test it further. (Creswell, 2009)

Constructivism is commonly regarded as a method for qualitative research (Creswell, 2009). According to social constructivists, people make subjective interpretations of their experiences in an attempt to understand the world surrounding them (Creswell, 2009). The multiplicity and variety of these meanings encourage scholars to investigate the depth of views rather than limiting them. To enable participants to create meaning through interactions, researchers attempt to rely on their perspectives and ask wide, open-ended questions. Interactions and cultural norms shape meanings, which are historically and socially negotiated. Constructivist scholars recognize how their origins affect their interpretations and concentrate on these interactions and situations. They seek to comprehend the implications that participants have, generally generating theories inductively using data (Creswell, 2009).

The transformative worldview is usually associated with qualitative research, although it can also serve as a basis for quantitative research (Creswell, 2009). It is also called a transformative worldview (Creswell & Plano Clark, 2018). Research, politics, and social reform are all interwoven in a transformative worldview (Creswell, 2009). Enhancing the lives of

participants and institutions, this approach tackles concerns such as oppression, inequality, and empowerment. Researchers partner with participants who may assist in the study's design, data collection, and analysis. For the goal of bringing about social change and reform, transformative research gives voice to underrepresented communities. It combines theoretical viewpoints with philosophical presuppositions to expose problems, study individuals, and determine what has to be changed (Creswell, 2009).

Pragmatism focuses on situations, actions, and outcomes over preconditions (Creswell, 2009). It places a strong emphasis on practical applications, solutions to problems, and outcomes (Creswell, 2009). The primary focus is placed on the implications of the research, the significance of the question posed over the methodologies, and the utilization of various data collection techniques to shed light on the issues being investigated (Creswell & Plano Clark, 2018). Therefore, researchers employ every method at their disposal to comprehend the research problem, giving it the greatest importance (Creswell, 2009). Pragmatism is pluralistic and focused on "what works" in actual practice, valuing knowledge that is both subjective and objective (Creswell & Plano Clark, 2018). By emphasizing the research problem and adopting pluralistic techniques to acquire knowledge, this strategy favors studies employing mixed methods (Creswell, 2009).

Furthermore, these worldviews are analyzed in the literature by placing them with particular philosophical assumptions and comparing and contrasting them (Creswell & Plano Clark, 2018). Table 9 illustrates how different worldviews differ in terms of ontology (what is real in the universe), epistemology (how we learn), axiology (the role values play in study), methodology (the process of conducting study), and rhetoric (the

language of study) (Creswell & Plano Clark, 2018), which are key generic terms of social science research, also referred to as the 'building blocks' of generic social research (Grix, 2002).

Table (9): Worldviews Elements and Implications for Practice (Source: adapted from Creswell and Plano Clark (Creswell & Plano Clark, 2018))

| Philosophical Question | Postpositivism | Constructivism | Transformative | Pragmatism |
|---|---|---|---|---|
| Ontology (What is the nature of reality?) | Singular reality (e.g., researchers reject or fail to reject hypotheses) | Multiple realities (e.g., researchers provide quotes to illustrate different perspectives) | Multifaceted and based on different social and cultural positions (e.g., researchers recognize different power positionalities in our society) | Singular and multiple realities (e.g., researchers test hypotheses and provide multiple perspectives) |
| Epistemology (What is the relationship between the researcher and that being researched?) | Distance and impartiality (e.g., researchers objectively collect data on instruments) | Closeness and subjectivity (e.g., researchers visit with participants at their sites to collect data) | Collaboration (e.g., researchers actively involve participants as collaborators, build trust, and honor participant standpoints) | Practicality (e.g., researchers collect data by "what works" to address research question) |
| Axiology (What is the role of values?) | Unbiased (e.g., researchers use checks to eliminate bias) | Biased (e.g., researchers actively talk about and use their personal biases and interpretations) | Based on human rights and social justice for all (e.g., researchers begin with and advocate for this premise) | Multiple stances (e.g., researchers include both biased and unbiased perspectives) |
| Methodology (What is the process of research?) | Deductive (e.g., researchers test an a priori theory) | Inductive (e.g., researchers start with participants' views and build "up" to patterns, theories, and interpretations) | Participatory (e.g., researchers involve participants in all stages of the research and engage in cyclical reviews of results) | Combining (e.g., researchers collect both quantitative and qualitative data and mix them) |
| Rhetoric (What is the language of research?) | Formal style (e.g., researchers use agreed-upon definitions of variables) | Informal style (e.g., researchers write in a literary, informal style) | Advocacy, activist-oriented (e.g., researchers use language that will help bring about change and advocate for human rights and social justice) | Formal or informal (e.g., researchers may employ both formal and informal styles of writing) |

Considering the abovementioned four worldviews (Creswell, 2009), pragmatic philosophy was the most suitable to adopt for conducting this study. The rationale for pursuing the study was grounded on the necessity to gain a greater understanding of H-GenAI collaboration in general and H-GenAI TF and H-GenAI SPTF in particular by investigating the factors contributing to the success of a PT and H-GenAI PTs in project management as well as H-GenAI interaction and collaboration effects on PT performance throughout the STD, due to the dearth of research on the

right components that support H-GenAI PTs in project management and how H-GenAI PTs develop throughout the STD when working on a project.

### 3.2.2 Strategies of Inquiry

A strategy of inquiry is referred to as "a bundle of skills, assumptions, and practices that researchers employ as they move from their paradigm to the empirical world" (Denzin & Lincoln, 2018). Strategies of inquiry move paradigms forward and, simultaneously, link the researcher to certain methods for the collection and analysis of empirical data (Denzin & Lincoln, 2018). A researcher's methodological approach is a decision made regarding the strategy and research techniques used in a particular study, and it is supported by and reflects particular ontological and epistemological views (Grix, 2002). Figure 17 illustrates how we go about research considering the generic terms of social science research (Grix, 2002).

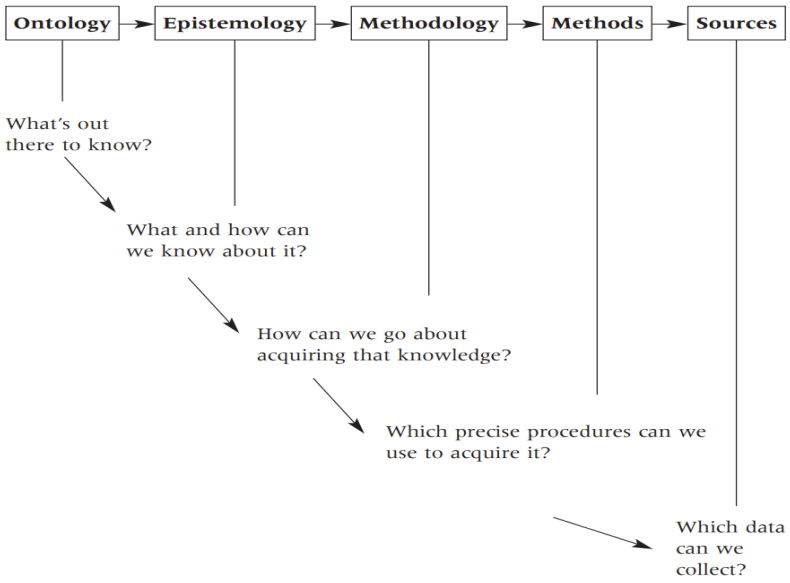



Fig. 17: The Interrelationship Between the Building Blocks of Research (Source: adapted from Grix (2002) (Grix, 2002))

While the pragmatism worldview urges researchers to concentrate on the problem of the study and allows the utilization of qualitative and

quantitative data to meet the inquiries of the study, as previously mentioned (Creswell, 2009), and considering the lack of H-GenAI models and studies examining the appropriate factors that aid in forming optimal H-GenAI PTs, how H-GenAI PTs develop throughout the STD, and H-GenAI collaboration effects on PT performance, it is evident that both qualitative and quantitative data are required to address the study's need for inquiries. Therefore, this need is met by employing qualitative and quantitative approaches to fulfill the objectives of the study.

### 3.2.3 Qualitative, Quantitative, & Mixed-Methods Research Approaches

Creswell (2013) defines qualitative research as “a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures; collecting data in the participants’ setting; analyzing the data inductively, building from particulars to general themes; and making interpretations of the meaning of the data. The final written report has a flexible writing structure” (Creswell, 2013).

Quantitative research is defined as “a means for testing objective theories by examining the relationship among variables. These variables can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures. The final written report has a set structure consisting of an introduction, literature and theory, methods, results, and discussion” (Creswell, 2013).

A mixed method is an inquiry that concentrates on collecting, analyzing, and combining both qualitative and quantitative empirical materials in one study or a set of studies (Denzin & Lincoln, 2018). According to Creswell (2013), mixed methods research is “an approach to inquiry that combines

both qualitative and quantitative forms of research. It involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing or integrating of both approaches in a study" (Creswell, 2013).

Thus, this study uses mixed methods approaches, a combination of qualitative and quantitative approaches throughout its 3 Phases, which the following Section will discuss.

## 3.3 The Research Methods of the Study

This Section presents the research methods and sources according to the employed research approaches for each Part of the study's 3 Phases, showing the acquired procedures for data collection, which are related to the combination use of qualitative and quantitative.

### 3.3.1 Phase 1 Part 1: Systematic Literature Review

Part 1 aims to discover the theories that support the dynamics of TF to better comprehend the basis on which H-AI teams are formed. Part 1 adapts a systematic literature review (SLR) method using secondary data collection from the literature by following a systematic methodology for conducting the SLR. The SLR is based on the three recommended phases (Al-Alawi et al., 2023) as presented in Figure 18: "(1) Planning the Review, (2) Conducting the Review, and (3) Reporting the Review" (Kitchenham et al., 2009; Kitchenham & Charters, 2007).

The first two phases will be presented in this Section along with some of the stages associated with each, while the third phase will be presented in Chapter 4 as the results of Part 1 from Phase 1 of the study.

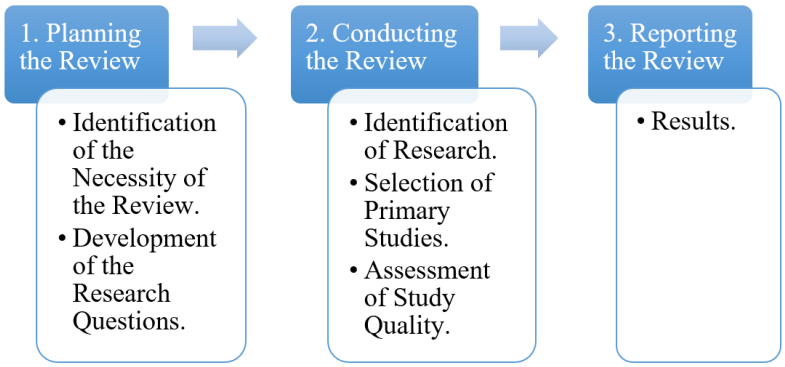



Fig. 18: Systematic Methodology of Literature Review (source: (Al-Alawi et al., 2023))

## *1. Planning the Review*

At this point, scholars determine whether a review is necessary, formulate research questions, and establish and assess a review process (Kitchenham & Charters, 2007),(Xiao & Watson, 2019).

### *1.1. Identification of the Necessity of the Review*

The process of TF continues to be an open and difficult matter since numerous quality standards need to be optimized while adhering to numerous constraints (D'Aniello et al., 2021).

In terms of the research being conducted, it was necessary to provide a comprehensive summary of the most recent findings that make use of theories to assist TF in general and H-AI teaming in particular.

As far as the authors are aware, no SLR was found to have been performed in this domain. Thus, by presenting the significant quantity of research that has advanced in this area and acting as a guide for other researchers, this study enhances the understanding of TF with an emphasis on the field of H-AI collaboration.

### *1.2. Development of Research Questions*

The questions for the study ought to be defined once the objectives of the study have been determined, as they serve as the foundation for the methodology of the SLR (Kitchenham & Charters, 2007). The three main points of view of the requirements for the study should be reflected in the formulation of research questions (RQ): population, intervention, and outcomes (Kitchenham & Charters, 2007). This SLR followed PICOC components, as presented in Table 10, which consist of "Population, Intervention, Comparison, Outcome, and Context" (Carrera-Rivera et al., 2022; Kitchenham & Charters, 2007; Petticrew & Roberts, n.d.).

Table (10): PICOC-Based Study Criteria

| PICOC | Description | Keywords | Synonyms |
|---|---|---|---|
| **Population** | A particular function, a category, a field of use, or a business domain. | Team formation, team selection, human-artificial intelligence collaboration | Team interaction, team collaboration, human-AI collaboration |
| **Intervention** | The application, process, tool, technique, or method associated with an issue. | Team formation theories | Theories of group formation, team building, team development, team construction, team composition |
| **Comparison** | The application, process, tool, technique, or method that is compared with the Intervention. | Human-Artificial Intelligence team formation theories | Human-AI team formation theories |
| **Outcome** | Aspects that matter to practitioners and/or the Intervention's outcomes. | Adapted or new team formation theories, theories for human-artificial intelligence collaboration | Adapted or new team formation theories, theories for human-AI collaboration |
| **Context** | The context for the comparison, the participants of the study, and the tasks undertaken. | Human-Artificial Intelligence collaboration, Human-Artificial Intelligence Teams | Human-AI Collaboration, Human-AI Teams |

Consequently, based on the components of PICOC listed in Table 10 that facilitate the design of RQs, the following RQs were formed to meet the study's objectives and map with its criteria:

RQ1: What are the theories that support the dynamics of team formation?

RQ2: What aspects can future studies explore concerning H-AI collaboration?

## *2. Conducting the Review*

This study adheres to some of Kitchenham's suggested protocols for conducting reviews in order to guarantee that suitable papers are adapted for the study (Kitchenham & Charters, 2007).

### *2.1. Identification of Research*

The comprehensiveness of the search procedure is a particular aspect that sets systematic reviews apart from conventional ones. Thus, it is essential to employ a neutral search approach to discover a significant number of primary studies pertaining to the RQ (Kitchenham & Charters, 2007).

This SLR creates and employs a search strategy that uses the "Keywords" and "Synonyms" listed in Table 10 to choose literature in related fields of study.

Since none of the databases may incorporate all of the published scientific papers (Xiao & Watson, 2019), the literature collected is from digital libraries related to computer science (Carrera-Rivera et al., 2022), specifically ScienceDirect, ACM, and IEEE Xplore/Access, and the time range chosen is from 2018 to 2023.

### *2.2. Selection of Primary Studies*

According to the study's selection criteria, the primary studies that may be relevant ought to be assessed for relevance, as it is essential for determining the most suitable papers that provide precise suggestions for addressing the RQs and are, therefore, considered for analysis (Kitchenham & Charters, 2007; Xiao & Watson, 2019).

As for this study, primary studies were first screened according to their abstracts, then a full-text thorough assessment was performed to filter out any papers that were irrelevant to the research questions, followed by inclusion and exclusion criteria based on applicability (Xiao & Watson, 2019), as indicated in Table 11.

Table (11): Criteria for Inclusion & Exclusion

| **Type** | **Inclusion** | **Exclusion** |
|---|---|---|
| **Database** | ScienceDirect, IEEE *Xplore/Access, or ACM* | Other sources |
| **Type** | Journals or conferences | Books & reports |
| **Language** | Written in English | Non-English |
| **Period** | From 2018 to 2023 | Before 2018 |
| **Relevance** | Relevant to a RQ or more | Irrelevant to any RQ |
| **Method** | Papers with theories supporting team formation | Not supporting team formation theories |

This study chose 20 papers for the SLR from among the 38 primary studies that were searched, as shown in Table 12. These papers constitute 53% of the entire number of publications that were examined. An identification number corresponding to the database is allocated to the chosen studies. Table 13 presents the papers' sources, IDs, and references of the papers together with years of publication based on this study.

Table (12): Previous Studies Search

| Database / Papers | Science-Direct | ACM | IEEE Xplore/ Access | Sum |
|---|---|---|---|---|
| **Searched Papers** | 16 | 16 | 6 | 38 |
| **Filtered Papers** | 8 | 6 | 4 | 18 |
| **Selected Papers** | 8 | 10 | 2 | 20 |

Table (13): Selected Previous Studies

| Source | ID | Ref. |
|---|---|---|
| **ScienceDirect (SD)** | SD1 | (Kalayathankal et al., 2021) |
| | SD2 | (D'Aniello et al., 2021) |
| | SD3 | (Bachrach et al., 2020) |
| | SD4 | (Fortino et al., 2020) |
| | SD5 | (Rahmanniyay et al., 2019b) |
| | SD6 | (Pollack & Matous, 2019) |
| | SD7 | (Andrejczuk et al., 2019) |
| | SD8 | (Bahargam et al., 2019a) |
| **IEEE Xplore/ Access (IE)** | IE1 | (Weilemann, 2019) |
| | IE2 | (Josue-Miguel Flores-Parra et al., 2018) |
| **ACM (AM)** | AM1 | (Munyaka et al., 2023) |
| | AM2 | (Eloy et al., 2023) |
| | AM3 | (Schelble et al., 2022) |
| | AM4 | (Caldwell et al., 2022b) |
| | AM5 | (Hwang & Won, 2021) |
| | AM6 | (Barambones et al., 2021) |
| | AM7 | (Gómez-Zará, DeChurch, et al., 2020) |
| | AM8 | (Gómez-Zará, Guo, et al., 2020) |
| | AM9 | (Ulfert & Georganta, 2020) |
| | AM10 | (Zhou et al., 2018) |

### *2.3. Assessment of Study Quality*

The final step in the preparation of the collection of suitable studies is the assessment of study quality, which serves as a filter to improve the papers' selection (Xiao & Watson, 2019). While there is no standard for defining the quality level of a study (Kitchenham & Charters, 2007; Okoli, 2015; Xiao & Watson, 2019), studies ought to be evaluated using a range

of quality criteria (Okoli, 2015) based on a checklist, which is a common method used for evaluating the standard of studies (Xiao & Watson, 2019).

This SLR measured the study quality (SQ) using the following five-question checklist:

SQ1: Does the study mention theories that support team formation?

SQ2: Does the study cover theories of H-AI teams?

SQ3: Does the study implement a theory?

SQ4: Does the study highlight potential drawbacks or challenges of theories implementation to H-AI teams?

SQ5: Does the study offer insights for further studies on TF in the future?

The outcomes of the study quality assessment concerning the five-question checklist are shown in Table 14.

Table (14): Outcomes of Study Quality Assessment

| | **Questions Checklist** | | | | |
|---|---|---|---|---|---|
| **Papers ID** | ***SQ1*** | ***SQ2*** | ***SQ3*** | ***SQ4*** | ***SQ5*** |
| **SD1** | x | x | x | | x |
| **SD2** | x | | x | | x |
| **SD3** | x | | x | | x |
| **SD4** | x | | | | |
| **SD5** | x | | | | x |
| **SD6** | x | | | | x |
| **SD7** | x | | | | |
| **SD8** | x | | | | x |
| **IE1** | x | | | | |
| **IE2** | x | | | | |
| **AM1** | x | x | | x | x |
| **AM2** | x | x | x | | x |
| **AM3** | x | x | x | x | x |
| **AM4** | | | | | x |
| **AM5** | x | x | x | x | x |
| **AM6** | x | x | x | | x |
| **AM7** | x | | | | x |
| **AM8** | x | | | | x |
| **AM9** | x | x | x | x | x |
| **AM10** | x | | x | | x |

### 3.3.2 Phase 1 Part 2: Quantitative Approach

In Part 2, the study aims to solve the H-H TFP by determining the factors that aid in forming PTs for project management in the service industry and the extent to which the factors affect the performance of the PT. To achieve the objectives of this part of the study, the study collects quantitative data through Text Mining techniques.

Text mining is a technique that computers typically use to extract information and obtain knowledge that could not have been recognized before (Widjaja et al., 2023). Text mining, also referred to as Knowledge-Discovery in Text and Text Data Mining, uses data mining techniques in text collections to extract non-trivial yet interesting information from unstructured text data or corpus and to find connotative knowledge (Gupta & Lehal, 2009), (Y. Zhang et al., 2015).

Text mining is a broad subject of study that encompasses AI, ML, database systems, mathematical statistics, and more (Y. Zhang et al., 2015). It is a multidisciplinary field that incorporates elements of information retrieval, computational linguistics, statistics, data mining, and ML (Gupta & Lehal, 2009). Text mining intelligence or knowledge is derived via NLP techniques (Reddy & Dr. Chaudhary, 2021).

NLP has led to the development of technologies that can teach computers natural language, enabling them to comprehend, analyze, as well as create text (Gupta & Lehal, 2009). Information extraction, summarization, topic tracking, information visualization, categorization, and clustering are a few of the established technologies that can be applied in the text-mining process (Gupta & Lehal, 2009). In addition, three stages are often involved in text mining: (a) text preprocessing; (b) applying text mining operations; and (c) postprocessing (Y. Zhang et al., 2015), (Kobayashi et al., 2018), as illustrated in Figure 19 (Kobayashi et al., 2018). According to (Kobayashi

et al., 2018), text data collection, text data cleansing, and text data transformation are subdivisions of text preprocessing. Text mining operations are the use of pattern mining algorithms with the primary objective of modelling characteristics of texts, while Postprocessing is the process of analyzing and validating knowledge obtained from text mining operations (Kobayashi et al., 2018).

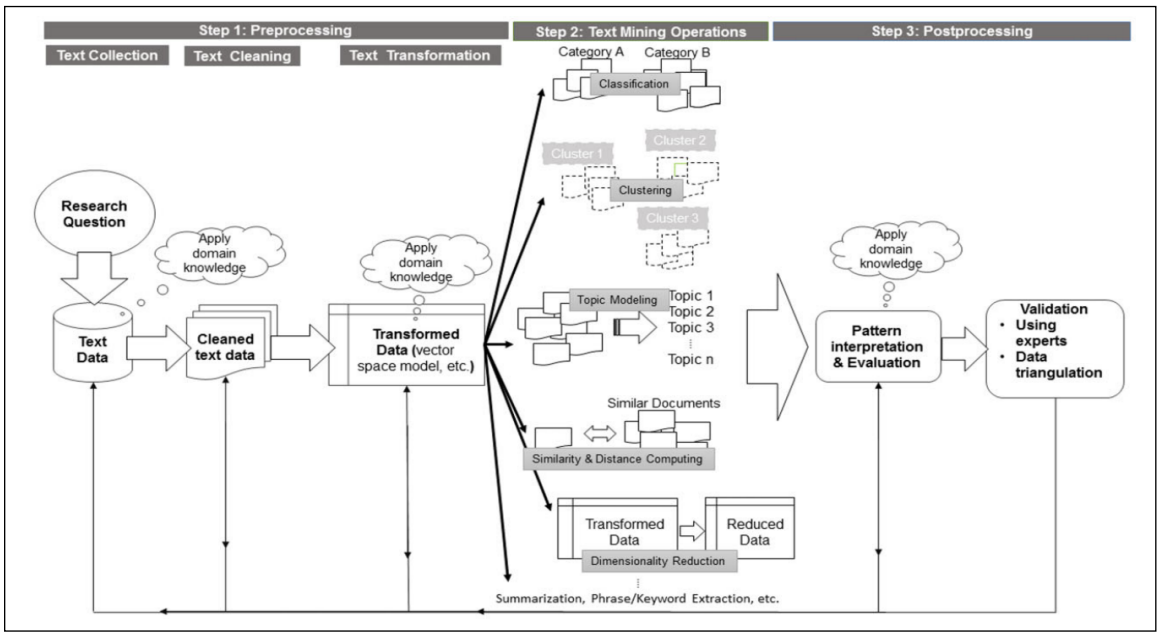



Fig. 19: Text Mining Process Flowchart (Kobayashi et al., 2018).

### 3.3.2.1 Text Mining Framework

As for this part of the study, since it is designed to solve the H-H TFP, it is important to first discover the factors that appear in literature, evaluate their importance, determine the main or key factors, and finally, prioritize the key factors according to their usage importance in the service industry.

Thus, the study proposed a Text Mining Framework (TMF), which is a hybrid process of text mining techniques, consisting of NLP, ML, and MCDM methods, to solve the H-H TFP. Figure 20 illustrates the TMF.

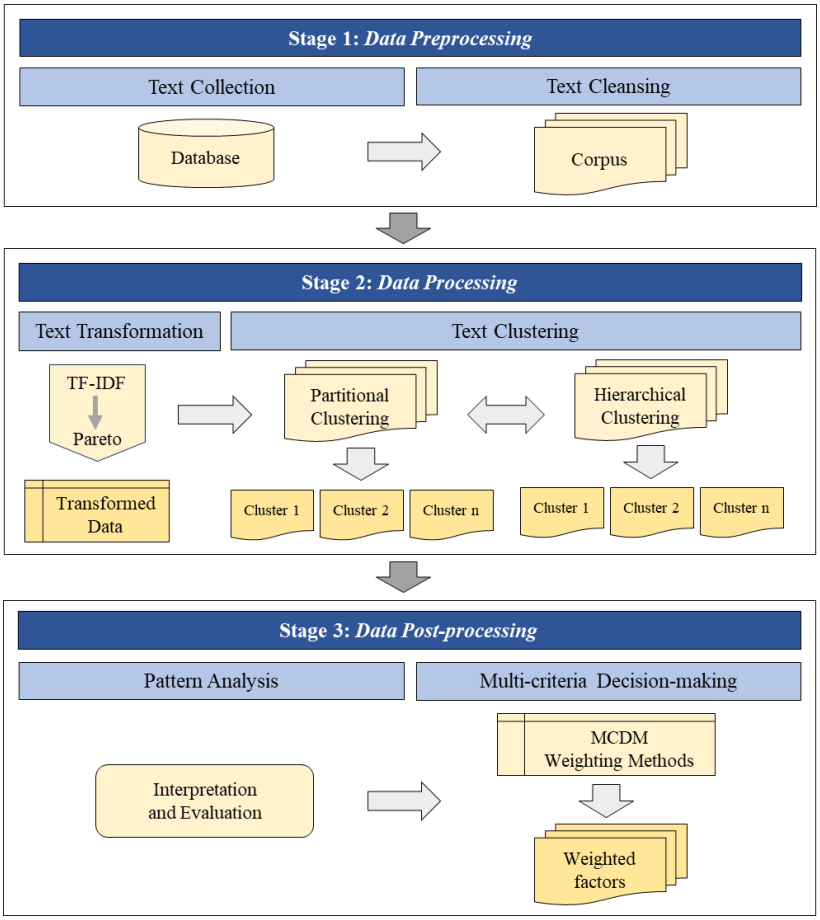



Fig. 20: Proposed Text Mining Framework (TMF)

The TMF consists of 3 stages: Data Preprocessing, Data Processing, and Data Post-processing, as illustrated in Figure 20. In the Data Preprocessing stage (Stage 1), the study will first discover the factors that appear in the literature to prepare for the next stage. In the Data Processing stage (Stage 2), the study will evaluate the importance of the TF factors that were extracted in Stage 1 using TF-IDF to rank the unique factors according to their weights, and then select the most important ones using the Pareto principle. After that, the study will employ ML text clustering methods to cluster the factors using K-means clustering and Hierarchical clustering, and determine the main or key factors. Finally, in the Data Post-processing stage (Stage 3), the study will prioritize the main factors according to PMs from different sectors within the service industry using an MCDM approach for weighing criteria.

The following sub-sections will explain the three stages of the TMF.

#### 3.3.2.1.1 Stage 1: Data Preprocessing

Since the first stage is exploratory in nature, it relies on exploratory research methods to analyze and synthesize the literature on the TFP and the factors that affect TF, to solve the H-H TFP. The data is collected in Stage 1 by exploring the literature to generate data using secondary data sources. The purpose is to discover all the used factors for PT formation in the project management domain.

By utilizing secondary research methods, the study conducted a literature search in the academic database Google Scholar, using related keywords and Boolean operators. The search string such as team formation, team formation problem, project team, factors, weights, and values was used with the Boolean operators “AND” and “OR”. Only the most related publications to the objectives of this study and published during the past ten years were chosen for this study, which resulted in a total number of 17 scientific papers. The study then cleanses the factors obtained from the 17 scientific papers in one document and considers it as its corpus.

#### 3.3.2.1.2 Stage 2: Data Processing

In the second stage, after this non-numeric stage of determining the most used factors associated with TF through a thorough literature search, the study utilizes a hybrid approach of several quantitative techniques for Text Transformation and Text Clustering.

In the Text Transformation, the study first employs the Term Frequency-Inverse Document Frequency approach value (TF-IDF) as a decision matrix for allocating weights to all the factors to evaluate the importance of terms (factors) in a specific document relative to a collection of other documents, aiming to undertake a more effective approach to forming

effective PTs by ranking the factors according to the level of influence on TF. After considering the highest-weighted terms or factors according to the TF-IDF, the study employs the Pareto principle, to consider the most influential factors for this study, also referred to as the most important or the most valued factors. Then, the study clusters these high-weighted factors into "Main Factors" and "Sub-Factors" by using the NLP approach based on ML clustering algorithms, the K-Means clustering and the Hierarchical clustering technique, which are non-supervised learning algorithms that group words based on similarity in terms of semantics. The study used Python Jupiter as a tool for data analytics, as well as Orange, which is a collection of tools for data mining and ML that uses Python scripting and visual programming to analyze data (Demšar et al., 2013).

#### 3.3.2.1.2.1 Term Frequency-Inverse Document Frequency

TF-IDF is a text-processing method utilized to quantify the tokens in the textual material (Dey & Das, 2023). The TF-IDF is a statistical metric that is widely used for assigning scores to the components of the text (Dey & Das, 2023). This method is frequently employed in information and text retrieval tasks by weighing the words in each document (Chou & Cho, 2023). By assigning a weight to each word in the document, the TF-IDF approach calculates the degree to which terms are connected to the document (Widjaja et al., 2023).

The TF-IDF method's core basis is to integrate the two concepts: Term Frequency (TF: $tf_{i,j} = \frac{f_{i,j}}{\|d_i\|}$) and Inverse Document Frequency (IDF: $\text{idf}_\text{i} = \log \frac{\|D\|}{\|d \in D : t_i \in d\|}$) (Widjaja et al., 2023), (Messaadia et al., 2018).

Term Frequency (TF) is the first parameter of the TF-IDF technique, and it is the frequency with which a term appears in a document, while Inverse Document Frequency (IDF) is the second parameter of the TF-IDF that

indicates the term's significance throughout the entire corpus, which is easily calculated by taking the log function of the term and dividing the total number of documents by the number of documents containing the term (Dey & Das, 2023), (Widjaja et al., 2023), (Messaadia et al., 2018).

$$w_{i,j} = \frac{f_{i,j}}{\|d_j\|} \times \log \frac{\|D\|}{\|d \in D: t_i \in d\|}$$

Where $t_{i,j}$ is the *i*-th feature word in *j*-th document $\|D\|$ is the number of documents in collection *D*, $tf_{i,j}$ is the term frequency (frequency of a term in a document) and $\mathrm{idf_i}$ is the inverse document frequency (inverse fraction of the documents that contain the word, and logarithmically scaled) (Chen et al., 2016), where in our context, $i \in [1, 247]$, while $j \in [1, 17]$, which means that we have used a corpus of 17 documents (*D)* with a focus on 247 factors.

The TF-IDF approach is often utilized as a common foundation for text mining and is renowned for its effectiveness, simplicity of use, and ability to produce reliable outcomes (Widjaja et al., 2023). However, to guarantee that the words in our cleaned corpus corresponded to the most significant components of each narrative (Kakatkar et al., 2023), this study uses the Pareto principle to prioritize the factors and consider only the most influential for the TF process.

#### 3.3.2.1.2.2 Machine Learning Clustering Algorithms

Clustering is a popular unsupervised learning technique (Li et al., 2022) and a type of data mining task that combines similar data items into groupings (Poomagal et al., 2023). Clustering primarily groups data according to how similar and unlike they are from one another, and once the data set has been categorized, it creates clusters or groups (Singh et al., 2021).

The majority of clustering algorithms are categorized into one of two categories: hierarchical and partitional (Kobayashi et al., 2018), as shown in Figure 21 (Pitafi et al., 2023).

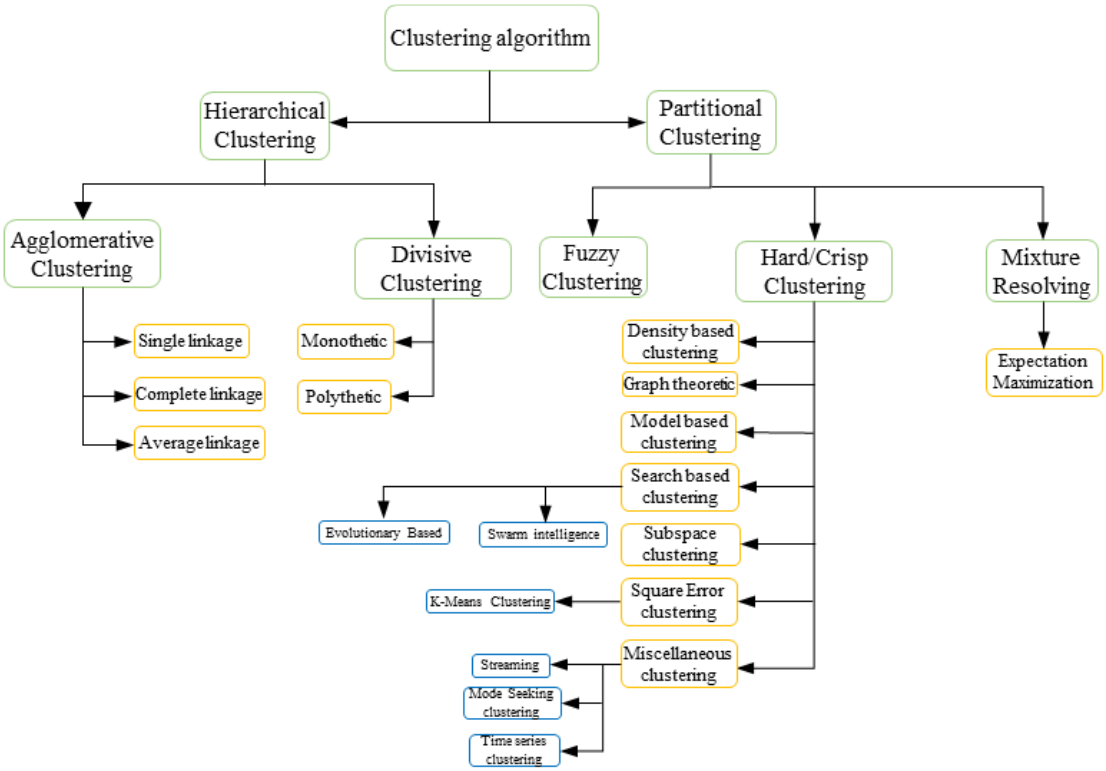



Fig. 21: Classification of Different Clustering Techniques (Pitafi et al., 2023)

According to the authors Murtagh & Contreras (2017), a fundamental objective for employing hierarchical clustering is to obtain several splits (Murtagh & Contreras, 2017). Each split corresponds to a hierarchical level, its dendrogram representation, or, in mathematical graph theory, a binary rooted tree (Murtagh & Contreras, 2017).

When using hierarchical clustering algorithms, either all objects are first placed under one cluster and then clusters are split recursively until each object is in its own cluster, or each object is treated as its own cluster, and clusters are gradually combined until all objects are affiliated to a single

cluster, and a tree or dendrogram represents how clusters merge (or split) (Kobayashi et al., 2018). Data exploration at different degrees of granularity is made possible by this clustering technique (Pitafi et al., 2023).

According to Pitafi et al. (2023), there are two types of methods: the agglomerative, which uses a bottom-up approach, and the divisive, which uses a top-down strategy. Agglomerative hierarchical clustering is a prominent and proven method in unsupervised machine learning (Pitafi et al., 2023). To determine the different levels of the hierarchy, the process agglomerative technique uses clusters that are created from identical components by correctly combining them repeatedly into larger clusters. The process continues until the entire object is converted into a specific cluster or the stopping criteria are satisfied. In other words, the data set is first divided into single nodes, which then progressively merge the two closest nodes into a single node until the entire data set arrives in a single node. However, when employing a divisive strategy, the opposite is true (Pitafi et al., 2023).

Most often, agglomerative hierarchical clustering has been used to build embedded classification techniques (Murtagh & Contreras, 2017). According to the authors Murtagh & Contreras (2012), this agglomerative criterion also makes hierarchies more balanced, which is frequently advantageous from a practical standpoint (Murtagh & Contreras, 2012). Besides, since they begin with a single instance in each cluster and progressively join the closest clusters, popular agglomerative hierarchical clustering techniques are simple to employ (Li et al., 2022).

In partitional clustering, the number of clusters to be created must be chosen by the user, and the objective function that is optimized to create clusters is typically based on the distances between the objects and the

cluster centres to which they have been assigned (Kobayashi et al., 2018). A typical example of partitional clustering is the well-known k-means algorithm (Kobayashi et al., 2018). This method uses an iterative algorithm to divide the data points into K groups, with each data set fitting into a cluster with the closest mean (centroid) and the highest degree of similarity (Singh et al., 2021). K-means cluster data points by using a random seed and the number of clusters (K) as input (Poomagal et al., 2023). K-means clustering is a non-hierarchical data clustering technique that divides or partitions collected data into one or more predefined groups or clusters based on how comparable the features/characteristics of the individual data are (Widjaja et al., 2023). The k-means clustering algorithm, in its simplest form, clusters existing data according to shared qualities or, at the very least, similarities between the data (Widjaja et al., 2023).

While K-means clustering is used when one is certain about the number of clusters one wants to build, hierarchical clustering may be used to see if interpretable categories appear when one is unsure of how many clusters to create (Kobayashi et al., 2018). In this study, both types of clustering are explored, hierarchical and partitional, by employing the "agglomerative hierarchical clustering algorithm" for hierarchical clustering, and the "k-means clustering algorithm" for partitional clustering. It is important to emphasize that when employing hierarchical clustering algorithms, a tree or dendrogram reflects how clusters merge (or split), which shows to which root each factor belongs. Then, the study evaluated the performance of these two clustering algorithms, along with others, using the Silhouette index, an unsupervised technique for assessing a clustering method's performance (Shutaywi & Kachouie, 2021), to compare the results of the clustering methods. The Silhouette width $S(x_i)$ for the point $x_i$ is defined as:

$$S(x_i) = \frac{b(x_i) - a(x_i)}{\max\{b(x_i), a(x_i)\}}$$

where $x_i$ is an element in cluster k, $a(x_i)$ is the average distance of $x_i$ to all other elements in the cluster k (within dissimilarity), and

$$b(x_i) = \min\{d_1(x_i)\}\text{ , among all clusters } l \neq \text{k},$$

where $d_1(x_i)$ is the average distance from $x_i$ to all points in cluster k for $l \neq$ k (between dissimilarity).

The following measurements are used to assess the quality of the Silhouette score (Shahapure & Nicholas, 2020):

- A Silhouette score close to +1 signifies that the data point is in the correct cluster,
- A Silhouette score close to 0 signifies that the data point might belong to other clusters, and
- A Silhouette score close to -1 signifies that the data point is in an incorrect cluster.

#### 3.3.2.1.2.3 Latent Dirichlet Allocation

As part of ML clustering algorithms, other text clustering methods are widely used, such as the Latent Dirichlet Allocation (LDA), a generative probabilistic technique for modeling collections of discrete data, such as a text corpus (Chen et al., 2016), (Onan et al., 2016). LDA is capable of handling lengthy documents and offering a complete generative model. It is utilized as a feature representation technique for text document classification, aiming to use the observable data to determine the underlying latent topic structure (Onan et al., 2016).

The generative process of LDA is summarized as follows (Onan et al., 2016):

For each document w in a corpus D:

1. Choose $N$ ~ Poisson (ξ).
2. Choose Θ ~ Dir (α).
3. For each of the $N$ words $w_n$:
    a. Choose a topic $z_n$ ~ Multinomial (Θ).
    b. Choose a word $w_n$ from $p(w_n|z_n, \beta)$, a multinomial probability conditioned on the topic $z_n$.

This study applied the LDA to compare its results with the results of the Data Processing stage, which included Text Transformation (TF-IDF + Pareto), followed by Text Clustering (k-means and agglomerative hierarchical clustering).

#### 3.3.2.1.3 Stage 3: Data Post-processing

The third stage adopts the MCDM approach, aiming to collect individuals' input through structured interviews with PMs who are required to form PTs. Through the PM's experiences with forming PTs in terms of the factors that contribute to the success of PTs or collaboration in general within the service industry, the study will determine the value of each factor influencing the formation of a PT, aiming to enhance its performance.

In the domain of project management, although projects require the successful development of teams for projects to succeed (Aryanee et al., 2020), different project requirements will lead to different combinations involving team members' attributes (Zainal et al., 2024). Thus, for this study, it is important to further analyze factors related to humans that will drive the project's success and exclude the factors that are related to projects, since in the conceptual model for Agile Software Development TF (Zainal et al., 2024), (Aryanee et al., 2020) (illustrated in Figure 1), the authors indicate that the Agile Team Composition

Characteristics can be influenced by the project characteristics. Therefore, the study will analyze the results of the ML clustering method, presented in Stage 2 in the TMF, and then carefully include and exclude the factors accordingly.

Considering the abovementioned point, for this Part, first, in the Pattern Analysis, the study interprets and evaluates the results of the Text Clustering which was conducted in the previous stage, and then generates quantitative data by conducting structured interviews to prioritize the Main or Key Factors, which will be referred to as criteria when plural and criterion when singular, the study investigates the influence of such factors on the TF process by using a MCDM approach namely the Best-Worst Method (BWM) by considering the input of decision-makers (project managers) in the service industry, to determine each factor's relative value or importance in the decision-making process of a TF when dealing with PTs. Only then, and with respect to the Main or Key Factors of the most influencing factors in the TF process, can PT members or candidates (also referred to as "alternatives" in this study) be compared with each other and hence ranked according to their priority value to form the best PT (also referred to as the "optimal goal" in this study).

The structured interviews' results reveal the factors that contribute to the success of a PT through the eyes of PMs from different sectors within the service industry, based on their knowledge and experiences in project management. The outcomes of the structured interviews are used to solve the H-H TFP. According to Creswell & Creswell (2018), survey research offers a quantitative or numerical perspective of the attitudes, trends, or views of that population, by examining a sample of a population (Creswell & Creswell, 2018). It comprises cross-sectional and longitudinal research to generalize findings from a sample to the entire population. These studies

collect data through questionnaires or structured interviews (Creswell & Creswell, 2018). Structured interviews are used in surveys and usually follow a similar logic to questionnaires since adopting standardized questioning techniques will produce responses that are capable of being compared and potentially quantified among participants (Denzin & Lincoln, 2018). During structured interviews, interviewees' opinions and attitudes are passively recorded (Denzin & Lincoln, 2018). Interviewers are expected to read questions to each interviewee exactly as written and are not supposed to offer information beyond the questions constructed in the survey (Denzin & Lincoln, 2018).

#### 3.3.2.1.3.1 Data Source, Sampling Procedures, & Instruments of Data Collection

To measure the variables of interest in quantitative research, researchers choose instruments, modify ones that already exist, or develop novel ones (Creswell & Plano Clark, 2018). As for stage 3 of the TMF, the structured interview constructs are developed based on the findings of the previous stage of the TMF. According to Creswell & Plano Clark (2018), the goal of random sampling, also known as probabilistic sampling, is to choose a large number of people who represent the entire population or a subset of it (Creswell & Plano Clark, 2018).

As for this study, structured interviews are conducted with 25 PMs from 5 organizations in 5 different sectors within the service industry using random sampling to collect quantitative data, in which the response categories are predetermined, and the scores are recorded in a closed-ended manner on scales. The five sectors that this study considered are Financial (FS), Telecommunication (TS), Real Estate (RS), Energy (ES), and Governmental or Public (GS). The researcher accessed the representatives through the HR Director (or equivalent) of the organizations.

### 3.3.2.1.3.2 Structured Interviews Representatives

Table 15 presents the 25 interview representatives and their job titles.

Table (15): Structured Interviews Representatives Information

| Sector | Project Manager | Job Title |
|---|---|---|
| **FS** | PM1 | Innovation & User Experience Manager |
| | PM2 | Assistant General Manager, Business Development |
| | PM3 | Head, Bahrain Credit Reference Bureau |
| | PM4 | Project Manager, Project Management Office |
| | PM5 | Assistant General Manager, Payment Services |
| **TS** | PM1 | Head of Procurement |
| | PM2 | Head of Infrastructure Maintenance |
| | PM3 | Head of Strategy Management & Data Analytics |
| | PM4 | Sr. Payroll and Operations Manager |
| | PM5 | Head of Projects |
| **RS** | PM1 | Chief Development Officer |
| | PM2 | Chief Operating Officer & Board Secretary |
| | PM3 | Head of Risk & Compliance |
| | PM4 | Chief Investment Officer |
| | PM5 | Chief Financial Officer |
| **ES** | PM1 | Manager, Major Projects |
| | PM2 | Manager, Facility Engineering and Projects |
| | PM3 | Acting Lead, NAG Wells Hookup and Pipeline Projects |
| | PM4 | Civil Projects Team Lead |
| | PM5 | Manager, Technical Services, Project Management Division |
| **GS** | PM1 | Chief of Project Management |
| | PM2 | Chief of Service Delivery |
| | PM3 | Head of Innovation Initiatives Analysis, Acting Chief of R&D, Innovation & Advanced Technologies Directorate |
| | PM4 | Head of AI Applications Development |
| | PM5 | Project Manager, Project Management Directorate |

#### 3.3.2.1.3.3 Multi-Criteria Decision-Making Approaches: Weights Allocation Methods

MCDM is concerned with structuring and resolving decision-making and planning problems that involve multiple criteria (Aruldoss et al., 2013). Several domains have employed MCDM since it offers strong decision-making in areas where choosing the optimal alternative is extremely difficult (Aruldoss et al., 2013). MCDM techniques are mathematical models that assist in making decisions in situations where potential options are weighed against several different criteria (Ceballos et al., 2016). According to (Ceballos et al., 2016), there are no precise instructions on which MCDM method should be applied to address a given MCDM problem, and each MCDM technique is distinct in its own way (Aruldoss et al., 2013). When numerous criteria exist, the MCDM method assists in selecting the best options. The best option can be determined by examining the various criterion scopes and weights, and then selecting the best options by employing any MCDM techniques (Aruldoss et al., 2013).

Assigning weights to criteria is a crucial step for nearly all MCDM models (Odu, 2019), and the choice of weighting technique is crucial when it comes to MCDM problems (Ayan et al., 2023). Numerous weighting techniques, including goal programming, the weighted score approach, the Analytic Hierarchy Process (AHP), VIKOR, the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS), and others, have been proposed in the literature and used to solve various MCDM problems (Odu, 2019), (Ayan et al., 2023). The traditional methods for assigning weights to criteria include AHP, MACBETH method (Measuring Attractiveness by Categorical Based Evaluation Technique), SMART method (the Simple Multi-Attribute Rating Technique), and Direct point allocation method, to name a few (Žižovic & Pamucar, 2019). The AHP,

first suggested by Thomas L. Saaty in 1977, has gained popularity across all MCDM methods (Odu, 2019), becoming the most common and extensively applied technique for making decisions (Omar et al., 2015), besides, the AHP method is among the most popular MCDM methods used in solving personnel selection, offering a way to rank the options and provide standards for making the ultimate decision (Piñero Pérez et al., 2022). However, a more recent study developed a novel MCDM method called the Best-Worst Method (BWM), in which the best and worst alternatives are compared with the other alternatives to determine the weights using the pairwise comparison (Rezaei, 2015). In his study, the author proved that BWM outperforms AHP by comparing the outcomes of the two methods while taking into account a variety of evaluation factors. In contrast to other MCDM methods, the main advantages of the BWM are that it demands fewer comparison data and results in more consistent comparisons, which implies more reliable outcomes (Rezaei, 2015).

According to (Odu, 2019), in multi-criteria assessment, weights allocated to criterion are based on qualitative data and quantitative data to ensure that the weight accounts for more precise and effective decision making. However, decision makers' preferences can affect how weights are assigned using qualitative data to criteria. As a result, Saaty developed a numerical scale with values of "1–9" to convert qualitative data into quantitative data, with '1' denoting equal importance and '9' denoting extreme importance (Saaty, 1977).

There are two types of weighting methods which are categorized into several weighting techniques: Indirect methods such as weight generated from mathematical models and theories, and Direct criteria weighting methods such as scaling, ranking-weight, and point allocation procedures (Odu, 2019). According to (Žižovic & Pamucar, 2019), the majority of

publications recommend dividing models into subjective and objective models to determine the weights of the criteria. Weight categorization may also be categorized into three groups: subjective, objective, and integrated weighting methods (Odu, 2019), (Ayan et al., 2023). Subjective weights are derived from decision-makers' assessments, which are usually impacted by their preferences (Odu, 2019), (Ayan et al., 2023) and show decision-makers' subjective reasoning and intuition (Žižovic & Pamucar, 2019). There are several subjective weighting methods such as Point allocation, Direct rating, Ranking method, and Pairwise comparison to name a few (Odu, 2019), (Ayan et al., 2023), along with the BWM (Rezaei, 2015). According to (Odu, 2019), the Pairwise comparison method is used to examine various populations in pairs and discover if they differ substantially from each other. It may also be described as a process where the decision-maker assesses the degree of preference for every pair of criteria by comparing them with one another. An ordinal scale of 1 to 9 is used to assist in comparing the preference value of one criterion to another.

Furthermore, the AHP method is among the most widely used pairwise comparison-based techniques (Odu, 2019), and in fact, the AHP method is a popular MCDM approach because it uses pairwise comparisons to enable verbal assessment and raises the precision of the results (Omar et al., 2015). While the AHP uses pairwise comparisons of the criteria to determine the weights and pairwise comparisons of the alternatives to determine the scores, followed by employing a function to determine the overall value of the alternatives, the pairwise comparison method faces a major challenge in the form of inconsistent pairwise comparison matrices, which commonly occur in practice (Rezaei, 2015). The author suggests that the main reason for the inconsistencies lay in the unstructured manner in which

comparisons are performed by pairwise comparison-based approaches. For this reason, the BWM is proposed as a novel approach to MCDM, which differs from the other MCDM approaches in that it determines weights through pairwise comparisons in its unique manner (Rezaei, 2015).

The BWM approach is relatively new, yet it has been successfully applied in several research (Rezaei, 2015), (Rezaei et al., 2018), (Rezaei et al., 2015). The reasons behind the popularity of the BWM lie in its practicality; the BWM needs fewer comparisons than a full pairwise comparison matrix because it only uses two vectors as opposed to a complete pairwise comparison matrix. This shortens the process and increases consistency among the comparisons because the comparison is carried out in a very structured manner. As a result, applying the BWM lessens the issues with pairwise comparison. In addition, the BWM employs an extremely structured and comprehensible approach to obtaining the information needed for the pairwise comparisons, leading to very reliable outcomes that are simple for the assessor to comprehend and can be simply modified to improve consistency (Rezaei, 2015), (Rezaei et al., 2018). For these main reasons, this study will apply the BWM to weigh the criteria once determined. By following the subjective weighting approach, the experts or decision-makers who provide input into the process are the ones who establish the weights of the criteria (Žižovic & Pamucar, 2019).

#### 3.3.2.1.3.3.1 Best-Worst Method

Generally, an MCDM problem for weight allocation is represented by the following matrix shown in Equation (1) where the top row $\{C_1, C_2, ...., C_n\}$ indicates a set of criteria for decision analysis that are used to assess the alternatives $\{A_1, A_2, ..., A_m\}$ and these alternatives will be evaluated according to the criteria. $P_{ij}$ indicates the different alternatives' scores according to the criteria (Rezaei, 2015), (Rezaei et al., 2018):

$$D= \begin{array}{c} \\ (w_1 \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{array}{cccc} w_2 & \cdots & w_n ) \end{array} \\ \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ p_{m1} & p_{m2} & \cdots & p_{mn} \end{bmatrix} \end{array} \quad (1)$$

The ultimate goal of the BWM is to evaluate and hence rank the alternatives per the given criteria and a common approach to evaluating an alternative is to allocate weights $w_j\left(w_j \geq 0, \Sigma_j w_j = 1\right)$ to the various criteria and use the weight additive function presented in Equation (2) for calculating the alternative's value ($V_i$) (Rezaei et al., 2018):

$$V_i = \sum_{j=1}^{n} w_j p_{ij} \quad (2)$$

The BWM follows five sequential steps for determining the weights, where an expert questionnaire is used to complete steps two through four, as follows (Rezaei, 2015), (Rezaei et al., 2018):

Step 1: Determine a set of decision/evaluation criteria.

This stage involves determining a set of decision criteria $\{C_1, C_2, \ldots, C_n\}$ that should be utilized when evaluating the alternatives. As for this study, our criteria would be the main factors.

Step 2: Determine the best criterion (BC) (most desirable or most important) and the worst criterion (WC) (least desirable or least important).

The decision-maker determines which criteria are generally the best and worst in this step. At this point, no comparison is made. For our study, PMs from the service industry act as the decision-makers and select the best and the worst criteria.

Step 3: Determine the priority/desire of the BC over all others by choosing a number between 1 and 9 by the decision-makers according to the fundamental scale for pairwise comparisons, as shown in Table 16 (Saaty, 1977),(Saaty, 1987), where 1 implies equal importance and 9 implies that the BC is far more significant than the criterion in question. The vector that results from Best-to-Others ($A_B$) would be:

$$A_B = \left(a_{B1}, a_{B2,\dots}, a_{Bn}\right)$$

Table (16): The Pairwise Comparison Scale (Saaty, 1977),(Saaty, 1987).

| **Weight intensity** | **Definition** | **Explanation** |
|---|---|---|
| 1 | Equally important | Two activities contribute equally to the objective |
| 3 | Moderately important | Experience and judgment slightly favor one over another |
| 5 | Strongly important | Experience and judgment strongly favor one over another |
| 7 | Very strongly important | An activity is strongly favored and its dominance is demonstrated in practice |
| 9 | Extremely important | The importance of one over another affirmed on the highest possible order |
| 2,4,6,8 | Intermediate weights | Used to represent compromise between the priorities listed above |

Step 4: Determine the priority/desire of all the criteria over the WC by choosing the numbers between 1 and 9 by the decision-maker. The vector that results from Others-to-Worst ($A_W$) would be:

$$A_W = \left(a_{1W}, a_{2W,\dots}, a_{nW}\right)^T$$

Step 5: Obtain the optimal weights.

This stage entails identifying the optimal weights $(w_1^*, w_2^*, \dots, w_n^*)$ via solving problem (3):

$$\min \max_j \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_W} - a_{jW} \right| \right\}$$

s.t.

$$\sum_j w_j = 1$$

$w_j \geq 0$, for all $j$ (3)

Problem (3) can be transferred to problem (4) as follows:

$\min \xi$

s.t.

$$\left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi, \text{ for all } j$$

$$\left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi, \text{ for all } j$$

$$\sum_j w_j = 1$$

$w_j \geq 0$, for all $j$ (4)

Thus, the optimal weights $(w_1^*, w_2^*, \dots, w_n^*)$ and $\xi^*$ are obtained by solving problem (4).

However, there could be more than one optimal solution for not-fully consistent problems having more than three criteria. Therefore, problem (2) optimal objective values are used to calculate the lower and upper bounds of the weight of the criterion $j$, using problems (5) and (6):

$\min w_j$

s.t.

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi^*, \text{ for all } j$$

$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \xi^*, \text{ for all } j$$

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j \qquad (5)$$

max $w_j$

s.t.

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi^*, \text{ for all } j$$

$$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \xi^*, \text{ for all } j$$

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j \qquad (6)$$

The consistency level of the comparisons should be calculated once the final results are obtained (Rezaei, 2015). The original consistency measurement (cardinal consistency) is based on $\xi^*$ , which is the optimal objective value (the output) of the optimization problem (4) (Liang et al., 2020). So, a pairwise comparison system is fully consistent if $a_{Bj}$ x $a_{jW}$ = $a_{BW}$ , for all $j$ , where $a_{Bj}$ is the preference of the BC over the criterion $j$ , $a_{jW}$ is the preference of criterion $j$ over the WC, and $a_{BW}$ is the preference of the BC over the WC (Rezaei et al., 2015). The consistency ratio (CR) is calculated using $\xi^*$ and the corresponding consistency index (CI), given in Table 17, as shown in (7). It should be noted that the smaller

the $\xi^*$, the smaller is the CR, which means the more consistent the vectors are (Rezaei et al., 2015).

$$CR = \frac{\xi^*}{CI} \tag{7}$$

Table (17): Consistency Index Table

| $a_{BW}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| CI (max $\xi$) | 0.00 | 0.44 | 1.00 | 1.63 | 2.30 | 3.00 | 3.73 | 4.47 | 5.23 |

By considering the subjective weighting method, the BWM approach using pairwise comparison allows the decision-makers, in our case the PMs, to assess the selection process by comparing the criteria with respect to the ultimate goal; first selecting the best and worst criteria, then comparing the best criteria to others, and finally comparing the others to the worst criteria. It should be noted that the components themselves (criteria or factors) could be clusters of various components (characteristics and attributes) viewed as a whole; the comparison with other clusters or with simpler components is the goal. Each cluster (criterion or factor) would receive a relative value from the outcome, but not its individual components (characteristics and attributes). To determine their relative values concerning the specified cluster, these would need to be internally compared. Thus, this study will focus on applying the BWM method only to the main or key criteria or factors (the simpler components) after clustering the pre-determined factors (the various components) using text mining techniques.

Generally, in MCDM weighting approaches, the mechanism of assigning weights to the criteria assists in ranking the alternatives to achieve the ultimate goal of a study. However, since the objectives of our study are,

first, to determine the factors and, second, to assign weights to the main factors, or key factors, our study will conduct the BWM by focusing on assigning weights to the criteria (main factors) only. This study will not continue with ranking the alternatives (team members/candidates) by comparing the alternatives with respect to the criteria.

### 3.3.3 Phase 1 Part 3: Mixed Methods Approach

In Part 3, the study aims to solve the H-GenAI TFP by determining the main capabilities of GenAI in PTs while considering the factors that aid in forming H-H PTs for project management and the extent to which these H-H TF factors affect the performance of the PT. The outcomes of the semi-structured interviews with AI experts (qualitative), the ML clustering algorithms (quantitative), and the results of the structured interviews with PMs from different sectors within the service industry (quantitative) which are utilized to solve the H-H TFP are also used to solve the H-GenAI TFP and build the H-GenAI model for TF. The following sub-section will explain the adoption of a mixed methods approach in Part 3 within Phase 1 of the study while considering the results of Part 2 of the study.

Since this study is designed to build a model for H-GenAI TF by first identifying the capabilities of GenAI and determining the main capabilities of GenAI for PTs, taking into consideration the strategy for solving the H-H TFP, the following sub-section will explain the adoption of the mixed methods approach in Part 3 within Phase 1 of the study to reach its objectives. To achieve the study's objectives for this particular part, this study will first identify the capabilities of GenAI and then cluster them. As for the human counterpart within the PT, this part will also consider the results of the H-H TFP, which were achieved by weighing the main factors that affect PTF.

Since this part of the study is exploratory in nature, it relies on exploratory research methods by first conducting semi-structured interviews and then analyzing the results using ML clustering algorithms, and finally using structured interviews that solve the H-H TFP. However, the third phase is not based on the constructs of the second phase, so there is no direct link between the two phases.

#### 3.3.3.1 First Phase: Qualitative Approach

To achieve the study's objectives for the first phase of this particular Part, the study adopts a qualitative approach to generate primary data.

##### 3.3.3.1.1 The Research Method: Semi-structured Interviews

The study will first collect data on the GenAI capabilities using semi-structured interviews with AI experts or practitioners to generate qualitative data, using purposive sampling. The purpose is to determine the capabilities of GenAI when integrated into PTs through the eyes of AI experts or practitioners.

Semi-structured interviews are described as interviews where the goal is to get the interviewee's life world to understand the significance of the phenomena being described (Denzin & Lincoln, 2018). According to Denzin and Lincoln (2018), semi-structured interviews have the potential to be much more productive than structured ones, making greater utilization of the "knowledge-producing potentials of dialogues", as they give the interviewer more freedom and a greater chance to follow up on any angles that the interviewee feels are important. In comparison with the unstructured interview, semi-structured interviews allow the interviewer to have more control over the topic of discussion, choosing themes that are relevant and significant to the research. Additionally, the interviewer is more likely to become visible as a knowledge-producing participant in the

process rather than remaining hidden behind a predetermined interview guide (Denzin & Lincoln, 2018).

In general, the purpose of conducting interviews with AI experts is to learn about their knowledge and experiences in the field of AI and explore GenAI capabilities and what enables them to function the way they do, as well as the factors that contribute to the success of H-GenAI PTs, and how H-GenAI collaboration enhances PTs performance in project management within the service industry. As for Part 3 specifically, the focus is to determine the GenAI capabilities in a collaborative setting. The results of the analyzed qualitative data are used to build the constructs for the second phase.

#### 3.3.3.1.2 Qualitative Data Source & Sampling Procedures

According to Creswell & Plano Clark (2018), to answer a research question, a sampling procedure is used by the researcher which entails deciding on the research site, the participants who will provide data for the study and how they will be chosen, as well as the total number of participants required to address the research questions (Creswell & Plano Clark, 2018).

As for this study, during this Part, semi-structured interviews were conducted with 16 AI experts/practitioners, which provided open-ended answers that helped in providing in-depth information regarding the interviewees' experiences with GenAI and how it may contribute to project success in H-GenAI collaboration in project management through effective PTs. The generated results are considered primary data for the study. The purposive type of sampling is used to select the AI experts/practitioners who are most useful for the research. Purposive sampling, also known as purposeful sampling, is the process by which researchers deliberately

choose (or recruit) people who have firsthand experience with the primary phenomenon or key concept under investigation (Creswell & Plano Clark, 2018). The data collection should continue until it reaches a certain point where no new themes or insights emerge based on the saturation principle.

#### 3.3.3.1.3 Interview Protocol

To collect data for research, information must be systematically collected and recorded so that "it can be preserved and analyzed by a single researcher or a team of researchers," (Creswell & Plano Clark, 2018). For collecting interview data, an interview protocol that contains the main open-ended questions to be asked during an interview is required, as it keeps the researcher organized and ensures that information is recorded in case the recording devices malfunction (Creswell & Plano Clark, 2018).

This study follows an interview protocol to guide the interviewer to focus on particular themes and questions. Table 18 presents the interview protocol, prepared for qualitative data collection. In this phase, the focus of the interviews will be on themes 1 and 2.

Table (18): Interview Protocol Agenda

| Themes | Topics/Items | Main Interest | Semi-structured Interview Questions |
|---|---|---|---|
| **Introduction** | • Thank the participants<br>• Provide thesis briefing<br>• Present interview agenda<br>• Ask for recording permission | • Interview purpose<br>• Ethical responsibilities<br>• Data utilization<br>• Participant confidentiality<br>• One hour interview | For AI experts = 14 questions<br>To start with interesting background of interviewee:<br>• What is your job title? Which department?<br>• How long have you been in your present position?<br>• How long have you been at this institution?<br>• What is your highest degree?<br>• What is your field of study?<br>• Briefly describe your role (AI expert, AI practitioner, etc.) as it relates to the field of AI, and if appropriate, your role as it relates to project management (PM, committee champion, etc.) |

| | | | |
|---|---|---|---|
| **1. Project Teams in Project Management** | • Project management<br>• GenAI | • Project teams challenges<br>• Advantages of GenAI for project teams | • What are the challenges of collaboration that we face today in project teams that cause project failure?<br>• Have you ever used GenAI in project teams? |
| **2. GenAI Capabilities & Challenges for Project Teams** | • H-GenAI Collaboration<br>• GenAI capabilities<br>• GenAI challenges | • Interested in the importance of GenAI integration into project teams<br>• Interested in GenAI characteristics and abilities<br>• Interested in GenAI disadvantages for project teams | • What is the contribution of GenAI to project teams?<br>• What are the characteristics of GenAI in project teams?<br>• What are the abilities of GenAI in project teams?<br>• What are the challenges of GenAI in project teams? |
| **3. Factors Supporting H-GenAI Collaboration & Integration in Project Teams** | • GenAI functionality<br>• Successful H-GenAI collaboration | • Interested in how GenAI function<br>• Interested in the factors that support H-GenAI collaboration | • What enables GenAI to function the way they do? (What makes GenAI work?)<br>• What qualifications can a human have to deal with GenAI?<br>• What are the factors that support H-GenAI collaboration?<br>• How can we ensure a good collaboration between humans and GenAI in project teams? |
| **4. Measuring H-GenAI Project Teams' Performance** | • Project Team performance measurement<br>• Project success | • Interested in measuring team performance<br>• Interested in the KPIs for measuring H-GenAI project teams<br>• Interested in what makes a project team successful | • How can you evaluate the gap between a team with or without using GenAI in a project setting?<br>• What are the KPIs of efficiency when GenAI is integrated into project teams? (time/cost/resources)<br>• What are the KPIs of effectiveness when GenAI is integrated into project teams? (accuracy/quality/clarity)<br>• How can you describe the satisfaction of a project team/teammate in a project? |
| **Concluding the interview** | • Additional remarks | | • Thank the participant |

### 3.3.3.1.4 Semi-structured Interviews Representatives

Table 19 presents the interviewees' information about 16 AI experts.

Table (19): Semi-structured Interviews Representatives Information

| | Position | Highest Educational Level | Other Related Roles | Other Related Certifications & Qualifications |
|---|---|---|---|---|
| **AIR1** | Executive Advisor to His Highness Sheikh Nasser AI R&D Centre | Ph.D. AI | | President, International Group of AI |
| **AIR2** | Director, Cybersecurity and Artificial Intelligence | Ph.D. | | |
| **AIR3** | CEO, Infiniteware | B.Sc. in Computer Science | Cyber security, Game Development, Hardware Design | Google Developer Expert in ML |
| **AIR4** | Data Architect and Reporting Lead | B.Sc. in Computer Engineering | Chief of Central Information | ML from AWS, DL from Nvidia |
| **AIR5** | Information Technology Advisor for the Undersecretary | Master's in Cybersecurity and Digital Forensics | Head of IT, Data Scientist | PMP, ML, DL, and Data Science |
| **AIR6** | CEO, Next Step | MBA, Business, Occupational Psychology | Executive and Board Advisor, Board Member, Executive Growth Alliance Leaders/ Facilitator | Practitioner and Qualitative Researcher, Innovator from Silicon Valley, guiding global companies committed to future readiness. |
| **AIR7** | Professor, Computer Science | Ph.D. in Computer Science | | |
| **AIR8** | Associate Professor, Computer Science | Ph.D. in Computer Science – Specialized in AI, ML & DL | | Habilitation to Direct Research |
| **AIR9** | Lecturer, BIBF | Master's in Data Science | Tutor/Assistant Tutor – Bahrain Polytechnic | Comptia Data+, Ethical AI, PMI-BPA, CSM, A-CSM, CSP-SM |
| **AIR10** | Director, Cybersecurity and Governance | Master's in Software System Design | AI Validation, Cybersecurity, Cloud Security, Compliance, Automation. | AWS AI Associate, Azure ML Operational Engineer |

| | | | | |
|---|---|---|---|---|
| **AIR11** | IT Strategy Consultant, Trainer, and Advisor in Information Systems | Ph.D. in Computer Science | Certified Scrum Master, Agile Methods Coach & Specialist, Enterprise Architect, AI Expert, Digital Transformation Specialist, IT Project Manager | Certified Scrum Master, Certified Agile Coach, TOGAF Certified (The Open Group Architecture Framework), Data Architecture & Management |
| **AIR12** | Chief of Project Management | Master's in Science, Project Management/ Field: IT/ Project Management | System Analysis, Project Manager, Business Analysis, | Scrum Master - ITIL (IT Infrastructure Library) |
| **AIR13** | Head, Technical Solutions, INSOMEA, Microsoft | | | |
| **AIR14** | Head,Innovation Initiatives Analysis, Acting Chief of R&D at Innovation and Advanced Technologies Directorate | MBA | Member of Generative AI Virtual Assistant Committee | BRICS Excellence Training Program on AI Technology and Governance, China |
| **AIR15** | AI/ML Specialist Solution Architect, Amazon | Master's in Computer Science | | |
| **AIR16** | Chief Information Security Officer | BS.c. in Business Information Systems | Data Protection Officer, Embedding responsible AI - Information security, Privacy and Resilience Professional | AI Governance Professional Certification from the International Association of Privacy Professionals |

#### 3.3.3.1.5 Conducting the Interviews

The interviews with AI representatives were conducted in parallel and the interview meetings were scheduled according to their availability. All interviews were conducted face-to-face and were either held at their offices or online via MS Teams, according to their preferences. To access the AI experts' representatives, the researcher used her connections from social

networks. All interviews were conducted in English and audio recorded. Each interview was approximately one hour long.

### 3.3.3.1.6 Qualitative Data Analysis

The strategy for analyzing the data may be discussed in several parts. According to Creswell (2009), making sense of text and visual data is part of the data analysis process (Creswell, 2009). It includes preparing the data for the analysis part, performing various analyses, comprehending the data in greater detail, displaying the data, and interpreting the data's greater significance (Creswell, 2009). Figure 22 shows an outline of the data analysis procedure in qualitative research that is adopted from Creswell (2009), representing a linear, hierarchical method that builds from bottom to top, yet is believed to be more interactive in practice (Creswell, 2009).

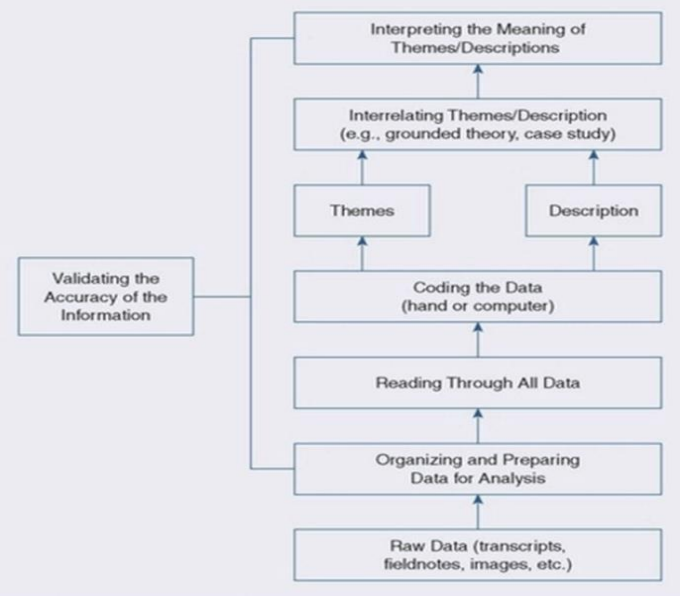



Fig. 22: Analysis Procedure in Qualitative Research (Source: adapted from Creswell (Creswell, 2009)

To prepare for the qualitative data analysis of this study, the recorded audios of the interviews were first transcribed using Transkriptor, a Transcription service provider software package. The accuracy of the transcriptions was then verified by cross-referencing them with the original

audio recordings. Appendix (A) in the Appendices provides a sample of one of the interview's transcripts. Then, the transcriptions were coded after screening the documents, classifying and organizing the data into various themes based on the information sources.

Coding refers to "the process of grouping evidence and labeling ideas so that they reflect increasingly broader perspectives" (Creswell & Plano Clark, 2018), or "the process of organizing the material into chunks or segments of text and assigning a word or phrase to the segment in order to develop a general sense of it" (Creswell, 2013). When coding, the researcher splits the text into smaller sections (sentences, phrases, or paragraphs) and gives a code label for each section, followed by organizing the codes into themes (Creswell & Plano Clark, 2018). While coding, the labels can either be the words used by the participants themselves (in vivo coding), the researcher's own phrases, or terms from the social or human sciences (Creswell & Plano Clark, 2018). After that, coding findings can be categorized into wide-ranging themes, and themes may then be combined into more comprehensive perspectives or dimensions, or they may be connected to form a bigger model or story (Creswell & Plano Clark, 2018). According to Creswell and Creswell (2018), (Creswell & Creswell, 2018), the coding process entails using text data or photos acquired during data collection, classifying sentences, paragraphs, or images, and assigning a term—referred to as an in vivo term—to each category. This term is frequently based on the participant's actual language (Creswell & Creswell, 2018).

As for the analysis of the qualitative approach of this part of the study, the study adopts the inductive thematic analysis approach for the analysis of the collected textual data.

#### 3.3.3.1.7 Validity and Reliability

One of the primary benefits of qualitative research is validity, which relies on assessing the extent to which the findings of the qualitative study are accurate from the perspective of the participant or the researcher (Creswell, 2009). According to Creswell, research findings are validated throughout the stages of the procedure (Creswell, 2009), as Figure 22 illustrates. As Creswell (2009) stated: "Qualitative validity means that the researcher checks for the accuracy of the findings by employing certain procedures, while qualitative reliability indicates that the researcher's approach is consistent across different researchers and different projects" (Creswell, 2009). According to Creswell (2009), using a variety of strategies should improve the researcher's capacity to evaluate the quality of the findings and persuade readers of their accuracy. Thus, this study employed different strategies to ensure the validity and reliability of the qualitative results.

Initially, the researcher of this study follows a reliability procedure by first checking the transcripts for errors and second by ensuring that the definition of codes has not drifted during the coding process, as suggested by Creswell (2009) (Creswell, 2009). Thus, the researcher confirms the accuracy of the transcriptions by comparing the transcriptions with the original audio recordings and correcting mistakes that are made by the transcription software. Then, the researcher ensures the consistency of the codes and their definitions by checking the codes and comparing them with the data. After validating the reliability procedure, the researcher validated the data with 13 out of the 16 AI experts who participated in the semi-structured interviews, as member checking is one of the ways to validate the qualitative data by determining the accuracy of the findings. Thus, the researcher discussed the findings and analysis with the interviewees, collected their feedback, and amended the results accordingly.

### 3.3.3.2 Second Phase: Quantitative Approach

In the second phase, after coding and analyzing the semi-structured interviews, and to achieve the study's objectives for this Part of Phase 1, the study first split the GenAI capabilities into GenAI's characteristics and abilities based on the definitions of the terms, then generates quantitative data by employing ML clustering algorithms to group or cluster the GenAI capabilities that were provided by the AI experts during the semi-structured interviews into main clusters of main characteristics and abilities. Then, the study will adopt a quantitative approach by following the Clustering Framework, which is developed by the author of this study, as shown in Figure 23, to cluster all the analysis results into main meaningful clusters or themes using the "Orange" software package. The ML clustering algorithms used in the framework are as follows: Hierarchical, Silhouette, and t-SNE.

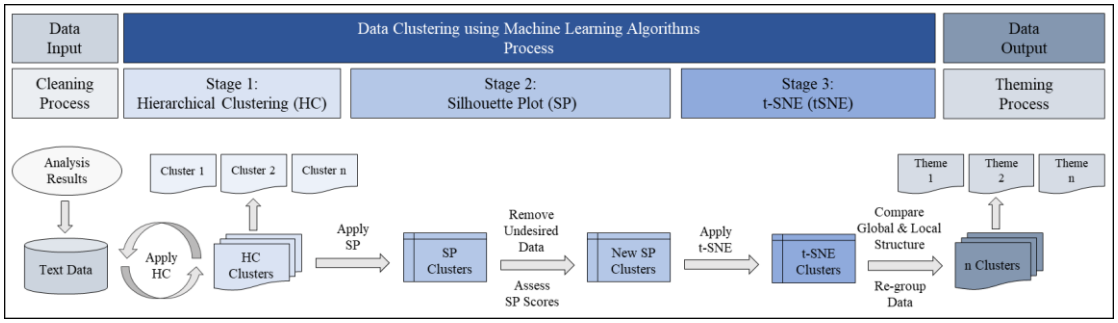



Fig. 23: Clustering Framework: developed by the author of this study

Clustering is a form of data mining task that groups similar data items into related categories (Poomagal et al., 2023). In data mining, the process of grouping is referred to as clustering (Kobayashi et al., 2018). The two primary categories of clustering methods are partitional and hierarchical (Kobayashi et al., 2018). The k-means algorithm is a renowned example of partitional clustering (Kobayashi et al., 2018). K-means clustering is a non-hierarchical technique for data clustering that divides collected data into

one or more predefined groups or clusters based on how similar the characteristics and attributes of the data's component elements are (Widjaja et al., 2023). In this algorithm, users decide how many clusters to form, and the distances that exist between the components and the cluster centers where they have been allocated typically determine the objective function that is optimized when generating clusters (Kobayashi et al., 2018). In hierarchical clustering algorithms, a Dendrogram, also called a tree, is used to show how groups merge or divide, showing which root each element belongs to (Kobayashi et al., 2018). In these algorithms, either all objects are treated as independent clusters and clusters are progressively combined until each object is linked to a single cluster, or all objects are at first grouped within a single cluster after which clusters are divided repeatedly until each object is in a distinct cluster (Kobayashi et al., 2018).

Clustering is considered an exploratory method, and a popular strategy is to experiment with various cluster densities (Kobayashi et al., 2018). To determine how many clusters to create, it is important to note that k-means clustering may be employed when one is certain of the number of clusters they wish to create, while hierarchical clustering may be used to determine whether interpretable categories emerge (Kobayashi et al., 2018). As a result, this study decides to cluster the GenAI capabilities that the interviews revealed using the hierarchical clustering algorithm until it considers several clusters where it is possible to grasp each of its components.

Applying the hierarchical clustering algorithm is the first stage of the clustering framework and is followed by the Silhouette plot. In this second stage, the study plots the hierarchical clustering results using the Silhouette index to assess its overall outcome and the clusters that the capabilities belong to. The silhouette index is a synthetic indicator that can be used to

evaluate the overall quality of clustering and is frequently utilized in cluster analysis to determine the optimal quantity for clusters as well as for final validation and assessment (Jajuga et al., 2020). It assesses the degree to which clusters are separable and compact (Jajuga et al., 2020). As stated earlier, the following measures are used to assess the quality of the Silhouette score (Shahapure & Nicholas, 2020):

- A Silhouette score close to +1 signifies that the data point is in the correct cluster,
- A Silhouette score close to 0 signifies that the data point might belong to other clusters, and
- A Silhouette score close to -1 signifies that the data point is in an incorrect cluster.

One common way to quantify the quality of clustering is to use the average Silhouette index overall points and finding the number of clusters in a partitioned dataset is one of its most common uses (Jajuga et al., 2020). Thus, the study employs the Silhouette index to verify the number of clusters as resulted from the hierarchical clustering algorithm.

The third stage of the clustering process employs the "t-Distributed Stochastic Neighbor Embedding" or t-SNE, a method for converting a high-dimensional collection of data into a pairwise similarity matrix, visually displaying the resulting similarity data (Van Der Maaten & Hinton, 2008). t-SNE is a ML algorithm invented by Laurens van der Maaten and Geoffrey Hinton (Perez & Tah, 2020), (Van Der Maaten & Hinton, 2008). It is considered a manifold-based, non-linear, unsupervised feature extraction technique that maps high dimension data to low dimension (usually 2 or 3 dimensions) while maintaining the important structure of the original data (Anowar et al., 2021). Finding the optimum way for projecting data points into a lower dimensional space so that their close

proximity or clustering is comparable to that of high-dimensional space is the aim of t-SNE (Goar et al., 2019). Essentially, it seeks to preserve the data's internal structure in low-dimensional space (Goar et al., 2019).

According to Maaten & Hinton (2008), whereas the majority of techniques are unable to preserve the data's global and local structures in a single map, t-SNE can effectively capture both the global and local structures of the high-dimensional data, including the existence of clusters at several scales, while also capturing a large portion of the local structure of the data in a single map (Van Der Maaten & Hinton, 2008).

#### 3.3.3.3 Third Phase: Quantitative Approach

In the third phase, the study adopted a quantitative method by employing the MCDM-BWM, as explained in Phase 1 Part 2, which required conducting structured interviews with the same PMs from the 5 sectors within the service industry to obtain their input regarding the factors that mostly influence PTs when forming H-GenAI PTs. The study then compared the results with those of the factors that influence H-H PTs, which were obtained to solve the H-H TFP. Accordingly, the study solved the H-GenAI TFP.

### 3.3.4 Phase 1 Part 4: Qualitative Approach

Part 4 aims to explore the GenAI enablers that enable GenAI to function the way they do and the factors that support the collaboration between humans and GenAI for better cooperation in PTs by adopting a qualitative approach. For this part, the study collected primary data from 16 AI experts or practitioners via semi-structured interviews. The study followed the qualitative research method for the semi-structured interviews, as presented in the qualitative phase of the sub-section Phase 1 Part 3 in Chapter 3 (3.3.3.1).

### 3.3.5 Phase 2 Part 1: Mixed Methods Approach

Aiming to develop H-GenAI SPTD by considering two models out of 9 models for group development, namely: Bruce Tuckman's and Mike Woodcock's, Phase 2 of the study is conducted in two Parts, Phase 2 Part 1 and Phase 2 Part 2, and adopted a mixed method approach, as both Parts require generating qualitative and quantitative data to meet their objectives.

The first part of Phase 2, referred to as Phase 2 Part 1, first listed the human behaviors and attitudes in the two models, generating qualitative data. Then, the study assessed the performance of the H-H teams by measuring the effectiveness of teams throughout the STD. In doing so, the study first quantified all human behaviors and attitudes that appear in Tuckman's model using the "+ / -" scale according to the categorization of behaviors and attitudes, whether they possess a "positive" or "negative" influence on PTs. The sign "+" corresponds to the behaviors and attitudes with a positive influence on the team's performance and has the value of "+1", while the sign "-" corresponds to the behaviors and attitudes with a negative influence on the team's performance and has the value of "-1". The study calculated the number of positive and negative behaviors and attitudes in each stage of the STD.

To measure the performance of traditional human teams (H-H) throughout each stage of the STD according to Tuckman's model, the value of the total number of positive influences in Tuckman's model for each stage is divided by the total number of human behaviors and attitudes of each stage. Then, the study illustrated how humans progress throughout the STD when working on a project according to Tuckman.

To measure the performance of traditional human teams (H-H) throughout each stage of the STD according to Woodcock's model, the value of the total number of positive influences in Woodcock's model for each stage is

divided by the total number of human behaviors and attitudes of each stage. Then, the study illustrated how humans progress throughout the STD when working on a project according to Woodcock. The study compared the results of both models. Then, the study combined the two models of Tuckman's and Woodcock's to have a comprehensive model of STD for traditional teams. As for measuring the performance of H-H teams throughout each stage of the STD for Tuckman's and Woodcock's models combined, the value of the total number of positive influences of both models for each stage is divided by the total number of behaviors and attitudes of each stage in the two models.

### 3.3.6 Phase 2 Part 2: Mixed Methods Approach

Phase 2 Part 2 adopted a mixed method approach as it also requires generating qualitative and quantitative data to meet its objectives. Phase 2 Part 2 first considered the list of human behaviors and attitudes in the two models, as qualitative data. Then, the study examined the applicability of the two models combined to cater to GenAI as a teammate and develop H-GenAI SPTD. In Part 2, the study assessed the performance of the H-GenAI PT by measuring its effectiveness throughout the STD.

To compare the performance of the traditional H-H teams and H-GenAI teams, the study illustrated how humans and GenAI progress throughout the STD when working on a project by replacing or substituting all human behaviors and attitudes that appear in Tuckman's and Woodcock's models with those characteristics and abilities of GenAI that were generated from the semi-structured interviews with AI experts or practitioners, first for each model separately and then combined. Then, the study also quantified all GenAI main characteristics and abilities that correspond to the human behaviors and attitudes using the "+ / -" scale, according to the categorization of its main characteristics and abilities, whether they possess

a “positive” or “negative” influence on PTs. The sign “+” corresponds to the characteristics and abilities with a positive influence on the team’s performance and has the value of “+1”, while the sign “-” corresponds to the characteristics and abilities with a negative influence on the team’s performance and has the value of “-1”. Then, the study calculated the number of positive and negative characteristics and abilities in each stage of the STD.

To measure the performance of H-GenAI teams throughout each stage of the STD, the value of the total number of positive influences of both Tuckman’s and Woodcock’s models, first for each model separately and then combined, for each stage was divided by the total number of human’s behaviors and attitudes of each stage, according to the model. Then, the study illustrated the progress of H-GenAI teams throughout the STD when working on a project, to examine whether or not GenAI is able to compensate for the behaviors and attitudes of humans that have a negative impact on collaboration, as reflected in the STD, through GenAI’s characteristics and abilities. Consequently, this determined the extent to which GenAI can bridge the gap in humans’ performance in PTs and enhance the team’s performance through GenAI capabilities.

### 3.3.7 Phase 3: Qualitative Approach

Phase 3 of the study aims to determine the KPIs for measuring the performance of H-GenAI PTs using a qualitative approach for data collection by collecting primary data from 16 AI experts/practitioners during semi-structured interviews. The study followed the qualitative research method for the semi-structured interviews, as presented in the qualitative phase of the sub-section Phase 1 Part 3 in Chapter 3 (3.3.3.1).

## 3.4 Conclusion

This Chapter presents the methodology and the research design that was adopted for this study and discusses the reasons behind choosing the qualitative, quantitative, and mixed methods of research approaches for addressing the research questions. The next Chapter reveals the findings obtained through the different research approaches.

# Chapter Four

# Results & Discussion

## 4.1 Introduction

As stated in the previous chapter, the researcher adopted qualitative, quantitative, and mixed methods approaches for this research. Following this introductory Section, this Chapter presents the findings of the study in Section 2, divided into 3 sub-sections according to its 3 Phases, followed by a summary of the results of all 3 Phases. Section 3 presents a discussion of the analysis of the results. Finally, Section 4 presents further findings of the study.

## 4.2 Results

This Section presents the results of the 3 Phases of the study in separate 3 sub-sections. The first sub-section presents the results of Phase 1 in 4 parts, followed by a summary of Phase 1. The second sub-section presents the results of Phase 2 in 2 parts, followed by a summary of Phase 2, and the third sub-section presents the results of Phase 3, followed by a summary of Phase 3. The fourth sub-section presents a summary of the results of all the 3 Phases.

### 4.2.1 Phase 1: H-GenAI Project Team Formation

The results of Phase 1 of the study, which addresses SRQ1, are revealed in four sub-sections: (1) SLR on Team Formation Theories, (2) Solving the H-H Team Formation Problem, (3) H-GenAI in Project Teams, and (4) GenAI Enablers & Factors Supporting H-GenAI Collaboration. Finally, the fifth sub-section presents a summary of the results of Phase 1.

Figure 24 illustrates the structure of this H-GenAI PTF section.

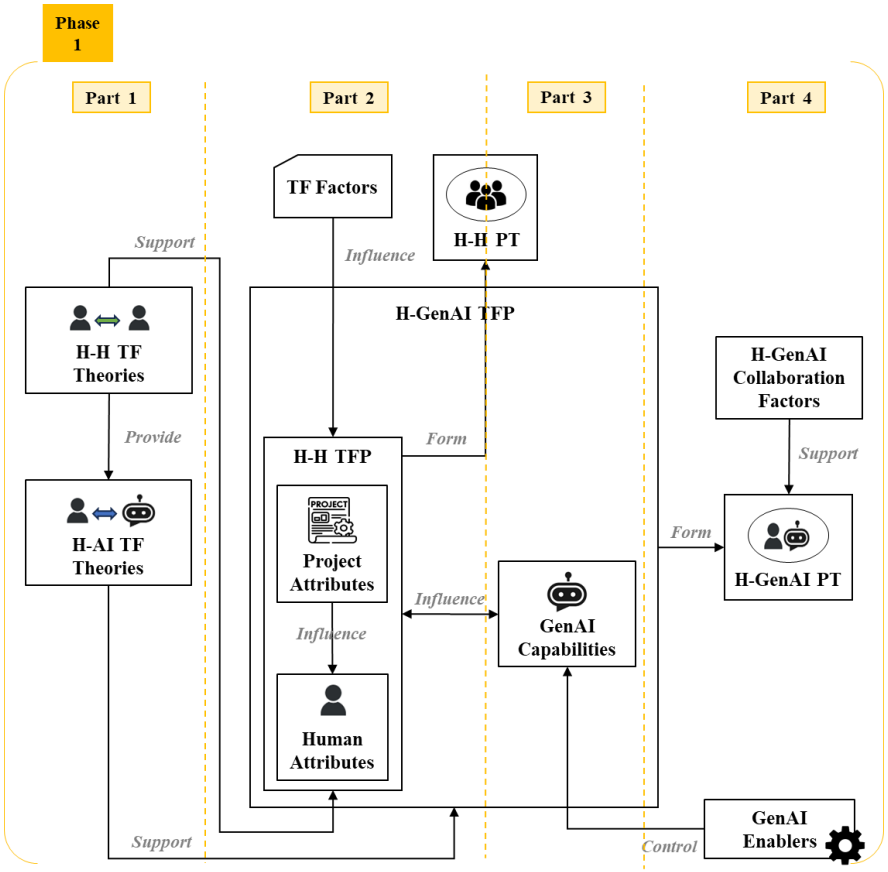



Fig. 24: H-GenAI PTF section (Phase 1)

#### 4.2.1.1 Phase 1 Part 1: SLR on Team Formation Theories

Based on the chosen publications that address the RQs of this study, the study reveals the main findings concerning each of the RQs in two sub-sections, a & b, where "a" addresses RQ1, and "b" addresses RQ2. A summary of these findings is shown in Table 20.

Table (20): Summary of SLR Study Findings

| Papers ID | Research Questions | | Papers ID | Research Questions | |
|---|---|---|---|---|---|
| | ***RQ1*** | ***RQ2*** | | ***RQ1*** | ***RQ2*** |
| SD1 | x | | AM1 | x | |
| SD2 | x | | AM2 | x | x |
| SD3 | x | | AM3 | x | x |
| SD4 | x | | AM4 | | x |
| SD5 | x | | AM5 | x | x |
| SD6 | x | | AM6 | x | x |
| SD7 | x | | AM7 | x | |
| SD8 | x | | AM8 | x | |
| IE1 | x | | AM9 | x | x |
| IE2 | x | | AM10 | x | |

### *a. Theories in Team Formation (RQ1: What are the theories that support the dynamics of team formation?)*

Previous publications have leaned on a variety of theories that support team formation. Table 21 lists the theories that were mentioned in the papers that were chosen for this SLR.

Table (21): Theories in Team Formation

| Theory | Paper |
|---|---|
| Fuzzy Set Theory | SD1, SD2, SD5, |
| Social Categorization Theory | AM7, AM8, AM9 |
| Belbin Theory | SD4, SD7, IE2 |
| Game Theory | SD3, SD4 |
| Social Identity Theory | SD6, AM3 |
| Graph Theory | SD6, AM6 |
| Similarity/Attraction Paradigm Theory | AM7, AM8 |
| Fuzzy Soft Set Theory | SD1 |
| Intuitionistic Fuzzy Soft Set | SD1 |
| Cooperative Game Theory | SD3 |
| Non-cooperative Game Theory | SD3 |
| Grey Theory | SD5 |
| Grey Decision Theory | SD5 |
| Swift Trust Theory | SD6 |
| Theory on Trust Development | AM2 |
| Theory of Personality: Post-Jungian | SD7 |
| Faultline Theory | SD8 |
| Grounded Theory approach | IE1 |
| Theory of Networks | IE2 |
| Theory of Mind | AM1 |
| Bandura's Social Cognitive Theory | AM1 |
| Theory of Interactive Team Cognition | AM3 |
| Theory of Reciprocity | AM1 |
| Expectation Violation Theory | AM1 |
| Dynamical Systems Theory | AM2 |
| Complex Systems Theory | AM2 |
| Social Facilitation Theory | AM5 |
| Distraction-Conflict Theory | AM5 |
| Information Decision-making Theory | AM8 |
| Structural Contingency Theory | AM10 |

The study SD1 (Kalayathankal et al., 2021) mentions three theories namely: the Fuzzy Set, the Fuzzy Soft Set, and the Intuitionistic Fuzzy Soft Set (IFSS), and according to SD1, the intuitionistic Fuzzy Soft Set theory is applied to artificial intelligence. The study presents a team selection model based on the IFSS theory.

According to the study SD2 (D'Aniello et al., 2021), the authors mention that the Fuzzy Set Theory is employed in modeling social factors between members of the team and also applied to knowledge modeling and management within the context of small and medium-sized companies, specifically, to identify the best team members by modeling workers' competencies.

Moreover, in the study SD3 (Bachrach et al., 2020) which investigates the dynamics of autonomous agents collaborating within a shared environment, with a particular focus on the challenge of accomplishing shared objectives through efficient collaboration, the study mentions that Game theory inevitably studies tasks that involve TF negotiation. Also, the study mentions that the primary focus of cooperative game theory is the interactions among agents that form teams and come to definitive agreements concerning outcomes. Furthermore, in cooperative game theory, certain actions, and negotiation methods that agents could use are disregarded while only the benefit that each member of the agents may accomplish is considered. Therefore, non-cooperative game theory can be used to theoretically conduct a thorough analysis of these aspects.

The study SD5 (Rahmanniyay et al., 2019b) mentioned fuzzy set theory and grey theory for a proposed group formation model, and grey decision theory is also utilized for selecting the most suitable team members in circumstances in which there is an absence of clarity or rather sophisticated information regarding a team member's ability or knowledge level.

With the focus on automated team formation, the study SD8 (Bahargam et al., 2019b) includes the concept of faultline in an algorithmic framework that facilitates automated team formation, by relying on the Faultline theory.

Moreover, the study SD6 (Pollack & Matous, 2019) expands on theories supporting the concept that the communication network of a team can be strengthened to produce better project outcomes. According to the study, some indications regarding the need for team cohesion for team success may be found in the Social Identity Theory, which indicates that team members are prone to commit to shared objectives and contribute to the group's well-being when they personally connect with each other. The study also mentions the Swift Trust Theory when discussing the influence of relational norms on both individual behavior and the team's relational structure, since individuals behave as though trust exists and only confirm or change their opinions after gaining ample exposure to the behavior of others, according to the Swift Trust Theory. Moreover, the authors argue that since social network analysis offers the chance to comprehend communication at the individual level as well as the teams as a network of interactions, it tackles how team building influences communication patterns. Therefore, they mention that Graph theory tools are used in social network analysis to examine social group structures.

The study SD4 (Fortino et al., 2020) indicates that Game theory offers a crucial indicator for the creation of successful groups. Also, the study mentions that the formation of working groups is encouraged by Belbin's role theory, particularly in an educational setting.

The theory of personality named Post-Jungian is mentioned in the study SD7 (Andrejczuk et al., 2019) as a means of measuring personality.

Regarding the type of personality role, the study also mentions that human primary roles are derived by the application of Belbin's theory.

The study IE1 (Weilemann, 2019) mentioned a Grounded Theory methodology to identify personality traits and connect them to tasks within software engineering.

The study IE2 (Josue-Miguel Flores-Parra et al., 2018) mentioned the Belbin Team Role taxonomy as being among the most significant theories concerning effective team dynamics. Moreover, the authors of the study argue that metrics from the theory of networks can be used to assess a team's effectiveness. They also mention that the theory of networks aids in locating groups with common characteristics.

The study AM1 (Munyaka et al., 2023) focuses on the field of H-AI and multi-agent teams and the different behavioral patterns among team members and mentions the theory of mind, Bandura’s social cognitive theory, theory of reciprocity, and the Expectation Violation Theory. According to the study, the theory of Expectation Violation argues that the user's evaluation of a conversational agent is influenced by the expectations they have made before the H-AI interaction.

Moreover, to lay the groundwork for the research, the study AM2 (Eloy et al., 2023) mentions the complex systems theory and the dynamical systems theory to evaluate interpersonal as well as team dynamics during human interfaces. The study also mentions the theory of trust development. Since the primary objective of the study AM2 is to find diagnostic metrics for team dynamics and interpersonal trust by examining the dynamics of human-human-agent collaborations, the theory of complex systems, the dynamical systems theory, and the theory of trust development apply to H-AI collaboration.

As AM3 (Schelble et al., 2022) seeks to highlight the significance of collective intelligence in optimizing the human and agent aspects for structuring H-AI teams, and how the composition of a team affects team cognition outcomes, the study mentions the interactive team cognition theory as it is considered a tool for measuring team cognition, as well as the social identity theory. In the study AM3, the authors mention theories that may apply to H-AI collaboration, namely: interactive team cognition and the social identity theory, as the study investigates how human-agent teams differ from H-H teams in their team dynamics and how the composition of the team affects trust, performance, and perceived team cognition.

In the study AM5 (Hwang & Won, 2021), the authors mention one of those first theories in social psychology namely the Social Facilitation theory, which claims that having other individuals around can inspire individuals to enhance their performance, as well as the Distraction-Conflict Theory. Since the study AM5 focuses on exploring the possibility of using a chatbot as a teammate to generate ideas, the authors claim that the Social Facilitation Theory has served as a major foundation for a lot of studies on teamwork, particularly studies looking at how humans and machines interact together. The study also employs the framework of the Distraction-Conflict Theory to examine whether attentional conflicts caused by behavioral and social triggers can facilitate human-machine collaboration. Based on these theories, the authors suggest that collaborating with a non-human agent could help minimize the disruption caused by worries about an individual's teammates.

In an attempt to address means that teams might reduce the amount of work they do in terms of communication and organization, the study AM6 (Barambones et al., 2021) mentions that previous graph-theory studies of

the agent network perspective align with the definition of stabilizability. As the primary contribution of the study AM6 is to show how stable teams can be resilient, and recoverable, and reduce the amount of work required for intra-team formation, which entails agent inclusion and deprivation, ensuring stability in decentralized systems, the authors based their study on the graph-theory functions.

The study AM7 (Gómez-Zará, DeChurch, et al., 2020) examines team assembly as a socio-cognitive process and mentions the social categorization theory, in which people classify themselves based on certain shared characteristics. The similarity/attraction paradigm is another theory that the study AM7 mentions, which suggests individuals search for those who are similar to themselves or whom they recognize.

In the study AM8 (Gómez-Zará, Guo, et al., 2020) which focuses on how individuals are organized by socio-technical systems, it also mentions the social categorization theory and the theory of similarity/attraction paradigm. Besides, according to the theory of information decision-making, which is mentioned in the study, group dynamics and functioning may benefit from diversity.

The study AM9 (Ulfert & Georganta, 2020) mentions the social categorization theory. The authors of the study present their perspective on how the social categorization theory could be used for human-agent teams. According to social categorization theory, the current team members assess the newly added team member's fit with the group by gauging how similar they are to the current team members, particularly when the new team member is first brought on board. When there is a high degree of perceived similarity, the current members of the team assume that the new person shares their values and beliefs. Higher levels of trust follow from the increased likelihood that the new team member will be seen as a crucial

member of the group. Likewise, a non-human member of a team could be seen as having less in common with other team members. According to studies, impressions of trust and resemblance only grow with repeated interactions, particularly in situations when users have never interacted with the agent before.

Finally, the authors of the study AM10 (Zhou et al., 2018) mention the structural contingency theory in their study, claiming that team-level evaluation can benefit from the same thinking that underpins structural contingency theory.

Out of the 30 theories that previous studies have mentioned in support of team formation, displayed in Table 21, only 11 apply to H-AI teams, according to the literature of the papers that were chosen for this SLR.

Table 22 lists the theories that support H-AI teaming in the papers that were chosen for this SLR.

Table (22): Theories in Team Formation for H-AI Collaboration

| Theory | Paper |
|---|---|
| Intuitionistic Fuzzy Soft Set Theory | SD1 |
| Expectation Violation Theory | AM1 |
| Complex Systems Theory | AM2 |
| Dynamical Systems Theory | AM2 |
| Theory on Trust Development | AM2 |
| Theory of Interactive Team Cognition | AM3 |
| Social Identity Theory | AM3 |
| Social Facilitation Theory | AM5 |
| Distraction-Conflict Theory | AM5 |
| Graph Theory | AM6 |
| Social Categorization Theory | AM9 |

### b. *Considerations for Human-AI Teams (RQ3: What aspects can future studies explore concerning H-AI collaboration?)*

Previous studies have identified key domains related to H-AI collaboration worthy of further investigation in future studies. The findings of the study AM2 (Eloy et al., 2023), which is centered on the observation of team dynamics and trust in collaborative human-agent tasks, provide useful guidelines and approaches for future studies concerning team dynamics and trust in collaborative human-agent tasks. The study recommends that the development of standards and methods to evaluate and improve trust dynamics among the team ought to have priority in future efforts at H-AI teaming. Since effective H-AI collaboration requires an understanding of how team cognition is affected by the reliability of AI agents, the study AM3 (Schelble et al., 2022) suggests further exploring the reliability of agents that fully function as team members, the impact of transparency on improving the performance of AI team members, the impact of AI agents on team cognition development and communication dynamics. Moreover, the study recommends further investigation to build an established method for assessing agent teammates' mental models, focusing on understanding the mental models that AI agents possess to compare them with their human partners.

The study AM4 (Caldwell et al., 2022b) suggests employing, testing, and improving the proposed framework of the study in the future through experimentation in a video game setting. Moreover, the study AM5 (Hwang & Won, 2021) recommends that future studies should examine how artificial agents' conversational patterns and sense of identity function on platforms that support naturalistic dialogue. Besides, even though the study has given both the bot and the human confederate the same amount of "thinking time", there's a chance that different conversational speeds

could have an impact on the outcomes. Thus, future studies need to explore the ideal speed for chatbots to generate ideas. Moreover, to have more control over human-bot conversations and to examine two variables (conversational style and perceived identity), the authors of the study deliberately adhered to a semi-structured script throughout their study and utilized the same human partner for each session to build the conversation. However, using a script and choosing the same partner during the human-bot brainstorming session are considered unusual scenarios. To address this limitation, the study recommends investigating the results of collaboration by randomly assigning teams consisting of two participants and giving true/false information related to the teammates' identity (human or bot). Besides, evaluating brainstorming results when participants engage independently might add a "true control" to the study's design framework.

The study AM6 (Barambones et al., 2021) suggests testing stabilisability in dynamic contexts using simulated real-world scenario experiments, particularly using "RoboCup Rescue Agent Simulation platform", to evaluate stabilisability with various job distribution methods from previous research. Besides, the authors of the study intend to expand their research by incorporating users into these environments, where dynamics emerge from unforeseen events resulting from human involvement with the system. Moreover, the study suggests enhancing the performance and expandability of issues concerning TF by examining various methods derived from heuristics, dynamic programming, and parallelization. According to the study AM9 (Ulfert & Georganta, 2020), the authors argue that to ensure optimal teamwork and excellent performance, agents will eventually have to assess the reliability of team members and respond accordingly by exhibiting actions that either confirm or deny their trustworthiness.

However, it is uncertain how people will respond if they feel mistrusted by the agent or if an agent mistrusts another member of their human team. These are the kinds of things that future research ought to examine. In addition, in future theoretical and empirical investigations, the idea of agent trust—which has been thoroughly studied in computer science and is especially important in multi-agent systems—should be taken into account. Based on the previous studies selected for this research, Table 23 presents an outline of the 17 aspects that future studies may explore concerning the various forms of H-AI teaming. In addition, the authors of this study categorize these aspects into 9 themes, as shown in Table 23.

Table (23): Future Research Aspects for H-AI Collaboration

| Themes | Considerations for H-AI Teams |
|---|---|
| **Trust** | 1. Examine the concept of trust among teams in collaborative human-agent tasks; |
| | 2. Investigate people's reactions when feeling mistrusted by agents; |
| | 3. Develop standards and methods to evaluate and improve trust dynamics. |
| **Reliability** | 4. Explore the reliability of agents that function as team members. |
| **Stabilisability** | 5. Test stabilisability in dynamic contexts. |
| **Transparency** | 6. Investigate how transparency and openness affect team members' ability to perform better. |
| **Communication & Cognition** | 7. Study the effects of AI agents on group communication, communication growth, and consequently, cognitive development; |
| | 8. Analyze the role of the conversational patterns and identities of artificial agents; |
| | 9. Investigate the optimal rate at which chatbots produce ideas; |
| | 10. Assess the outcomes of brainstorming when participants participate on their own |
| **Team Composition** | 11. Investigate randomly assigning teammates and giving true or false teammate's identity; |
| | 12. Integrate users into environments where dynamics are created by unanticipated incidents brought about by interactions between people and the system |
| **Mental Models** | 13. Comprehend mental models that AI agents possess and compare them with their human partners; |
| | 14. Develop standards and methods for assessing agent teammates' mental models. |
| **Team Formation Models** | 15. Improve team formation challenges' outcomes by looking at techniques based on parallelization, dynamic programming, and heuristics. |
| **Experimentation** | 16. Employ, test, and improve proposed frameworks through experimentations in video game settings; |
| | 17. Use simulated real-world scenario experiments. |

#### 4.2.1.2 Phase 1 Part 2: Solving H-H Team Formation Problem

The results of Part 2 are revealed in three sub-sections since this Part follows the TMF (Figure 20) of three stages: (1) Stage 1: Data Preprocessing, (2) Stage 2: Data Processing, and (3) Stage 3: Data Post-processing.

It is important to mention that the study considered all factors supporting TF that were used in TF models, to first solve the TFP for H-H PTs, whether they were driven from theories of TF or not, since there were not many thorough theories nor systematic evaluations of suggested paths under a theoretical framework to collect the factors that mostly affect the formation of project teams. Therefore, the study followed the TMF, as shown in Figure 20, where the Data Preprocessing stage extracted data from the literature, the Data Processing stage transformed the data by providing a value for each factor using TF-IDF and Pareto, and then clustered them using ML clustering algorithms, and finally the Data Post-processing stage employed the BWM of the MCDM methods and conducted structured interviews to rank the factors that affect TF in the service industry in a systematic manner.

##### 4.2.1.2.1 Stage 1: Data Preprocessing

Initially, for data collection through Text Mining, the study chooses 17 publications that were published during the past ten years and developed TF models as the most relevant publications to the objectives of this study. By considering only the results of these previous publications, this study prepares a list of all the factors that influence TF, as mentioned in the publications' results or developed models, without removing the redundancy of factors. In other words, the study's list of factors covers all the factors that each publication has considered an outcome. Table 24 presents the list of the factors that appear in the selected publications (SP).

Table (24): Factors for Project Team Formation

| SP | Papers Titles | Objectives of Study | Factors |
|---|---|---|---|
| 1 | *"Team Formation for Agile Software Development - Crowdsourcing-based Empirical Study"* (Zainal et al., 2024) | The study aims to validate the Agile team formation conceptual model. This paper reports the initial empirical study that was done using a crowdsourcing-based method.<br>The study was done in an Agile professional network group platform on the Internet. The respondents validated that the team formation characteristics in the conceptual model were applicable with an emphasis on continuous learning and having a growth mindset. | ➢ **Project characteristics:**<br>• project size<br>• project criticality<br>➢ **Agile team composition characteristics:**<br>• knowledge<br>o education background<br>o technical<br>o domain/business<br>• skill<br>o interpersonal<br>o technical<br>o domain/business<br>• ability<br>o learnability<br>o adaptability<br>• experience<br>o quantity of similar past projects<br>• personality traits (HEXACO)<br>o honesty-humility<br>o emotionality<br>o extraversion<br>o agreeableness<br>o conscientiousness<br>o openness to experience<br>• commitment<br>o level of commitment |
| 2 | *"A Reinforcement Learning-assisted Genetic Programming Algorithm for Team Formation Problem Considering Person-Job Matching"* (Guo et al., 2023) | The study aims to solve the team formation problem by considering person-job matching. | • skills<br>• required number of members<br>• positions within teams<br>• personnel relationships (the willingness to communicate) |
| 3 | *"A Realistic Criterion for Team Formation in Social Network"* (Samie & Rajabzadeh, 2023) | The study aims to select a team of experts who would be able to perform the defined project tasks, along with the ability to communicate with each other with the lowest personal and communication costs. The main contributions are:<br>– A new personal cost function is presented;<br>– A novel model for selecting team members is proposed based on the new definition of personal cost;<br>– A human consideration is considered during the selection of experts by machines, and so, the problem-solving scenario becomes more similar to the desirable human one. | • skills<br>• experts<br>• nature of task<br>• field of work<br>• wages or personal cost<br>• communication cost |

| | | | |
|---|---|---|---|
| 4 | *"A Data-driven Framework to Support Team Formation in Software Projects"* (Cunha et al., 2022) | The study aims to provide a framework to support the development of solutions that can help managers form software teams. | • social characteristics<br>• technical characteristics<br>• level of technology<br>  ○ programming language<br>• tool's project-level focus<br>• adaptability to changing technology requirements and team members after launching the project<br>• project's and professionals' reliable/consistent information |
| 5 | *"A Genetic Algorithm-Based Approach to Support Forming Multiple Scrum Project Teams"* (Costa et al., 2022) | The study aims to address the gap in the literature in which the existing solutions for the Multiple Team Formation Problem are found not suitable for Scrum projects, by developing an approach composed of two main steps: first, to design a Structured Task Model to support creating developers' profiles given their performance on past Scrum projects, and then, to develop a Genetic Algorithm to form the teams for a set of target projects given a set of target projects' technology requirements and the available developers' profiles. | • Allocate available developers of the organization into multiple software projects<br>• Provide recommendations for teams whose members possess competencies that align with the requirements of the projects |
| 6 | *"Building Contrastive Explanations for Multi-Agent Team Formation"* (Georgara et al., 2022) | The study aims to make improvements in the problem of providing explanations for team formation decisions and hence proposes a general method that allows to build justifications for the decisions of team formation algorithms without modifying them. | • skills,<br>• personality,<br>• agents' preference over tasks |
| 7 | *"Team Formation for Agile Software Development: A Review"* (Aryanee et al., 2020) | The study aims to identify the necessary characteristics and their attributes for composing a competent team that is well-balanced and can create coherent teamwork, which can be considered in Agile software development (ASD) team formation by reviewing past studies including existing models that are related to software development team formation. The characteristics identified are then consolidated into a conceptual model, containing characteristics needed to form a capable ASD team. | ➢ **Project characteristics:**<br>• project size<br>• project criticality<br>➢ **Agile team composition characteristics:**<br>• knowledge<br>  ○ education background<br>  ○ technical<br>  ○ domain/business<br>  ○ project management<br>• skill<br>  ○ interpersonal<br>  ○ technical<br>  ○ domain/business<br>  ○ project management<br>• ability<br>  ○ learnability,<br>  ○ adaptability<br>• experience<br>  ○ quantity of similar past projects<br>• personality traits (HEXACO)<br>  ○ honesty-humility<br>  ○ emotionality<br>  ○ extraversion |

| | | | |
|---|---|---|---|
| | | | ○ agreeableness<br>○ conscientiousness<br>○ openness to experience<br>• commitment<br>○ level of commitment |
| 8 | *"Team Formation in Software Engineering: A Systematic Mapping Study"* (Costa et al., 2020) | The study aims to analyze and synthesize the software team formation research using a Snowballing-based systematic mapping study, considering 51 primary studies, out of 2516, and also to organize the identified body of knowledge in software team formation as a taxonomy. The study proposed a taxonomy of software team formation. | • **Technical**<br>○ programming experience<br>○ network techniques<br>○ software design<br>○ quality control<br>○ database<br>○ other attributes<br>• **Individual cost**<br>○ salary per hour<br>• **Personality traits**<br>○ attributes derived from psychometric instruments such as Belbin's team roles and Myers-Briggs type indicator<br>• **Interpersonal**<br>○ positive criticism<br>○ communication<br>○ creativity<br>○ leadership<br>○ emotional intelligence<br>○ other attributes<br>• **Social attributes**<br>○ measures that can connect members, such as how many projects and how long they worked together, how close they are to one another, how many coworker friends in common, and so on. |
| 9 | *"Template-Driven Team Formation"* (Apostolou et al., 2020) | The study aims to introduce and study the novel problem of template-driven team formation (TDTF). The study showed that the problem is NP-hard in the general case, but it can be solved in polynomial time using dynamic programming for tree templates when workers have a single skill, and the template positions have unique skills. | • skills<br>• positions<br>• tasks<br>• communication costs |
| 10 | *"Automation of Team Formation in Software Development Projects in an Enterprise: What Needs to Improve?"* (Prashandi & Kirupananda, 2019) | The study aims to gather knowledge on the previous research that has been carried out in the team formation problem domain and to analyze them to identify their benefits and limitations in addressing the problem, by using a systematic method to build a tool that supports team formation in software development projects by filling in the gaps in the available work. | • **Skills and soft skills:**<br>○ skills<br>- skills<br>- capabilities<br>- experience<br>- technical knowledge<br>○ soft skills<br>- analytic<br>- problem-solving<br>- commitment<br>- responsibility<br>- eagerness to learn<br>- motivation<br>- teamwork |

| | | | |
|---|---|---|---|
| | | | • **Personality:**<br>  o human characteristics<br>  - personality<br>  - teamwork<br>  - coordination<br>  - conflict<br>  - cohesion<br>  o social psychology factors<br>  - introversion<br>  - extraversion<br>  - sensing<br>  - thinking<br>  - feeling<br>  - perceiving<br>  - judging<br>• **Team collaboration:**<br>  o team communication<br>  o specifications<br>  o configuration management<br>  o time zone differences<br>  o technical difficulties<br>  o language problems<br>  o time spent on training<br>• **Project features and organizational needs:**<br>  o team size<br>  o required roles<br>  o technologies used<br>  o maximum team monthly cost<br>  o estimated development time<br>• **Other general factors:**<br>  o salary<br>  o education<br>  o working conditions<br>  o job satisfaction<br>  o age<br>  o 360- degree feedback score<br>  o overtime<br>  o absenteeism rate<br>  o environment satisfaction<br>  o hourly rate<br>  o gender<br>  o distance from home<br>  o performance rating<br>  o total working years<br>  o training times last year<br>  o years since last promotion<br>  o business travel<br>  o job role<br>  o peer indication<br>  o availability<br>  o task preference |
| 11 | *"Multiple Team Formation Using an Evolutionary Approach"* | The main objective of the multiple team formation problem (MTFP) is to allocate people for different projects according to the project requirements, such that the global efficiency of | • set of projects<br>• skills<br>• people/experts |

| | | | |
|---|---|---|---|
| | (Baghel & Bhavani, 2018) | allocation is maximized. | • sociometric matrix in terms of members' happiness to work with one another |
| 12 | *"Team Formation in Business Process Context"* (Yu et al., 2017) | The study aims to study the problem of forming a team of skillful experts who meet the requirements of all tasks while ensuring a smooth handover between individuals performing successive tasks. | • individual expertise<br>• handover relations |
| 13 | *"A New Optimization Model for Reliable Team Formation Problem Considering Experts' Collaboration Network"* (Fathian et al., 2017) | The study aims to propose a new optimization model for the formation of a reliable team of experts, who have a certain number of skills and the best collaboration with each other.<br>The proposed mathematical model maximized team reliability by considering the probability of unreliable experts that may leave the team with the probability (1-Q) and proposed a backup<br>for each unreliable member. | • skills of experts<br>• collaboration network of experts<br>• reliability of experts |
| 14 | *"A model for project team formation in complex engineering projects under uncertainty: A knowledge-sharing approach"* (Hosseini & Akhavan, 2017) | The study aims to develop a model for selecting project team members. In this model, while knowledge sharing among individuals is maximized, the project costs and the workload balance among employees are also optimized. Thus, a method is proposed that serves the purpose of project team member selection to solve the problem. | ➢ **Characteristics of project team candidates:**<br>• expertise level<br>• knowledge-absorption ability<br>• knowledge-sharing ability<br>• knowledge-sharing willingness<br>• knowledge-sharing motivation<br>• knowledge absorption<br>• sharing opportunity<br>➢ **Project requirements:**<br>• expertise requirement<br>• cost of performing the task by an individual with an average expertise level and the workload of maxwl<br>• duration of performing the task by an individual with an average expertise level and the workload of maxwl<br>• task delivery time<br>• project budget |
| 15 | *"The multiple team formation problem using sociometry"* (Gutiérrez et al., 2016) | The study aims to, first, add two new dimensions to the Team Formation Problem (TFP) by considering multiple projects and fractions of people's dedication, to solve the new problem called Multiple Team Formation Problem (MTFP), and second, solve the MTFP by proposing an optimization model consisting of a quadratic objective function, linear constraints, and integer variables. | • set of projects<br>• people available<br>• skills/areas of expertise<br>• people's allowed time allocation<br>• project requirement matrix<br>• sociometric matrix<br>• weight/priority of project |
| 16 | *"Team formation model of selecting team leader: An analytic hierarchy process (AHP) approach"* | The study aims to construct a software team formation model for selecting team leaders by using the AHP approach and to evaluate the model by employing an experimental research design. | • skills<br>o technical skills<br>o management skills<br>o communication skills<br>• aptitudes<br>• interests |

| | | | |
|---|---|---|---|
| | (Omar et al., 2015) | | • age<br>• gender<br>• race<br>• ethnic background<br>• country of origin<br>• intelligence<br>• training<br>• experience<br>  ○ work experience<br>  ○ teamwork experience<br>• personality<br>• personality characteristics<br>• personal profile<br>• knowledge<br>• unique knowledge<br>• flexibility in job assignments<br>• grade point average (GPA)<br>• class schedule<br>• student housing location |
| 17 | *"Team Formation in Social Networks based on Local Distance Metric"*(Ashenagar et al., 2015) | The study aims to tackle the problem of finding the best-suited expert team in social networks for assigned projects, to complete a project that requires a set of skills. | • experts<br>• skills<br>• personnel costs<br>• communication costs |

#### 4.2.1.2.2 Stage 2: Data Processing

##### 4.2.1.2.2.1 Text Transformation using TF-IDF

Following the search process of Text Collection and Cleansing in the Data Preprocessing stage in Stage 1 of the TMF, the data transformation is practiced in Stage 2 to prepare a dataset. This is performed by the process of Text Transformation, where the study uses Python as its tool for data analytics. In Python, the study employs TF-IDF to allocate weights to each unique factor, after eliminating the redundant factors, on the prepared list, which resulted in 171 unique factors (from 247). Following the application of the TF-IDF, the study employs the Pareto principle and hence defines 89 factors, consisting of characteristics and attributes, as the most important or valued factors that influence team formation, according to the selected previous studies. Table 25 presents the 89 factors that are mostly used in the literature and considered the most important, first, according to the scores of TF-IDF and then the Pareto Cumulative Percentage (CP).

Then, the study prepares a new dataset that contains only the 89 factors in preparation for the Text Clustering in the Data Processing (Stage 2).

Table (25): TF-IDF & Pareto Results of the Most Used Factors for Project Team Formation

| Factors | TF-IDF | CP | Factors | TF-IDF | CP |
|---|---|---|---|---|---|
| skills | 19.55610526 | 6.3% | positions | 2 | 61.0% |
| projects | 13.50503101 | 10.7% | salary | 2 | 61.6% |
| knowledge | 12.27214051 | 14.7% | workload | 2 | 62.3% |
| experience | 7.090188911 | 17.0% | level | 1.941991282 | 62.9% |
| technical | 6.975508777 | 19.2% | job | 1.90382304 | 63.5% |
| personality | 6.647834268 | 21.4% | teamwork | 1.789400275 | 64.1% |
| characteristics | 6.60053201 | 23.5% | attributes | 1.726132878 | 64.7% |
| communication | 5.6873077 | 25.4% | roles | 1.726132878 | 65.2% |
| team | 5.601732899 | 27.2% | PM | 1.697158534 | 65.8% |
| cost | 5.466102918 | 29.0% | criticality | 1.696886955 | 66.3% |
| commitment | 5 | 30.6% | past | 1.696886955 | 66.9% |
| experts | 4.998024426 | 32.2% | intelligence | 1.681144474 | 67.4% |
| task | 4.090675507 | 33.5% | openness | 1.57880055 | 67.9% |
| adaptability | 3.96883871 | 34.8% | management | 1.54335426 | 68.4% |
| members | 3.913793547 | 36.1% | programming | 1.496507056 | 68.9% |
| business | 3.884153016 | 37.4% | background | 1.452265755 | 69.4% |
| personnel | 3.690436205 | 38.5% | matrix | 1.414213562 | 69.8% |
| expertise | 3.644538817 | 39.7% | sociometric | 1.414213562 | 70.3% |
| requirements | 3.618712563 | 40.9% | satisfaction | 1.407277352 | 70.8% |
| domain | 3.294970032 | 42.0% | collaboration | 1.396685618 | 71.2% |
| sharing | 3.234175274 | 43.0% | language | 1.388251256 | 71.7% |
| extraversion | 3 | 44.0% | rate | 1.362288949 | 72.1% |
| people | 2.924053519 | 44.9% | working | 1.362288949 | 72.5% |
| interpersonal | 2.699448884 | 45.8% | preference | 1.354977802 | 73.0% |
| size | 2.442893218 | 46.6% | professionals | 1.303483147 | 73.4% |
| education | 2.375108787 | 47.4% | network | 1.288429817 | 73.8% |
| relationship | 2.344977556 | 48.1% | consistent | 1.224309376 | 74.2% |
| traits | 2.295038514 | 48.9% | information | 1.224309376 | 74.6% |
| reliability | 2.269291822 | 49.6% | changing | 1.11106549 | 75.0% |
| training | 2.21972252 | 50.3% | aptitudes | 1 | 75.3% |
| technology | 2.21931833 | 51.1% | capabilities | 1 | 75.6% |
| work | 2.20657251 | 51.8% | cohesion | 1 | 75.9% |
| social | 2.12134661 | 52.5% | competencies | 1 | 76.3% |
| availability | 2.106327271 | 53.1% | conflict | 1 | 76.6% |
| time | 2.099699029 | 53.8% | coordination | 1 | 76.9% |
| duration | 2.091658523 | 54.5% | creativity | 1 | 77.2% |
| ability | 2 | 55.1% | criticism | 1 | 77.6% |
| age | 2 | 55.8% | database | 1 | 77.9% |
| agreeableness | 2 | 56.4% | ethnicity | 1 | 78.2% |
| conscientiousness | 2 | 57.1% | feeling | 1 | 78.5% |
| emotionality | 2 | 57.7% | GPA | 1 | 78.9% |
| gender | 2 | 58.4% | interests | 1 | 79.2% |
| honesty | 2 | 59.0% | introversion | 1 | 79.5% |
| humility | 2 | 59.7% | judging | 1 | 79.8% |
| learnability | 2 | 60.3% | | | |

The study utilized the 89 factors, which are considered the data output of the Text Transformation, as data input for the Text Clustering with two ML algorithms: K-Means and Hierarchical clustering.

#### 4.2.1.2.2.2 Text Clustering using ML Algorithms: Partitional Clustering: K-Means

This study clustered the 89 factors by applying the K-means algorithm, a type of partitional clustering method, in Python Jupyter. The study employed the Elbow Method to determine the ideal number of clusters (Optimal k), as illustrated in Figure 25, which revealed that the best number of clusters for our data is 3, while Figure 26 plots the 3 clusters.

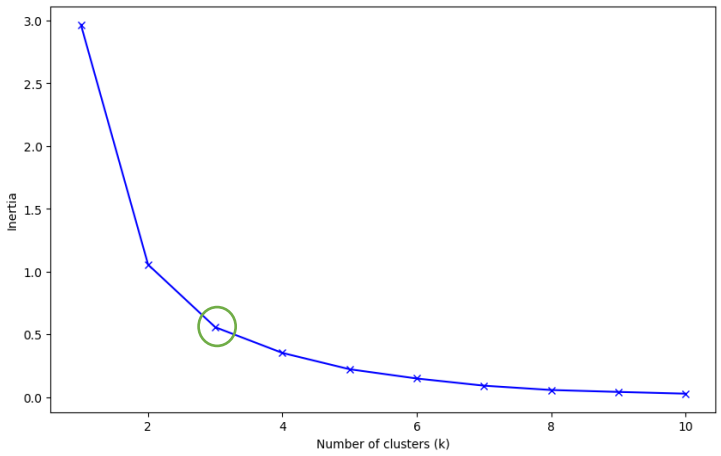



Fig. 25: K-Means Clustering: Elbow Method for Optimal k

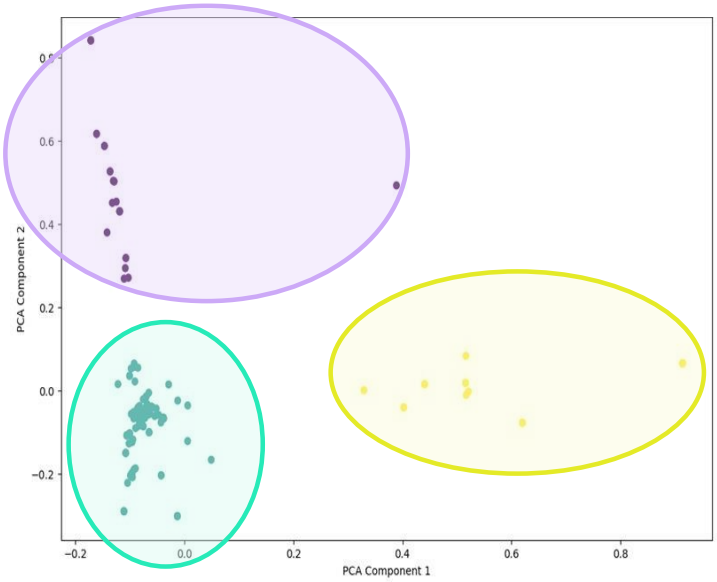



Fig. 26: K-Means Clustering of Factors

#### 4.2.1.2.2.3 Text Clustering using ML Algorithms: Hierarchical Clustering: Agglomerative

This study clustered 89 factors by applying the agglomerative hierarchical clustering algorithm, a type of hierarchical clustering method, in Orange.

When employing hierarchical clustering algorithms in this stage for this Part of our study, a tree or dendrogram shows the manner in which factors merge (or split) and to which root each factor belongs.

As mentioned earlier in our study, it is important to assign the number of clusters in the hierarchical clustering, unlike the k-means clustering which uses the Elbow method to determine the optimal number of clusters. Therefore, we first clustered the 89 factors in hierarchical clustering into 3 clusters, influenced by the results of the Elbow method for optimal k in the k-means clustering, to examine the clusters and compare the results of the hierarchical clustering with those of k-means. Accordingly, the study revealed the results of the 3 main clusters that represent TF factors of our study, as illustrated in Figure 27. The study found that the components of the 3 clusters are grouped under the following 3 themes: human-related factors (C1), project-related factors (C2), and team-related factors (C3).

However, when unclear of how many clusters to form, hierarchical clustering might be employed to determine if interpretable categories emerge (Kobayashi et al., 2018). Thus, this study increased the number of clusters until it reached some clusters where their components were easily interpreted. Consequently, the study proposed 8 clusters that influence the TF process under the 3 themes, according to the hierarchical clustering algorithm, as illustrated in Figure 28.

Table 26 presents the 3 main themes, the 8 main or key clusters or factors, and the sub-factors or attributes corresponding to the main factors.

Table (26): Clustering Factors Under Themes

| Main Theme | Cluster (CL) | Main Factor | Sub-Factor: Characteristics & Attributes |
|---|---|---|---|
| **Human-related factors** | CL1 | Characteristics | Background, relationship, ethnicity, gender, social, etc. |
| | CL2 | Personality | Emotionality, feeling, agreeableness, honesty, conscientiousness, humility, extraversion, openness, introversion, reliability, adaptability, etc. |
| **Project-related factors** | CL3 | Project Characteristics | Salary, level, cost, rate, size, time, duration, etc. |
| **Team-related factors** | CL4 | Teamwork | Cohesion, collaboration, coordination, members, team, etc. |
| | CL5 | Skills & Competencies | Positions, roles, competencies, skills, aptitudes, abilities, capabilities, etc. |
| | CL6 | Work Experience | Job, work, task, workload, projects, project management, etc. |
| | CL7 | Education & Knowledge | Knowledge, information, intelligence, education, learnability, training, preference, business, interest, management, GPA, etc. |
| | CL8 | Expertise & Proficiency | Programming, communication, language, network, technical, domain, etc. |

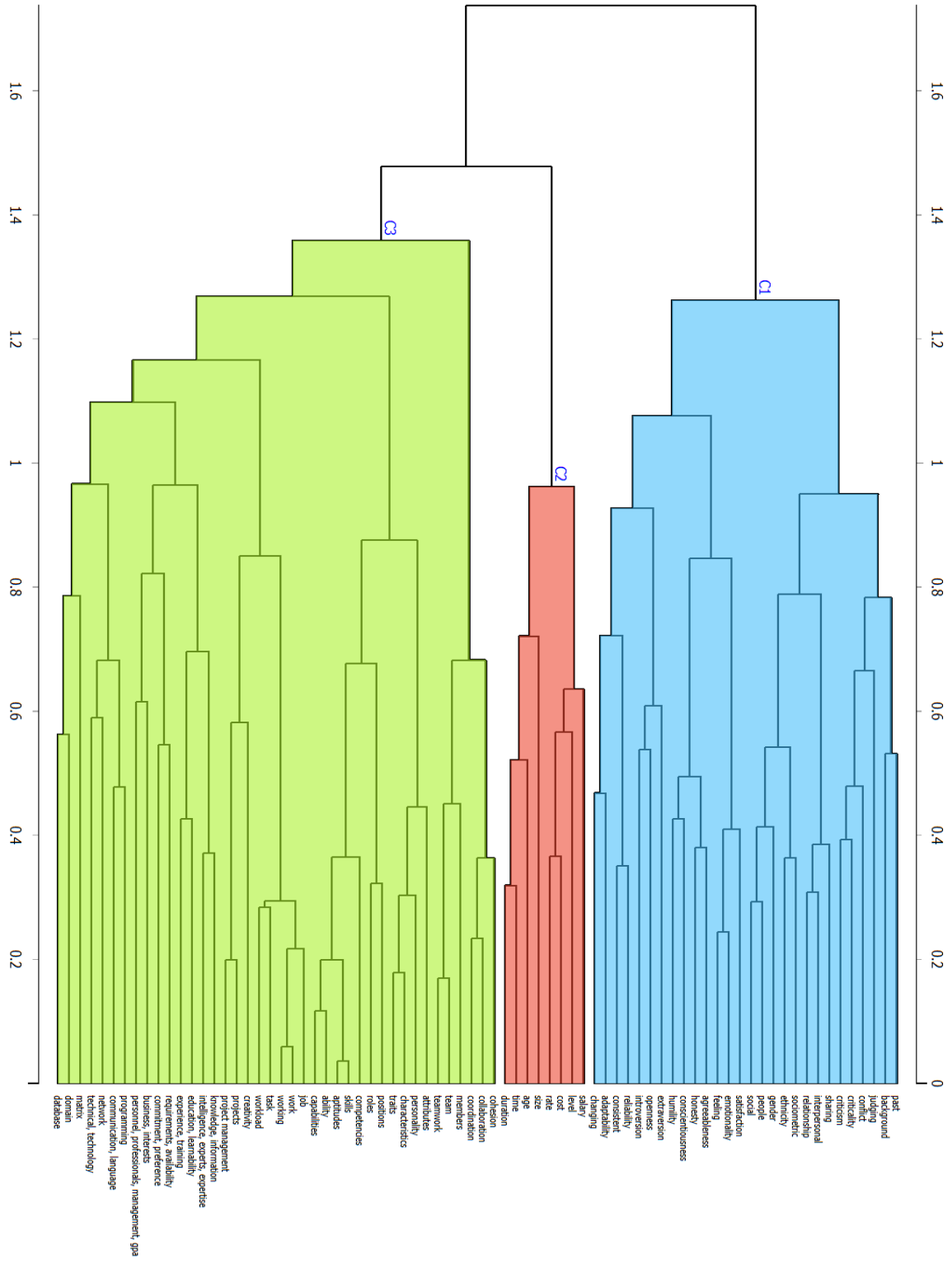



Fig. 27: Three Clusters of Factors in Hierarchical Clustering: Human-related Factors (C1), Project-related Factors (C2), and Team-related Factors (C3)

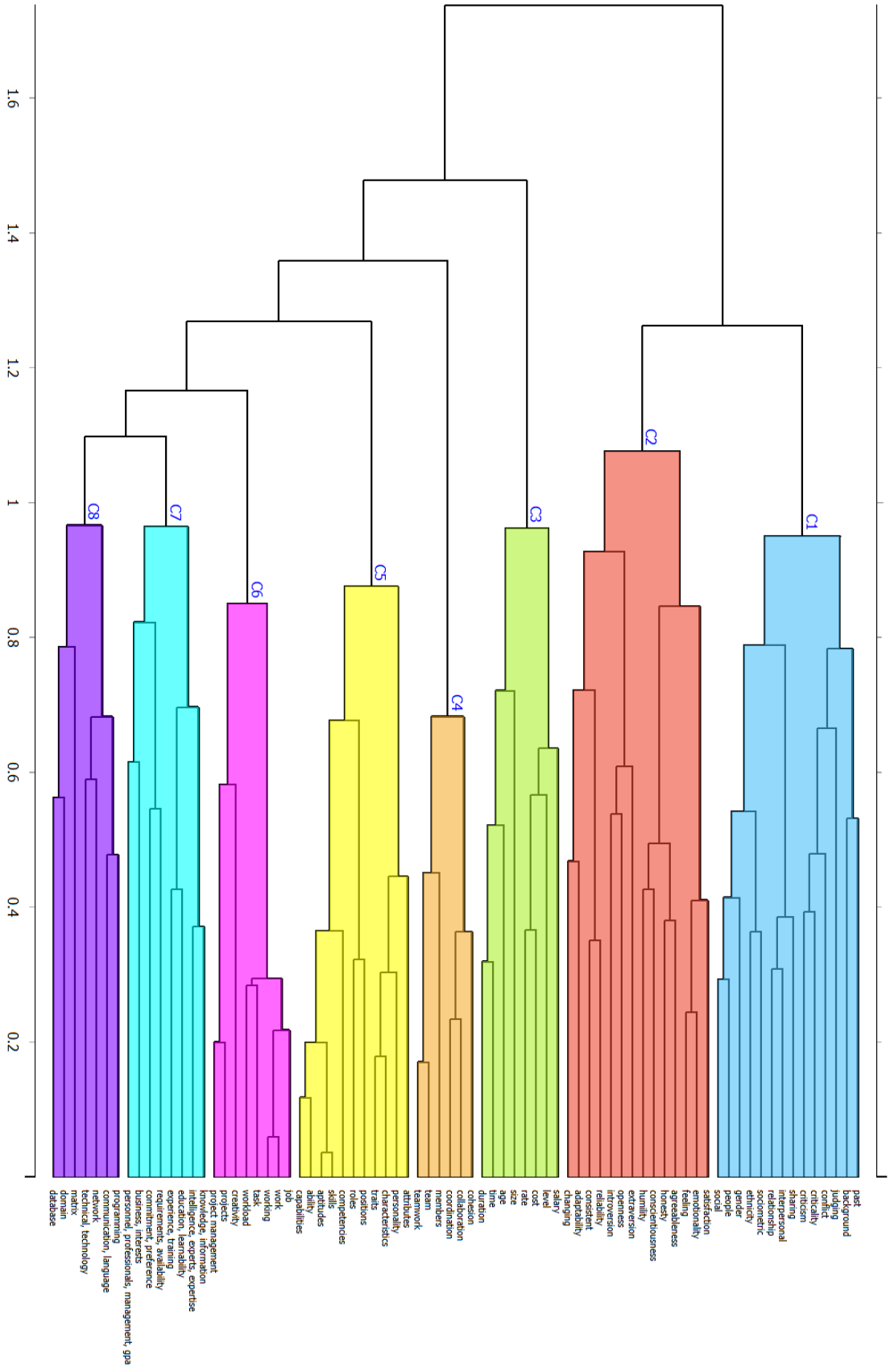
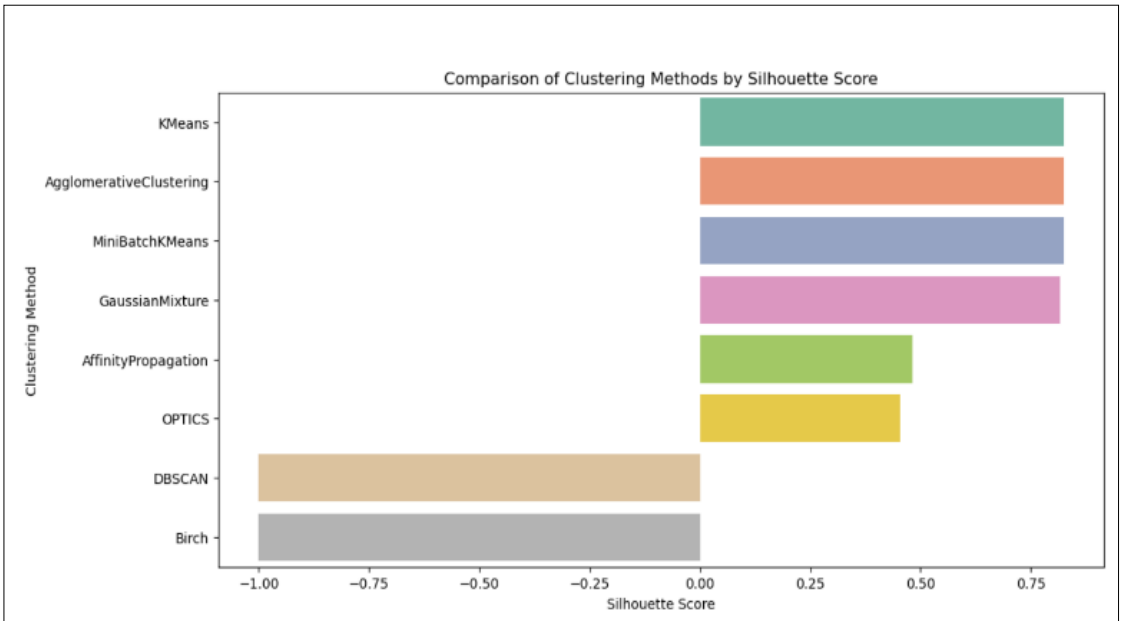



Fig. 28: Eight Main Clusters of Factors in Hierarchical Clustering

#### 4.2.1.2.2.4 Text Clustering using ML Algorithms: Silhouette Index

Figure 29 presents a comparison of clustering methods by Silhouette score. According to the Silhouette score, the most appropriate clustering algorithms are the K-means and the Agglomerative Hierarchical Clustering algorithms, as they have the highest score in comparison with the other popular clustering methods that have a low Silhouette score, indicating their ineffectiveness for our data.




| Clustering Method | Silhouette Score |
|---|---|
| KMeans | 0.824913 |
| AgglomerativeClustering | 0.824913 |
| MiniBatchKMeans | 0.824913 |
| GaussianMixture | 0.815634 |
| AffinityPropagation | 0.481450 |
| OPTICS | 0.453953 |
| DBSCAN | -1.000000 |
| Birch | -1.000000 |

Fig. 29: Comparison of Clustering Methods using Silhouette

### 4.2.1.2.2.5 Latent Dirichlet Allocation

The study applied the LDA method to compare the results of the Data Processing stage, which included Text Transformation (TF-IDF + Pareto), followed by Text Clustering (k-means and agglomerative hierarchical clustering). Figure 30 and Table 27 reveal the results of the LDA.




Fig. 30: Latent Dirichlet Allocation Clustering Results

Table (27): Latent Dirichlet Allocation Clustering Results

| Main Factor | Sub-Factors |
|---|---|
| **Topic 1:** team | team, communication, honesty, age, conscientiousness, satisfaction, work, language, working, problem |
| **Topic 2:** expert | expert, business, education, collaboration, background, emotionality, humility, gender, information, consistent |
| **Topic 3:** project | project, member, people, availability, relationship, requirement, criticality, workload, openness, tool |
| **Topic 4:** knowledge | knowledge, technical, project, sharing, time, size, duration, training, domain, past |
| **Topic 5:** characteristic | characteristic, personality, team, trait, reliability, job, flexibility, assignment, last, promotion |
| **Topic 6:** skill | skill, commitment, task, technical, time, preference, matrix, sociometric, domain, pm |
| **Topic 7:** experience | experience, cost, personnel, communication, social, attribute, role, learnability, programming, psychology |
| **Topic 8:** adaptability | adaptability, expertise, extraversion, interpersonal, member, technology, requirement, position, salary, changing |

The LDA clusters the data or factors into 8 clusters. These clusters are very similar to the 8 clusters that resulted from the agglomerative hierarchical clustering, as shown in Table 26. Table 28 presents the 8 corresponding clusters of both LDA and Agglomerative Hierarchical clustering with their factors and sub-factors.

Table (28): Comparison between Latent Dirichlet Allocation & Agglomerative Hierarchical Clustering Results

| **LDA Clustering** | | **Hierarchical Clustering** | |
|---|---|---|---|
| **Main Factor** | **Sub-Factors** | **Main Factor** | **Sub-Factors** |
| **Topic 1:** Team | team, communication, honesty, age, conscientiousness, satisfaction, work, language, working, problem | **CL4:** Teamwork | Cohesion, collaboration, coordination, members, team, etc. |
| **Topic 2:** Expert | expert, business, education, collaboration, background, emotionality, humility, gender, information, consistent | **CL8:** Expertise & Proficiency | Programming, communication, language, network, technical, domain, etc. |
| **Topic 3:** Project | project, member, people, availability, relationship, requirement, criticality, workload, openness, tool | **CL3:** Project Characteristics | Salary, level, cost, rate, size, time, duration, etc. |
| **Topic 4:** Knowledge | knowledge, technical, project, sharing, time, size, duration, training, domain, past | **CL7:** Education & Knowledge | Knowledge, information, intelligence, education, learnability, training, preference, business, interest, management, GPA, etc. |
| **Topic 5:** Characteristic | characteristic, personality, team, trait, reliability, job, flexibility, assignment, last, promotion | **CL1:** Characteristics | Background, relationship, ethnicity, gender, social, etc. |
| **Topic 6:** Skill | skill, commitment, task, technical, time, preference, matrix, sociometric, domain, pm | **CL5:** Skills & Competencies | Positions, roles, competencies, skills, aptitudes, abilities, capabilities, etc. |
| **Topic 7:** Experience | experience, cost, personnel, communication, social, attribute, role, learnability, programming, psychology | **CL6:** Work Experience | Job, work, task, workload, projects, project management, etc. |
| **Topic 8:** Adaptability | adaptability, expertise, extraversion, interpersonal, member, technology, requirement, position, salary, changing | **CL2:** Personality | Emotionality, feeling, agreeableness, honesty, conscientiousness, humility, extraversion, openness, introversion, reliability, adaptability, etc. |

Although the results reveal homogeneity of the clusters in terms of their factors, some factors are found in clusters with other factors that are not fully compatible. For example, Topic 2 (Expert) with CL8 (Expertise & Proficiency); Topic 2 starts with factors that are related to "experts", such as "business", "education", "collaboration", and "background", but also consists of unrelated factors such as "emotionality", "humility", and "gender". However, all factors that CL8 consists of are related to "Expertise & Proficiency". Another example is Topic 8 (Adaptability) with CL2 (Personality); Topic 8 consists of factors that are related to personality, such as "adaptability", "extraversion", and "interpersonal", but also consists of other unrelated factors, such as "expertise", "technology", and "salary". However, all factors that CL2 consists of are related to "Personality". Thus, the study confirms that the results of the Data Processing stage in the TMF are better than the results of the LDA.

It is important to highlight that, in the Data Processing stage, the study chose to apply TF-IDF since the goal was to extract the most used factors associated with team formation, and TF-IDF works as a decision matrix for allocating weights to all the factors to evaluate the importance of terms (factors) in a specific document relative to a collection of other documents, which is a simple method to highlight the most important words in the corpus, aiming to undertake a more effective approach to forming effective project teams by ranking the factors according to the level of influence on team formation. After that, it was important to consider the similarities of the factors. In our approach, it was necessary to first explore the factors by extracting them from the models in the documents, and then cluster similar factors together.

#### 4.2.1.2.3 Stage 3: Data Post-processing

It is important to mention that, in Stage 3, this study further analyzed the "human-related" and "team-related" factors since they consist of human attributes. This study excluded "project-related" factors since different project requirements will lead to different combinations of project team members; team composition can be influenced by the "project-related" factors or project characteristics, as illustrated in Figure 1.

Therefore, this study focused on the 7 main factors of the two themes, human-related and team-related, that are important to consider for TF when working on projects, excluding the factors that belong to the theme project-related, as they influence the formation of PTs.

After defining the main factors that affect team formation, which is considered the first step of the BWM of the MCDM method, the study followed the rest of the BWM steps, from 2 to 5, to assign weights to the factors that are related to and mostly influence PTs, for successful TF in the domain of project management. The study used "BWM solver", which was created by the author of BWM, to assign weights to the factors according to the input of the PMs after conducting the structured interviews, and measured the consistency and reliability of the PMs' input.

This study considered the views of 25 PMs from 5 different sectors within the service industry, namely: Financial (FS), Telecommunication (TS), Real Estate (RS), Energy (ES), and Governmental (or public sector) (GS).

In our study, Step 1 was accomplished by determining the criteria (C), as follows: Personality ($C_1$), Characteristics ($C_2$), Skills & Competencies ($C_3$), Education & Knowledge ($C_4$), Teamwork ($C_5$), Work Experience ($C_6$), and Expertise & Proficiency ($C_7$).

After accomplishing Step 1, the study repeated the steps from 2 to 5 for all the PMs from all sectors to assign weights to the factors that mostly influence PTs according to each PM. Then, the study took the average weights of each factor, first from the input of each PM within the sector and then from all sectors combined, to determine the weights for the factors that are related to and mostly influence PTs, according to the service industry.

This study presents the results of the steps from 2 to 5 according to each sector.

### *The Financial Sector (FS)*

In Step 2, the PMs within the FS selected the BC and the WC from the list of determined criteria. PM1 selected "$C_3$" as the BC and "$C_2$" as the WC. PM2 selected "$C_1$" as the BC and "$C_2$" as the WC. PM3 selected "$C_3$" as the BC and "$C_4$" as the WC. PM4 selected "$C_6$" as the BC and "$C_2$" as the WC. And finally, PM5 selected "$C_3$" as the BC and "$C_2$" as the WC.

For Step 3, the PMs determined the priority of the BC over all the determined criteria by giving it a number from 1 to 9 according to the fundamental scale for pairwise comparisons of Saaty (1977, 1987). Table 29 presents the results of the pairwise comparison vector for the BC according to each PM within the FS.

Table (29): Financial Sector: Pairwise Comparison Vector for Best Criterion

| **FS PMs** | **Criteria (C)** | **$C_1$** | **$C_2$** | **$C_3$** | **$C_4$** | **$C_5$** | **$C_6$** | **$C_7$** |
|---|---|---|---|---|---|---|---|---|
| **PM1** | BC: $C_3$ | 4 | 9 | 1 | 5 | 3 | 2 | 2 |
| **PM2** | BC: $C_1$ | 1 | 9 | 2 | 2 | 5 | 3 | 2 |
| **PM3** | BC: $C_3$ | 3 | 6 | 1 | 7 | 2 | 5 | 2 |
| **PM4** | BC: $C_6$ | 4 | 9 | 3 | 2 | 3 | 1 | 5 |
| **PM5** | BC: $C_3$ | 3 | 8 | 1 | 5 | 2 | 4 | 7 |

In Step 4, the PMs within the FS determined the priority of all criteria over the WC, by selecting a number from 1 to 9, also by using the pairwise comparison scale. Table 30 presents the results of the Pairwise Comparison vector for the WC according to each PM.

Table (30): Financial Sector: Pairwise Comparison Vector for Worst Criterion

| Criteria (C) | PM1 WC: $C_2$ | PM2 WC: $C_2$ | PM3 WC: $C_4$ | PM4 WC: $C_2$ | PM5 WC: $C_2$ |
|---|---|---|---|---|---|
| $C_1$ | 7 | 9 | 4 | 7 | 6 |
| $C_2$ | 1 | 1 | 4 | 1 | 1 |
| $C_3$ | 9 | 8 | 8 | 8 | 8 |
| $C_4$ | 5 | 8 | 1 | 8 | 4 |
| $C_5$ | 7 | 5 | 6 | 7 | 7 |
| $C_6$ | 7 | 7 | 7 | 9 | 5 |
| $C_7$ | 8 | 8 | 8 | 6 | 2 |

The study finally calculated the results of each PM input, within the FS, using the solver option, which is embedded in MS Excel, to get the weights of each criterion or factor, as revealed in Table 31, as well as the reliability score (Ksi) which shows to what extent the results are reliable; the closer the Ksi to zero the better. Accordingly, the results are reliable.

Table (31): Financial Sector: PMs Criteria Weights

| Criteria (C) | PM1 Weights | PM2 Weights | PM3 Weights | PM4 Weights | PM5 Weights | PMs Average Weights |
|---|---|---|---|---|---|---|
| $C_1$ | 0.094624246 | 0.281759763 | 0.133333333 | 0.100995316 | 0.142276423 | **0.150597816** |
| $C_2$ | 0.024684586 | 0.024715769 | 0.066666667 | 0.026346604 | 0.035569106 | **0.035596546** |
| $C_3$ | 0.300329128 | 0.170538804 | 0.293333333 | 0.134660422 | 0.355691057 | **0.250910549** |
| $C_4$ | 0.075699397 | 0.170538804 | 0.026666667 | 0.201990632 | 0.085365854 | **0.112052271** |
| $C_5$ | 0.126165661 | 0.068215522 | 0.2 | 0.134660422 | 0.213414634 | **0.148491248** |
| $C_6$ | 0.189248491 | 0.113692536 | 0.08 | 0.320550351 | 0.106707317 | **0.162039739** |
| $C_7$ | 0.189248491 | 0.170538804 | 0.2 | 0.080796253 | 0.06097561 | **0.140311832** |
| **Ksi** | 0.078167855 | 0.059317845 | 0.106666667 | 0.083430913 | 0.071138211 | |

According to the BWM outcomes conducted for the 5 PMs of the FS, Table 32 reveals the weights of the main/key factors, ranked according to their weights.

Table (32): Financial Sector: Factors Rank

| Main Factors | Weights |
|---|---|
| **1. Skills & Competencies** | 0.250910549 |
| **2. Work Experience** | 0.162039739 |
| **3. Personality** | 0.150597816 |
| **4. Teamwork** | 0.148491248 |
| **5. Expertise & Proficiency** | 0.140311832 |
| **6. Education & Knowledge** | 0.112052271 |
| **7. Characteristics** | 0.035596546 |

### *The Telecommunication Sector (TS)*

In Step 2, the PMs within the TS selected the BC and the WC from the list of determined criteria. PM1 selected "$C_3$" as the BC and "$C_2$" as the WC. PM2 selected "$C_1$" as the BC and "$C_2$" as the WC. PM3 selected "$C_3$" as the BC and "$C_2$" as the WC. PM4 selected "$C_5$" as the BC and "$C_2$" as the WC. And finally, PM5 selected "$C_6$" as the BC and "$C_2$" as the WC.

For Step 3, the PMs determined the priority of the BC over all the determined criteria by giving it a number from 1 to 9, according to the fundamental scale for pairwise comparisons. Table 33 presents the results of the pairwise comparison vector for the BC according to each PM within the TS.

Table (33): Telecommunication Sector: Pairwise Comparison Vector for Best Criterion

| TS PMs | Criteria (C) | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
|---|---|---|---|---|---|---|---|---|
| **PM1** | BC: $C_3$ | 3 | 8 | 1 | 3 | 2 | 2 | 4 |
| **PM2** | BC: $C_1$ | 1 | 9 | 3 | 4 | 2 | 5 | 6 |
| **PM3** | BC: $C_3$ | 2 | 9 | 1 | 5 | 4 | 3 | 2 |
| **PM4** | BC: $C_5$ | 2 | 7 | 3 | 4 | 1 | 5 | 5 |
| **PM5** | BC: $C_6$ | 3 | 9 | 5 | 6 | 5 | 1 | 2 |

In Step 4, the PMs within the TS determined the priority of all criteria over the WC, by selecting a number from 1 to 9, also by using the pairwise comparison scale. Table 34 presents the results of the Pairwise Comparison vector for the WC according to each PM.

Table (34): Telecommunication Sector: Pairwise Comparison Vector for Worst Criterion

| Criteria (C) | PM1 WC: $C_2$ | PM2 WC: $C_2$ | PM3 WC: $C_2$ | PM4 WC: $C_2$ | PM5 WC: $C_2$ |
|---|---|---|---|---|---|
| $C_1$ | 7 | 8 | 8 | 6 | 7 |
| $C_2$ | 1 | 1 | 1 | 1 | 1 |
| $C_3$ | 8 | 6 | 9 | 4 | 5 |
| $C_4$ | 6 | 5 | 4 | 4 | 5 |
| $C_5$ | 7 | 5 | 5 | 7 | 7 |
| $C_6$ | 7 | 4 | 3 | 3 | 9 |
| $C_7$ | 5 | 4 | 7 | 3 | 8 |

The study finally calculated the results of each PM input, within the TS, using the solver option, which is embedded in MS Excel, to get the weights of each criterion or factor, as revealed in Table 35, as well as the reliability score (Ksi) which shows to what extent the results are reliable; the closer the Ksi to zero the better. Accordingly, the results are reliable.

Table (35): Telecommunication Sector: PMs Criteria Weights

| Criteria (C) | PM1 Weights | PM2 Weights | PM3 Weights | PM4 Weights | PM5 Weights | PMs Average Weights |
|---|---|---|---|---|---|---|
| $C_1$ | 0.119241192 | 0.352112676 | 0.183989671 | 0.205479452 | 0.149156939 | **0.201995986** |
| $C_2$ | 0.027100271 | 0.035211268 | 0.029051001 | 0.04109589 | 0.027237354 | **0.031939157** |
| $C_3$ | 0.287262873 | 0.14084507 | 0.314719174 | 0.136986301 | 0.089494163 | **0.193861516** |
| $C_4$ | 0.119241192 | 0.105633803 | 0.073595868 | 0.102739726 | 0.07457847 | **0.095157812** |
| $C_5$ | 0.178861789 | 0.211267606 | 0.091994835 | 0.349315068 | 0.089494163 | **0.184186692** |
| $C_6$ | 0.178861789 | 0.084507042 | 0.122659781 | 0.082191781 | 0.346303502 | **0.162904779** |
| $C_7$ | 0.089430894 | 0.070422535 | 0.183989671 | 0.082191781 | 0.223735409 | **0.129954058** |
| **Ksi** | 0.070460705 | 0.070422535 | 0.053260168 | 0.061643836 | 0.101167315 | |

According to the BWM outcomes conducted for the 5 PMs of the TS, Table 36 reveals the weights of the main factors, ranked according to their weights.

Table (36): Telecommunication Sector: Factors Rank

| Main Factors | Weights |
|---|---|
| **1. Personality** | 0.201995986 |
| **2. Skills & Competencies** | 0.193861516 |
| **3. Teamwork** | 0.184186692 |
| **4. Work Experience** | 0.162904779 |
| **5. Expertise & Proficiency** | 0.129954058 |
| **6. Education & Knowledge** | 0.095157812 |
| **7. Characteristics** | 0.031939157 |

### *The Real Estate Sector (RS)*

In Step 2, the PMs within the RS selected the BC and the WC from the list of determined criteria. PM1 selected "$C_1$" as the BC and "$C_4$" as the WC. PM2 selected "$C_1$" as the BC and "$C_3$" as the WC. PM3 selected "$C_7$" as the BC and "$C_2$" as the WC. PM4 selected "$C_3$" as the BC and "$C_4$" as the WC. And finally, PM5 selected "$C_3$" as the BC and "$C_2$" as the WC.

For Step 3, the PMs determined the priority of the BC over all the determined criteria by giving it a number from 1 to 9, according to the fundamental scale for pairwise comparisons. Table 37 presents the results of the pairwise comparison vector for the BC according to each PM within the RS.

Table (37): Real Estate Sector: Pairwise Comparison Vector for Best Criterion

| RS PMs | Criteria (C) | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
|---|---|---|---|---|---|---|---|---|
| **PM1** | BC: $C_1$ | 1 | 3 | 2 | 6 | 2 | 5 | 5 |
| **PM2** | BC: $C_1$ | 1 | 6 | 7 | 4 | 5 | 3 | 2 |
| **PM3** | BC: $C_7$ | 2 | 8 | 3 | 5 | 2 | 3 | 1 |
| **PM4** | BC: $C_3$ | 2 | 5 | 1 | 6 | 2 | 3 | 2 |
| **PM5** | BC: $C_3$ | 3 | 7 | 1 | 2 | 3 | 2 | 3 |

In Step 4, the PMs within the RS determined the priority of all criteria over the WC, by selecting a number from 1 to 9, also by using the pairwise comparison scale. Table 38 presents the results of the Pairwise Comparison vector for the WC according to each PM.

Table (38): Real Estate Sector: Pairwise Comparison Vector for Worst Criterion

| Criteria (C) | PM1 WC: $C_4$ | PM2 WC: $C_3$ | PM3 WC: $C_2$ | PM4 WC: $C_4$ | PM5 WC: $C_2$ |
|---|---|---|---|---|---|
| $C_1$ | 9 | 7 | 7 | 2 | 7 |
| $C_2$ | 5 | 2 | 1 | 5 | 1 |
| $C_3$ | 6 | 1 | 7 | 6 | 9 |
| $C_4$ | 1 | 4 | 5 | 1 | 8 |
| $C_5$ | 8 | 3 | 7 | 2 | 7 |
| $C_6$ | 7 | 5 | 5 | 3 | 8 |
| $C_7$ | 6 | 6 | 8 | 2 | 8 |

The study finally calculated the results of each PM input, within the RS, using the solver option, which is embedded in MS Excel, to get the weights of each criterion or factor, as revealed in Table 39, as well as the reliability score (Ksi) which shows to what extent the results are reliable; the closer the Ksi to zero the better. Accordingly, the results are reliable.

Table (39): Real Estate Sector: PMs Criteria Weights

| Criteria (C) | PM1 Weights | PM2 Weights | PM3 Weights | PM4 Weights | PM5 Weights | PMs Average Weights |
|---|---|---|---|---|---|---|
| $C_1$ | 0.282493369 | 0.352603526 | 0.182119205 | 0.157392687 | 0.117948718 | **0.218511501** |
| $C_2$ | 0.132625995 | 0.069700697 | 0.027593819 | 0.076311606 | 0.025641026 | **0.066374628** |
| $C_3$ | 0.198938992 | 0.04100041 | 0.121412804 | 0.290937997 | 0.266666667 | **0.183791374** |
| $C_4$ | 0.027851459 | 0.104551046 | 0.072847682 | 0.033386328 | 0.176923077 | **0.083111918** |
| $C_5$ | 0.198938992 | 0.083640836 | 0.182119205 | 0.157392687 | 0.117948718 | **0.148008088** |
| $C_6$ | 0.079575597 | 0.139401394 | 0.121412804 | 0.12718601 | 0.176923077 | **0.128899776** |
| $C_7$ | 0.079575597 | 0.209102091 | 0.292494481 | 0.157392687 | 0.117948718 | **0.171302715** |
| **Ksi** | 0.115384615 | 0.065600656 | 0.071743929 | 0.090620032 | 0.087179487 | |

According to the BWM outcomes conducted for the 5 PMs of the RS, Table 40 reveals the weights of the main factors, ranked according to their weights.

Table (40): Real Estate Sector: Factors Rank

| Main Factors | Weights |
|---|---|
| **1. Personality** | 0.218511501 |
| **2. Skills & Competencies** | 0.183791374 |
| **3. Expertise & Proficiency** | 0.171302715 |
| **4. Teamwork** | 0.148008088 |
| **5. Work Experience** | 0.128899776 |
| **6. Education & Knowledge** | 0.083111918 |
| **7. Characteristics** | 0.066374628 |

### *The Energy Sector (ES)*

In Step 2, the PMs within the ES selected the BC and the WC from the list of determined criteria. PM1 selected "$C_6$" as the BC and "$C_2$" as the WC. PM2 selected "$C_3$" as the BC and "$C_2$" as the WC. PM3 selected "$C_3$" as the BC and "$C_2$" as the WC. PM4 selected "$C_6$" as the BC and "$C_2$" as the WC. And finally, PM5 selected "$C_3$" as the BC and "$C_2$" as the WC.

For Step 3, the PMs determined the priority of the BC over all the determined criteria by giving it a number from 1 to 9, according to the fundamental scale for pairwise comparisons. Table 41 presents the results of the pairwise comparison vector for the BC according to each PM within the ES.

Table (41): Energy Sector: Pairwise Comparison Vector for Best Criterion

| ES PMs | Criteria (C) | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
|---|---|---|---|---|---|---|---|---|
| **PM1** | BC: $C_6$ | 4 | 8 | 3 | 4 | 2 | 1 | 2 |
| **PM2** | BC: $C_3$ | 3 | 7 | 1 | 5 | 4 | 2 | 5 |
| **PM3** | BC: $C_3$ | 3 | 8 | 1 | 2 | 3 | 2 | 3 |
| **PM4** | BC: $C_6$ | 2 | 7 | 2 | 6 | 2 | 1 | 3 |
| **PM5** | BC: $C_3$ | 2 | 7 | 1 | 5 | 6 | 4 | 3 |

In Step 4, the PMs within the ES determined the priority of all criteria over the WC, by selecting a number from 1 to 9, also by using the pairwise comparison scale. Table 42 presents the results of the Pairwise Comparison vector for the WC according to each PM.

Table (42): Energy Sector: Pairwise Comparison Vector for Worst Criterion

| Criteria (C) | PM1 WC: $C_2$ | PM2 WC: $C_2$ | PM3 WC: $C_2$ | PM4 WC: $C_2$ | PM5 WC: $C_2$ |
|---|---|---|---|---|---|
| $C_1$ | 5 | 5 | 5 | 6 | 6 |
| $C_2$ | 1 | 1 | 1 | 1 | 1 |
| $C_3$ | 7 | 7 | 8 | 5 | 7 |
| $C_4$ | 6 | 3 | 7 | 2 | 4 |
| $C_5$ | 7 | 4 | 7 | 6 | 2 |
| $C_6$ | 8 | 6 | 8 | 7 | 3 |
| $C_7$ | 6 | 3 | 7 | 5 | 4 |

The study finally calculated the results of each PM input, within the ES, using the solver option, which is embedded in MS Excel, to get the weights of each criterion or factor, as revealed in Table 43, as well as the reliability score (Ksi) which shows to what extent the results are reliable; the closer the Ksi to zero the better. Accordingly, the results are reliable.

Table (43): Energy Sector: PMs Criteria Weights

| Criteria (C) | PM1 Weights | PM2 Weights | PM3 Weights | PM4 Weights | PM5 Weights | PMs Average Weights |
|---|---|---|---|---|---|---|
| $C_1$ | 0.092307692 | 0.137484836 | 0.115789474 | 0.17 | 0.210970464 | **0.145310493** |
| $C_2$ | 0.027692308 | 0.040436717 | 0.026315789 | 0.033333333 | 0.039381153 | **0.03343186** |
| $C_3$ | 0.123076923 | 0.347755762 | 0.278947368 | 0.17 | 0.348804501 | **0.253716911** |
| $C_4$ | 0.092307692 | 0.082490902 | 0.173684211 | 0.056666667 | 0.084388186 | **0.097907531** |
| $C_5$ | 0.184615385 | 0.103113627 | 0.115789474 | 0.17 | 0.070323488 | **0.128768395** |
| $C_6$ | 0.295384615 | 0.206227254 | 0.173684211 | 0.286666667 | 0.105485232 | **0.213489596** |
| $C_7$ | 0.184615385 | 0.082490902 | 0.115789474 | 0.113333333 | 0.140646976 | **0.127375214** |
| **Ksi** | 0.073846154 | 0.064698746 | 0.068421053 | 0.053333333 | 0.073136428 | |

According to the BWM outcomes conducted for the 5 PMs of the ES, Table 44 reveals the weights of the main factors, ranked according to their weights.

Table (44): Energy Sector: Factors Rank

| Main Factors | Weights |
|---|---|
| **1. Skills & Competencies** | 0.253716911 |
| **2. Work Experience** | 0.213489596 |
| **3. Personality** | 0.145310493 |
| **4. Teamwork** | 0.128768395 |
| **5. Expertise & Proficiency** | 0.127375214 |
| **6. Education & Knowledge** | 0.097907531 |
| **7. Characteristics** | 0.03343186 |

### *The Governmental Sector (GS)*

In Step 2, the PMs within the GS selected the BC and the WC from the list of determined criteria. PM1 selected "$C_6$" as the BC and "$C_4$" as the WC. PM2 selected "$C_3$" as the BC and "$C_5$" as the WC. PM3 selected "$C_7$" as the BC and "$C_6$" as the WC. PM4 selected "$C_3$" as the BC and "$C_6$" as the WC. And finally, PM5 selected "$C_6$" as the BC and "$C_1$" as the WC.

For Step 3, the PMs determined the priority of the BC over all the determined criteria by giving it a number from 1 to 9, according to the fundamental scale for pairwise comparisons. Table 45 presents the results of the pairwise comparison vector for the BC according to each PM within the GS.

Table (45): Governmental Sector: Pairwise Comparison Vector for Best Criterion

| GS PMs | Criteria (C) | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
|---|---|---|---|---|---|---|---|---|
| **PM1** | BC: $C_6$ | 3 | 7 | 3 | 8 | 3 | 1 | 3 |
| **PM2** | BC: $C_3$ | 3 | 3 | 1 | 4 | 7 | 2 | 3 |
| **PM3** | BC: $C_7$ | 4 | 6 | 3 | 2 | 6 | 7 | 1 |
| **PM4** | BC: $C_3$ | 2 | 7 | 1 | 5 | 4 | 8 | 3 |
| **PM5** | BC: $C_6$ | 5 | 4 | 2 | 3 | 4 | 1 | 2 |

In Step 4, the PMs within the GS determined the priority of all criteria over the WC, by selecting a number from 1 to 9, also by using the pairwise comparison scale. Table 46 presents the results of the Pairwise Comparison vector for the WC according to each PM.

Table (46): Governmental Sector: Pairwise Comparison Vector for Worst Criterion

| Criteria (C) | PM1 WC: $C_4$ | PM2 WC: $C_5$ | PM3 WC: $C_6$ | PM4 WC: $C_6$ | PM5 WC: $C_1$ |
|---|---|---|---|---|---|
| $C_1$ | 7 | 6 | 7 | 8 | 1 |
| $C_2$ | 7 | 6 | 2 | 2 | 5 |
| $C_3$ | 7 | 8 | 6 | 9 | 6 |
| $C_4$ | 1 | 7 | 7 | 5 | 5 |
| $C_5$ | 7 | 1 | 2 | 7 | 3 |
| $C_6$ | 8 | 6 | 1 | 1 | 7 |
| $C_7$ | 7 | 7 | 9 | 3 | 6 |

The study finally calculated the results of each PM input, within the GS, using the solver option, which is embedded in MS Excel, to get the weights of each criterion or factor, as revealed in Table 47, as well as the reliability score (Ksi) which shows to what extent the results are reliable; the closer the Ksi to zero the better. Accordingly, the results are reliable.

Table (47): Governmental Sector: PMs Criteria Weights

| Criteria (C) | PM1 Weights | PM2 Weights | PM3 Weights | PM4 Weights | PM5 Weights | PMs Average Weights |
|---|---|---|---|---|---|---|
| $C_1$ | 0.146946565 | 0.12962963 | 0.111702128 | 0.220546114 | 0.037267081 | **0.129218303** |
| $C_2$ | 0.062977099 | 0.12962963 | 0.074468085 | 0.063013175 | 0.093167702 | **0.084651138** |
| $C_3$ | 0.146946565 | 0.291666667 | 0.14893617 | 0.340843995 | 0.186335404 | **0.22294576** |
| $C_4$ | 0.025763359 | 0.097222222 | 0.223404255 | 0.088218446 | 0.124223602 | **0.111766377** |
| $C_5$ | 0.146946565 | 0.027777778 | 0.074468085 | 0.110273057 | 0.093167702 | **0.090526637** |
| $C_6$ | 0.323473282 | 0.194444444 | 0.031914894 | 0.03007447 | 0.279503106 | **0.171882039** |
| $C_7$ | 0.146946565 | 0.12962963 | 0.335106383 | 0.147030743 | 0.186335404 | **0.189009745** |
| **Ksi** | 0.117366412 | 0.097222222 | 0.111702128 | 0.100248234 | 0.093167702 | |

According to the BWM outcomes conducted for the 5 PMs of the GS, Table 48 reveals the weights of the main factors, ranked according to their weights.

Table (48): Governmental Sector: Factors Rank

| Main Factors | Weights |
|---|---|
| **1. Skills & Competencies** | 0.22294576 |
| **2. Expertise & Proficiency** | 0.189009745 |
| **3. Work Experience** | 0.171882039 |
| **4. Personality** | 0.129218303 |
| **5. Education & Knowledge** | 0.111766377 |
| **6. Teamwork** | 0.090526637 |
| **7. Characteristics** | 0.084651138 |

According to the BWM outcomes conducted for 25 PMs from 5 sectors of the service industry, Table 49 reveals the average weights of all 7 criteria.

Table (49): Average Criterion Weights from All Sectors

| Criteria (C) | FS PMs Weights | TS PMs Weights | RS PMs Weights | ES PMs Weights | GS PMs Weights | Average Criterion Weights |
|---|---|---|---|---|---|---|
| $C_1$ | 0.150597816 | 0.201995986 | 0.218511501 | 0.145310493 | 0.129218303 | **0.16912682** |
| $C_2$ | 0.035596546 | 0.031939157 | 0.066374628 | 0.03343186 | 0.084651138 | **0.050398666** |
| $C_3$ | 0.250910549 | 0.193861516 | 0.183791374 | 0.253716911 | 0.22294576 | **0.221045222** |
| $C_4$ | 0.112052271 | 0.095157812 | 0.083111918 | 0.097907531 | 0.111766377 | **0.099999182** |
| $C_5$ | 0.148491248 | 0.184186692 | 0.148008088 | 0.128768395 | 0.090526637 | **0.139996212** |
| $C_6$ | 0.162039739 | 0.162904779 | 0.128899776 | 0.213489596 | 0.171882039 | **0.167843186** |
| $C_7$ | 0.140311832 | 0.129954058 | 0.171302715 | 0.127375214 | 0.189009745 | **0.151590713** |

Table 50 reveals the weights of the main factors, ranked according to their weights.

Table (50): Service Industry Factors Rank

| Main Factors | Weights |
|---|---|
| 1. **Skills & Competencies** | 0.221045222 |
| 2. **Personality** | 0.16912682 |
| 3. **Work Experience** | 0.167843186 |
| 4. **Expertise & Proficiency** | 0.151590713 |
| 5. **Teamwork** | 0.139996212 |
| 6. **Education & Knowledge** | 0.099999182 |
| 7. **Characteristics** | 0.050398666 |

According to the input of all 25 PMs in all 5 sectors within the service industry, the most important factor that affects TF when considering PTs in the project management domain within the service industry is “Skills & Competencies”, while the least important is “Characteristics”. Based on the results of the MCDM-BWM, this study developed a model for the most influential factors that affect the formation of traditional human teams in the service industry, as presented in Figure 31.

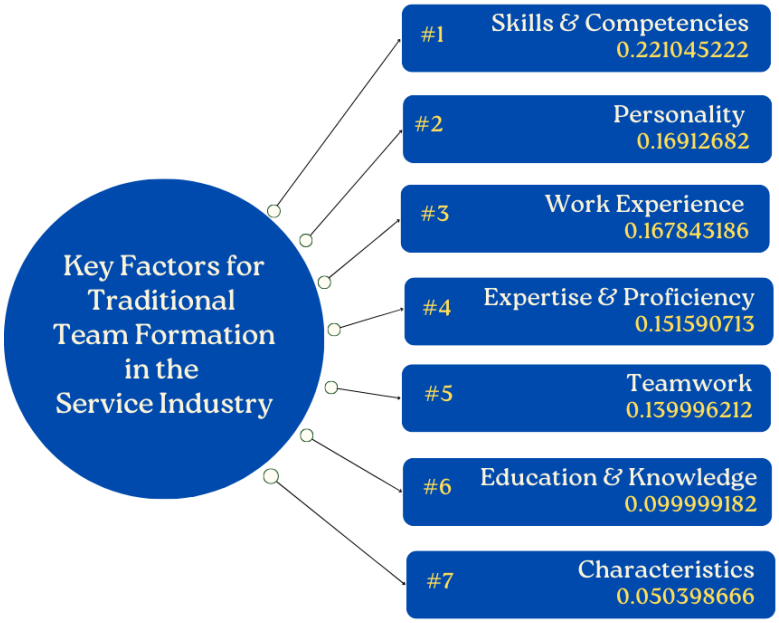



Fig. 31: Factors Affecting Traditional H-H Team Formation in the Service Industry (developed by the authors)

As per the results of the study, the top three most important factors in the team formation process of a project team in the service industry are “Skills & Competencies”, “Personality”, and “Work Experience”. However, the results of the study illustrated in Figure 32, which plots the percentages of the 7 factors that influence the formation of project teams, show that the factor “Work Experience” is almost of equal importance to the factor “Personality”, since they both affect the TF process with 17% of the total

number of factors. Therefore, this study considers them of equal value. Hence, the study ranks them both as the second-best factors and considers the next factor in rank as the third-best, which is “Expertise & Proficiency”.

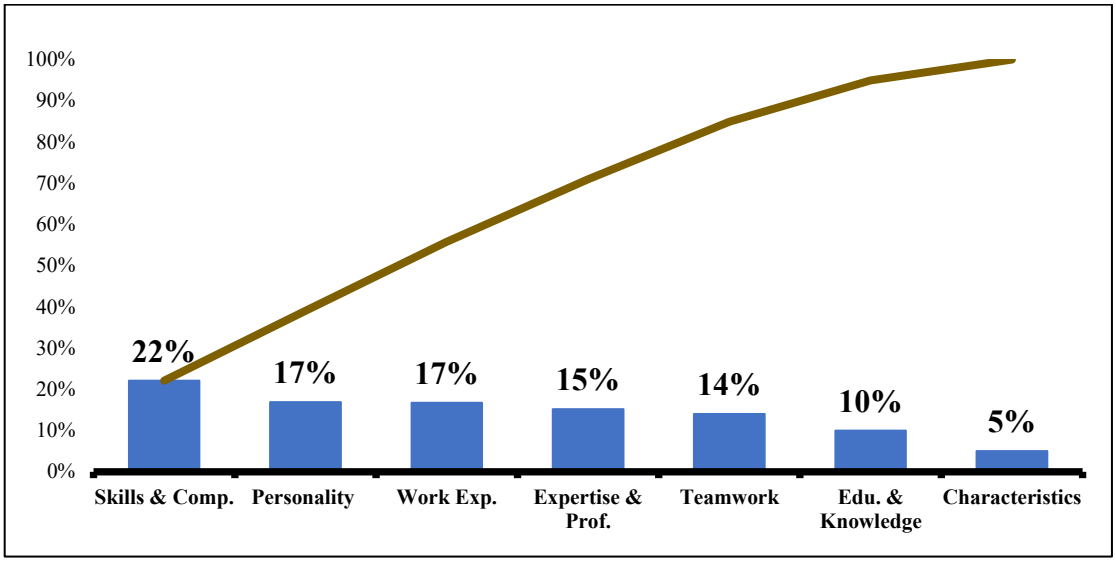



Fig. 32: Pareto Principle: Factors Affecting Traditional H-H Team Formation in the Service Industry

#### 4.2.1.3 Phase 1 Part 3: H-GenAI in Project Teams

The results of Part 3 are revealed in three sub-sections since this Part applied a mixed method; the first phase of this part followed a qualitative method by conducting semi-structured interviews, the second followed a quantitative method using ML clustering algorithms, and the third adopted a quantitative method by employing MCDM-BWM which required conducting structured interviews with the same PMs from the 5 sectors within the service industry to capture their views regarding the formation of H-GenAI PT. The study then compares the results of the main TF factors for forming H-GenAI PTs with those factors when forming H-H PTs.

#### 4.2.1.3.1 First Phase: Generative AI Capabilities

This section presents the findings of the qualitative data collection of GenAI capabilities, which are 64 capabilities according to the interview outcomes with the 16 AI experts or practitioners.

It is important to mention that the interview respondents referred to AI and GenAI interchangeably.

Table 51 lists the 64 capabilities of GenAI, as revealed by the interview respondents. Then, for this study, the researcher splits the GenAI capabilities into two categories: characteristics and abilities, based on the definitions of the terms.

Table 52 lists the characteristics of GenAI, and Table 53 lists the abilities of GenAI.

Table (51): Generative AI Capabilities: Semi-structured Interview Results

| Generative AI Capabilities | | | |
|---|---|---|---|
| 1 | Analyzing | 33 | Recommendation |
| 2 | Training | 34 | Detection |
| 3 | Generation | 35 | Facilitation |
| 4 | Learning | 36 | Guidance |
| 5 | Processing | 37 | Assistance |
| 6 | Decision-Making | 38 | Connectivity |
| 7 | Forecasting | 39 | Designing |
| 8 | Distinguishing | 40 | Deciphering |
| 9 | Memorization | 41 | Summarization |
| 10 | Understanding | 42 | Communication |
| 11 | Translation | 43 | Programming |
| 12 | Creation | 44 | Listening |
| 13 | Simulation | 45 | Mocking |
| 14 | Problem-Solving | 46 | Prediction |
| 15 | Categorization | 47 | Identification |
| 16 | Awareness | 48 | Clustering |
| 17 | Copying | 49 | Association |
| 18 | Recognition | 50 | Mimicking |
| 19 | Recollection | 51 | Thinking |
| 20 | Adaptability | 52 | Automation |
| 21 | Consistency | 53 | Beyond Automation |
| 22 | Stability | 54 | Creativity |
| 23 | Neutral | 55 | Intelligent |
| 24 | Accuracy | 56 | Simplicity |
| 25 | Sympathy | 57 | Rational |
| 26 | Insightfulness | 58 | Interoperability |
| 27 | User-Friendliness | 59 | Integration |
| 28 | Easy | 60 | Emotionless |
| 29 | Explainability | 61 | Compliance |
| 30 | Transparent | 62 | Accountability |
| 31 | Controllability | 63 | Interactivity |
| 32 | Personalization | 64 | Maintainability |

Table (52): Generative AI Characteristics

| Generative AI Characteristics | | | |
|---|---|---|---|
| 1 | Adaptability | 15 | Simplicity |
| 2 | Consistency | 16 | Rational |
| 3 | Stability | 17 | Interoperability |
| 4 | Neutral | 18 | Integration |
| 5 | Accuracy | 19 | Emotionless |
| 6 | Thinking | 20 | Explainability |
| 7 | Automation | 21 | Transparent |
| 8 | Beyond Automation | 22 | Controllability |
| 9 | Creativity | 23 | Personalization |
| 10 | Intelligent | 24 | Compliance |
| 11 | Sympathy | 25 | Accountability |
| 12 | Insightfulness | 26 | Interactivity |
| 13 | User-Friendliness | 27 | Maintainability |
| 14 | Easy | | |

Table (53): Generative AI Abilities

| Generative AI Abilities | | | |
|---|---|---|---|
| 1 | Analyzing | 20 | Recommendation |
| 2 | Training | 21 | Detection |
| 3 | Generation | 22 | Facilitation |
| 4 | Learning | 23 | Guidance |
| 5 | Processing | 24 | Assistance |
| 6 | Decision-making | 25 | Connectivity |
| 7 | Forecasting | 26 | Designing |
| 8 | Distinguishing | 27 | Deciphering |
| 9 | Memorization | 28 | Summarization |
| 10 | Understanding | 29 | Communication |
| 11 | Translation | 30 | Programming |
| 12 | Creation | 31 | Listening |
| 13 | Simulation | 32 | Mocking |
| 14 | Problem-solving | 33 | Prediction |
| 15 | Categorization | 34 | Identification |
| 16 | Awareness | 35 | Clustering |
| 17 | Copying | 36 | Association |
| 18 | Recognition | 37 | Mimicking |
| 19 | Recollection | | |

#### 4.2.1.3.2 Second Phase: Clustering Generative AI Capabilities

This section reveals the findings of the quantitative data collection of the two categories of GenAI capabilities, which are characteristics and abilities, using the clustering framework of ML clustering algorithms. Aiming to determine the main characteristics of GenAI, the study first clustered the GenAI characteristics using the ML clustering framework (Figure 23) and then determined themes for the clustered GenAI characteristics.

To determine the main abilities of GenAI, the study first clustered the GenAI abilities using the ML clustering framework (Figure 23) and then determined themes for the clustered GenAI abilities.

##### 4.2.1.3.2.1 Clusters of Generative AI Characteristics

It is worth mentioning that some of the GenAI characteristics have similar meanings which can be grouped under one group. Accordingly, this study clusters the 27 GenAI characteristics that the interviews revealed using the hierarchical clustering algorithm until it considers several clusters where it is possible to grasp each of its components. The study identified 12 clusters for the pre-defined GenAI characteristics, as shown in the Dendrogram in Figure 33.

Furthermore, the study plots the hierarchical clustering results using the Silhouette index to assess its overall outcome and the clusters that the characteristics belong to, as illustrated in Figure 34 and Figure 35.

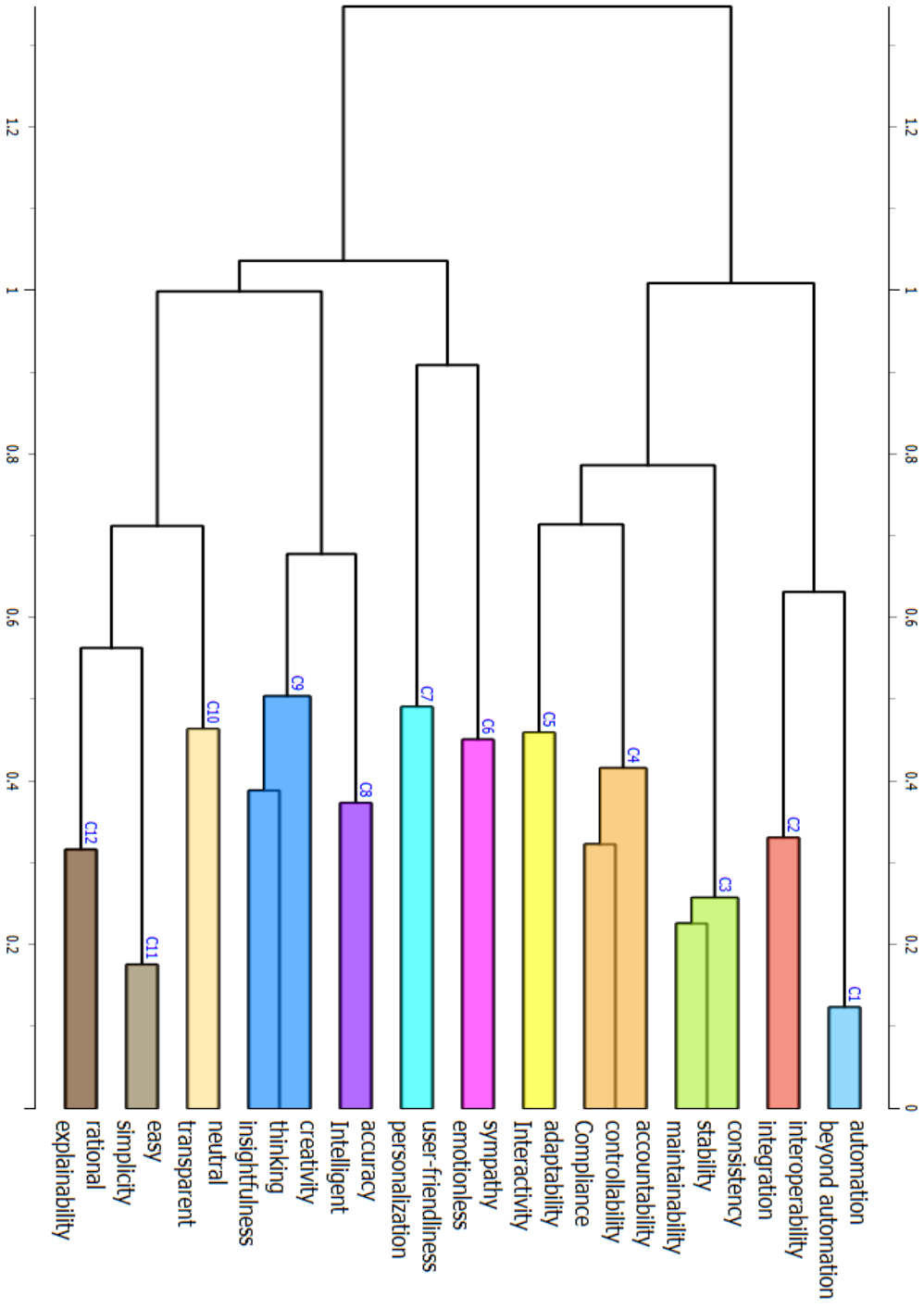



Fig. 33: Clusters of Generative AI Characteristics Using Hierarchical Clustering Algorithm

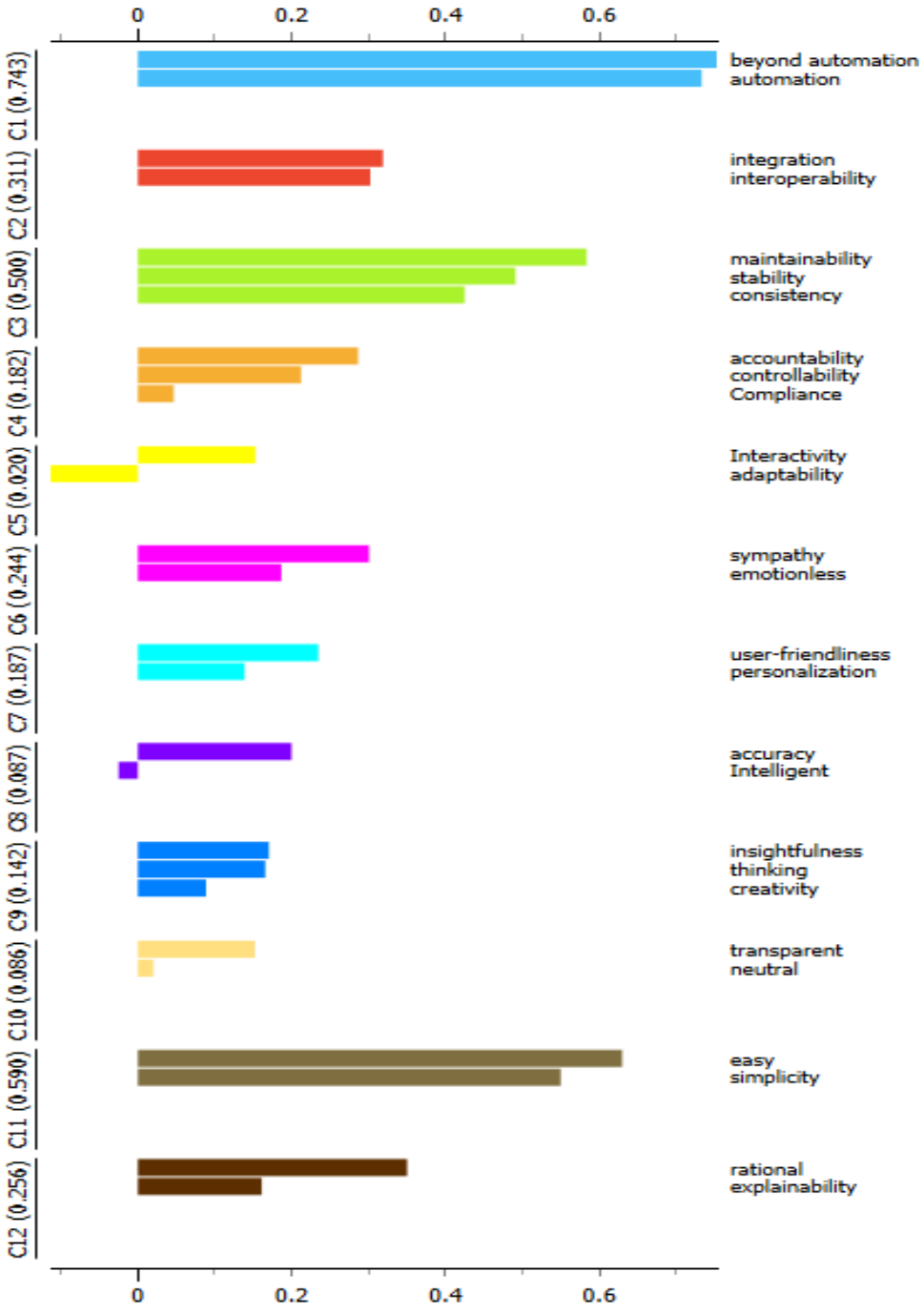



Fig. 34: Silhouette plot for Hierarchical Clustering Results (12 clusters): clustering 27 GenAI Characteristics

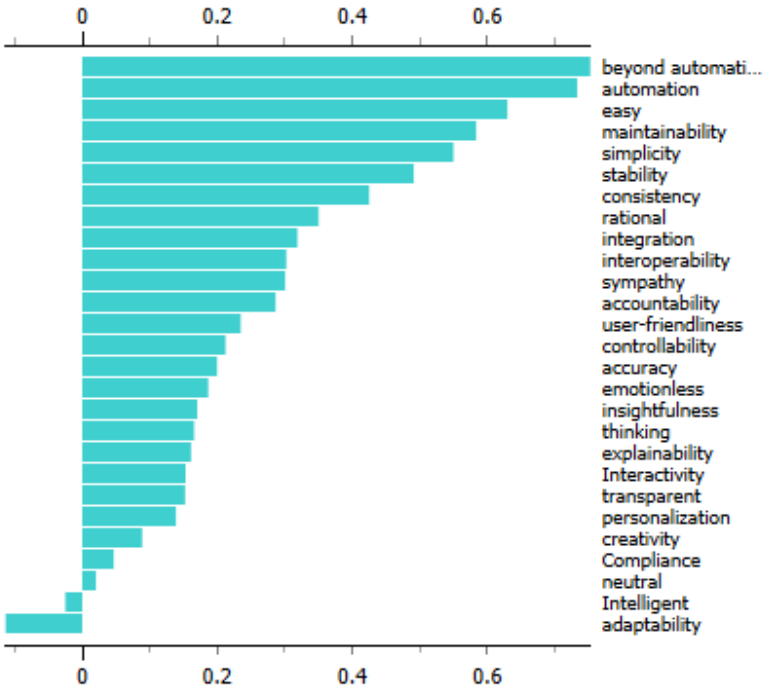



Fig. 35: Silhouette plot for Hierarchical Clustering Results (overall): GenAI Characteristics

The results of the Silhouette are identical to those of the hierarchical clustering, as shown in Figure 34. However, the Silhouette scores, as they appear in Figure 34 and Figure 35, which display the results of the clustered characteristics and the overall characteristics respectively, indicate that two characteristics —namely: "intelligent" and "adaptability"—have a negative score. This implies that they appear in incorrect clusters and have the features of the incorrect clusters. Thus, this study further assesses the components of the cluster by using the t-SNE. The study illustrates t-SNE's performance, preserving both structures, the global and local, as shown in Figure 36 and Figure 37 respectively. Since the "intelligent" characteristic is located closer to the characteristics of "insightfulness, thinking, and creativity", and at a distinct distance to the "accuracy" characteristic, when preserving the global and local structures, therefore, this study decides to group "intelligent" with the cluster of the characteristics "insightfulness, thinking, and creativity", as its attributes

hold a similar meaning. This results in keeping the characteristic "accuracy" in a stand-alone cluster.

As for the characteristic "adaptability", although its Silhouette score is negative, their distance appears close to "interactivity" in the t-SNE plot. Therefore, the study decides to separate them from their cluster to keep both of the unique characteristics of GenAI in a stand-alone cluster.

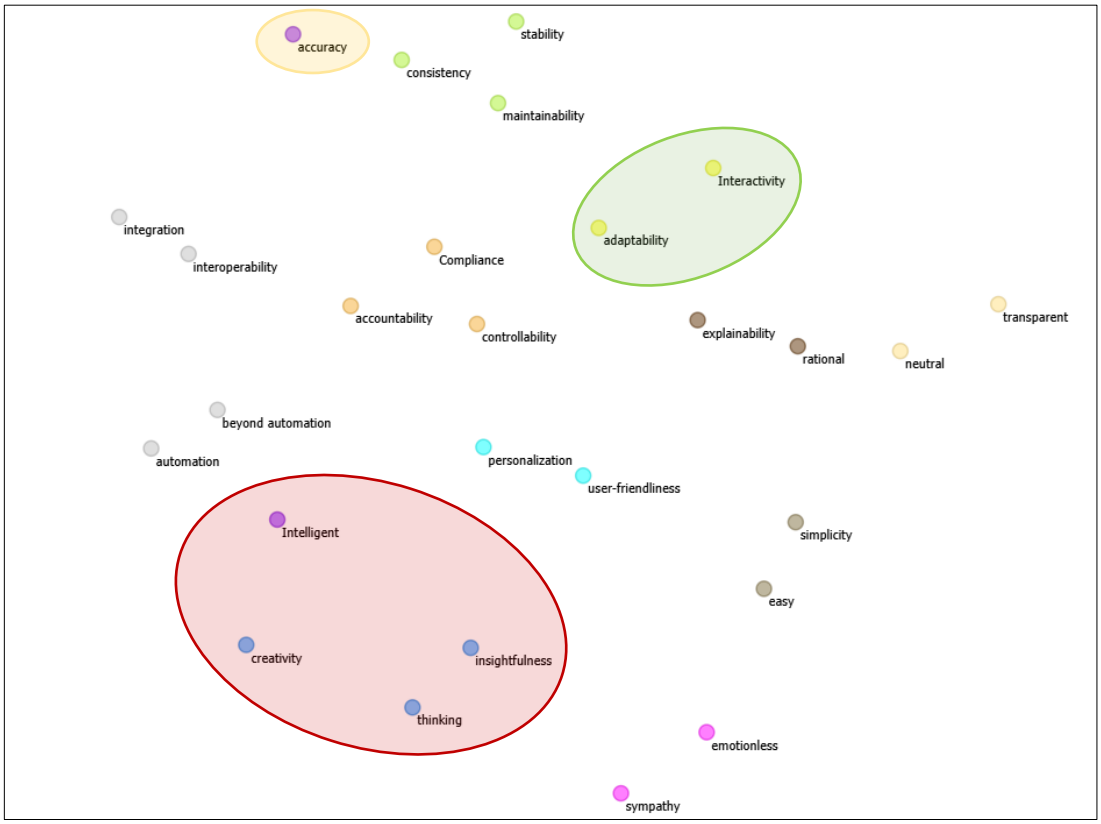



Fig. 36: t-SNE: Preserving Global Structure

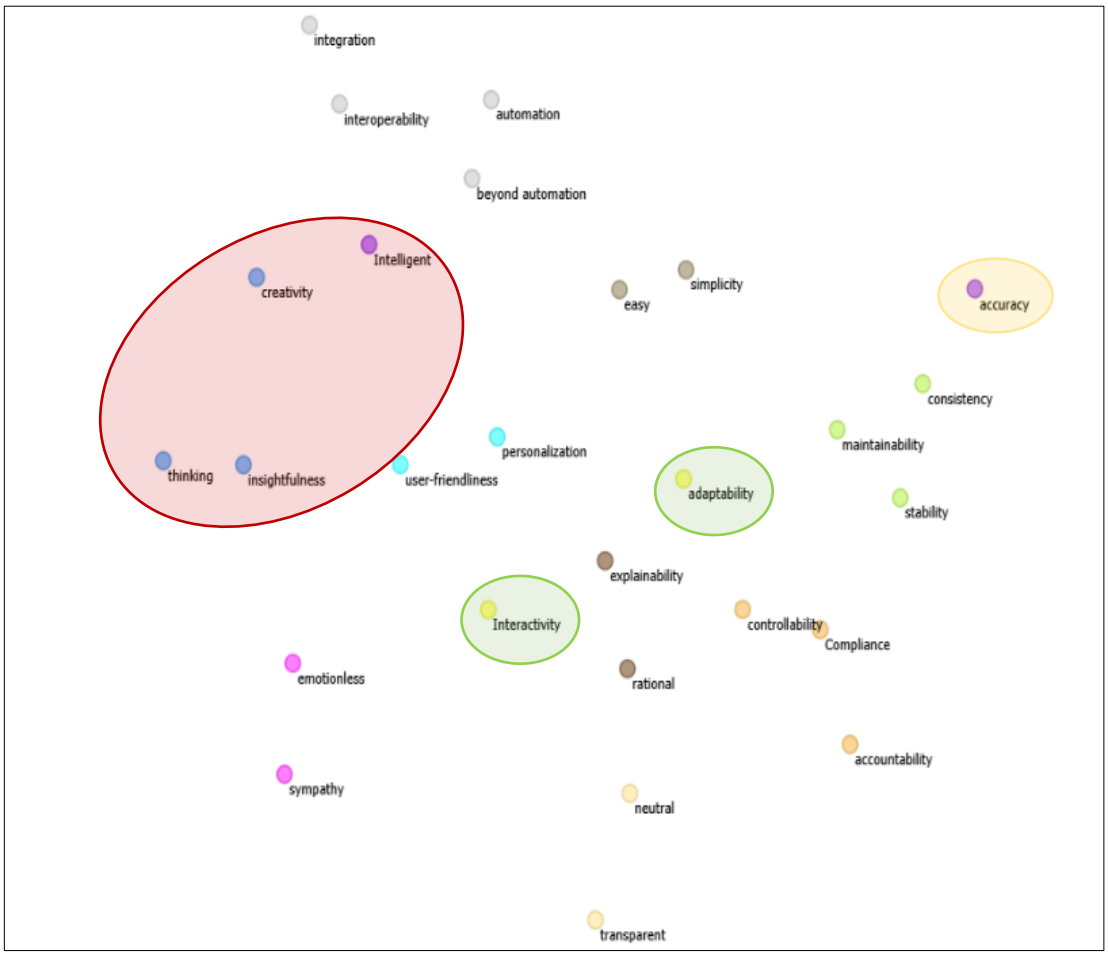



Fig. 37: t-SNE: Preserving Local Structure

#### 4.2.1.3.2.1.1 Themes of Generative AI Main Characteristics

According to the analysis of the previous sub-section, the study identifies themes for the 13 clusters of the 27 GenAI characteristics based on the outcomes of the hierarchical clustering, the Silhouette score, and t-SNE, as indicated in Table 54.

This sub-section discusses the 13 themes of the clusters of GenAI characteristics, also referred to as main GenAI characteristics. It is important to mention that the interview respondents referred to AI and GenAI interchangeably.

Table (54): Generative AI Main Characteristics

| Clusters | Themes | Characteristics |
|---|---|---|
| CC1 | **Autonomous** | Automation<br>Beyond-automation |
| CC2 | **Integrated & Interoperable** | Integration<br>Interoperability |
| CC3 | **Stable & Consistent** | Maintainability<br>Stability<br>Consistency |
| CC4 | **Reliable & Controllable** | Accountability<br>Controllability<br>Compliance |
| CC5 | **Interactive & Reactive** | Interactivity |
| CC6 | **Adaptable & Adjustable** | Adaptability |
| CC7 | **Dispassionate & Emotionless** | Sympathy<br>Emotionless |
| CC8 | **Customized & Personalized** | User-friendliness<br>Personalization |
| CC9 | **Accurate** | Accuracy |
| CC10 | **Smart & Innovative** | Intelligent<br>Insightfulness<br>Thinking<br>Creativity |
| CC11 | **Transparent** | Transparent<br>Neutral |
| CC12 | **Simple** | Easy<br>Simplicity |
| CC13 | **Logical** | Rational<br>Explainability |

### *1. Autonomous (CC1)*

GenAI can act independently once the process is automated, which frees up a project team member to focus on more complex activities and creative aspects of the project. For instance, it can help with stakeholder management as these tools can enhance collaboration, generate meeting minutes automatically, get insights, and send out reminders automatically. In this context, AIR5 remarked, *"You just have to automate the process."* AIR1 added, "*It can also automate routine tasks of documentation, freeing up team members to focus on more complex and creative aspects of the*

*project."* AIR5 added, *"I will just emphasize the importance of task automation, we have many tasks that are automated which frees up a PT member to focus on more complex activities."* AIR9 added, *"It can really help with stakeholder management with tools that can enhance collaboration, generate our meeting minutes automatically for us, get insights for us, send our reminders automatically."*

Respondent AIR3 gave an example of how they utilize their own product called *"Nora Knows" in automatically obtaining the needful information, "For example, in our products, Nora knows, it's not a matter of saying, okay, how many leaves do I get? The system will automatically use AI to contact the HR system, and then it's going to give you the information."*

Respondent AIR2 added that GenAI acts beyond automation, *"It's more than automation, it's like human thought."*

***2. Integrated & Interoperable (CC2)***

GenAI can be connected to and integrated into external bodies, as remarked by AIR2, *"AI helps you to come up with outcomes, or let's say try to connect the dots between the data and try to come up with a new thought."* GenAI is interoperable and easy to integrate with, depending on the tool and the way one would like to utilize it because AI, as a teammate, is able to be integrated into the workflow. In this context, respondent AIR6 remarked, "*It's very interoperable, very integrable."* According to AIR1, *"It's important to know that with GenAI, the LLM, we don't talk about datasets provided, but how we can integrate that with the LLMs."* AIR5 added, *"It will depend on the tool and how you want to use it, where you are using it because it will be embedded in the workflow, AI, as a teammate will be integrated into the workflow."*

Moreover, respondent AIR3 gave an example of how GenAI enhances the performance of the systems when integrated with other systems or tools, *"Notion is a tool, project management tool. It's a multipurpose tool for any project that you have. And I noticed that before AI integration with Notion, let's say the board was not that clear. And now it's much, much more professional, clear, and it is straightforward."*

***3. Stable & Consistent (CC3)***

According to the respondents, the integration of GenAI into project teams will enhance the team's performance in terms of consistency since GenAI is stable and consistent, unlike humans; human consistency fluctuates. In this context, respondent AIR1 highlighted, *"AI is consistent, and human consistency fluctuates."* AIR6 added, *"It absolutely can be more stable."* Respondent AIR6 said, *"PTs have consistency challenges in meeting schedules because teams are made up of multiple people and things can go wrong"*.

***4. Reliable & Controllable (CC4)***

GenAI is responsible and can be depended on for PTs. In this context, AIR1 remarked, *"The role we're going to get, at what stage AI will take more responsibilities and diminish humans."* Besides, GenAI is controllable and can comply with the rules to reach the desirable outcomes. For instance, when the GenAI follows guidelines, the model becomes controlled by such guidelines, and hence, the output is guaranteed to be reliable. In this context, respondent AIR5 remarked, *"So, if it's at the beginning, at the technical level, it is like, ethically, the ethical guidelines are controlling this model, and the model output is guaranteed to be okay, so once it's embedded in the workflow, it should not be an issue. No one can manipulate the output of the model. Usually, AI would be a problem when*

*it's open and it's very general to be used."* AIR2 remarked, *"Actually, the results, the time which will be consumed to analyze real data. Of course, it's way advanced from what humans can deliver. So, these results will help, let's say, mandate such tools in order to comply with time, reduce time, and reduce accuracy errors."*

***5. Interactive & Reactive (CC5)***

GenAI is an interactive body that interacts with different bodies in several ways. In this context, AIR2 remarked, *"The concept of human-AI models are interactive because we are using many AI models in the world, like Copilot."* Moreover, respondent AIR3 explained how GenAI can interact and react to situations by giving an example of multi-agents interacting in a controlled environment: *"When you have two different AI agents and they have two different worldviews, their wisdom is coming from two different places, you can see them actually interacting."*

***6. Adaptable & Adjustable (CC6)***

GenAI is adaptable as it can adjust to different situations and scenarios. Many respondents emphasized how easy it is for GenAI to adapt to a corporate environment. In this context, AIR6 remarked, *"One of the characteristics that stand out to me today is the fact that it is as a technology, if you will, it is very easy to adapt."* AIR1 added, *"AI is created to adapt and mimic human beings."* AIR5 said, *"An AI tool is easier to adapt and learn than a human being because it performs predefined tasks."* AIR6 added, *"It's, in general, easy to adapt to a corporate environment."*

***7. Dispassionate & Emotionless (CC7)***

GenAI is emotionless. GenAI will not have good days and bad days in terms of their mood, unlike humans and the mood of the human. AI will not have such problems with feelings. In this context, AIR2 said, *"Let's say, the*

*mood of the human, AI will not have such problems with feelings and errors."* AIR2 continued, *"AI is doing what it's supposed to do without any feelings or involvement of feeling."* AIR3 added, *"AI agents basically escape all the drama that you have in human beings, such as their mood and everything, if you perfect this operation."*

However, a respondent has remarked that since GenAI can simulate human behavior, it can show behaviors of sympathy by simulating some emotions. In this context, AIR4 said, *"GenAI can be considered as having emotions and not having emotions because GenAI now can simulate emotions."* The respondent explained further by giving an example of how ChatGPT can reply with emotional responses rather than logical ones and turn the conversation into a purely emotional one, sympathizing with the human user: *"So, when one asks it a logical question and then just dives deep into emotions, it would also dive deep into emotions."*

### *8. Customized & Personalized (CC8)*

GenAI can personalize the user's experience, making it much easier to use. Some respondents mentioned that one of the biggest strengths of GenAI is that it is easier to customize and is very user-friendly, and OpenAI's ChatGPT is an ideal example. Other respondents explained how a conversation with GenAI one can have while it saves one's profile. These benefits can enhance the collaboration between team members when working on projects. According to respondent AIR6, *"I think one of the biggest strengths of the GenAI, and OpenAI's ChatGPT is an ideal example, is that it is very user-friendly."* AIR14 said, *"It is capable of personalizing. As long as you're logging in using a username, it can save you, it can build a profile for the person, and understand based on the memory that is set."* AIR5 added that GenAI is easier to customize: *"AI teammates can be personalized much better than human beings. If you, let's say, have a*

*repetitive task, this AI teammate can be personalized to the task, to the job, better than a human being."* AIR3 remarked*, "When AI comes into the picture, because it has the capacity to understand people and their attitude and their behaviors, it'll be the ultimate piece in the middle. It's going to be able to personalize everybody's experience."*

However, some respondents revealed the challenges of GenAI personalization and the fact that it can sometimes learn the wrong way, either when being fed with biased information or being used by different members of the team. The GenAI, in those cases, cannot differentiate between what's right and wrong. Thus, this necessitates reteaching the GenAI model to fix the customization aspect of it, making it learn again the right way. In this context, respondent AIR5 remarked, *"In the personalization of AI teammates, you always have to be careful that if the AI model goes in a specific direction, it will not have the strength of a human being to differentiate if it's always biased."* AIR14 added, *"Every time I prompt to write a certain letter, it ends with writing the name of another person in the signature because once I copy-paste the name of the other person, it now recognizes me as someone else. This is just an example of how it might learn the wrong way. So, we need to reteach or make it learn again to fix the customization aspect of it."*

***9. Accurate (CC9)***

The decisions of GenAI enhance the accuracy of results presented by PTs that incorporate GenAI as a team member while working on projects, in terms of enhancing the precision and reducing the errors. Many respondents emphasized the fact that the level of accuracy that GenAI can reach is much better than what humans can deliver. Besides, improving the accuracy of tasks can make project management much more effective by correctly and responsibly using GenAI to do technical, detailed routine

work. In this context, AIR4 said, *"It will improve accuracy."* AIR6 remarked, *"It can make project management much more effective, much more accurate by correctly and responsibly using AI and other forms of technology to do the technical, detailed routine work."* AIR2 commented, *"The accuracy is way better than what humans can deliver."* AIR8 added, *"GenAI presents faster and more accurate results because it can handle more certain data and more historical data to make a decision."* AIR8 continued, *"The decision is more accurate, and then you can reach an accuracy that you never dreamed about because you cannot do it by yourself. Or maybe you can take months to reach that."*

However, one should not take the output of GenAI without verifying it. During the collaboration with GenAI, someone will have to oversee the output of the GenAI and evaluate it, as sometimes GenAI makes errors, even when it seems to be confident when providing outputs. In this context, AIR15 remarked, *"GenAI models sound clear; they sound confident and accurate, and they are probably right most of the time. But you need an expert eye to make sure that what the model is saying is actually correct. So, there is a human reasoning element to it."*

***10. Smart & Innovative (CC10)***

GenAI is smart and intelligent, and its intelligence can be seen in several aspects throughout the collaboration in project teams, enhancing the project outcome. However, its smartness or intelligence comes from what humans feed it. In this context, AIR3 remarked, *"The one thing that everybody agrees on about GenAI is the ability to give the machine the capability to compete with human beings in terms of intelligence, be it planning, be it writing, be it action-wise. It's a very big spectrum, but the one thing that we all agree on is giving it the qualities to be intelligent."* Some respondents mentioned how GenAI can think, and by using the "chain of thoughts", one

can lead GenAI towards a certain way of thinking. In this context, AIR4 mentioned, *"For example, you can give it a specific thing to think about and then another thing to think about, and then you can give it your question."*

Moreover, GenAI is insightful, as it enhances the project lifecycle by providing tools and insights that will improve decision-making, optimize resource use, mitigate risks, and streamline processes. In this context, AIR5 remarked, *"It enhances the project lifecycle by providing tools and insights that will improve decision-making, optimize resource use, mitigate risks, and streamline processes."* AIR5 continued*, "When you have AI-driven tools that can continuously monitor project performance against key metrics, they can provide real-time insights and alerts. If the project deviates from the plan, it will help you with quick corrective actions."*

Furthermore, several respondents mentioned the creativity and innovation of GenAI that is seen in the ideas and content it generates. In this context, AIR5 remarked, *"It will foster innovation and creativity, as simple as idea generation."* AIR10 added, *"Now with GenAI, what we do is we innovate based upon the existing data."*

***11. Transparent (CC11)***

GenAI is transparent and integrating GenAI in PTs will enable PTs to present the actual status of projects to the management, which can then build their decisions grounded on accurate information. In this context, AIR2 commented, *"When it comes to big projects, people, let's say, try to hide the facts or the actual progress when it comes to delivery or completing milestones. When you integrate it with the AI model, or let's say feed it to the AI model, they will be all clear, visibility clear, what is actual, which is*

*not giving the higher management fake information or results that they build their strategic decision in it."*

***12. Simple (CC12)***

GenAI is designed to be simple and easy to use. As mentioned by the respondents, it is noticed that the accelerated growth of ChatGPT was based primarily on the fact that it's the first tool that has come to market that is designed to be easy. It's a very simple user interface. Some respondents commented on how data scientists who build the GenAI models are responsible for building a very simple interface for the users. Respondent AIR6 remarked, *"I believe the accelerated growth of ChatGPT was based primarily on the fact that it's the first tool that has come to market that is designed to be easy. It's a very simple user interface."* According to AIR8, *"The AI expert needs to and is making now a lot of effort to give the simplest interface to the other domain expert, it gives a very simple interface."*

***13. Logical (CC13)***

GenAI is logical and rational. According to AIR6, *"New GenAI tools more than anything ever before, to, in essence, think, process, rationalize and generate results as people do."*

#### 4.2.1.3.2.2 Clusters of Generative AI Abilities

It is worth mentioning that some of the GenAI abilities have similar meanings which can be grouped under one group. Accordingly, this study clusters the 37 GenAI abilities that the interviews revealed using the hierarchical clustering algorithm until it considers several clusters where it is possible to grasp each of its components.

The study identified 12 clusters for the pre-defined GenAI abilities, as shown in the Dendrogram in Figure 38. Furthermore, to evaluate the study's clusters of abilities produced by the hierarchical clustering technique and

the clusters to which the abilities belong, the Silhouette index is used to illustrate the hierarchical clustering results, as illustrated in Figure 39.

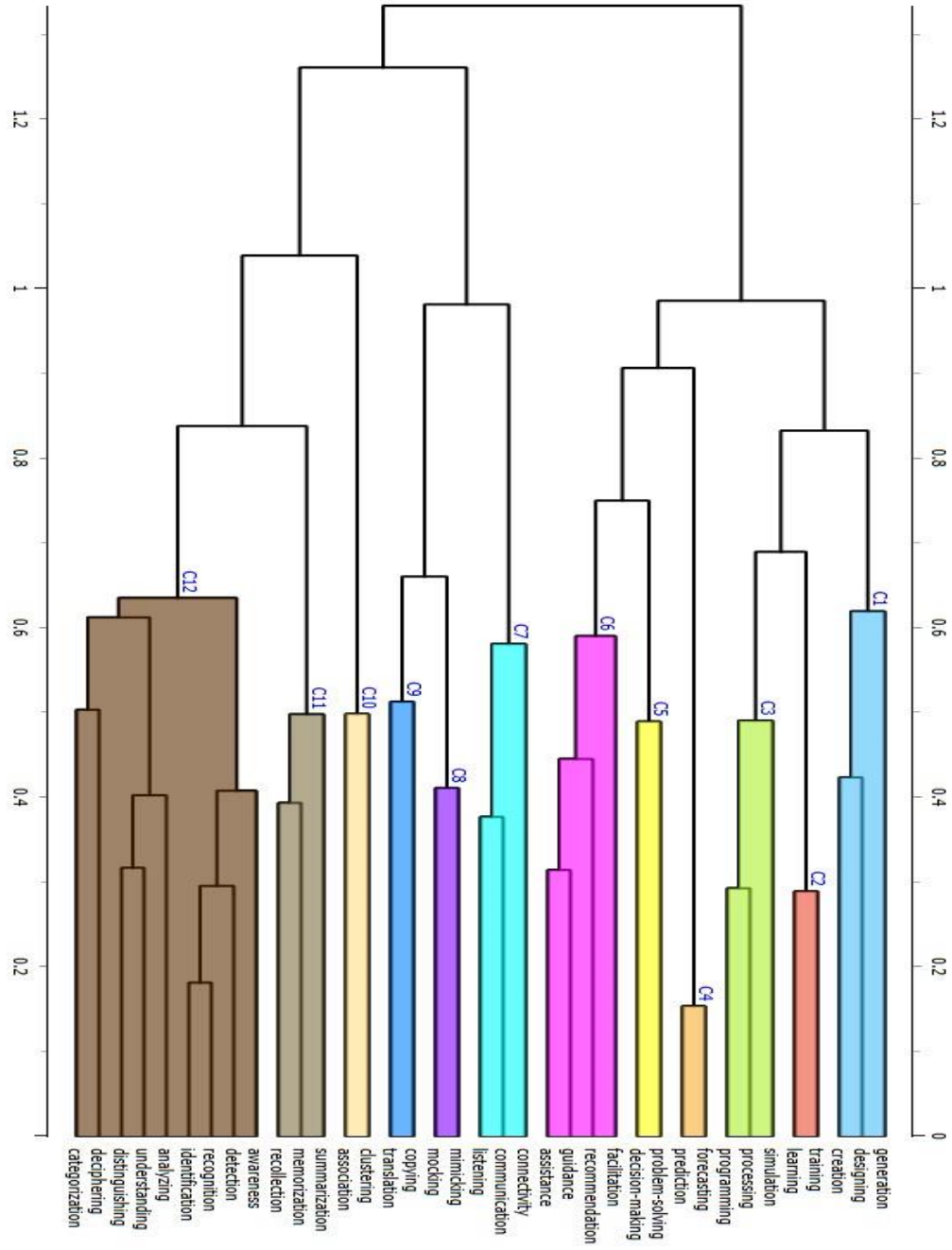



Fig. 38: Clusters of Generative AI Abilities Using Hierarchical Clustering Algorithm

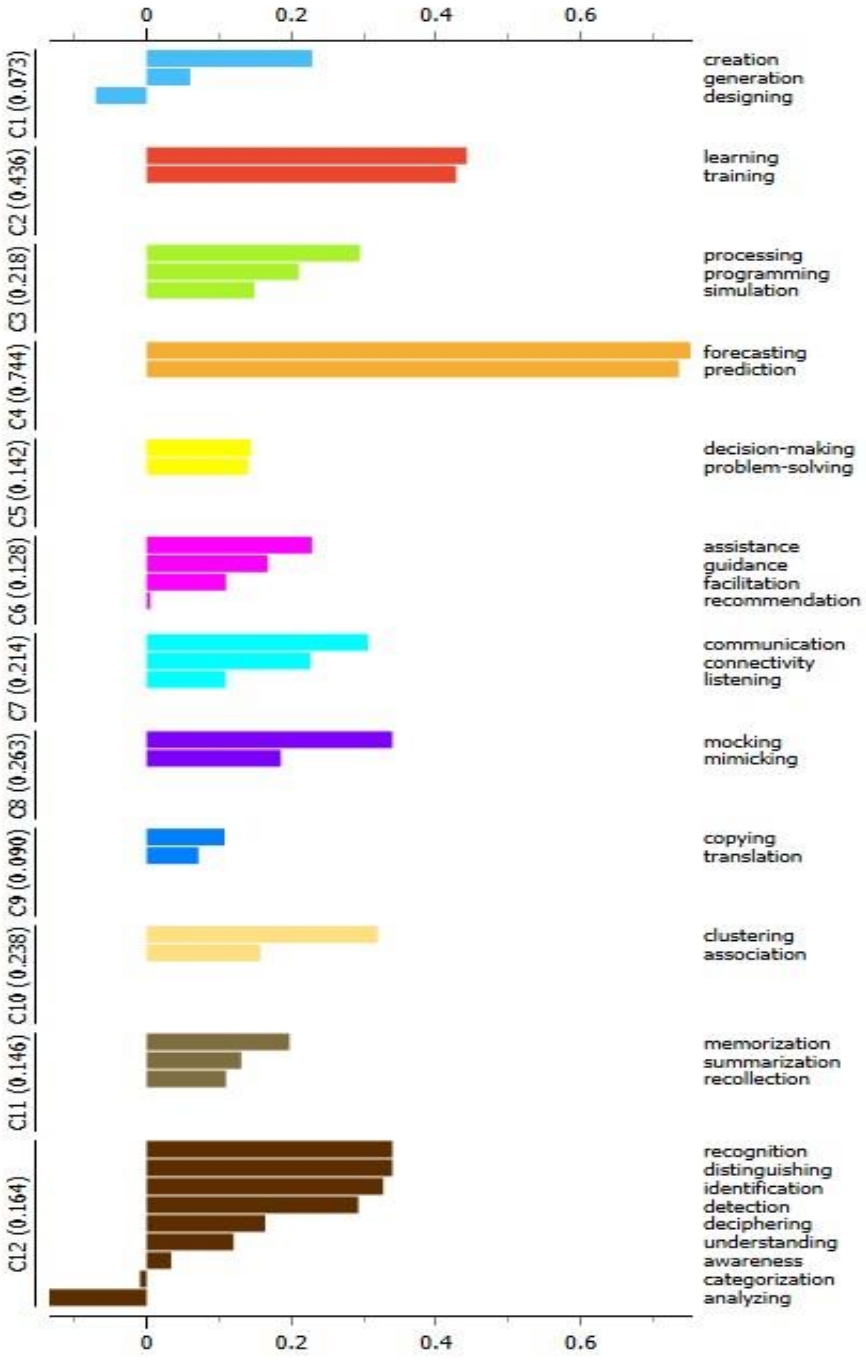



Fig. 39: Silhouette plot for Hierarchical Clustering Results (12 clusters): clustering 37 GenAI Abilities

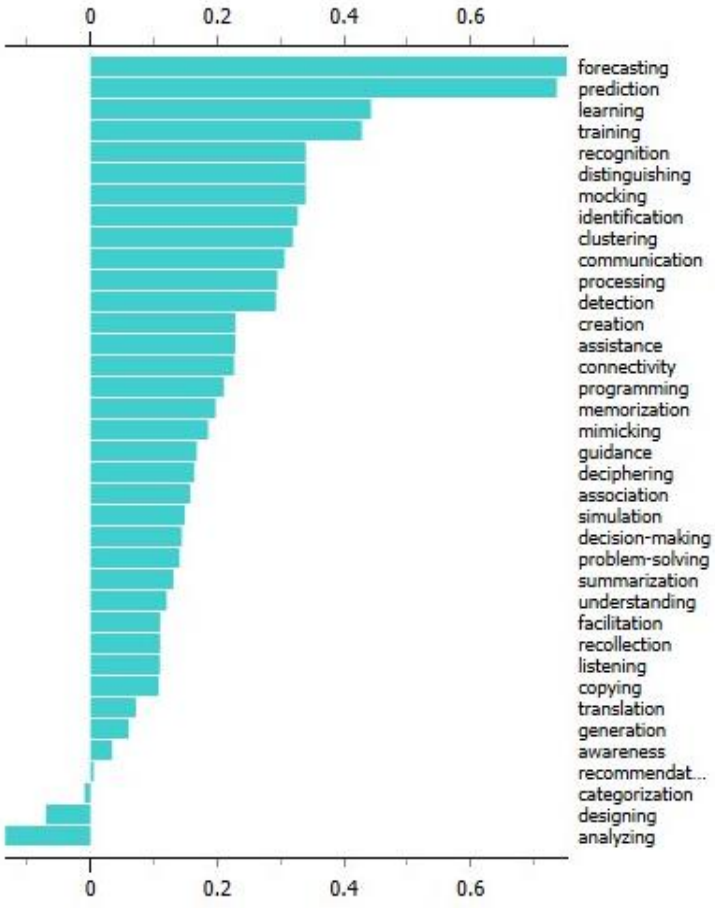



Fig. 40: Silhouette plot for Hierarchical Clustering Results (overall): GenAI Abilities

The results of the Silhouette are identical to those of the hierarchical clustering, as shown in Figure 38. However, the Silhouette scores, as they appear in Figure 39 and Figure 40, which display the results of the clustered abilities and the overall abilities, respectively, indicate that three abilities—namely: “designing”, “categorization”, and “analyzing”—have a negative score. This implies that they appear in incorrect clusters and have the features of the incorrect clusters. To guarantee uniformity in the clusters based on semantic analysis and provide an improved representation of their findings, this study removes these undesirable attributes. Thus, the study exclusively re-clusters the 34 GenAI abilities, as Figure 41 illustrates.

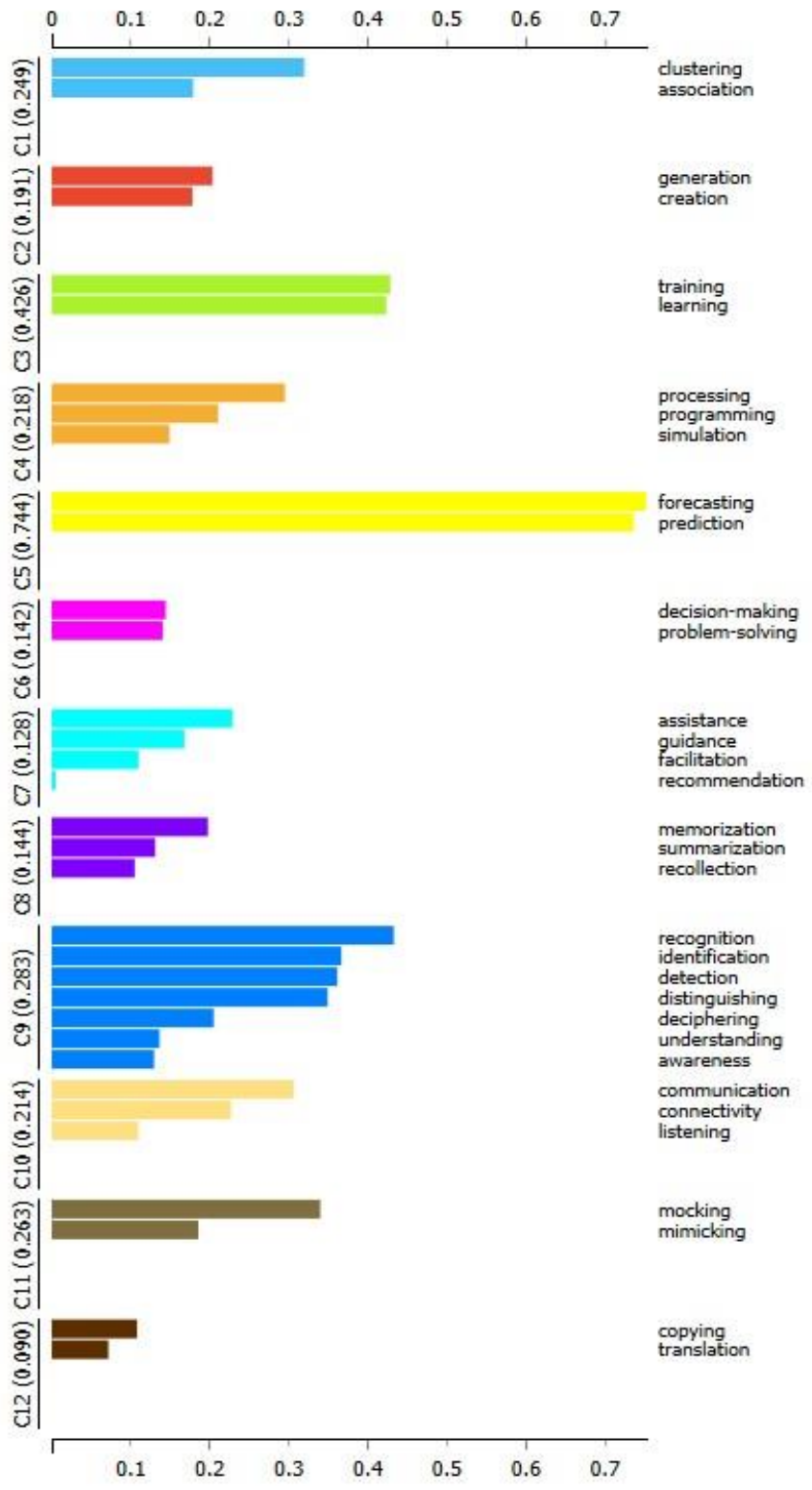



Fig. 41: Silhouette plot for Hierarchical Clustering Results (12 clusters): clustering 34 GenAI Abilities (amended plot)

However, by investigating the results of the Silhouette plot further, we find that C12 which consists of the two abilities “copying” and “translation” has the worst score (0.090), as shown in Figure 41. Knowing that a Silhouette score that is near 0 implies that the data point may belong to another cluster, this study further assesses the components of the cluster by using the t-SNE method.

This study illustrates t-SNE’s performance, preserving both structures, the global and local, as shown in Figure 42 and Figure 43 respectively. Since the “copying” ability is located closer to the abilities of “mimicking” and “mocking”, and at a distinct distance to the “translation” ability, especially when preserving the global structure, therefore, this study decides to group the ability of “copying” with the abilities of “mocking and mimicking”.

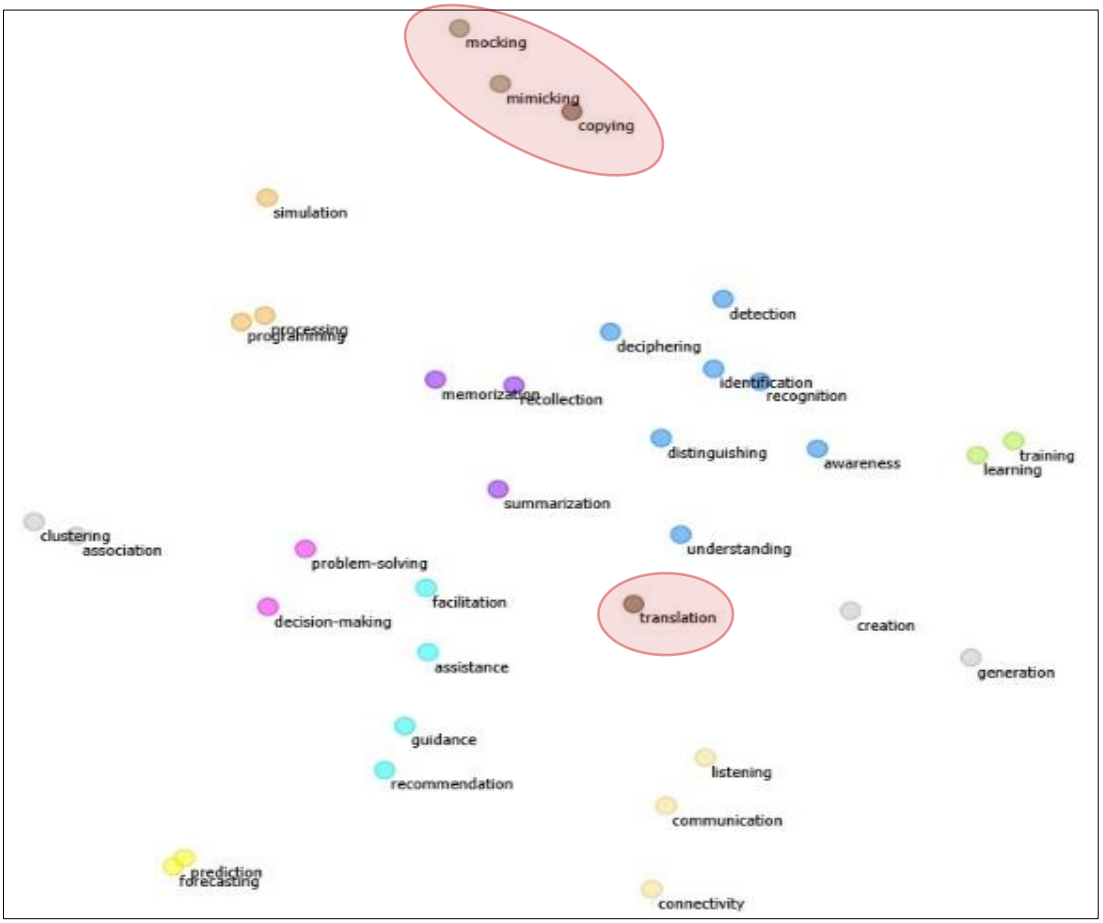



Fig. 42: t-SNE: preserving Global Structure

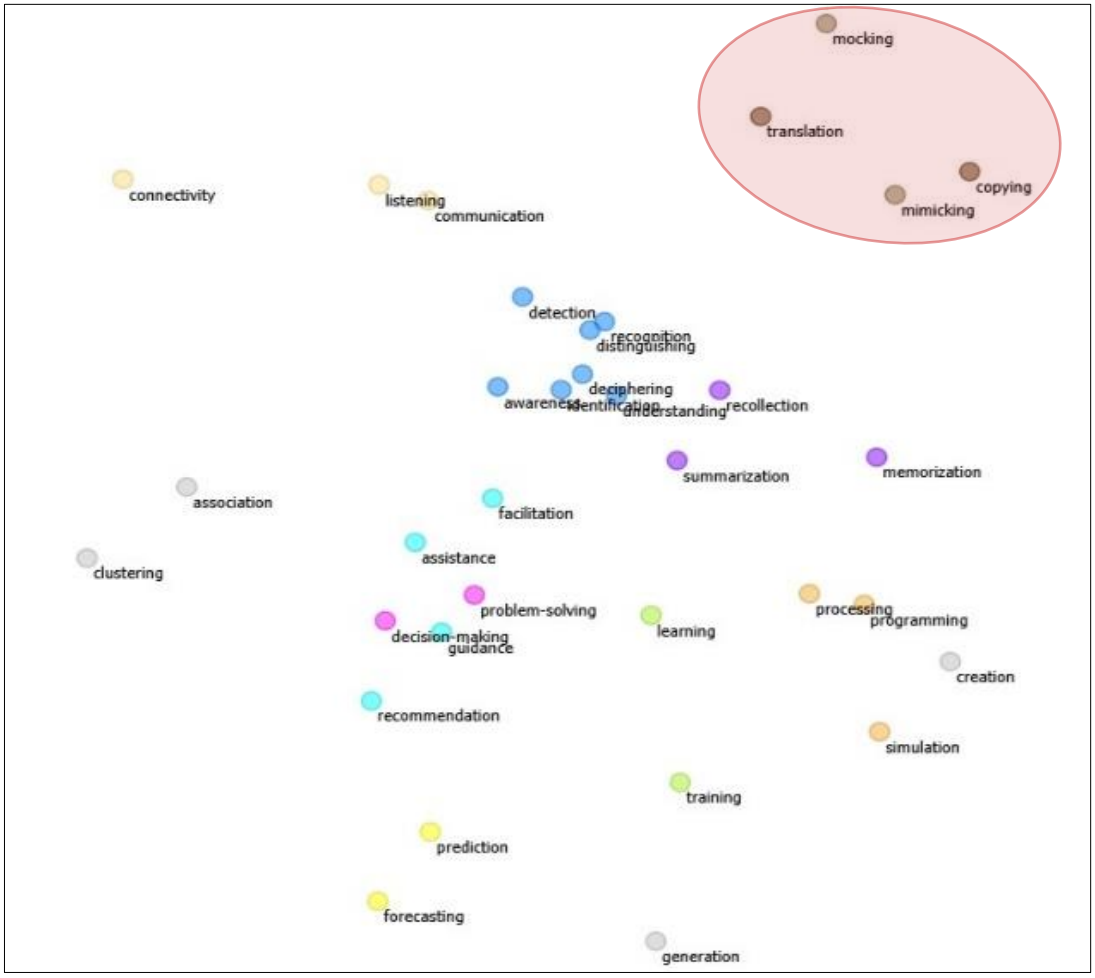



Fig. 43: t-SNE: preserving Local Structure

#### 4.2.1.3.2.2.1 Themes of Generative AI Main Abilities

According to the analysis of the previous sub-section, the study identifies themes for the 12 clusters of the 34 GenAI abilities based on the outcomes of the hierarchical clustering, the Silhouette score, and t-SNE, as indicated in Table 55. This sub-section discusses the 12 themes of the clusters of GenAI abilities. It is important to mention that the interview respondents referred to AI and GenAI interchangeably.

Table (55): Generative AI Main Abilities

| Clusters | Themes | Abilities |
|---|---|---|
| AC1 | **Categorization** | Clustering<br>Association |
| AC2 | **Content Creation** | Generation<br>Creation |
| AC3 | **Learning & Training** | Training<br>Learning |
| AC4 | **Computation & Processing** | Processing<br>Programming<br>Simulation |
| AC5 | **Prediction** | Forecasting<br>Predicting |
| AC6 | **Decision & Solution** | Decision-making<br>Problem-solving |
| AC7 | **Assistance & Recommendation** | Assistance<br>Guidance<br>Facilitation<br>Recommendation |
| AC8 | **Information Recollection** | Memorization<br>Summarization<br>Recollection |
| AC9 | **Situational Analysis & Interpretation** | Recognition<br>Identification<br>Detection<br>Distinguishing<br>Deciphering<br>Understanding<br>Awareness |
| AC10 | **Interaction & Communication** | Communication<br>Connectivity<br>Listening |
| AC11 | **Imitation** | Mocking<br>Mimicking<br>Copying |
| AC12 | **Translation & Transformation** | Translation |

### *1. Categorization (AC1)*

GenAI can categorize the data into categories or clusters, and associate the patterns using ML algorithms or models and DL models. Respondent AIR5 remarked, *"It can categorize data, cluster data, associate data, or predict data based on the previous data."* AIR5 continued, *"By using ML*

*models and DL models, you can learn the data patterns. And this learning technique can help you to create another clustering, identifying, associating, and regression models to deal with that."* Respondent AIR1 gave an example of how categorization is beneficial for the business when employing ML clustering algorithms: *"K-Means Clustering can cluster potential team members into groups based on similarities (e.g., skills, experience) and select members from different clusters to ensure diversity for a balanced team."*

### *2. Content Creation (AC2)*

GenAI can generate and create data, creating purely new content that cannot be identified from anywhere. With GenAI, you can create content, generate text, and generate images. Respondent AIR3 mentioned, *"A GenAI, by nature, is generative, which means it is somehow random every now and then. And this is what it glitzes it."* According to AIR2, *"It's like a learning model that can help you in designing the outcomes."* AIR10 said, *"Anything that you have never seen can be generated. Anything that you have never imagined is possible. Now that can be in the form of creating a new image, new text, new voice or audio."* GenAI can help with documentation, whether to produce documentation, meeting minutes, or governance work.

In this context, respondent AIR16 remarked, *"Some of the things we can do is to ease up the documentation and have something that will produce the documentation, produce the meeting minutes or the governance work. One of the biggest issues in projects is mainly documentation, and probably one of the easiest things to do is to ensure that documentation is at least produced effectively. So, minutes of meeting, summaries of meetings and things of that sort can be done by GenAI."* AIR3 added, *"With GenAI, you have the ability to create content, to generate text, to generate images. As*

*you can understand, the applications are huge, and the majority of what we do as human beings revolve around language and text, even visual stuff is. And nonetheless, most of the stuff that we do generative-wise can also apply in images and they can apply in text."* AIR5 added, *"GenAI is a step higher, which by using that amount of data and parameters used in the LLM, transformer models, the generative adversarial networks (GANs), neural networks, and DL models, it can create data, purely synthetically generated data, from the data. So, you have new data which has never been there before; generating new data from huge amounts of data, like what you see in ChatGPT."*

Moreover, using GenAI in project teams would help in generating ideas and improving products and services. According to respondent AIR5, *"The professional development of the team will become much easier using AI."* Respondent AIR5 added, *"Using GenAI would help you in generating ideas, and improving products and services, and of course, the professional development of the team will become much easier using AI."*

Although GenAI models are very powerful, successful, and useful, and many of their applications are widely used across several domains, in security, multimedia, medicine, and defense, to name a few, they have several drawbacks. Many respondents mentioned the negative aspects of data generated by GenAI, as data can be purely synthesized. One of the problems is that these models must be used ethically because you can generate fake data of human beings and misuse the data. In this context, respondent AIR8 mentioned, *"The one problem I can see is that these models must be used ethically because you can generate fake data of human beings."* The same thing happens with creating voices or creating new books. For example, you can write a book now using GenAI, and no one can identify who wrote it. In this context, respondent AIR5 remarked*, "You*

*can ask the model to create a face, a photographic face, or a real face of a person that does not exist in reality. This knowledge is based on accumulative ML that happens in the hidden layers of the DL models. And it came up with this new content. The same thing happens with creating voices, creating even the author attribution, and creating new books. You can write a book now using GenAI, and no one can identify who wrote this,"* and continued, *"After a few years, all market trends will be generated using AI."* Yet the pros and cons, as well as the level of generating data, depend on the scenario and the reasons behind content creation. In this context, AIR3 mentioned, *"These systems are now going to be tweaked in this fashion depending on the domain they're in. For instance, if you're doing a LLM for a company that offers lyrics or music generation, it might dial up the whole conversation all the way up, so that you basically can generate great music. But on the other hand, if you have things that cannot tolerate any inconsistency or verification, you will need to dial down the whole generative, creative part, so that you can control the operation."* Yet, it is very important to generate more data to be able to train the generative models so that the models will be able to differentiate between fake and real data. In this context, AIR8 said, *"We have to generate more and augment the data so that we can train our models and have reasonable performance."* AIR8 continued, *"For example, I want to create a system that will detect fake tumor images in a medical system in the hospital. How will I do it? I will take the real images, and I will use a generated model to create or extract from these real images, fake images. Then I will train the model, and which model I will use is my choice, which will make the difference. It will be trained on what is fake and what is real. And then the system will know the difference between fake and real." Finally, AIR8 concluded, "So, you cannot get rid of the generative models."*

### *3. Learning & Training (AC3)*

GenAI can continuously learn and act as a learning method. It can continuously learn about the current project in project management and improve many things throughout the process of the project lifecycle, such as risk management, resulting in better performance of the PT and, hence, project success. In this context, AIR13 remarked, *"It is kind of continuous learning about the current PT and project management and improvement at the same time, and it's an ongoing thing."* According to AIR1, *"AI will learn from previous experiences and understanding."* AIR5 added, *"Once you have an AI model that can learn from this data, you can manage risk better."* However, it is important to feed the AI systems accurate non-biased information to get the desired outcomes. In this context, AIR5 explained, *"That's why there is something called AI poisoning, where the models, which will continuously learn from data, you just try to give this model the biased information, continuous biased information, so you can make sure that the model will always go to that bias or to push towards specific narratives."*

Moreover, GenAI has to be trained to act, as mentioned by respondent AIR3: *"AI has to be trained to do actions"*, and training is one of the main abilities that GenAI possesses. Training GenAI in project management is very important. Since the process of project management contains a lot of detailed work, having to go back and look at the various schedules, track the work plans, track the Gantt charts, and a lot of various specifics can become a daunting process. GenAI is capable of performing many of these aspects, if not all. According to respondent AIR5, *"Technology, specifically AI, can be trained to do those repetitive scientific-technical analysis tasks honestly much better than people."* It is important to mention that the results of GenAI are determined by how it is trained. AIR2 said, *"How you train*

*AI will give you better results. The more trained, the more experienced, the more exposed to problems, it will help."* Furthermore, pre-built models can also be trained on new datasets, as mentioned by AIR1, *"If you go today and you look for pre-defined models for training, there are vast numbers of those algorithms that are pre-defined, especially on the open source, that's available in the market, that you can take and train. What you do with that the model is, since you have data, train, then test, and then evaluate and train and test and evaluate through self-learning or comparison with the previous models."* AIR2 continued, *"And also, the next level is to connect to the external body. The external body will help you to give more experience, will train it, and will give the model more enrichment."*

However, there will be concerning situations where the GenAI finds a new situation to which it has to respond. This will be a challenge for the system; if it isn't trained to deal with a particular situation, it will have to come up with a new action. In this context, AIR2 remarked, *"The only concern will be the expectation of outcome. So, if you are comparing human and AI models on what I will be expecting from both of them, in case they face this kind of situation or problem or whatever, so human they will, based on the brain power they have, they can expect something, how to solve the new problems. Maybe your AI model is mature enough to make such a decision. So that will be more accurate if they are programmed or let's say trained in a way that can give this kind of outcome. The challenge will be with the AI model, that you didn't train AI to deal with such a problem. So, it's a new, totally new. So, AI will try the assumption, and try possible ways to come up with the result. So that's only the difference."*

In addition, it is extremely important to also train GenAI models on non-biased data, as many respondents mentioned, to ensure that AI remains accurate and unbiased and to avoid false information that will not be

obvious in the beginning. In this context, respondent AIR1 remarked, *"This will not be very obvious right from the beginning. As you train the data based on those biased datasets, in the future, you will see the result of it coming."* Respondent AIR5 explained further, *"The output of this AI model will always be based on the data that it's generated from, where it was learned. So, if the data distribution is somehow biased, it will give you a biased outcome."*

### *4. Computation & Processing (AC4)*

GenAI is capable of performing computational techniques, and its processing power can process data and transform it into meaningful information or solve problems. According to AIR1, *"It is by using different algorithms to solve those problems, to react to them, and using different processing units to process them within the time that is required."* AIR1 continued, *"When you get to AI, the processing is far better, but one thing you have to be always conscious of is that if these models are built for your project, then it means a lot of engagement of algorithms and processes that will happen. If it is a pre-built model, it is something that is already in function for a similar function and similar sociality by others that you can take and fine-tune. That is, you don't go and build the whole model, but you amend it according to your requirements."* However, this will depend on which model you will use, what kind of GenAI capability you are looking for, and the nature of the project. Some respondents gave practical applications of how the processing power of GenAI is useful for project teams. According to AIR8, GenAI can be used to extract meaningful information from meetings: "*We can have very useful statistics about meetings, and then these statistics could be sent to other people."* AIR16 said, *"For example, for a development project, you can use a service that*

*will, for example, produce code for you or produce a connectivity string. There are certain challenges with that."*

Moreover, GenAI is capable of simulating scenarios to help in decision-making. In this context, AIR13 remarked, *"With GenAI, you can do a lot of stimulation from potential outcomes, planning, any measures of risk or something that you can take care of, depending on the input that we are basically putting in place."* Furthermore, the processing power comes at a cost. In enterprises, as much as you go deep into ChatGPT or into any GenAI, you will have to have the processing power, and that will add up to the cost of the project. According to respondent AIR4, *"With the processing power, you will have a huge investment. Although that investment will add some costs to your work, it will increase efficiency. But maybe, eventually, your investment will have a really good return of investment."*

### *5. Prediction (AC5)*

GenAI can predict or forecast, and forecasting results can be enhanced with more data. In situations of pattern recognition, the more historical data one has, the better the results. Only then can one get to the recommendation or forecasting in the intel. Many respondents highlighted the fact that GenAI can predict a learned situation accurately, superseding human capabilities. In this context, AIR2 mentioned, *"When it comes to the same level of problem thought or prediction, for sure the AI will be overriding the human thought."* AIR2 added, *"And if there is suspicious behavior, it can be predicted."* AIR4 remarked, *"Machines can have specific decisions, can forecast, and can do the things that humans can do."* Respondent AIR1 added, *"So, in the whole situation of pattern recognition, the more historical data that you have, the better it is. And then we can get to the recommendation or forecasting in the intel."*

Respondents mentioned examples of how GenAI helps the process of project management with its prediction ability. According to respondent AIR1, GenAI helps to predict project team members: *"Neural Networks can be used for predicting the best team composition based on historical data, learning patterns of successful teams, and applying them to new TF scenarios."* AIR1 added, *"Random Forest can be utilized to evaluate potential team configurations and predict their likelihood of success."* Respondent AIR5 remarked on how GenAI predicts market trends: *"It's more efficient now using ML models as simple as market performance, forecasting, and predicting market behavior."*

Prediction is extremely important for project management, as explained by AIR9, *"At the beginning of the project we are looking at a foresight, which means I want to see what will happen in the future and how can I manage. But this can maybe give me a deeper analysis of what has been done. Maybe there will be patterns that I as a person, I'm not able to recognize and the AI will be able to recognize. So, these were your weaknesses, these were your strengths, and these are the lessons to take further."* However, predictions result from clean datasets, as indicated by AIR1, *"Any successful algorithm will have clean and verified data behind it to predict the outcome."* AIR5 added, *"AI uses the old or the huge amount of data in a way that helps you to predict patterns based on the data. The model is learned from the data. So, whenever it sees unseen data, it can categorize it, cluster it, associate it, or predict based on the previous data. So, you are using the old data to predict what is coming based on the parameters."*

### *6. Decision & Solution (AC6)*

GenAI can act as a decision-making aid by taking action, making its own decisions and solutions based on data analysis. Respondent AIR12 said,

*"They can provide you with a solution."* Respondents emphasized the importance of GenAI integration into project teams for better decision-making and problem-solving; as AIR9 remarked, *"GenAI would be able to give us better solutions to the problems that we have."* AIR8 added, *"GenAI can handle more certain data and more historical data to make a decision."* According to AIR2, *"This will help the leadership to decide or build their assumption on actual data, which is directly fed to the model, and of course, the model will work on analyzing it and come up with the right measures that help the leadership to make their strategic decision."* Moreover, many respondents highlighted the speech in which the GenAI can make decisions, as GenAI decision-making ability is much faster than that of humans. In this context, respondent AIR5 confirmed, *"AI will have quicker decision-making."*

However, users should be aware of the several techniques used when dealing with GenAI to get good results, such as "the chain of thoughts" and "prompt engineering," as not everybody can get good results when using GenAI. In this context, respondent AIR4 remarked, *"Not everybody can get good results using AI, it's different from one another. Even if two people, let's say, use AI for a specific goal, each of them will get different results."* AIR4 continued, *"Prompt engineering is the art of dealing with AI,"* and AIR4 advised, "*ChatGPT cannot give you the result straight away. To deal with it, you have to have something called a chain of thoughts, for example, it's a methodology of how to deal with AI. For example, you can give it a specific thing to think about and then another thing to think about, and then you can give it your question. But you cannot directly ask it questions. So, there is a different way to deal with AI. And even if you want to ask it a question directly, you don't want to use the chain of thought, there are*

*different ways to deal with it. For example, you can give it a specific hint or context and then ask ChatGPT the required question."*

### *7. Assistance & Recommendation (AC7)*

In general, GenAI excels in assisting humans in different ways. In project management, it is important to use GenAI to help the PM and the PT with several tasks. In this context, respondent AIR4 mentioned, *"Whatever your work is, AI can help you."*

Besides, using AI will help you with analyzing real-time data. According to AIR12, *"It can help the project manager to write the project plan and how to organize the documentation."* AIR5 added, *" Using AI will help you to analyze real-time data. It helps much with the tracking progress of the like cost, resource usage, and all that."* AIR5 added, *" Once you start the project, it will help you have a bigger visibility because you are using an advanced tool that will help you to analyze quicker and analyze the bigger data."* AIR5 continued, *" Using AI will help you assess the future project based on the life cycle of the project itself."* In this context, AIR4 remarked, *"It can be a really great personal assistant."* AIR3 added, *"Technology can assist in mitigating some of the challenges that humans will create in the process."* Besides, according to AIR6, *"Technology can assist in mitigating some of the challenges that humans will create in the process. But at the end of the day, there are still those elements."*

Yet, it is important to understand that the assistance we get from GenAI is to help us with the project rather than replace project team members. In this context, AIR13 commented, *"GenAI is not to replace us, but to help and assist us in finalizing the tasks."* Respondent AIR5 added, *"You will have smart assistance, like systems, voice assistants, and chatbots, this will improve collaboration."*

### *8. Information Recollection (AC8)*

GenAI can be considered a source of knowledge for the vast amount of information it holds. AIR13 said, *"GenAI helps us in getting more learning, to have more ideas on some subjects and some projects."* GenAI relies on LLMs to assist with the search process and retrieve the needful information, as indicated by AIR1: *"An important part of going forward is to use the LLMs and APIs with project management."* When working in PTs, team members do not need to have all sorts of information if they can easily get it from a source that holds unlimited knowledge, as AIR15 said, *"Unlimited knowledge."* According to AIR1, *"Today in project management I'm sure many tasks are not dependent on your knowledge."* AIR9 added, *"GenAI, it's able to look at a wider range of sources."* AIR15 remarked, *"GenAI is a form of simplified search,"* and continued, *"In the past, when Google was invented, we had Google indexed all the pages and made them searchable through the Internet. But now we don't even need to go and search by page. GenAI would go and do that searching for us and give us the final assembled piece of information."* AIR3 remarked: *"With AI, it can basically summarize everything that you've done in the past, can tell you upfront what you've done and where you are."* AIR4 added, *"AI can summarize the stuff, AI can do a lot of good things in organizing all the mess that we make."*

Since GenAI can summarize, memorize, and recollect information from its history, the capacity of a project team will be enhanced when integrating GenAI. GenAI can summarize everything that happened in the past and can advise upfront what you have done in the project and where you are. The project team will not need to memorize or even remember most of the things that happened during the project. In this context, AIR13 commented, *"It*

*can help us to summarize the actions discussed and then share it with the people and with the teams."*

According to AIR3, *"They don't forget."* AIR1 commented, *"If you're looking at the Project Management, on memorizing, conjunctions between the certain calibers, we're looking at recollections, and we're looking at the processing, so here when we bring AI and then through the machine's abilities, we cover all those characteristics and overcome them by "n" number of times in terms of capabilities."*

Respondents highlighted the importance of data in providing knowledge, as AIR3 commented, *"Data is really important, and not to train the AI, but to give it access to knowledge, give it access to wisdom."* AIR3 continued, *"With semantic search, and this is where AI excels in currently with the GenAI space, you can have really accurate answers. A simple function in terms of concepts like search is going to be amplified and you're going to have very different results now."*

Besides, AI becomes knowledgeable when used with external bodies such as LLMs. According to AIR5, *"Using LLMs, which were trained on the general chat knowledge, then added to the organization or specific organizational data so the same chatbot that can communicate with you as a person. They have enough knowledge to communicate with you like a normal person."* AIR5 provided an example of GenAI: *"Like what we see in ChatGPT. ChatGPT was trained on the Internet, and they were trained on 1.7 billion parameters. This parameter, when you say parameter like facts, like general knowledge, all Internet knowledge or books, science fiction."*

However, according to AIR3, GenAI shouldn't be used heavily only as a source of knowledge: *"A lot of people are using it in a very wrong way, in*

*my humble opinion. They use it as a database to remember stuff, but it was not meant to be used this way, it was meant to understand language and then to decipher the language of humans and then to translate it to tasks or knowledge."*

### *9. Situational Analysis & Interpretation (AC9)*

GenAI can analyze situations, interpret them, and make decisions accordingly. GenAI takes the entire history, understands and learns from situations, and then detects any unusual behavior, as highlighted by the respondents. According to respondent AIR4: *"GenAI can classify the words to detect these words, extract them, and then transform them into text."* According to AIR1, *"GenAI takes the entire history, understanding and learning situations."* AIR9 said, *"If we were talking towards focusing more on the GenAI, I think, it's capability of not only collating information and retrieving information because that's what traditional search engines could do for us, which is retrieve information, but it should be able to retrieve, analyze, synthesize and come up with results out of that analysis and synthesis. That's not just regular collating data, but higher level of analysis and synthesis and coming up with effect, final results."* Several respondents emphasized that the analysis ability of GenAI is greater than that of humans, and, for this reason, it becomes important to integrate GenAI into project teams. Since project teams are interested in getting information about the project status, GenAI can be a great help for team members with real-time data analysis. Besides, GenAI will play a huge part in the post-project analysis. In this context, AIR2 remarked, *"AI is better than humans in terms of analyzing."* Respondent AIR2 added: *"Sometimes there are human errors when it comes to analyzing numbers, and data. These are all good indications and help the leadership to come up with a decision to support the involvement of such AI tools."* AIR2 continued, *"The power of AI comes*

*with analytics. Usually, these PTs are interested in getting information about the project status."* AIR3 remarked, *"If you're talking about GenAI specifically, it excels when it comes to understanding text, therefore, it's going to be very functional and very helpful across the whole journey."* AIR5 added, *"AI also can be a great help for team members with real-time data analysis."* AIR5 continued, *"AI will play a huge part in the post-project analysis."* AIR5 added, *"The team members are making decisions based on big data analysis that cannot be done by human beings, it only can be done with AI, and quickly."* AIR8 remarked, *"Sometimes the data is very complicated to such a level that we, even experts, cannot make a decision. We give the machine information, we train the machine, and the machine will give us the decision. So, the machine will be able to analyze better than humans."*

However, the ability to analyze is dependent on the maturity of the GenAI models. In this context, respondent AIR2 explains, "*This will depend on the model, and how the model matures, so you can trust the outcome of it."* AIR3 added, *"As long as you have your information and data in a format that a machine can read, basically you're in good hands. The challenge is to build really great models that can understand the semantics of the sentiment of this text."*

Yet, a few respondents still find this challenging for GenAI and accordingly advised to review the analysis that you get from GenAI, as AIR6 raised, *"The other thing that I feel extremely strongly about when people use AI is even the best GenAI or any other tool, can't fully understand the context, the sensitivity, the full background, and the history of how the results it produces would be utilized. And so, it's triply critical for the human to take the results, what comes back from the tool, to take that and carefully review it against the environment."*

### *10. Interaction & Communication (AC10)*

GenAI is great with interaction and communication. Using GenAI helps with project communication between members; it can make the conversation or the communication between team members much clearer, which is extremely important for PTs to enhance not only the performance of the PTs but also project success. Besides, GenAI can facilitate communication among multi-language, multinational teams. In this context, AIR13 remarked, *"GenAI helps a lot in enhancing communication and improving communication between the different PTs."* AIR4 added, *"It will improve the clarity of communication between the team and the project manager."* AIR5 commented, *"Using AI helps with project communication between members."* AIR5 added, *"AI will help you with the collaboration, you have more facilitated and better communication and coordination between team members."*

Furthermore, respondent AIR3 explained that in some cases, you need to deal with difficult people, socially, and social-wise, in that case, GenAI can change its attitude. GenAI can also tailor its own tone and language to cater to specific individuals and their moods. According to AIR3, *"There are cases where, for example, you need to deal with hard people, socially, social-wise, let's say, in that case, GenAI can change its attitude. If you have a hard engineer to work with, somebody who's moody, GenAI can also tailor its own tone and language to cater to that guy or that lady."* AIR4 added, *"AI can help a lot to make the conversation or the communication much, much clearer."* AIR5 commented, *"AI will facilitate communication among multi-language, multinational teams."* AIR8 added, *"For example, a meeting is group work, teamwork, the AI is widely used in this. Communication between the different parts of the team. The interpretations, what people are saying, so it is a tool that could easily ease communication*

*between the team members. I think there is a lot of work, especially in NLP in text mining, in these directions."* According to AIR4, *"AI can understand or empathize with humans much better, from what I tested and my knowledge, human and AI can get much better collaboration than human-to-human collaboration."*

The level of maturity of GenAI interaction differs, and this can be measured by the users. According to AIR3, *"If you can't tell the difference and you are talking to a machine, then basically you, as a machine, you won. So, it's the same concept. If you put a very smart LLM behind a chatbot screen and you don't tell people when they interact with it that this is a machine and they can't tell the difference, that nobody's going to know. And you can then productionize this. When you do this without people knowing, they're not going to know the difference, so they're not going to have any bad feelings."* AIR3 added, *"With AI, if you do it in this fashion, the majority of people are not going to be able to tell the difference. In ChatGPT, if you converse with it now, you might pick up a few cues here and there because everybody's using it. But when you really tweak it well to generate content in conversations in different tones, you know, with different caveats and even personalize its tone depending on the customer, nobody's going to know. It's very hard to do this."*

However, even when GenAI can interact with humans in a way that one fails to tell the difference between interacting with systems or humans, people would prefer dealing with humans instead of machines at times. In this context, AIR2 commented, *"However, when it comes to dealing with humans, especially when they have concerns or customer service, there will be challenges. In the interaction part, sometimes, even if they can deliver like humans, humans like to interact with humans. This concept is seen especially if you have a case and or problem you want to complain about.*

*Human mentality would love to talk to someone human so he can express his feelings and anger."*

In addition, it is important that the user is aware of how to interact with the system, as respondent AIR8 mentioned, "*You should understand how the machine is working, this is the main point. I believe that the trainer should give some idea about the models, how they work, how you can use the data, how you can interact with the software, etcetera. The more you understand the way to use it, the more you will be comfortable with the AI."*

### *11. Imitation (AC11)*

GenAI is created to adapt and mimic human beings. GenAI can copy or mimic humans in terms of actions and interactions. GenAI can copy human strengths and is able to overcome human weaknesses. Some respondents explained how GenAI is, for instance, able to write a poem in the style of any writer; it will mimic the style, but the content will be new. According to AIR1, *"AI is created to adapt and mimic human beings."* AIR1 added, "*AI can copy human strengths and is able to overcome human weaknesses."* Respondent AIR5 commented, *"It mocks the data, copies the data, the style, the characteristics, and the tone, even the sentiment, the sentimental behavior."* AIR5 added, *"If you ask ChatGPT now to write a poem in the style of any writer, it will mock the style, but the whole content will be new."* AIR5 continued, *"Like, if you ask ChatGPT to write in the style of Shakespeare, it will give you an almost identical writing style. The annotation, even the sentiment, the sentimental behavior of the writer, you can see it because this model was trained on a huge amount of data, like a lot of books, Shakespeare books. So, the model can identify the style."* This can also be seen in the interaction between AI agents, as AIR3 mentioned, *"You can see AI agents say: I like this, this is wrong, I think we got to check this out. This conversation actually happens even between AI agents, which*

*is very weird, but it's awesome. But when this happens, you can see that we're almost mimicking what humans go through, might not be 100% similar, but nonetheless, this concept of debate this concept of reasoning actually happens, and this is the beautiful thing and the most powerful thing, in my humble opinion, about AI."*

### *12. Translation & Transformation (AC12)*

GenAI is capable of translating human commands and inputs and transforming them into actions or outputs. AIR3 said, *"GenAI was meant to understand language and then to decipher the language of humans and then to translate it to tasks or knowledge."* AIR3 added, *"If you want to do applications, you don't have to reproduce what ChatGPT has done and the rest of the companies, you basically have to connect your data sources to a LLM and use a LLM, let's say, as a translator for your unstructured requests and demands, and then you push them into this structured systems that you have, like a CRM or HRM systems, you name it, and then it gets you what you want."* Respondent AIR14 commented on the different forms of commands that GenAI is able to receive: *"It's not just generating, it's not just the output, it's the input and output. So, AI applications can work on transforming text to text, which is the normal daily activity that we do in our directorate. We use it like, for example, we can prompt to write us a certain letter, giving it the command or the aspects of the letter, and it can give us the letter in text format. So, this is text to text. And then, we've got text to, for example, video. So, I can prompt it with text and then it gives me the video and then we've got the text to images like Sora and then we've got non text like for example, I can give it a document or an image and then it gives me a description and text. So, there's the different varieties of how it understands the different types of data and gives us different types of data based on what we need."*

In addition, since GenAI is capable of understanding different languages, it will take action in any language that it encounters. In this context, AIR16 remarked, *"You have something that can write multiple languages at once. For example, you have a technical product, and you want to use C language. When it's C sharp, you want to use a new language, it would be able to produce a code for you."*

#### 4.2.1.3.3 Third Phase: Solving H-GenAI Team Formation Problem

This study considered the views of 15 PMs out of the 25 PMs from 5 different sectors within the service industry, namely: Financial (FS), Telecommunication (TS), Real Estate (RS), Energy (ES), and Governmental (or public sector) (GS). The study followed the 5 steps of the BWM of the MCDM method to assign weights to the factors that are related to and mostly influence PTs for successful TF in the domain of project management and utilized the "BWM solver" to assign weights to the factors according to the input of the PMs after conducting the structured interviews.

Step 1 was accomplished by determining the criteria (C), as follows: Personality ($C_1$), Characteristics ($C_2$), Skills & Competencies ($C_3$), Education & Knowledge ($C_4$), Teamwork ($C_5$), Work Experience ($C_6$), and Expertise & Proficiency ($C_7$). Then, the study repeated the steps from 2 to 5 for all the PMs from all sectors to assign weights to the factors that mostly influence PTs according to each PM. Then, the study took the average weights of each factor from all the 5 sectors combined, to determine the weights for the factors that are related to and mostly influence PTs according to the service industry.

In Step 2, 15 PMs from 5 sectors within the service industry selected the BC and the WC from the list of determined criteria. PM1 from FS selected "$C_3$" as the BC and "$C_2$" as the WC. PM2 from FS selected "$C_7$" as the BC and "$C_2$" as the WC. PM4 from FS selected "$C_6$" as the BC and "$C_2$" as the WC. PM5 from FS selected "$C_3$" as the BC and "$C_2$" as the WC. PM2 from TS selected "$C_3$" as the BC and "$C_5$" as the WC. PM1 from RS selected "$C_5$" as the BC and "$C_2$" as the WC. PM2 from RS selected "$C_5$" as the BC and "$C_2$" as the WC. PM3 from RS selected "$C_6$" as the BC and "$C_3$" as the WC. PM1 from ES selected "$C_3$" as the BC and "$C_2$" as the WC. PM2 from ES selected "$C_7$" as the BC and "$C_2$" as the WC. PM4 from ES selected "$C_4$" as the BC and "$C_2$" as the WC. PM5 from ES selected "$C_4$" as the BC and "$C_2$" as the WC. PM1 from GS selected "$C_5$" as the BC and "$C_2$" as the WC. PM3 from GS selected "$C_3$" as the BC and "$C_1$" as the WC. PM5 from GS selected "$C_6$" as the BC and "$C_2$" as the WC.

For Step 3, the PMs determined the priority of the BC over all the determined criteria by giving it a number from 1 to 9, according to the fundamental scale for pairwise comparisons. Table 56 presents the results of the pairwise comparison vector for the BC according to each PM from the 5 sectors of the service industry.

In Step 4, the PMs determined the priority of all criteria over the WC, by selecting a number from 1 to 9, also by using the pairwise comparison scale. Table 57 presents the results of the Pairwise Comparison vector for the WC according to each PM within the service industry.

The study finally calculated the results of each PM input to obtain the average of all PMs within the service industry, using the solver option, which is embedded in MS Excel, to get the weights of each criterion or factor, as revealed in Table 58, as well as the reliability score (Ksi) which

shows to what extent the results are reliable; the closer the Ksi to zero the better. Accordingly, the results are reliable.

Table (56): Service Industry: Pairwise Comparison Vector for Best Criterion

| **PMs** | **Criteria (C)** | **$C_1$** | **$C_2$** | **$C_3$** | **$C_4$** | **$C_5$** | **$C_6$** | **$C_7$** |
|---|---|---|---|---|---|---|---|---|
| **1.FS-PM1** | BC: $C_3$ | 6 | 9 | 1 | 5 | 7 | 4 | 3 |
| **2.FS-PM2** | BC: $C_7$ | 4 | 5 | 2 | 2 | 4 | 2 | 1 |
| **3.FS-PM4** | BC: $C_6$ | 4 | 9 | 5 | 5 | 3 | 1 | 2 |
| **4.FS-PM5** | BC: $C_3$ | 8 | 9 | 1 | 2 | 7 | 4 | 3 |
| **5.TS-PM2** | BC: $C_3$ | 7 | 7 | 1 | 2 | 9 | 2 | 3 |
| **6.RS-PM1** | BC: $C_5$ | 3 | 7 | 2 | 5 | 1 | 2 | 4 |
| **7.RS-PM2** | BC: $C_5$ | 8 | 9 | 5 | 6 | 1 | 3 | 4 |
| **8.RS-PM3** | BC: $C_6$ | 2 | 6 | 7 | 2 | 2 | 1 | 4 |
| **9.ES-PM1** | BC: $C_3$ | 6 | 7 | 1 | 2 | 5 | 3 | 2 |
| **10.ES-PM2** | BC: $C_7$ | 4 | 6 | 2 | 5 | 3 | 3 | 1 |
| **11.ES-PM4** | BC: $C_4$ | 4 | 5 | 2 | 1 | 4 | 2 | 3 |
| **12.ES-PM5** | BC: $C_4$ | 6 | 9 | 2 | 1 | 5 | 3 | 4 |
| **13.GS-PM1** | BC: $C_5$ | 7 | 9 | 3 | 2 | 1 | 6 | 8 |
| **14.GS-PM3** | BC: $C_3$ | 9 | 8 | 1 | 2 | 8 | 3 | 3 |
| **15.GS-PM5** | BC: $C_6$ | 2 | 5 | 2 | 3 | 3 | 1 | 4 |

Table (57): Service Industry: Pairwise Comparison Vector for Worst Criterion

| Criteria (C) | 1.FS-PM1 WC: $C_2$ | 2.FS-PM2 WC: $C_2$ | 3.FS-PM4 WC: $C_2$ | 4.FS-PM5 WC: $C_2$ | 5.TS-PM2 WC: $C_5$ | 6.RS-PM1 WC: $C_2$ | 7.RS-PM2 WC: $C_2$ | 8.RS-PM3 WC: $C_3$ | 9.ES-PM1 WC: $C_2$ | 10.ES-PM2 WC: $C_2$ | 11.ES-PM4 WC: $C_2$ | 12.ES-PM5 WC: $C_2$ | 13.GS-PM1 WC: $C_2$ | 14.GS-PM3 WC: $C_1$ | 15.GS-PM5 WC: $C_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 3 | 2 | 7 | 2 | 2 | 6 | 3 | 6 | 2 | 3 | 2 | 4 | 5 | 1 | 4 |
| $C_2$ | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| $C_3$ | 9 | 4 | 5 | 9 | 9 | 5 | 5 | 1 | 7 | 6 | 4 | 8 | 7 | 9 | 4 |
| $C_4$ | 5 | 4 | 5 | 8 | 8 | 3 | 4 | 6 | 6 | 4 | 5 | 9 | 8 | 8 | 3 |
| $C_5$ | 5 | 2 | 8 | 3 | 1 | 7 | 9 | 6 | 5 | 5 | 2 | 5 | 9 | 2 | 3 |
| $C_6$ | 7 | 4 | 9 | 5 | 8 | 6 | 8 | 7 | 6 | 2 | 4 | 7 | 4 | 7 | 5 |
| $C_7$ | 8 | 5 | 8 | 7 | 7 | 5 | 6 | 4 | 6 | 7 | 3 | 6 | 3 | 7 | 4 |

Table (58): Average Criterion Weights from All Project Managers of the Five Sectors within the Service Industry

| C | 1.FS-PM1 | 2.FS-PM2 | 3.FS-PM4 | 4.FS-PM5 | 5.TS-PM2 | 6.RS-PM1 | 7.RS-PM2 | 8.RS-PM3 | 9.ES-PM1 | 10.ES-PM2 | 11.ES-PM4 | 12.ES-PM5 | 13.GS-PM1 | 14.GS-PM3 | 15.GS-PM5 | AVRG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 0.08540 | 0.08228 | 0.10675 | 0.05556 | 0.05674 | 0.12447 | 0.06438 | 0.17442 | 0.06484 | 0.09934 | 0.08730 | 0.07114 | 0.06675 | 0.03130 | 0.17727 | **0.08986** |
| $C_2$ | 0.03342 | 0.05063 | 0.02785 | 0.03221 | 0.05674 | 0.03275 | 0.03433 | 0.05814 | 0.03204 | 0.03974 | 0.05291 | 0.03049 | 0.03162 | 0.05399 | 0.04091 | **0.04052** |
| $C_3$ | 0.40659 | 0.16456 | 0.08540 | 0.36719 | 0.32813 | 0.18670 | 0.10300 | 0.03488 | 0.30664 | 0.19868 | 0.17460 | 0.21341 | 0.15576 | 0.35681 | 0.17727 | **0.21731** |
| $C_4$ | 0.10248 | 0.16456 | 0.08540 | 0.22225 | 0.19860 | 0.07468 | 0.08584 | 0.17442 | 0.19451 | 0.07947 | 0.30688 | 0.35061 | 0.23364 | 0.21596 | 0.11818 | **0.17383** |
| $C_5$ | 0.07320 | 0.08228 | 0.14233 | 0.06350 | 0.02878 | 0.30134 | 0.41202 | 0.17442 | 0.07780 | 0.13245 | 0.08730 | 0.08537 | 0.37593 | 0.05399 | 0.11818 | **0.14726** |
| $C_6$ | 0.12810 | 0.16456 | 0.33880 | 0.11112 | 0.19860 | 0.18670 | 0.17167 | 0.29651 | 0.12967 | 0.13245 | 0.17460 | 0.14228 | 0.07788 | 0.14397 | 0.27955 | **0.17843** |
| $C_7$ | 0.17080 | 0.29114 | 0.21349 | 0.14817 | 0.13240 | 0.09335 | 0.12876 | 0.08721 | 0.19451 | 0.31788 | 0.11640 | 0.10671 | 0.05841 | 0.14397 | 0.08864 | **0.15279** |
| **Ksi*** | 0.10582 | 0.03797 | 0.08818 | 0.07730 | 0.06908 | 0.07206 | 0.10300 | 0.05233 | 0.08238 | 0.07947 | 0.04233 | 0.07622 | 0.09135 | 0.07512 | 0.07500 | |

According to the BWM outcomes conducted for the 15 PMs from all 5 sectors within the service industry, Table 59 reveals the weights of the main/key factors, ranked according to their weights.

Table (59): Service Industry: Factors Rank

| Main Factors | Weights |
|---|---|
| 1. **Skills & Competencies** | 0.217308 |
| 2. **Work Experience** | 0.178432 |
| 3. **Education & Knowledge** | 0.173832 |
| 4. **Expertise & Proficiency** | 0.152789 |
| 5. **Teamwork** | 0.147260 |
| 6. **Personality** | 0.089862 |
| 7. **Characteristics** | 0.040518 |

According to the input of all 15 PMs from all 5 sectors within the service industry, the most important factor that affects TF when considering PTs in the project management domain within the service industry is "Skills & Competencies", while the least important is "Characteristics". Based on the results of the MCDM-BWM, this study developed a model for the most influential factors that affect the formation of H-GenAI PTs in the service industry, as presented in Figure 44.

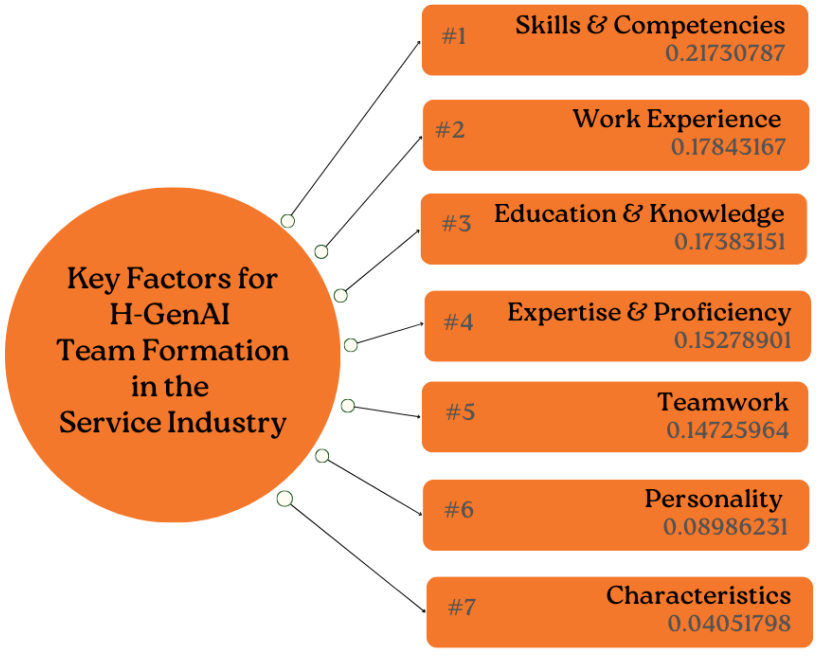



Fig. 44: Factors Affecting H-GenAI Team Formation in the Service Industry (developed by the authors)

As per the results of the study, the top three most important factors in the team formation process of project teams consisting of humans and GenAI as team members in the service industry are “Skills & Competencies”, “Work Experience”, and “Education & Knowledge”. Figure 45 illustrates the results of the study, which plots the percentages of the 7 factors that influence the formation of project teams.

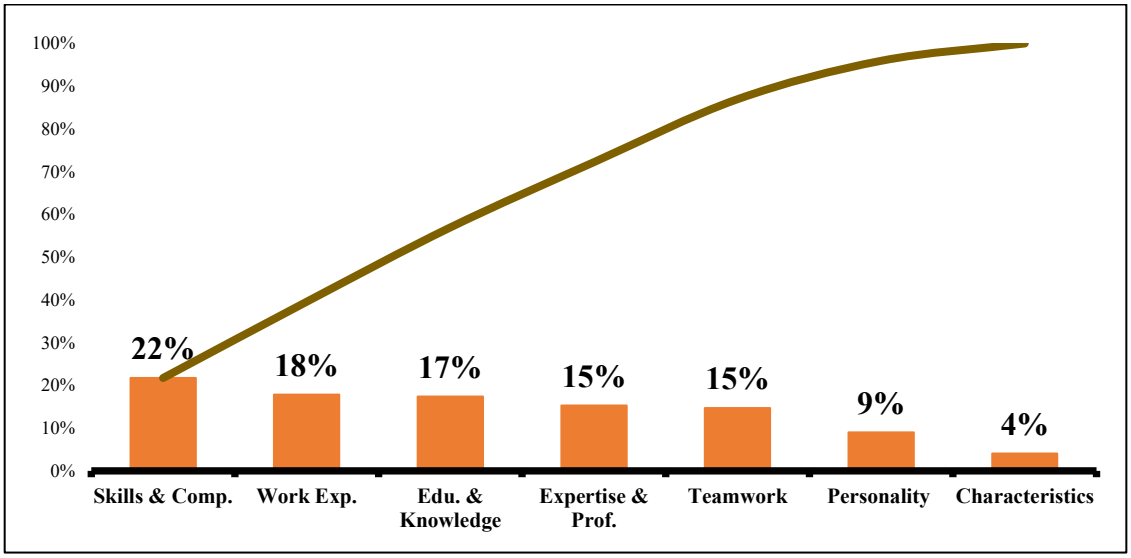



Fig. 45: Pareto Principle: Factors Affecting H-GenAI Team Formation in the Service Industry

Figure 46 shows the difference between the factors that affect the formation of H-H and H-GenAI PTs. According to the results of the study, although the ranking of the factors differs when considering them for the formation of H-H PTs or H-GenAI PTs, the percentage of the factors remains close to one another when forming the two types of PTs, as presented in Figure 46. However, this does not apply to two of the factors, which are “Personality” and “Education & Knowledge”, where the type of PT, whether H-H or H-GenAI, tremendously affects the two factors.

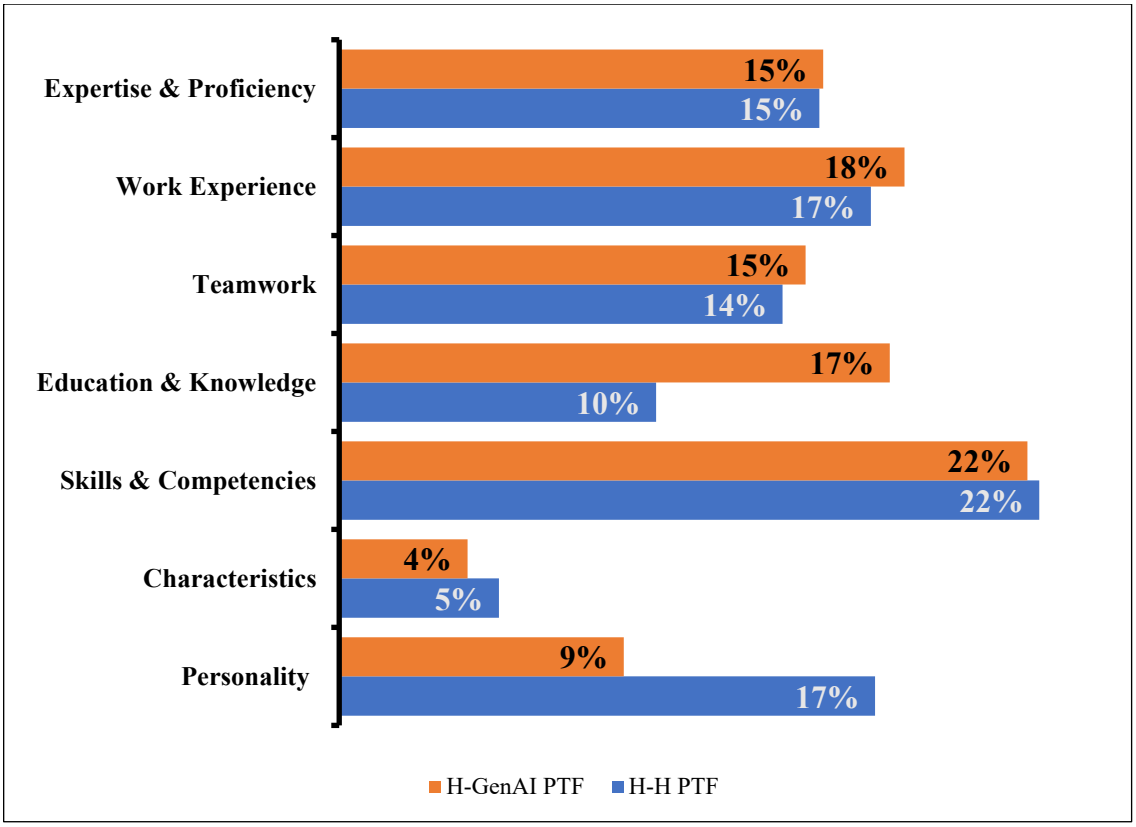



Fig. 46: A Comparison Between the Factors that Influence Project Team Formation for Traditional H-H Project Teams & H-GenAI Project Teams in the Service Industry

#### 4.2.1.4 Phase 1 Part 4: GenAI Enablers & Factors Supporting H-GenAI Collaboration

This section presents the findings of the qualitative data collection of GenAI enablers and the factors that support the collaboration between humans and GenAI in PTs, as revealed by the 16 interview respondents. It is important to mention that the interview respondents referred to AI and GenAI interchangeably.

##### 4.2.1.4.1 GenAI Enablers

This sub-section reveals the enablers of GenAI followed by the discussion. Table 60 summarizes the findings of the qualitative data by listing the GenAI enablers, as revealed by the interviewees.

Table (60): Interview Results: List of Generative AI Enablers

| **Generative AI Enablers** |
|---|
| • Deep Learning Models (DL) |
| • Large Language Models (LLMs) |
| • Transformer Models |
| • Generative Adversarial Networks (GANs) |
| • Gated Recurrent Unit (GRU) |
| • Long Short-Term Memory (LSTM) & Bidirectional Long Short-Term Memory network (BiLSTM) |
| • Autoencoders |
| • Machine Learning Models (ML) |
| • (Artificial) Neural Network Models (ANN) |
| • Natural Language Processing (NLP) |
| • Statistics |
| • Processing Powers: Central Processing Unit (CPU), Graphical Processing Unit (GPU), Tenser Processing Unit (TPU), and Language Processing Unit (LPU) |
| • GenAI Eco System |

According to the interview results, interviewees explain how GenAI can function and can be generative in the strict sense of being able to generate and create content.

GenAI is supported by many enablers, mostly technical systems, according to the interview results. The interviewees highlighted the most important enablers for GenAI to function the way it does. In this context, AIR6 remarked, "As a global society moved life to digital, which with the intelligence and the vast amount of research that had already been done and how AI could do some of the things that generative AI is bringing to life, that research, combined with the vast quantity of data in a short period of time, allowed for massive amounts of training of these LLMs in order for the new generative AI tools more than anything ever before, to, in essence, think, process, rationalize and generate results as people do. And that's clearly way, way ahead of where we were five years ago as a society." AIR13 remarked, *"GenAI is basically based on the models that the tools are using and the different models that are in place. And there are different*

*models, for example, we have LLMs that are based on GenAI and there is kind of interaction with humans."* AIR5 added, *"Generative AI is, let's say, a step higher, which by using that amount of data and parameters used in the LLM, transformational models, the GANs, neural networks, and DL models, it can create data, purely synthetically generated data, from the data. So, you have new data which has never been there before."*

Respondents highlighted the importance of using ML and DL algorithms for GenAI to function. Respondent AIR5 said*, "Generative AI can generate a pure person that you can't identify as a fake. But this person, if you run his face on all, let's say, all identification systems in the world, of all the countries, you won't find this person. This person does not exist. This knowledge is based on accumulative ML that happens in the hidden layers of the DL models. And it came up with this new content."* Respondent AIR5 added, *"By using ML models and DL models, you can learn the data patterns. And this learning technique can help you to create another clustering, identifying, associating, and regression models to deal with that."* AIR5 continued, *"Big data analysis is using AI to analyze big data. It's more efficient now using machine learning models."*

Respondents mentioned the use of LLMs for GenAI to function as it does to generate content. AIR14 added, *"First of all, The Natural Language understanding and then the Natural Language processing. They usually come together as a pack. So those two components in the LLMs are what differentiates them from other AI tools and it's what gives power to those applications, let's say. This is one of the reasons why we need to use those tools in our directorate because they save time and it understands what human says without having to know how to code, for example."* AIR14 continued, *"One of the things is the HOT encoding, stemming and hot encoding and tokenization. Those are key phases that every prompt that is*

*given to the LLM goes through. So, this is one of the differentiators that makes LLMs stand out."* AIR3 mentioned, *"If you're doing a LLM for a company that offers lyrics or music generation, it might dial up the whole conversation all the way up, so that you basically can generate great music."*

Respondents explained how GenAI works on transformers and utilizes GANs to generate content. AIR11 said, *"GenAI uses an algorithm called transformers, transformers. It's neural networks."* However, respondents highlighted how the architecture of transformers outperforms GANs. AIR15 remarked, *"So, in the past we had models that had the ability to generate using machine learning. So, generating is not really a new thing. We had the GANs in the past, but they weren't really good. They weren't able to go beyond simple sentences, and they weren't able to understand the context between the entities and your documents and your data and your prompt. Today with generative AI, and I think what powers the generative AI is the transformer architecture. So, there is an academic paper, I'm not sure which year you can look it up, but it's called "Attention is All You Need." From there we realized that we could actually have the ability to give these models an attention span. So, now instead of looking at just a few sentences then past, now we could look 200 words, 1000 words and be able to understand all of that generate output, and while generating the output I can keep feeding my output back and build a better output. And then I end up with this model being generative because they don't lose context, and they don't forget what they are saying currently."*

Some respondents mentioned the use of sequential models, such as the GRU, the LSTM, and bi-directional STM for GenAI to function as well as the autoencoders. AIR8 said, "*One of the applications is for the meetings, to conclude and extract statistics from meetings. So here, there is natural*

*language processing. Then from the processing, you go to the text. So here you are using some sequential model, such as the GRU, the LSTM, bi-directional STM, etc. Then from there, you go to the statistics, and then this statistic could be sent to other people."* AIR8 added, *"So, in this case, we use generative models, the GANs, and the autoencoders. The autoencoders are also generative models. They have different principles from the GANs. These two models are the most used, and I think they are the most relevant generative models that exist. The GANs have many variants of the GANs, many, many variants. Now about six, or seven variants, they are widely used. The autonomous variation autoencoder, the convolution autoencoder, the classical autoencoder, the LSTM autoencoder, all these in the other part or another side, you see that for example, the autoencoder is used while in the clustering, there are many having a subcategory which is called or named the "autoencoder based clustering models" and could provide a very high performance comparatively to the shallow models, compared to the k-means, to the hierarchical."*

Respondents highlighted the use of Neural Networks or Artificial Neural Network Models for prediction. In this context, AIR1 said, *"Neural Networks can be used for predicting the best team composition based on historical data, learning patterns of successful teams, and applying them to new team formation scenarios."*

It is important to mention that GenAI uses NLP to decipher human language. AIR8 said, *"For example, a meeting is group work, teamwork, the AI is widely used in this. Communication between the different parts of the team. The interpretations, what people are saying, so it is a tool that could easily ease communication between the team members. I think there is a lot of work, especially in natural language processing in text mining, in these directions."* Respondents mentioned how the processing powers, such

as the Central Processing Unit, Graphical Processing Unit, Tenser Processing Unit, and Language Processing Unit, support GenAI functionalities, as indicated by AIR4, *"In enterprises, as much as you go deep into ChatGPT or into any AI, you will have to have the processing powers, the CPU, GPU, TPU, and LPU."* Also, the GenAI ECO system is important for GenAI to function, as well as the funding, as mentioned by AIR9, *"I think one of the key enablers for AI is the big data ecosystems such as the Hadoop ecosystem that allows building models with vast and diverse datasets."* AIR10 said, *"You cannot build GenAI without funding."*

#### 4.2.1.4.2 Factors Supporting H-GenAI Collaboration

This sub-section reveals the factors that support the collaboration between humans and GenAI, followed by the discussion. Table 61 summarizes the findings of the qualitative data by listing the supporting factors that influence H-GenAI collaboration.

Table (61): List of Influential Factors for Human-AI Collaboration

| **Factors Supporting H-GenAI Collaboration** | |
|---|---|
| 1. | General Understanding of GenAI |
| 2. | Realization of GenAI Capabilities |
| 3. | User-friendly GenAI |
| 4. | Acceptance & Adoption of GenAI |
| 5. | Reskill & Upskill Human Skills |
| 6. | Prompt Engineering<br>- Chain of Thoughts |
| 7. | Context & Business Understanding |
| 8. | Governance |
| 9. | Security & Privacy |
| 10. | Reliable Data |
| 11. | Well-designed GenAI Models:<br>*GenAI Model Learning, GenAI Model Training, and GenAI Model Testing & Validating*<br>- GenAI Explainability (Explainable AI) |
| 12. | Trust & Ethics |
| 13. | Humans & GenAI Roles |
| 14. | Tasks Delegation & Assignment |
| 15. | Critical Thinking |
| 16. | Monitor Collaboration Performance |

### *1. General Understanding of GenAI*

According to the respondents, it is important to have a good understanding of GenAI before using it. This can be acquired by training users. In this context, AIR11 remarked, *"If we need to use it in a good way, we need to know how it works."* AIR8 said, *"I think we have to have some understanding of AI before using it."* AIR8 added, *"You have to give training to the staff so they can use this tool."* AIR8 continued, *"You have to understand and have to train properly on these AI tools."*

Some respondents highlighted the importance of being aware of the updates on GenAI capabilities, as AIR14 advised, *"It's very important to have this background knowledge and to keep updated with whatever is happening, because every update on the existing LLMs, it's very impressive. So, it's important to have the knowledge about those tools."*

When people understand what GenAI could bring to the PT, they will appreciate it more. AIR9 remarked, *"If they are able to see what these tools are going to do for them in terms of eliminating all the waste, in terms of enhancing communication, instead of having long meetings, giving us the summary of them, instead of me writing meeting minutes and summarizing them, it's automatically doing it. So, once they're able to see the benefit and how that is reducing their workload and giving them more space for the more creative elements of it, that would have a positive impact on them otherwise, if they're culturally not aware of how these tools could benefit them, naturally we say when people are not, people fear what they are unaware of. That's the natural psychology that we have. Right? So, anything nowadays when we hear the word AI, and for a lot of people who are not looking into it or researching into it, it's a word or a thing out there and a lot of people are scared of it."*

Besides, people tend to fear the unknown, as remarked by AIR9, *"When people are not aware of these tools and when they are a black box, and they don't understand what's happening in the black box that can actually increase the fear and kind of resistance to the change that is coming."*

In addition, some respondents highlighted the concern of people towards AI technologies in general that these technologies will probably take over human's jobs. In this context, AIR9 remarked, *"There is a concern from people and if AI is doing my job, what am I doing? So, I think over here we need kind of a mindset change, where people need to start believing that AI is there to support."*

***2. Realization of GenAI Capabilities***

To ensure a successful collaboration between humans and GenAI, one should acknowledge the importance of GenAI integration into PTs from several perspectives, such as the capabilities of GenAI and the limitations of humans. Once humans realize their own limitations, humans will appreciate the value of GenAI and the benefits it brings to teams, believing in the complementary skills of both parties.

In this context, AIR14 remarked, *"It's very important to understand those AI tools, to understand the capabilities of the tools."* AIR14 continued, *"Whatever can be done through AI should be done through AI. And then the rest of the time should be redistributed to doing things that are currently difficult to do with AI."* AIR2 said, *"Sometimes there are human errors when it comes to analyzing numbers, and data. These are all good indications and help the leadership to come up with a decision to support the involvement of such AI tools."* AIR1 added, *"As humans, there are limitations, for instance, if you're looking at the Project Management, on memorizing, conjunctions between the certain calibers, we're looking at*

*recollections, and we're looking at the processing, so here when we bring AI and then through the machine's abilities, we cover all those characteristics and overcome them by "n" number of times in terms of capabilities."* AIR2 continued, *"Humans after a certain number of hours, will get tired. AI can function 24/7 and these factors will add plus value to the model or the outcomes."* AIR1 added, *"For humans, you don't have different models, just one model and then consistency width compared to humans."* AIR3 remarked, *"Human beings have a limited capacity in terms of their attention, in terms of their memory, in terms of their power, and in their capacity can go basically limited."* AIR3 continued, *"We humans, again, have limitations. We have to respect our limitations. And so, some of the breakthroughs that we did not get through are due to our limitations. People forget, people don't do things well, and they get tired. And now we have the ultimate creation, that even though it runs on transistors, might not be the best fit, these things that we created can really complement our mishaps or our shortcomings."*

However, it is also important to not only understand the capabilities of GenAI tools, but also their limitations. In this context, AIR16 remarked, *"One of the important things is to understand the limitations of the AI and not to assign it with superpowers because you will be somehow disappointed by the result. So, the expectations have to be set right, the capabilities have to be understood."*

### *3. User-friendly GenAI Models*

Building a user-friendly GenAI model is an important factor to ensure a successful collaboration between humans and GenAI. This requires tremendous work from these AI experts or the computer scientists to remove the gap between these GenAI tools and the user within the other

domains for effective collaboration. AI experts should make a lot of effort to give the simplest interface to the other domain expert. The more user-friendly these tools are, the stronger the collaboration is between humans and GenAI. According to AIR8, *"To remove the gap between the computer scientist, the AI expert, and the physician or the other domain expert, a lot of work is done for them. The AI expert needs to and is making now a lot of effort to give the simplest interface to the other domain expert, it gives a very simple interface."* Respondent AIR6 commented, *"I think one of the biggest strengths of GenAI, and OpenAI's ChatGPT is an ideal example, is that it is very user-friendly. I mean, in reality, we've had a lot of AI tools and research for many, many years. I believe the accelerated growth of ChatGPT was based primarily on the fact that it's the first tool that has come to market that is designed to be easy. It's a very simple user interface. So that's a huge positive."*

***4. Acceptance & Adoption of GenAI***

According to some respondents, it is important to embrace and adopt GenAI and accept the fact that it has so much to add to the team and the business itself. Humans need to look at GenAI as a tool that will open their minds and allow them to be innovative and creative. However, they should work carefully with the tools to ensure effective collaboration.

In this context, AIR6 remarked, *"The most important thing in all settings, I believe, is that humans need to look at AI as a tool that will open their minds, and allow them to be innovative and creative."* AIR8 commented, *"If you want to progress in any domain, including AI, you have to take the risk. Of course, we have to at the same time use some restrictions, some rules, and some protection, processes, and mechanisms. But you cannot stop it."* AIR6 advised, *"Work carefully with the tool to be effective."*

Some respondents highlighted that it is easier to accept the outcomes of the work that is done by a GenAI when you lower your expectations. In this context, AIR2 explained, *"How I will deal with AI is that I will give it excuses. If AI is emotionally not connecting with me, or giving me a flat task without shaping it, or putting it in a nice way, I will understand because it's a machine in the end, so, my acceptance of AI will be very normal, because I know AI is doing what it's supposed to do without any feelings or involvement of feeling, and so on. So, the outcome from its side, I will not try to resist it, or I will accept it, even if it's against my part or whatever you call it. So that's what human nature is like. But if I know the same outcome comes from a human, of course, I will come up with a different approach with him. I would not reconsider these. I will think many times about why he put this outcome. These facts may be affecting my part and how he put it on the table in such a way. These are my feelings because there are feelings involved in our work, our decisions, and our outcomes. So that part will be there."*

However, generally, it is quite difficult for people to accept anything new, and they tend to resist change, according to some respondents. In this context, AIR3 commented, *"I think human beings are going to get very picky. It's our nature to resist anything new, unless we understand it and we get to know it."* AIR3 continued, *"If someone tells you upfront that I'm a machine, your emotions are going to kick in."*

Besides, human beings will show some sort of resistance toward working with GenAI, especially when they are being directed by an AI agent. According to respondent AIR4, *"For example, in any project, you have to have some requests, you have to have some orders let's say, but we as humans cannot accept that from an AI."*

### *5. Reskill & Upskill Human Skills*

According to the respondents, it is necessary to possess the right skills for better collaboration with GenAI. People should be very skilled, determined, and discerning in how they use the tool. Therefore, it is important to continuously train to acquire the necessary skills for collaborating successfully with GenAI. In this context, AIR6 remarked, *"They have to be very skilled, very determined, and discerning in how they use the tool."* In this context, AIR1 highlighted the importance of training to acquire the necessary skills, *"Team members should have the necessary skills to work effectively with AI, which can be achieved through reskilling and upskilling to understand both the tool itself and its limitations."* AIR15 added, *"I think first and foremost training the people on how to use AI. This is often, I would say under looked and forgotten. We usually jump and use the tool. I think it's more important to teach people when to use AI. Sometimes rephrasing the right question or actually giving your AI the right task is more important than just jumping to the tool and getting an output, pasting it in a document."* AIR15 continued, *"You need people to be trained on how to use generative AI efficiently and the technology is very accessible."* AIR13 remarked, *"Human beings need to know how to interact with GenAI. Like for example, ask the right questions, use the right models, ensure that you have the right data sets basically to interact with, put on the right protocols and policies from compliance and security perspective."*

### *6. Prompt Engineering*

Many respondents advised that users should be very specific in their requests; as mentioned by respondent AIR6, *"Be very clear and specific in asking."* AIR5 added, *"If you ask ChatGPT something, you have to be very*

*defined with the AI model, with proper parameters to get proper data."* AIR6 remarked, *"People learn to ask the right questions or create prompts."* Therefore, users should be aware of the several techniques used when dealing with GenAI to get good results and attain positive outcomes when collaborating with GenAI, such as in "prompt engineering".

In this context, respondent AIR4 remarked, *"Prompt engineering is the art of dealing with AI."* AIR4 confirmed, *"Everybody will need to learn prompt engineering."* AIR9 remarked, *"We as human beings will need to enhance our skills in being able to convey the messages correctly, giving the right prompts. Lately they are saying there will be prompt engineers, this is a new skill."* AIR11 added, *"We have some characteristics, special characteristics in the prompting engineering so that I use the best prompt to have the best answer."* AIR13 said, *"If you want to use Copilot or ChatGPT, you need to ask the right questions and then the human being needs to have knowledge in the art of prompting."* AIR14 commented, *"Knowing how to prompt, even though if you don't give a full sentence or like a structured sentence when you prompt, it understands, but it might not give you what you need from the first prompt. So, knowing and having those skills is very important."*

For better results, some respondents mentioned practicing the concept of "the chain of thoughts" when dealing with GenAI to direct it toward obtaining the desired results. AIR4 advised, "*ChatGPT cannot give you the result straight away. To deal with it, you have to have something called a chain of thoughts, for example, it's a methodology of how to deal with AI.* AIR3 added*, "There is a beautiful concept on a chain of thought, when you have two different AI agents and they have two different worldviews, their wisdom is coming from two different places, you can see them actually interacting."*

Interestingly, some respondents highlighted that by being aware of the techniques used to prompt GenAI systems, users will eventually enhance their communication skills with others. In this context, respondent AIR6 remarked, *"A side benefit of using GenAI by being skilled at writing a good prompt, people can become a lot more effective at human-to-human communication."*

### *7. Context & Business Understanding*

To ensure good H-GenAI collaboration, it is important to have a good business understanding of the situation and know the business context, for instance the business stakeholders, the problem statement, the business objectives, etc. as suggested by respondent AIR1, *"It is the business understanding and having, first of all, appropriate datasets to start with here."*

### *8. Governance*

Governments and businesses should have GenAI governance for H-GenAI collaboration, determining the rules and regulations along with the level of authority for each party. In this context, AIR1 remarked, *"The factors that support the collaboration in H-AI teams is the collaboration between humans and AI, human trust in AI, it's all about the governance; this comes under the governance."* AIR5 added, *"In the end, AI will help humanity big time. But again, there is a huge amount of risk if this is not controlled. There has to be AI governance, a way to govern AI, especially in teamwork, especially in critical types of work."* Besides, the business organizations should provide the necessary information on the way PTs should utilize GenAI tools, as remarked by AIR12, *"The organization should set the standard for the GenAI before they provide to the project team."*

### *9. Security & Privacy*

Security and privacy are among the most important factors that humans are concerned about. To ensure a successful collaboration, one should control the security aspect of GenAI and the data being used in those GenAI models. According to AIR3, *"Security is a very big circle here. AI can go haywire if you don't control it. As we are discovering this whole space of LLMs and GenAI, you might want to think about security not in the cybersecurity fashion, but how to "security" from an AI perspective. Just to give you a small trivia, if a skilled hacker comes in, they can basically push in a prompt, and that prompt can extract a lot of the training data that was used in the beginning."* AIR6 remarked, *"Many of the concerns that people have about AI, have it creating issues stem from concerns about data."* AIR8 added, *"Maybe we have to secure also the data sets or databases."*

Even when GenAI is becoming inevitable, one should not share anything that is extremely confidential. AIR6, *"I, personally, do not believe any of the technology companies, technology entrepreneurs, business leaders, or tycoons in this world, I don't believe any of them are out to destroy, out to capture, out to benefit. Not at all. However, having said that, if you have truly private, confidential, sensitive information it's never good to share it in any open tool."* Respondents AIR6 and AIR8 advised, respectively, *"Never share anything confidential into those applications," and*, *"People should be concerned about putting their images on the Internet."* AIR14 commented, *"One of the main things that we face, especially that we are a public institution, is uploading sensitive data or personal documents that have got sensitive data or personal information. So, the security aspect is very important and hence one of the notes that I always deliver to the*

*employees in our directorate is not to upload any data that could be misused or mishandled. So, security aspect and data privacy."*

In addition, it is advised not to use any public GenAI in the government sector unless it is tailored for the organization to ensure data privacy and avoid data leaks, as AIR12 commented, *"We don't use GenAI at work for projects because our work is very sensitive and at the current time we don't have like a closed AI for our organization. And the OpenAI is public. It's not a great option to use that at the current moment because people can still see your data. It's not confidential to use the OpenAI in the government sector."* AIR12 continued, *"You will have to build this AI based on your organization process, based on your organization requirement."*

***10. Reliable Data***

Having reliable data is extremely important to ensure successful collaboration between humans and GenAI, especially in the field of project management, as remarked by respondent AIR1: *"With reliable data, AI can significantly enhance project outcomes, manage expectations, and maintain high satisfaction levels."* AIR9 added, *"One Important element that I can just think of on top is the touch points, the data touch points. Which is again going back to collecting the right data, the ability to collect the right data. So, having a proper data set, having proper tools and technologies to capture the data that needs to be captured. I cannot measure the performance of my team if I do not have a mechanism to capture that type of data. If performance, for example, I'm measuring it using traditional methods, the number of hours he spent, the number of hours he finished a specific task in. I'm probably not going to benefit a lot from predictive modeling and stuff like that."*

However, getting data that is reliable is an ongoing challenge for many organizations. AIR12 remarked, *"Anything that you feed it will make it work better, and when you feed it with the correct information and accurate information with the reference detail."* AIR16 said, *"One of the biggest challenges that a lot of organizations will face is the availability of data and the quality of the data they have. The worse the data that is available, the more difficult it will be to achieve their objectives."*

Therefore, some respondents highlighted the necessity of being flexible in providing data under agreements and emphasized the importance of having reliable data to build reliable intelligent systems. In this context, respondent AIR5 remarked, *"AI is based on ML and ML on data."* AIR3 commented, *"Data is the way to go to build more intelligent machines."* AIR8 added, *"Look if you want to make progress in AI and use AI in society, we have to be a little bit flexible and certain about providing computational data because it is data science. Without data, you cannot do it."* AIR8 continued, *"I believe that we can use data with some agreements because AI tools cannot exist without data. So, we have to have some flexibility from the companies, from the government or institutions, to have this data, so we can release these products."*

### *11. Well-designed GenAI Models*

While collaborating with GenAI, it is important to rely on well-designed models. Working with well-designed models is important to avoid manipulation of the data, as AIR3 raised, *"So, these systems can be manipulated if you don't design them really well. And it's not all pink, as we'd like to find. These systems can be abused by a skilled hacker."*

Some respondents raised other challenges for building well-designed models, as AIR3 said, *"As long as you have your information and data in*

*a format that a machine can read, basically you're in good hands. The challenge is to build really great models that can understand the semantics of the sentiment of this text."* Besides, for building well-designed models, AI experts should consider the simplicity aspect of the model in terms of it being user-friendly enough for the user to effectively utilize it. In this context, AIR8 said, *"Either you give training to the staff or other domain experts, or you have to make an effort as an AI expert to provide a very easy tool, a very simple tool with the assumption that this other domain expert does not know anything about computers and AI. So, it will be very simple software."*

In general, a well-designed model goes through the following three stages: *(1) GenAI Model Learning, (2) GenAI Model Training,* and *(3) GenAI Model Testing & Validating.*

*(1) GenAI Model Learning:*

Teaching the GenAI models is the first step to an effective collaboration between humans and GenAI. The more accurate the datasets are, the more accurate the results will be. According to the respondents, well-designed models are built with reliable data and then trained so that they will be able to deliver reliable outcomes. Also, the datasets you provide after that should be reliable datasets to ensure good outcomes. In this context, AIR3 said, *"The first thing you need to basically, as you know, give it data."* According to AIR2, *"An AI model is like a learning model that can help you in designing the outcomes. That's how I can explain it. So that model is based on what you feed, how you train it, the type of data you inject into that model that helps you to come up with outcomes and this, and think of outcomes, or let's say try to connect the dots between the data and try to come up with a new thought, not automation, it's more than automation, it's like human thought. And try to come up with, let's say direction or decision that helps*

*you to perform the activity."* According to AIR8, *"It's called ML or DL. It is learning. What you will teach the machine is what you will get as a decision. First of all, it depends on "me", how you want to train the model, you'll get it. So, for this conflict, if your data, there is a lot of conflict, can mislead the machine, can give you even some noises in the data and, you know, can affect the performance. So, the accuracy of the data."* AIR5 added, *"The output of this AI model will always be based on the data that it's generated from where it was learned. So, if the data distribution is somehow biased, it will give you a biased outcome."*

It is also important to consider the business environment that the GenAI will be used in so serve PTs better. In this context, AIR15 added, *"To have a successful GenAI journey, the data is important. So, whenever you're building a GenAI model for your business or you're, let's say you're a government or startup, whatever entity or an academia, right? You'd always have your exclusive set of data that nobody else has. And this is the knowledge you have cultivated over the years to have productive AI in your team. Make sure it understands this data. And it's not a one day process. It is an iterative process to keep refining and enhancing the model's understanding of your data to give your project team better responses."*

Besides, one should be aware that not all data should go into the model, as AIR15 said, *"The hygiene, like what should you put in a generative AI model and what you shouldn't. For example, some data should never be in a generative AI model. For example, health data or your personal information data should not end up in a generative AI model. And if the human is going to use or interact with the model, they should redact or remove this information before sending it to the model."*

Also, it is important to have the right caliber to prepare for reliable datasets, such as AI Scientists and Data Scientists, as remarked by

respondent AIR1, *"We don't need only AI scientists, we need data scientists because you cannot have the same people analyze the data in our business. These people, the data scientists, will do the data cleansing, categorization, and looking at the structured or unstructured data. This is a very important part of it, because then we will not end up looking at the project where putting the right algorithms and your data is not helping you to do anything, and you don't have enough historical data. So, it will put certain recommendations or generate certain data that is based on nothing."*

Biased models are models that have learned from biased data. If the GenAI models were fed with biased data continuously, it would always divert the results towards giving biased outcomes, which would result in the so-called "AI poisoning", which is when deliberately wanting to direct the outcomes of the GenAI models towards the biased outcome. In this context, respondent AIR5 commented, *"We have one problem that can be seen in many models. In NLP, if you dig deeper into ChatGPT models or NLP models, you will find that AI tends to be biased. You can't prevent that, it's very hard to prevent a language model or AI model from becoming biased because it's biased based on the data it sees."* AIR5 continued, *"That's why there is something called AI poisoning, where the models, which will continuously learn from data, you just try to give this model the biased information, continuous biased information, so you can make sure that the model will always go to that bias or to push towards specific narratives."*

*(2) GenAI Model Training:*

After feeding the GenAI system with reliable data, the GenAI models should be trained to do actions. According to AIR1, *"The real work is superseding what your model is, to train that model."* AIR3 added, *"AI has to be trained to do actions."* However, it is extremely important to train these models on non-biased data. In this context, respondent AIR1 said, *"So*

*in your project, for instance, it's biased to use male project managers more, using certain resources from certain companies. This will not be very obvious right from the beginning. As you train the data based on those biased datasets, in the future, you will see the result of it coming."*

At times, there is a need to augment data to ensure better results when using GenAI models, as AIR8 suggested, *"DL models need more data to be trained. We cannot train a DL model, like CNN and STM, or any DL model, on a small dataset because it will give you biased results. So that's why we need sometimes to do something which is called data augmentation. We need to augment the data, but when we augment the data, we need to have some data that is of the same nature or close to the existing data. So, in this case, we use generative models, the GANs, and the autoencoders."*

*(3) GenAI Model Testing & Validating:*

After building the models using reliable data, and training them on non-biased data, the models are tested to ensure their level of accuracy. In this context, respondent AIR5 commented, *"When we test the ML model or the AI model, we run accuracy curves, and we test the model accuracy and how many, true-negatives, true-false, false-negative, false-positives, all this. So, the model has to be trusted and tested, and it has to be run through ethical guidelines that will prevent hallucination and prevent this bias issue from showing in the output of the model itself."*

- *Explainable AI:*

As challenging as it may be, respondents highlighted the importance of having an explainable AI, in terms of being able to explain the way it solves a problem or decision-making, as this may comfort the users. This becomes even more challenging with huge datasets and complex problems. In this context, AIR5 commented, *"One of the ways to prove that the collaboration*

*between AI and human beings is safe is through explainable AI."* ARI5 continued, *"The bigger the dataset, the more complex the dataset, the harder for the AI result or the output to be explainable."* AIR5 said, *"Explainability of the model itself. Once you step into the DL models, you start realizing that it is very hard for any person, even the experts, to explain or to understand how the black box, which we call the AI black box, or the hidden layers of the neural network. What happens within the layers of ML models, specifically DL, how the model reaches this conclusion, or how the model comes up with this knowledge, you don't know."* AIR5 added, *"There is much research about explainable AI and how you make sure that the AI model you create is ethical, and it's based on an explainable model."*

However, it is important to mention that "Explainable AI" or the explainability of GenAI is not the concern of the users; it is rather the concern of the data scientist or engineer to build AI and GenAI models that are explainable. According to AIR8, *"I think explainable AI is a problem of AI research scientists; it's not the problem or a common problem for all the society members or the user. No, this is our problem, as AI scientists, to understand these tools. For example, when you say explainable AI, we are concerned by it; as experts in AI, we are concerned with this."*

### *12. Trust & Ethics*

Trust is a very important factor in the collaboration process between humans and GenAI, and one should start the collaboration by building trust in GenAI after being aware of its downsides. In this context, respondent AIR1 remarked, *"The factors that support the collaboration in H-AI teams is the collaboration between humans and AI, human trust in AI."* However, for better collaboration between both parties, one should first set the boundaries of trust and know when to build trust in GenAI throughout the

collaboration process and what for, as AIR2 said, *"Trust is a big area. You can trust AI in certain circles, like where you want to trust AI. You should draw the boundary that where AI will be, let's say, playing their role."* An example of building trust in GenAI is when using GenAI for a search that is based on information from the internet, then GenAI could be trustworthy since it is able to retrieve data, as commented by respondent AIR5, *"It will give me the general facts so I can trust the data coming from AI. This will retrieve the data based on facts and the parameters will guarantee that this data is the fact. ChatGPT will not tell you that the sun will sunrise from the west, you know."* Moreover, some respondents emphasized the importance of building trust through learning and experiencing collaboration with GenAI, as suggested by AIR6, *"I completely think trust is at the core of any organization or person successfully using AI. I mean, firstly, to build trust, you have to have understanding. So, to build trust, you must start by using it."* AIR6 continued, *"AI is something that I believe is impossible to read a book or take a course and be an expert. You've got to explore; you've got to learn for yourself. So, build trust through learning."*

"Trust" per se, as a factor, is a result of other factors, such as the data or the algorithms. According to AIR2, *"If the data is clear, I know what the feed-in and feed-out are, of course, I will trust this model to give me this certain data. The trust level goes down or lessens -I will try to minimize my trust- when the data gets connected; that is if I don't have control of the data, which is "feed-in", or if I don't have control over the algorithm."* AIR2 continued, *"If I don't know how the algorithm is improving itself or is connected to many algorithms, I will not be able to expect the right income, right outcome. So here I will not trust it, here I will build my measures and try to protect the outcome or to divert it. So that's the dependency of it."*

Several respondents advised not to trust GenAI with its results fully. In this context, AIR4 commented, *"I would say not to trust it. There should always be, or I'd suggest, a human to validate the response of AI."* Others have advised to carefully look at the generated results and revise them, considering the environment of the situation, to weigh things better. In this context, AIR6 remarked, *"You then go back, and you take what the AI provided, and you modify it, because you as a person, know much better today than AI can, the human reactions and the environment and the setting in which it will be utilized."* Besides, one of the respondents would not consider "trust" as a factor that enhances the collaboration with humans in PTs since humans are supposed to control these technologies. AIR13 remarked, *"Between humans and GenAI, we cannot say trust because definitely every GenAI should be controlled by humans, whether tasks or summary or any of the activities that will be shared. However, we can coexist and try to use it and not rely on it 100%, but try to use it in order to be more efficient."* In addition to the "trust" factor, respondents mentioned the importance of using GenAI models ethically, otherwise, these GenAI models will have ethical considerations for their capability of generating fake data and the user will not be able to build trust with GenAI. According to AIR8, *"The one problem I can see is that these models must be used ethically. Because you can generate fake data of human beings."* AIR8 continued, *"These data can be abused by some users on the Internet. And these can generate, for example, other photos or images from the same person."*

### *13. Role of Humans & GenAI*

Respondents raised the importance of having defined roles and authorities to work on specified tasks for either party, humans and GenAI, for effective collaboration between the two. In this context, AIR1

commented, *"The role definition, as well. The role we're going to get, at what stage AI will take more responsibilities and diminish humans."* AIR1 continued, *"Because sometimes you need the authority for the definition, who's authorized to do what? Do you come in and you overrule every time?"*

Some of the respondents highlighted the importance of assigning humans as the PM or leader while delegating most of the tasks in project management for the GenAI to work on. In this context, AIR1 remarked, *"Having certain tasks for the AI and the human will be the higher level, to supervise and monitor."* AIR1 added, *"The human role, in terms of supervisory and supervisory not on the results."* AIR1 continued, *"The human will be the higher level, to monitor."* AIR1 added, *"We'll let the AI do the functionalities, but we'll have one or two or whatever number of supervisory characters required to oversee the performance of AI in managing that project."*

Besides, one should assign roles to GenAI teammates only when needed, as remarked by AIR13, *"To try to minimize the role of GenAI on the things that you need help with. So, if you don't need help with, for example, summarizing the data or getting into specific ones, specific data and not the others, so you can control this. And then you can set the roles between you and GenAI to make it happen."*

However, it is important to mention the fact that understanding the capabilities of GenAI and its limitations will aid in defining the roles of PT members, whether for humans or GenAI teammates. AIR14 remarked, "*If you understand the capabilities, you will be able to define the roles appropriately and you will understand what could be done using the existing AI tools."*

### *14. Tasks Delegation & Assignment*

According to the respondents, delegation of tasks ensures a successful collaboration between humans and GenAI in PTs. In this context, AIR3 remarked, *"AI is very valuable when you give it some capacity to accomplish things on your behalf."* AIR3 continued, *"As of now, the way forward is you have a hybrid setup where humans can do one thing, and they can delegate the really daunting stuff to the machine."* AIR3 advised, *"Delegate the wheel to AI, to take actions on your behalf."*

However, delegation is only successful as long as you feed it legit information with clear delegation. Respondent AIR3 commented, *"But it's only as good as you feed it legit stuff. But again, it depends on how much you want to delegate to it."*

### *15. Critical Thinking*

It is extremely important to use your wisdom when collaborating with GenAI. Although the GenAI will arrive at a decision and give recommendations, one should never rely fully on its results without evaluating them critically. In this context, AIR3 commented, *"You don't take it as is, but you got to bring your wisdom to the table and you got to debate your points."* Respondent AIR6 remarked, *"You need critical thinking about what you're asking for and why you're asking for it."* AIR6 continued, *"I think the biggest way that people can overcome the fear factor and build trust in using the tools is to recognize that they are just tools, and you have to be humanly cognizant and aware and think critically about how you use them."*

Certain respondents continue to find it difficult for GenAI to understand the whole situation and recommended studying the analysis that GenAI provides, as AIR6 commented, *"The other thing that I feel extremely*

*strongly about when people use AI is even the best GenAI or any other tool, can't fully understand the context, the sensitivity, the full background, and the history of how the results it produces would be utilized. And so, it's triply critical for the human to take the results, what comes back from the tool, to take that and carefully review it against the environment."* AIR6 advised, *"Use it intelligently and it doesn't mean you don't need to think. It means you work carefully with the tool to be effective."*

***16. Monitor Collaboration Performance***

To ensure a successful H-GenAI collaboration, it is important to monitor the performance of GenAI during the collaboration process. In this context, AIR1 remarked, *"Setting up mechanisms to continuously monitor the performance and collaboration of AI and making adjustments as needed will be required to improve efficiency, effectiveness, and outcomes."*

#### 4.2.1.5 Summary of Phase 1

Figure 47 presents the findings of Phase 1.

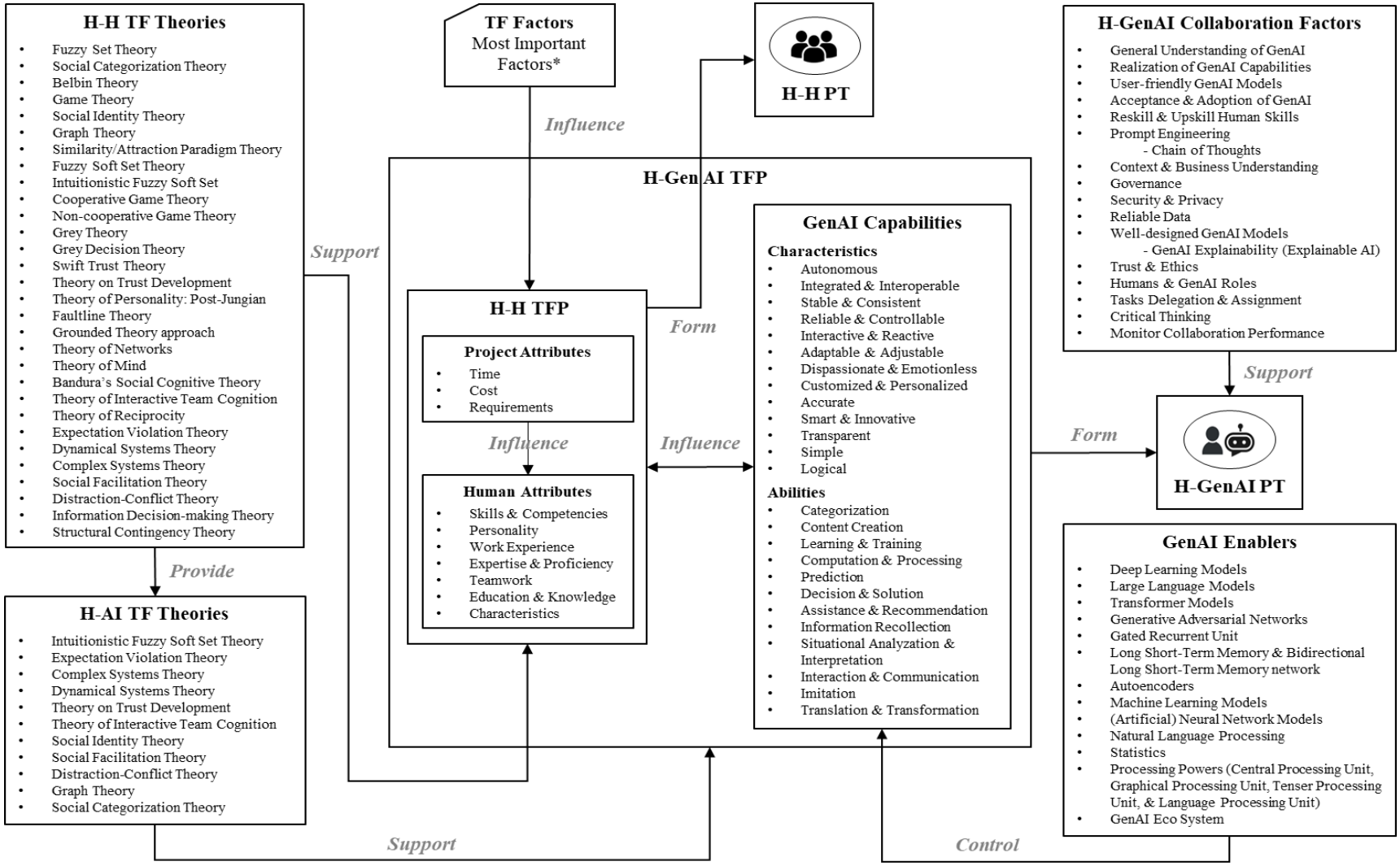



Fig. 47: H-GenAI PTF Model

**TF Factors**

Most Important Factors*

| | | | |
|---|---|---|---|
| 1. skills | 25. size | 49. level | 73. information |
| 2. projects | 26. education | 50. job | 74. changing |
| 3. knowledge | 27. relationship | 51. teamwork | 75. aptitudes |
| 4. experience | 28. traits | 52. attributes | 76. capabilities |
| 5. technical | 29. reliability | 53. roles | 77. cohesion |
| 6. personality | 30. training | 54. PM | 78. competencies |
| 7. characteristics | 31. technology | 55. criticality | 79. conflict |
| 8. communication | 32. work | 56. past | 80. coordination |
| 9. team | 33. social | 57. intelligence | 81. creativity |
| 10. cost | 34. availability | 58. openness | 82. criticism |
| 11. commitment | 35. time | 59. management | 83. database |
| 12. experts | 36. duration | 60. programming | 84. ethnicity |
| 13. task | 37. ability | 61. background | 85. feeling |
| 14. adaptability | 38. age | 62. matrix | 86. GPA |
| 15. members | 39. agreeableness | 63. sociometric | 87. interests |
| 16. business | 40. conscientiousness | 64. satisfaction | 88. introversion |
| 17. personnel | 41. emotionality | 65. collaboration | 89. judging |
| 18. expertise | 42. gender | 66. language | |
| 19. requirements | 43. honesty | 67. rate | |
| 20. domain | 44. humility | 68. working | |
| 21. sharing | 45. learnability | 69. preference | |
| 22. extraversion | 46. positions | 70. professionals | |
| 23. people | 47. salary | 71. network | |
| 24. interpersonal | 48. workload | 72. consistent | |

*Part of H-GenAI PTF Model

### 4.2.2 Phase 2: Stages of H-GenAI Project Team Development

This section presents the results of Phase 2 of the study, which addresses SRQ2 and SRQ3, in 2 sub-sections: Part 1: Building & Evaluating the H-H STD and Part 2: Building & Evaluating the H-GenAI SPTD. Finally, the third sub-section presents a summary of the results of Phase 2.

Figure 48 illustrates the structure of the H-GenAI SPTD section.

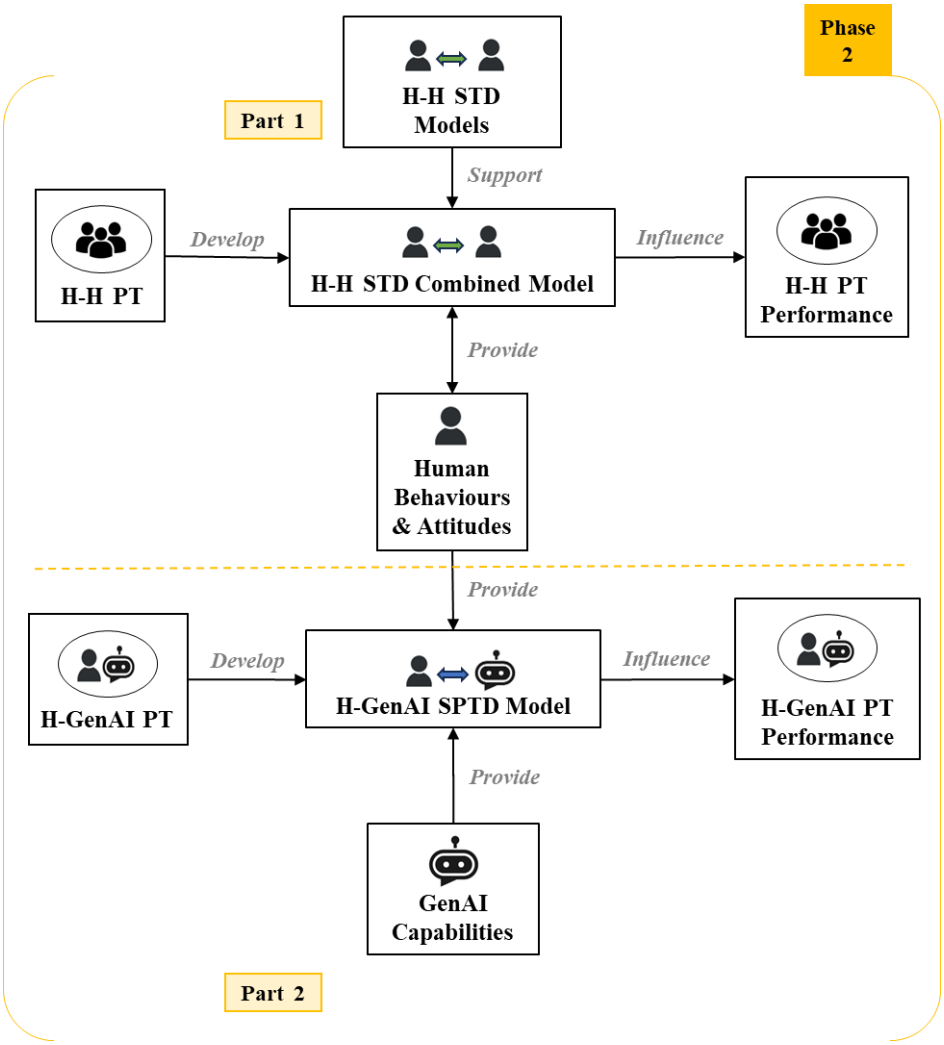



Fig. 48: H-GenAI SPTD section (Phase 2)

#### 4.2.2.1 Phase 2 Part 1: Building & Evaluating the H-H STD

The study explored nine models of STD and found that both models, Tuckman's and Woodcock's, are similar to each other in terms of team development, except that Tuckman has five stages while Woodcock has four. However, the fifth stage of Tuckman's model considers the termination of the team, which Woodcock does not cover in his model. Meaning, the stages from one to four are aligned and similar in terms of their characteristics, leading to similar development of their stages. After examining the two models, the study combined the models of Tuckman and Woodcock for a comprehensive traditional model for STD.

In an attempt to evaluate the TP during the STD and illustrate the models of Tuckman and Woodcock, first individually for both models and then combined, the study assessed the value of each of the attributes of human behaviors and attitudes shown in Tuckman's and Woodcock's models according to their positive or negative influence on team performance and, hence, development, using the value of "1" and the scale of "+" for positive influence and "-" for negative influence. Table 62 presents the human behaviors and attitudes of Tuckman's and Woodcock's models and their influence on team development.

Table (62): Human Behaviors and Attitudes in Tuckman's and Woodcock's Models

| STD | Human Behaviors & Attitudes in PTs | + or - Influence |
|---|---|---|
| **Stage 1: Tuckman** | 1. Orientation. | + |
| | 2. Testing. | + |
| | 3. Dependency. | - |
| | 4. Excitement. | + |
| | 5. Unclear objectives. | - |
| | 6. Uninvolvement. | - |
| | 7. Uncommitted members. | - |
| | 8. Confusion. | - |
| | 9. Hidden feelings. | - |
| | 10. Politeness. | + |
| | 11. Displaying eagerness. | + |
| | 12. Socializing. | + |
| | 13. Sticking to safe topics. | + |
| | 14. Unclear about how one fits in. | - |
| | 15. Some anxiety and questioning. | - |

| | | |
|---|---|---|
| **Stage 1: Woodcock** | 1. Feelings not dealt with. | - |
| | 2. Workplace is for work. | + |
| | 3. Established line prevails. | + |
| | 4. No "rocking the boat". | + |
| | 5. Poor listening. | - |
| | 6. Weaknesses covered up. | - |
| | 7. Unclear objectives. | - |
| | 8. Low involvement in planning. | - |
| | 9. Bureaucracy. | - |
| | 10. Boss takes most decisions. | - |
| **Stage 2: Tuckman** | 1. Conflict. | - |
| | 2. Polarization around interpersonal issues. | - |
| | 3. Emotional responding. | - |
| | 4. Lack of cohesion. | - |
| | 5. Subjectivity. | - |
| | 6. Confrontation. | - |
| | 7. Frustration. | - |
| | 8. Volatility. | - |
| | 9. Inconsistency. | - |
| | 10. Failure. | - |
| | 11. Some resistance. | - |
| | 12. Lack of participation. | - |
| | 13. Competition. | + |
| **Stage 2: Woodcock** | 1. Experimentations. | + |
| | 2. Risky issues debated. | + |
| | 3. Wider options considered. | + |
| | 4. Personal feelings raised. | - |
| | 5. More listening. | + |
| | 6. Concern for others. | + |
| **Stage 3: Tuckman** | 1. Overcome resistance. | + |
| | 2. Develop ingroup feeling and cohesiveness. | + |
| | 3. New standards evolve. | + |
| | 4. New roles are adopted. | + |
| | 5. Intimate, personal opinions are expressed. | + |
| | 6. Performance questioning. | + |
| | 7. Objectives review/clarification. | + |
| | 8. Roles confirmation. | + |
| | 9. Assertiveness. | + |
| | 10. Listening. | + |
| | 11. Testing new grounds. | + |
| | 12. Strengths and weaknesses identification. | + |
| | 13. Purpose and goals are well-understood. | + |
| | 14. More confident. | + |
| | 15. Improved commitment. | + |
| | 16. Members are engaged and supportive. | + |
| | 17. Relief (lowered anxiety). | + |
| **Stage 3: Woodcock** | 1. Experimentations. | + |
| | 2. Risky issues debated. | + |
| | 3. Wider options considered. | + |
| | 4. Personal feelings raised. | - |
| | 5. More listening. | + |
| | 6. Concern for others. | + |
| | 7. Methodical working. | + |
| | 8. Agreed procedures. | + |
| | 9. Established groundrules. | + |
| **Stage 4: Tuckman** | 1. Roles become flexible and functional. | + |
| | 2. Group energy is channeled into the task. | + |
| | 3. Resolved structural issues. | + |
| | 4. Supportive structure of task performance. | + |
| | 5. Creativity. | + |

| | | |
|---|---|---|
| | 6. Initiative. | + |
| | 7. Flexibility. | + |
| | 8. Open relationships. | + |
| | 9. Pride. | + |
| | 10. Learning. | + |
| | 11. Confidence. | + |
| | 12. High morale. | + |
| | 13. Success. | + |
| | 14. High motivation, trust and empathy. | + |
| | 15. Individuals defer to team needs. | + |
| | 16. Effectively producing deliverables. | + |
| | 17. Consistent performance. | + |
| | 18. Demonstrations of interdependence and self-management. | + |
| **Stage 4: Woodcock** | 1. Experimentations. | + |
| | 2. Risky issues debated. | + |
| | 3. Wider options considered. | + |
| | 4. Personal feelings raised. | - |
| | 5. More listening. | + |
| | 6. Concern for others. | + |
| | 7. Methodical working. | + |
| | 8. Agreed procedures. | + |
| | 9. Established groundrules. | + |
| | 10. High flexibility. | + |
| | 11. Appropriate leadership. | + |
| | 12. Maximum use of energy and ability. | + |
| | 13. Essential principles & social aspects considered. | + |
| | 14. Needs of all met. | + |
| | 15. Development a priority. | + |
| **Stage 5: Tuckman** | 1. Termination. | + |
| | 2. Separation. | + |
| | 3. Disbandment. | + |
| | 4. Potential sadness. | - |
| | 5. Recognition of team and individual efforts. | + |

#### 4.2.2.1.1 Tuckman's Model

Table 63 presents a summary of the number of positive and negative influences of human behaviors and attitudes on TP throughout the STD in Tuckman's model. To measure the performance of H-H teams throughout each stage of the STD according to Tuckman's model, the value of the number of positive influences for each stage is divided by the total number of behaviors and attitudes of each stage in Tuckman's model.

Table (63): Performance of H-H Teams in Tuckman's Models

| Type of Team: Human-Human | Human Behaviors & Attitudes in Tuckman's Models | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Stage 1* | | *Stage 2* | | *Stage 3* | | *Stage 4* | | *Stage 5* | |
| | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** |
| Positive & Negative Influence in Tuckman's Model | 7 | 8 | 1 | 12 | 17 | 0 | 18 | 0 | 4 | 1 |
| Total of Human Behaviors & Attitudes in Tuckman's models | 15 | | 13 | | 17 | | 18 | | 5 | |
| TP per Stage in Tuckman's Model | 0.47 | | 0.077 | | 1 | | 1 | | 0.8 | |
| TP per Stage in Tuckman's Model (%) | 47% | | 7.7% | | 100% | | 100% | | 80% | |

The study reveals the level of performance of H-H teams in each of the stages according to Tuckman's model as follows: stage 1= 0.47 (47%), stage 2= 0.077 (7.7%), stage 3= 1 (100%), stage 4= 1 (100%), and stage 5= 0.8 (80%). Figure 49 illustrates how teams of humans proceed throughout the STD when working on a project according to Tuckman's model.

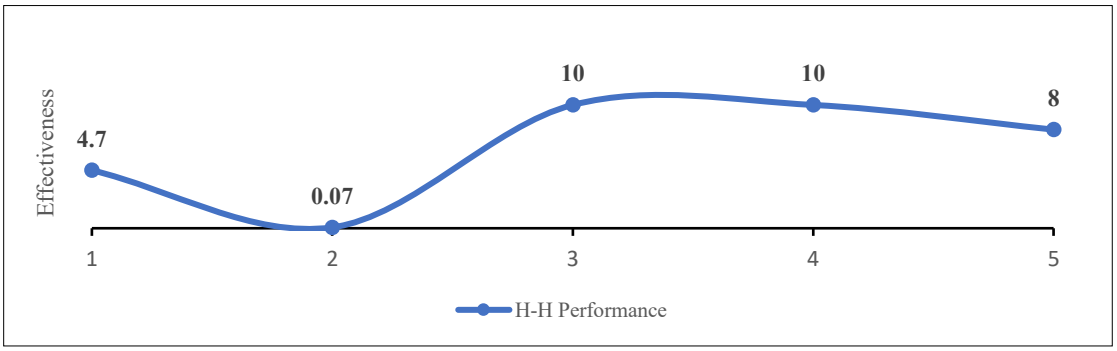



Fig. 49: H-H Team Performance in Tuckman's Model for Stages of Team Development

#### 4.2.2.1.2 Woodcock's Model

Table 64 presents a summary of the number of positive and negative influences of human behaviors and attitudes on TP throughout the STD in Woodcock's model. To measure the performance of H-H teams throughout each stage of the STD according to Woodcock's model, the value of the number of positive influences for each stage is divided by the total number of behaviors and attitudes of each stage in Woodcock's model.

Table (64): Performance of H-H Teams in Woodcock's Models

| Type of Team: Human-Human | Human Behaviors & Attitudes in Woodcock's Models | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Stage 1* | | *Stage 2* | | *Stage 3* | | *Stage 4* | |
| | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** |
| Positive & Negative Influence in Woodcock's Model | 3 | 7 | 5 | 1 | 8 | 1 | 14 | 1 |
| Total of Human Behaviors & Attitudes in Woodcock's models | 10 | | 6 | | 9 | | 15 | |
| TP per Stage in Woodcock's Model | 0.3 | | 0.83 | | 0.88 | | 0.93 | |
| TP per Stage in Woodcock's Model (%) | 30% | | 83% | | 88% | | 93% | |

The study reveals the level of performance of H-H teams in each of the stages according to Woodcock's model as follows: stage 1= 0.3 (30%), stage 2= 0.83 (83%), stage 3= 0.88 (88%), and stage 4= 0.93 (93%). Figure 50 illustrates how teams of humans proceed throughout the STD when working on a project according to Woodcock's model.

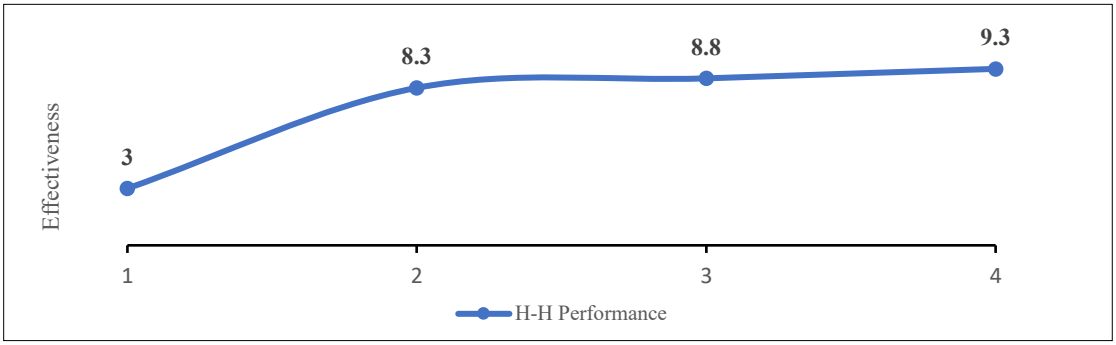



Fig. 50: H-H Team Performance in Woodcock's Model for Stages of Team Development

### 4.2.2.1.3 Tuckman's & Woodcock's Models Combined

For a more comprehensive model for the STD, the study combines the results of the two models, Tuckman's and Woodcock's. To measure the performance of H-H teams throughout each stage of the STD for both models combined, the value of the total number of positive influences of both Tuckman's and Woodcock's models for each stage is divided by the total number of behaviors and attitudes of each stage in the two models. Accordingly, the study reveals the level of performance of H-H teams in

each of the stages as shown in Table 65: stage 1= 0.4 (40%), stage 2= 0.32 (32%), stage 3= 0.96 (96%), stage 4= 0.97 (97%), and stage 5= 0.8 (80%). Figure 51 illustrates how teams of humans proceed throughout the STD when working on a project.

Table (65): Performance of H-H Teams in Tuckman's & Woodcock's Models

| **Type of Team: Human-Human** | **Human Behaviors & Attitudes in Tuckman's & Woodcock's Models** | | | | |
|---|---|---|---|---|---|
| | ***Stage 1*** | ***Stage 2*** | ***Stage 3*** | ***Stage 4*** | ***Stage 5*** |
| Total of Positive Influence in both models Tuckman's & Woodcock's | 10 | 6 | 25 | 32 | 4 |
| Total of Human Behaviors & Attitudes in both models | 25 | 19 | 26 | 33 | 5 |
| TP per Stage in both models | 0.4 | 0.32 | 0.96 | 0.97 | 0.8 |
| TP per Stage in both models (%) | 40% | 32% | 96% | 97% | 80% |

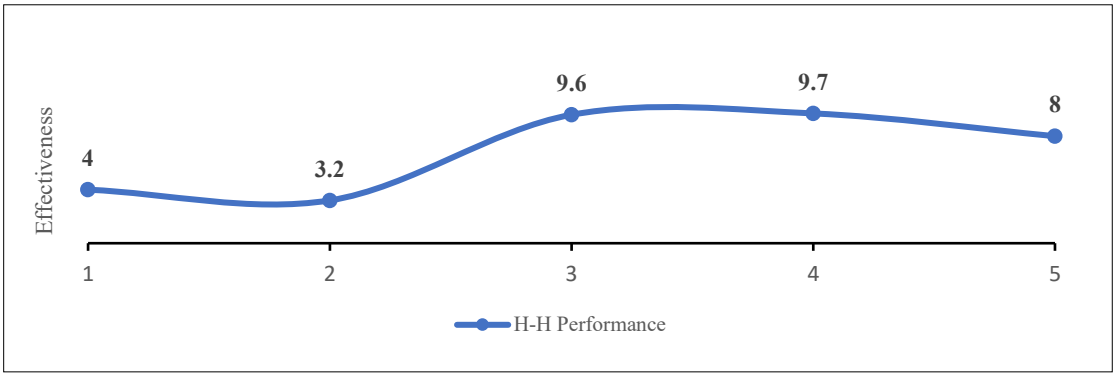



Fig. 51: H-H Team Performance in Both Tuckman's & Woodcock's Models for Stages of Team Development

### 4.2.2.2 Phase 2 Part 2: Building & Evaluating the H-GenAI SPTD

To build the model of H-GenAI SPTD, the study took several steps. First, in an attempt to evaluate the TP during the SPTD and illustrate the H-GenAI SPTD according to the models of Tuckman and Woodcock, first individually and then combined, the study mapped the pre-determined main characteristics and abilities of GenAI with those behaviors and attitudes of humans. Then, the study considered the assessment of the

values of the human behaviors and attitudes shown in Tuckman's and Woodcock's models according to their positive or negative influence on team development, which were revealed in Phase 2 Part 1, and assessed the GenAI characteristics and abilities according to their positive or negative influence on team development, using the value of "1" and the scale of "+" for positive influence and "-" for negative influence.

Table 66 presents the human behaviors and attitudes and their value according to their positive or negative influence on team development as well as the GenAI characteristics and abilities that correspond to those behaviors and attitudes of humans along with their positive or negative influence on PT development.

Table (66): Humans & Generative AI Attributes

| STD | Human Behaviors & Attitudes in PTs | + or - Influence | H-GenAI Characteristics & Abilities in PTs Corresponding to Human Behaviors & Attitudes | + or - Influence |
|---|---|---|---|---|
| **Stage 1: Tuckman** | 1. Orientation. | + | AC3 | + |
| | 2. Testing. | + | AC3, AC4 | + |
| | 3. Dependency. | - | AC8, AC9, AC10 | + |
| | 4. Excitement. | + | CC7 | - |
| | 5. Unclear objectives. | - | AC7, AC8, CC11 | + |
| | 6. Uninvolvement. | - | CC2 | + |
| | 7. Uncommitted members. | - | AC10 | + |
| | 8. Confusion. | - | AC6, AC8, CC10, CC11 | + |
| | 9. Hidden feelings. | - | CC7, CC11 | + |
| | 10. Politeness. | + | CC7 | + |
| | 11. Displaying eagerness. | + | CC7 | + |
| | 12. Socializing. | + | CC7 | + |
| | 13. Sticking to safe topics. | + | CC11, CC13 | + |
| | 14. Unclear about how one fits in. | - | CC5, CC6, CC8 | + |
| | 15. Some anxiety and questioning. | - | AC7, AC10, CC7 | + |
| **Stage 1: Woodcock** | 1. Feelings not dealt with. | - | CC7 | + |
| | 2. Workplace is for work. | + | CC4 | + |
| | 3. Established line prevails. | + | CC3, CC4 | + |
| | 4. No "rocking the boat". | + | CC3, CC4 | + |
| | 5. Poor listening. | - | AC10 | + |
| | 6. Weaknesses covered up. | - | CC11 | + |
| | 7. Unclear objectives. | - | CC11 | + |
| | 8. Low involvement in planning. | - | AC2, AC4, AC5, AC6, AC7, AC9, AC12, CC4, CC6 | + |
| | 9. Bureaucracy. | - | CC1 | + |
| | 10. Boss takes most decisions. | - | AC6, AC7 | + |
| **Stage 2: Tuckman** | 1. Conflict. | - | CC7 | + |
| | 2. Polarization around interpersonal issues. | - | CC7, CC11, CC13 | + |
| | 3. Emotional responding. | - | CC7 | + |
| | 4. Lack of cohesion. | - | AC6, AC7, AC9, CC10, CC13 | + |
| | 5. Subjectivity. | - | CC7, CC11 | + |
| | 6. Confrontation. | - | CC5, CC7 | + |
| | 7. Frustration. | - | CC7 | + |
| | 8. Volatility. | - | CC3, CC4 | + |
| | 9. Inconsistency. | - | CC3 | + |
| | 10. Failure. | - | AC3, AC5, CC3, CC4 | + |
| | 11. Some resistance. | - | CC6, CC7, CC12 | + |
| | 12. Lack of participation. | - | AC10, CC1, CC2, CC5 | + |
| | 13. Competition. | + | CC3, CC4 | + |

| | | | | |
|---|---|---|---|---|
| **Stage 2: Woodcock** | 1. Experimentations. | + | AC4, AC5, AC12 | + |
| | 2. Risky issues debated. | + | AC3, AC4, AC5, AC6, AC7, AC8, AC9, AC10, CC4, CC9, CC10, CC13 | + |
| | 3. Wider options considered. | + | AC2, AC4, AC7, AC9, CC10 | + |
| | 4. Personal feelings raised. | - | CC7, CC11 | + |
| | 5. More listening. | + | AC10, CC2, CC8 | + |
| | 6. Concern for others. | + | CC7 | + |
| **Stage 3: Tuckman** | 1. Overcome resistance. | + | CC6, CC7, CC8, CC12 | + |
| | 2. Develop ingroup feeling and cohesiveness. | + | CC6, CC7, CC8 | + |
| | 3. New standards evolve. | + | AC1, AC3, AC8, AC9, CC2, CC6 | + |
| | 4. New roles are adopted. | + | CC4, CC6 | + |
| | 5. Intimate, personal opinions are expressed. | + | CC7, CC11 | + |
| | 6. Performance questioning. | + | AC7, AC9, AC10, CC10, CC13 | + |
| | 7. Objectives review/clarification. | + | AC3, AC4, AC7, AC8, CC6 | + |
| | 8. Roles confirmation. | + | CC1, CC6 | + |
| | 9. Assertiveness. | + | AC12, CC3, CC4 | + |
| | 10. Listening. | + | AC10, CC2 | + |
| | 11. Testing new grounds. | + | AC1, AC3, AC4, AC7, AC8, CC6, CC10, CC13 | + |
| | 12. Strengths and weaknesses identification. | + | AC5, AC7, AC9, CC5, CC9, CC10, CC11, CC13 | + |
| | 13. Purpose and goals are well-understood. | + | AC3, AC8, AC9, CC10, CC13 | + |
| | 14. More confident. | + | AC6, AC8, AC9, CC2, CC9, CC10, CC13 | + |
| | 15. Improved commitment. | + | AC3, CC3, CC4 | + |
| | 16. Members are engaged and supportive. | + | AC7, AC10, CC2, CC5, CC6, CC8 | + |
| | 17. Relief (lowered anxiety). | + | CC7 | + |
| **Stage 3: Woodcock** | 1. Experimentations. | + | AC4, AC5, AC12 | + |
| | 2. Risky issues debated. | + | AC3, AC4, AC5, AC6, AC7, AC8, AC9, AC10, CC4, CC9, CC10, CC13 | + |
| | 3. Wider options considered. | + | AC2, AC4, AC7, AC9, CC10 | + |
| | 4. Personal feelings raised. | - | CC7, CC11 | + |
| | 5. More listening. | + | AC10, CC2, CC8 | + |
| | 6. Concern for others. | + | CC7 | + |
| | 7. Methodical working. | + | AC4, AC9, AC12 | + |
| | 8. Agreed procedures. | + | AC8, AC11, CC1, CC3, CC4, CC6, CC9 | + |
| | 9. Established groundrules. | + | AC8, AC11, CC1, CC3, CC4, CC6, CC9 | + |
| **Stage 4: Tuckman** | 1. Roles become flexible and functional. | + | AC12, CC3, CC6, CC8 | + |
| | 2. Group energy is channeled into the task. | + | AC12, CC3 | + |
| | 3. Resolved structural issues. | + | CC4, CC7 | + |
| | 4. Supportive structure of task performance. | + | AC12, CC1, CC4 | + |
| | 5. Creativity. | + | CC10 | + |
| | 6. Initiative. | + | CC1 | + |
| | 7. Flexibility. | + | CC6 | + |
| | 8. Open relationships. | + | CC7 | + |
| | 9. Pride. | + | CC7 | + |
| | 10. Learning. | + | AC3 | + |
| | 11. Confidence. | + | CC9 | + |
| | 12. High morale. | + | CC7 | - |
| | 13. Success. | + | CC3, CC4 | + |
| | 14. High motivation, trust and empathy. | + | CC7 | + |
| | 15. Individuals defer to team needs. | + | CC6, CC7, CC8 | + |
| | 16. Effectively producing deliverables. | + | CC3, CC4 | + |
| | 17. Consistent performance. | + | CC3 | + |
| | 18. Demonstrations of interdependence and self-management. | + | CC1 | + |
| **Stage 4: Woodcock** | 1. Experimentations. | + | AC4, AC5, AC12 | + |
| | 2. Risky issues debated. | + | AC3, AC4, AC5, AC6, AC7, AC8, AC9, AC10, CC4, CC9, CC10, CC13 | + |
| | 3. Wider options considered. | + | AC2, AC4, AC7, AC9, CC10 | + |
| | 4. Personal feelings raised. | - | CC7, CC11 | + |
| | 5. More listening. | + | AC10, CC2, CC8 | + |
| | 6. Concern for others. | + | CC7 | + |
| | 7. Methodical working. | + | AC4, AC9, AC12 | + |
| | 8. Agreed procedures. | + | AC1, AC8, AC11, CC1, CC3, CC4, CC6, CC9 | + |
| | 9. Established groundrules. | + | AC8, AC11, CC1, CC3, CC4, CC6, CC9 | + |
| | 10. High flexibility. | + | CC6 | + |
| | 11. Appropriate leadership. | + | CC1 | + |
| | 12. Maximum use of energy and ability. | + | CC2, CC3 | + |
| | 13. Essential principles & social aspects considered. | + | CC3 | + |

| | | | | |
|---|---|---|---|---|
| | 14. Needs of all met. | + | CC3, CC6 | + |
| | 15. Development a priority. | + | CC4, CC11 | + |
| **Stage 5: Tuckman** | 1. Termination. | + | CC3 | + |
| | 2. Separation. | + | CC3 | + |
| | 3. Disbandment. | + | CC3 | + |
| | 4. Potential sadness. | - | CC7 | + |
| | 5. Recognition of team and individual efforts. | + | CC11 | + |

#### 4.2.2.2.1 Tuckman's Model

Table 67 presents a summary of the number of positive and negative influences of GenAI characteristics and abilities that correspond to human behaviors and attitudes on TP throughout the SDT in Tuckman's model. To measure the performance of H-GenAI teams throughout each stage of the STD, the value of the total number of positive influences in Tuckman's model for each stage is divided by the total number of human behaviors and attitudes of each stage.

Table (67): Performance of Human-Generative AI Teams According to Tuckman's Models

| **Type of Team: Human-GenAI** | **Influence of Generative AI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Tuckman's Model** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***Stage 1*** | | ***Stage 2*** | | ***Stage 3*** | | ***Stage 4*** | | ***Stage 5*** | |
| | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** |
| Positive & Negative Influence of GenAI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Tuckman's Model | 14 | 1 | 13 | 0 | 17 | 0 | 17 | 1 | 5 | 0 |
| Total of Positive Influence of GenAI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Tuckman's Model | 14 | | 13 | | 17 | | 17 | | 5 | |
| Total of Human Behaviors & Attitudes in Tuckman's Model | 15 | | 13 | | 17 | | 18 | | 5 | |
| TP per Stage according to Tuckman's Model | 0.93 | | 1 | | 1 | | 0.94 | | 1 | |
| TP per Stage according to Tuckman's Model (%) | 93% | | 100% | | 100% | | 94% | | 100% | |

Accordingly, the study reveals the level of performance of H-GenAI teams in each of the stages according to Tuckman's model is as follows: stage 1= 0.93 (93%), stage 2= 1 (100%), stage 3= 1 (100%), stage 4= 0.94 (94%), and stage 5= 1 (100%).

Figure 52 illustrates how H-GenAI teams proceed throughout the STD when working on a project according to Tuckman's model.

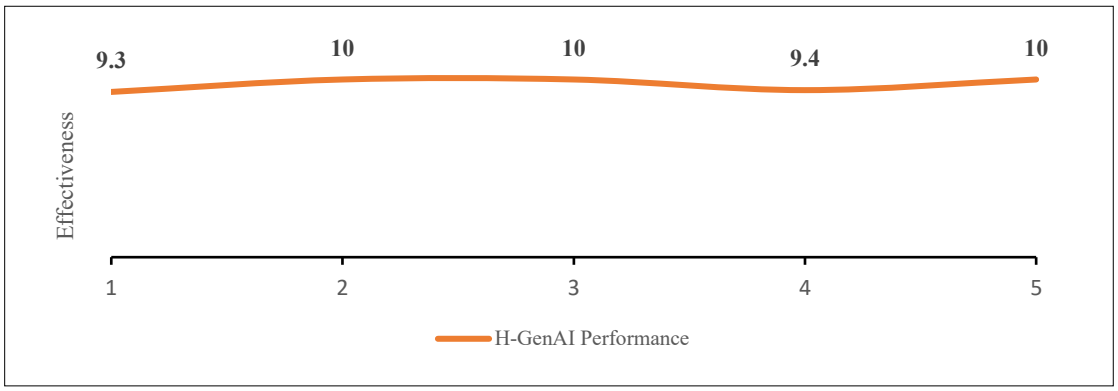



Fig. 52: H-GenAI Team Performance through Stages of Team Development According to Tuckman's Model

Table 68 presents the performance of H-H teams as well as the performance of H-GenAI teams throughout the STD according to Tuckman's model. Accordingly, the study reveals the difference in performance level between H-H teams and H-GenAI teams in each of the stages and the percentage of their differences as follows: stage 1= 4.6, which represents 97.87%, stage 2= 10 (141.85%), stage 3= 0 (0%), stage 4= -0.6 (-6.00%), and stage 5= 2 (25%). The table also shows the successive performance growth of H-GenAI teams throughout the STD: 198%, 14286%, 100%, 94%, and 125%.

Table (68): Performance Comparison Between H-H & H-GenAI Teams According to Tuckman's Models

| STD | H-H Performance Level | H-GenAI Performance Level | The Difference in Performance (between H-H & H-GenAI Teams) | The Difference in Performance (%) (between H-H & H-GenAI Teams) | Human-GenAI Performance Growth (%) |
|---|---|---|---|---|---|
| **Stage 1** | 4.7 | 9.3 | 4.6 | 97.87% | 198% |
| **Stage 2** | 0.07 | 10 | 9.93 | 14186% | 14286% |
| **Stage 3** | 10 | 10 | 0 | 0% | 100% |
| **Stage 4** | 10 | 9.4 | -0.6 | -6% | 94% |
| **Stage 5** | 8 | 10 | 2 | 25% | 125% |

Figure 53 shows the difference in the performance of H-H teams in comparison to H-GenAI teams throughout the STD when working on a project according to Tuckman's model.

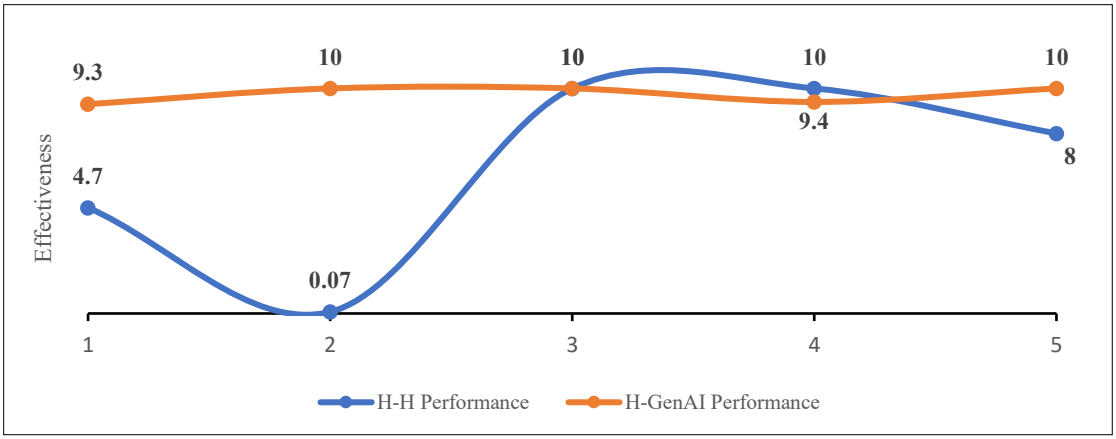



Fig. 53: The Difference in Performance of H-H & H-GenAI Teams According to Tuckman's Model

The study's results reveal that the H-GenAI teams' second stage of the STD has the largest increase in performance compared to H-H teams according to Tuckman's model, followed by the first stage, and the fifth stage. The third stage shows no difference in performance. As for the fourth stage, there is a decrease in performance because the performance of H-GenAI teams is less than the performance of H-H teams in this stage.

#### 4.2.2.2.2 Woodcock's Model

Table 69 presents a summary of the number of positive and negative influences of GenAI characteristics and abilities that correspond to human behaviors and attitudes on TP throughout the SDT in Woodcock's model. To measure the performance of H-GenAI teams throughout each stage of the STD, the value of the total number of positive influences in Woodcock's model for each stage is divided by the total number of human behaviors and attitudes of each stage.

Table (69): Performance of H-GenAI Teams According to Woodcock's Models

| **Type of Team: Human-GenAI** | **Influence of Generative AI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Woodcock's Model** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ***Stage 1*** | | ***Stage 2*** | | ***Stage 3*** | | ***Stage 4*** | |
| | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** |
| Positive & Negative Influence of GenAI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Woodcock's Model | 10 | 0 | 6 | 0 | 9 | 0 | 15 | 0 |
| Total of Positive Influence of GenAI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Woodcock's Model | 10 | | 6 | | 9 | | 15 | |
| Total of Human Behaviors & Attitudes in Woodcock's Model | 10 | | 6 | | 9 | | 15 | |
| TP per Stage according to Woodcock's Model | 1 | | 1 | | 1 | | 1 | |
| TP per Stage according to Woodcock's Model (%) | 100% | | 100% | | 100% | | 100% | |

Accordingly, the study reveals the level of performance of H-GenAI teams in each of the stages according to Woodcock's model is as follows: stage 1= 1 (100%), stage 2= 1 (100%), stage 3= 1 (100%), and stage 4= 1 (100%). Figure 54 illustrates how H-GenAI teams proceed throughout the STD when working on a project according to Woodcock's model.

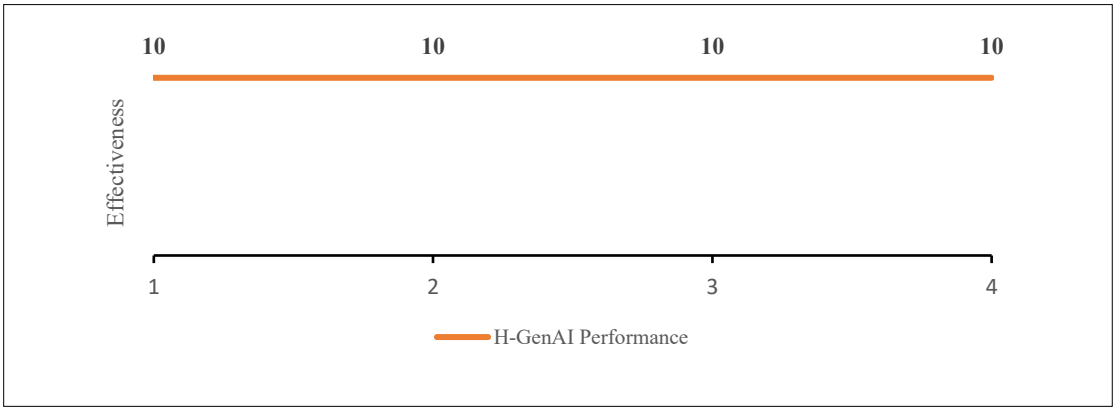



Fig. 54: H-GenAI Team Performance through Stages of Team Development According to Woodcock's Model

Table 70 presents the performance of H-H teams as well as the performance of H-GenAI teams throughout the STD according to Woodcock's model. Accordingly, the study reveals the difference in performance level between

H-H teams and H-GenAI teams in each of the stages and the percentage of their differences as follows: stage 1= 7, which represents 233.3%, stage 2= 1.7 (20.48%), stage 3= 1.2 (13.64%), and stage 4= 0.7 (7.53%). The table also shows the successive performance growth of H-GenAI teams throughout the STD: 333%, 120%, 114%, and 108%.

Table (70): Performance Comparison Between H-H & H-GenAI Teams According to Woodcock's Models

| STD | H-H Performance Level | H-GenAI Performance Level | The Difference in Performance (between H-H & H-GenAI Teams) | The Difference in Performance (%) (between H-H & H-GenAI Teams) | Human-GenAI Performance Growth (%) |
|---|---|---|---|---|---|
| **Stage 1** | 3 | 10 | 7 | 233.33% | 333% |
| **Stage 2** | 8.3 | 10 | 1.7 | 20.48% | 120% |
| **Stage 3** | 8.8 | 10 | 1.2 | 13.64% | 114% |
| **Stage 4** | 9.3 | 10 | 0.7 | 7.53% | 108% |

Figure 55 shows the difference in the performance of H-H teams in comparison to H-GenAI teams throughout the STD when working on a project, according to Woodcock's model.

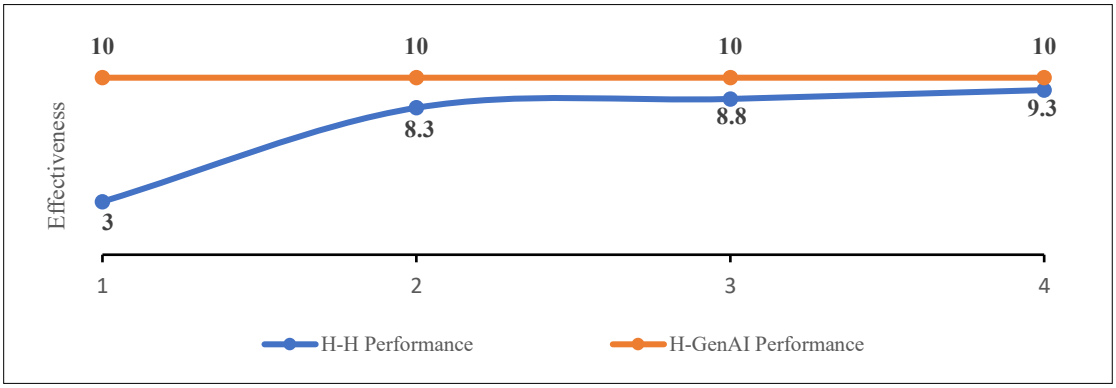



Fig. 55: The Difference in Performance of H-H & H-GenAI Teams According to Woodcock's Model

The study's results reveal that the H-GenAI teams' first stage of the STD has the largest increase in performance compared to H-H teams according to Woodcock's model, followed by the second stage, the third stage, and the fourth stage.

#### 4.2.2.2.3 Tuckman's & Woodcock's Models Combined

Table 71 presents a summary of the number of positive and negative influences of GenAI characteristics and abilities that correspond to human behaviors and attitudes on TP throughout the SDT in both models of Tuckman and Woodcock. To measure the performance of H-GenAI teams throughout each stage of the STD, the value of the total number of positive influences of both Tuckman's and Woodcock's models for each stage is divided by the total number of human behaviors and attitudes of each stage.

Accordingly, the study reveals the level of performance of H-GenAI teams in each of the stages: stage 1= 0.96 (96%), stage 2= 1 (100%), stage 3= 1 (100%), stage 4= 0.97 (97%), and stage 5= 1 (100%).

Table (71): Performance of Human-Generative AI Teams according to Tuckman's & Woodcock's Models

| **Type of Team: Human-GenAI** | **Influence of Generative AI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Tuckman's & Woodcock's Models** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***Stage 1*** | | ***Stage 2*** | | ***Stage 3*** | | ***Stage 4*** | | ***Stage 5*** | |
| | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** | ***P*** | ***N*** |
| Positive & Negative Influence of GenAI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Tuckman's Model | 14 | 1 | 13 | - | 17 | - | 17 | 1 | 5 | - |
| Positive & Negative Influence of GenAI Characteristics & Abilities Corresponding to Human Behaviors & Attitudes in Woodcock's Model | 10 | - | 6 | - | 9 | - | 15 | - | - | - |
| Total of Positive Influence in both models Tuckman's & Woodcock's | 24 | | 19 | | 26 | | 32 | | 5 | |
| Total of Human Behaviors & Attitudes in both models Tuckman's & Woodcock's | 25 | | 19 | | 26 | | 33 | | 5 | |
| TP per Stage in both models | 0.96 | | 1 | | 1 | | 0.97 | | 1 | |
| TP per Stage in both models (%) | 96% | | 100% | | 100% | | 97% | | 100% | |

Figure 56 illustrates how teams of humans and GenAI proceed throughout the STD when working on a project.

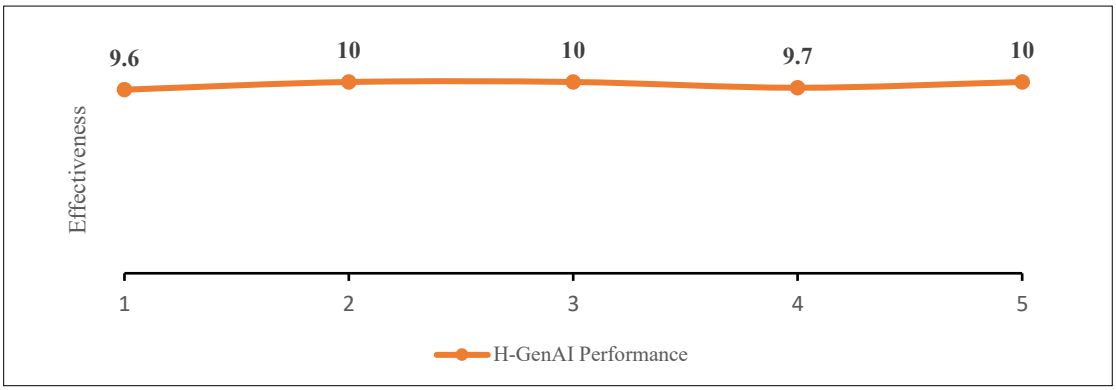



Fig. 56: H-GenAI Team Performance through Stages of Team Development

Table 72 presents the performance of H-H teams as well as the performance of H-GenAI teams throughout the STD. Accordingly, the study reveals the difference in performance level between H-H teams and H-GenAI teams in each of the stages and the percentage of their differences as follows: stage 1= 5.6, which represents 140%, stage 2= 6.8 (212.5%), stage 3= 0.4 (4.17%), stage 4= 0 (0%), and stage 5= 2 (25%). The table also shows the successive performance growth of H-GenAI teams throughout the STD: 240%, 312.5%, 104.17%, 100%, and 125%.

Table (72): Performance Comparison Between H-H & H-GenAI Teams According to Tuckman's and Woodcock's Models Combined

| STD | H-H Performance Level | H-GenAI Performance Level | The Difference in Performance (between H-H & H-GenAI Teams) | The Difference in Performance (%) (between H-H & H-GenAI Teams) | Human-GenAI Performance Growth (%) |
|---|---|---|---|---|---|
| **Stage 1** | 4 | 9.6 | 5.6 | 140% | 240% |
| **Stage 2** | 3.2 | 10 | 6.8 | 212.5% | 312.5% |
| **Stage 3** | 9.6 | 10 | 0.4 | 4.17% | 104.17% |
| **Stage 4** | 9.7 | 9.7 | 0 | 0% | 100% |
| **Stage 5** | 8 | 10 | 2 | 25% | 125% |

Figure 57 shows the difference in the performance of H-H teams in comparison to H-GenAI teams throughout STD when working on a project.

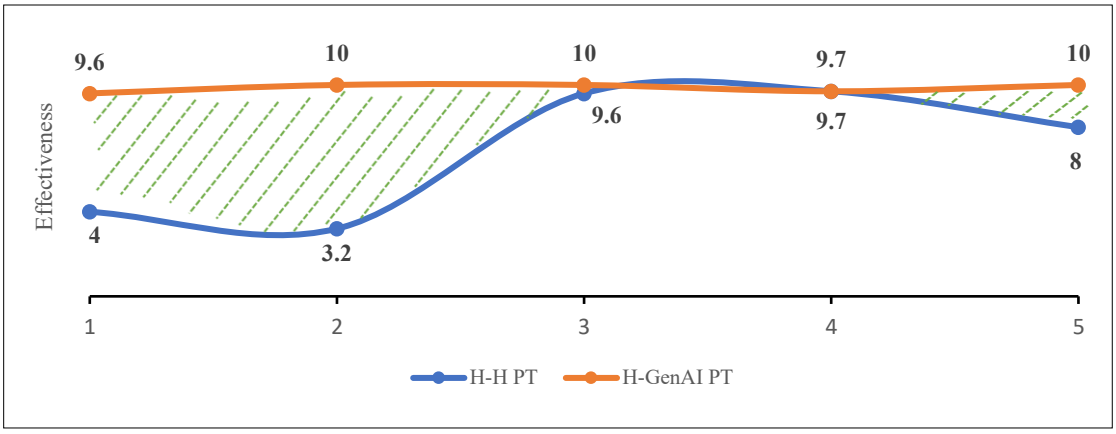



Fig. 57: The Difference in Performance of H-H & H-GenAI Teams

The study's results reveal that the H-GenAI teams' second stage of the STD has the largest increase in performance compared to H-H teams, followed by the first stage, the fifth stage, and the third stage. As for the fourth stage, there is no increase in performance because the performance of H-GenAI teams is equal to the performance of H-H teams in this stage.

#### 4.2.2.3 Summary of Phase 2

Accordingly, Table 73 shows the GenAI characteristics and abilities—without redundancy—that appear in each stage of the STD.

Table (73): Generative AI Characteristics & Abilities for SPTD

| STD | GenAI Characteristics & Abilities Throughout the SPTD | |
|---|---|---|
| **Stage 1** | CC1: Autonomous | AC2: Content Creation |
| | CC2: Integrated & Interoperable | AC3: Learning & Training |
| | CC3: Stable & Consistent | AC4: Computation & Processing |
| | CC4: Reliable & Controllable | AC5: Prediction |
| | CC5: Interactive & Reactive | AC6: Decision & Solution |
| | CC6: Adaptable & Adjustable | AC7: Assistance & Recommendation |
| | CC7: Dispassionate & Emotionless | AC8: Information Recollection |
| | CC8: Customized & Personalized | AC9: Situational Analysis & Interpretation |
| | CC10: Smart & Innovative | AC10: Interaction & Communication |
| | CC11: Transparent | AC12: Translation & Transformation |
| | CC13: Logical | |
| **Stage 2** | CC1: Autonomous | AC2: Content Creation |
| | CC2: Integrated & Interoperable | AC3: Learning & Training |
| | CC3: Stable & Consistent | AC4: Computation & Processing |
| | CC4: Reliable & Controllable | AC5: Prediction |
| | CC5: Interactive & Reactive | AC6: Decision & Solution |
| | CC6: Adaptable & Adjustable | AC7: Assistance & Recommendation |
| | CC7: Dispassionate & Emotionless | AC8: Information Recollection |
| | CC8: Customized & Personalized | AC9: Situational Analysis & Interpretation |
| | CC9: Accurate | AC10: Interaction & Communication |
| | CC10: Smart & Innovative | AC12: Translation & Transformation |
| | CC11: Transparent | |
| | CC12: Simple | |
| | CC13: Logical | |
| **Stage 3** | CC1: Autonomous | AC1: Categorization |
| | CC2: Integrated & Interoperable | AC2: Content Creation |
| | CC3: Stable & Consistent | AC3: Learning & Training |
| | CC4: Reliable & Controllable | AC4: Computation & Processing |
| | CC5: Interactive & Reactive | AC5: Prediction |
| | CC6: Adaptable & Adjustable | AC6: Decision & Solution |
| | CC7: Dispassionate & Emotionless | AC7: Assistance & Recommendation |
| | CC8: Customized & Personalized | AC8: Information Recollection |
| | CC9: Accurate | AC9: Situational Analysis & Interpretation |
| | CC10: Smart & Innovative | AC10: Interaction & Communication |
| | CC11: Transparent | AC11: Imitation |
| | CC12: Simple | AC12: Translation & Transformation |
| | CC13: Logical | |
| **Stage 4** | CC1: Autonomous | AC1: Categorization |
| | CC2: Integrated & Interoperable | AC2: Content Creation |
| | CC3: Stable & Consistent | AC3: Learning & Training |
| | CC4: Reliable & Controllable | AC4: Computation & Processing |
| | CC6: Adaptable & Adjustable | AC5: Prediction |
| | CC7: Dispassionate & Emotionless | AC6: Decision & Solution |
| | CC8: Customized & Personalized | AC7: Assistance & Recommendation |
| | CC9: Accurate | AC8: Information Recollection |
| | CC10: Smart & Innovative | AC9: Situational Analysis & Interpretation |
| | CC11: Transparent | AC10: Interaction & Communication |
| | CC13: Logical | AC11: Imitation |
| | | AC12: Translation & Transformation |
| **Stage 5** | CC3: Stable & Consistent | |
| | CC7: Dispassionate & Emotionless | |
| | CC11: Transparent | |

The results of the study show that all the main characteristics and abilities of GenAI are important for the collaboration between humans and GenAI teams and increase the performance (effectiveness) of the PTs.

According to the findings of Phase 2, Figure 58 illustrates Tuckman's H-H STD Model, Figure 59 illustrates H-GenAI SPTD Model (According to Tuckman's Model), and Table 74 presents the Human Behaviors & Attitudes (B&A) & GenAI Characteristics & Abilities (C&A) throughout STD according to Tuckman's Model.

Figure 60 illustrates Woodcock's H-H STD Model, Figure 61 illustrates H-GenAI SPTD Model (According to Woodcock's Model, and Table 75 presents Human Behaviors & Attitudes (B&A) & GenAI Characteristics & Abilities (C&A) throughout STD according to Woodcock's Model.

Finally, Figure 62 illustrates H-H STD Combined Model, Figure 63 illustrates H-GenAI SPTD Model (according to Tuckman's & Woodcock's STD Models Combined, and Table 76 presents the developed model of H-GenAI SPTD.

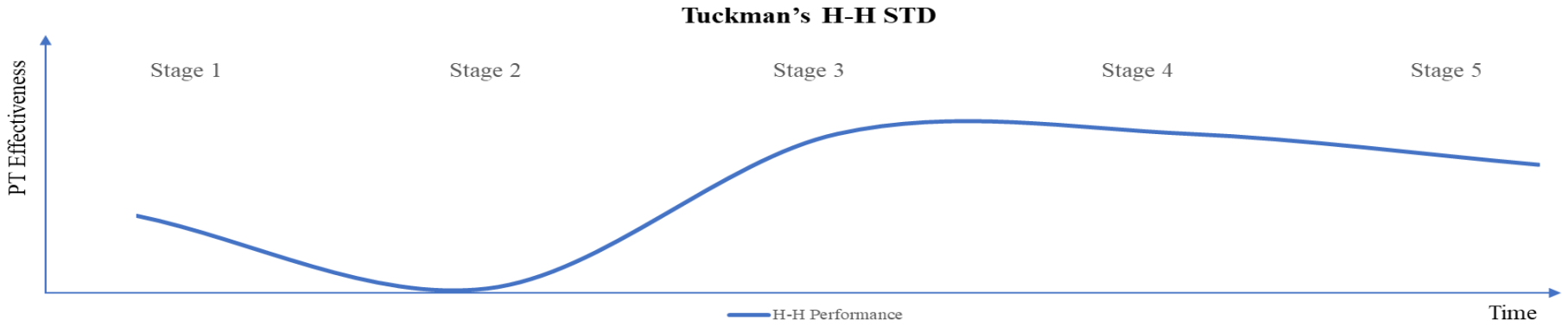



Fig. 58: Tuckman's H-H STD Model

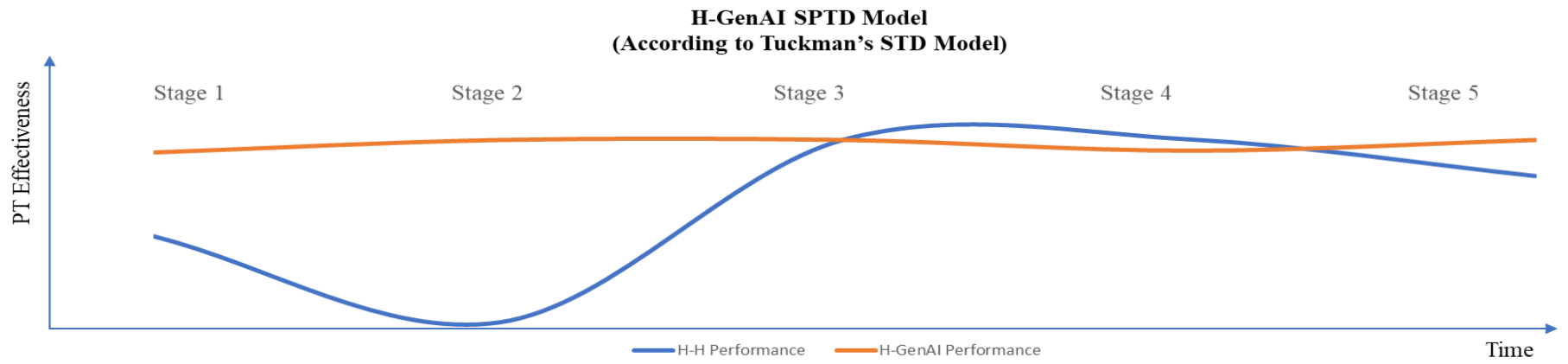



Fig. 59: H-GenAI SPTD Model (According to Tuckman's Model)

Table (74): Human Behaviors & Attitudes (B&A) & GenAI Characteristics & Abilities (C&A) throughout STD According to Tuckman's Model

**H-GenAI SPTD Model**
**(According to Tuckman's STD Model)**

**Stage 1**

**Human B&A**
1. Orientation.
2. Testing.
3. Dependency.
4. Excitement.
5. Unclear objectives.
6. Uninvolvement.
7. Uncommitted members.
8. Confusion.
9. Hidden feelings.
10. Politeness.
11. Displaying eagerness.
12. Socializing.
13. Sticking to safe topics.
14. Unclear about how one fits in.
15. Some anxiety and questioning.

**GenAI C&A**
1. Learning & Training
2. Computation & Processing
3. Decision & Solution
4. Assistance & Recommendation
5. Information Recollection
6. Situational Analyzation & Interpretation
7. Interaction & Communication
8. Integrated & Interoperable
9. Interactive & Reactive
10. Adaptable & Adjustable
11. Dispassionate & Emotionless
12. Customized & Personalized
13. Smart & Innovative
14. Transparent
15. Logical

**Stage 2**

**Human B&A**
1. Conflict.
2. Polarization around interpersonal issues.
3. Emotional responding.
4. Lack of cohesion.
5. Subjectivity.
6. Confrontation.
7. Frustration.
8. Volatility.
9. Inconsistency.
10. Failure.
11. Some resistance.
12. Lack of participation.
13. Competition.

**GenAI C&A**
1. Learning & Training
2. Prediction
3. Decision & Solution
4. Assistance & Recommendation
5. Situational Analyzation & Interpretation
6. Interaction & Communication
7. Autonomous
8. Integrated & Interoperable
9. Stable & Consistent
10. Reliable & Controllable
11. Interactive & Reactive
12. Adaptable & Adjustable
13. Dispassionate & Emotionless
14. Smart & Innovative
15. Transparent
16. Simple
17. Logical

**Stage 3**

**Human B&A**
1. Overcome resistance.
2. Develop ingroup feeling and cohesiveness.
3. New standards evolve.
4. New roles are adopted.
5. Intimate, personal opinions are expressed.
6. Performance questioning.
7. Objectives review/clarification.
8. Roles confirmation.
9. Assertiveness.
10. Listening.
11. Testing new grounds.
12. Strengths and weaknesses identification.
13. Purpose and goals are well-understood.
14. More confident.
15. Improved commitment.
16. Members are engaged and supportive.
17. Relief (lowered anxiety).

**GenAI C&A**
1. Categorization
2. Learning & Training
3. Computation & Processing
4. Prediction
5. Decision & Solution
6. Assistance & Recommendation
7. Information Recollection
8. Situational Analyzation & Interpretation
9. Interaction & Communication
10. Translation & Transformation
11. Autonomous
12. Integrated & Interoperable
13. Stable & Consistent
14. Reliable & Controllable
15. Interactive & Reactive
16. Adaptable & Adjustable
17. Dispassionate & Emotionless
18. Customized & Personalized
19. Accurate
20. Smart & Innovative
21. Transparent
22. Simple
23. Logical

**Stage 4**

**Human B&A**
1. Roles become flexible and functional.
2. Group energy is channeled into the task.
3. Resolved structural issues.
4. Supportive structure of task performance.
5. Creativity.
6. Initiative.
7. Flexibility.
8. Open relationships.
9. Pride.
10. Learning.
11. Confidence.
12. High morale.
13. Success.
14. High motivation, trust and empathy.
15. Individuals defer to team needs.
16. Effectively producing deliverables.
17. Consistent performance.
18. Demonstrations of interdependence and self-management.

**GenAI C&A**
1. Learning & Training
2. Translation & Transformation
3. Autonomous
4. Stable & Consistent
5. Reliable & Controllable
6. Adaptable & Adjustable
7. Dispassionate & Emotionless
8. Customized & Personalized
9. Accurate
10. Smart & Innovative

**Stage 5**

**Human B&A**
1. Termination.
2. Separation.
3. Disbandment.
4. Potential sadness.
5. Recognition of team and individual efforts.

**GenAI C&A**
1. Stable & Consistent
2. Dispassionate & Emotionless
3. Transparent

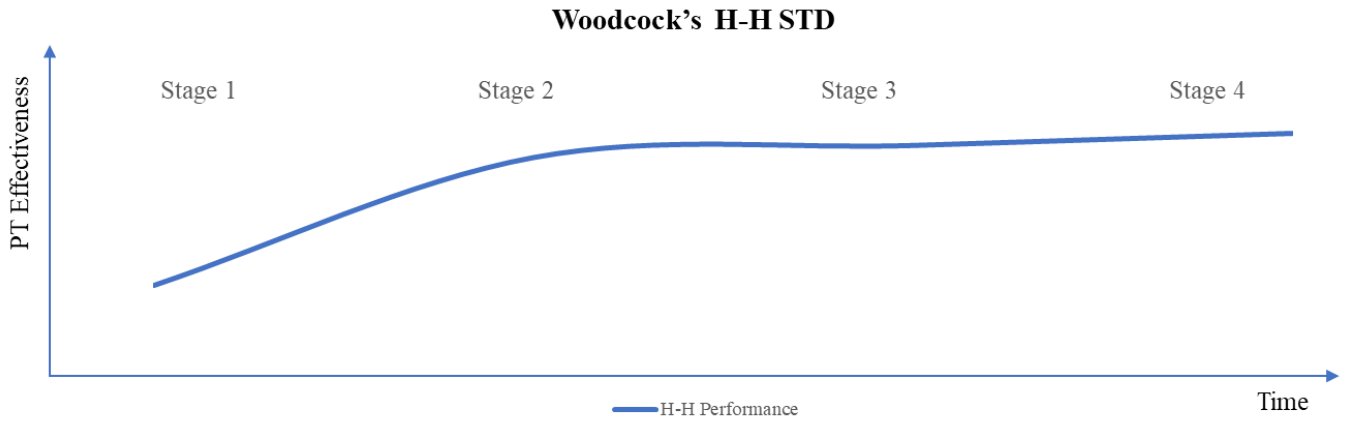



Fig. 60: Woodcock's H-H STD Model

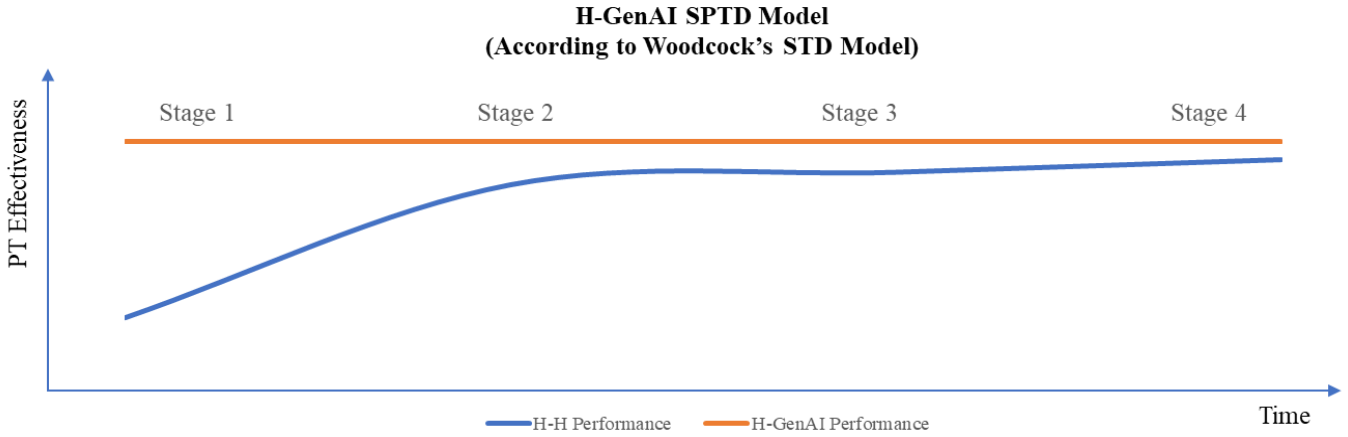



Fig. 61: H-GenAI SPTD Model (According to Woodcock's Model)

Table (75): Human Behaviors & Attitudes (B&A) & GenAI Characteristics & Abilities (C&A) throughout STD According to Woodcock's Model

**H-GenAI SPTD Model**
**(According to Woodcock's STD Model)**

**Stage 1**

**Human B&A**

1. Feelings not dealt with.
2. Workplace is for work.
3. Established line prevails.
4. No "rocking the boat".
5. Poor listening.
6. Weaknesses covered up.
7. Unclear objectives.
8. Low involvement in planning.
9. Bureaucracy.
10. Boss takes most decisions.

**GenAI C&A**

1. Content Creation
2. Computation & Processing
3. Prediction
4. Decision & Solution
5. Assistance & Recommendation
6. Situational Analyzation & Interpretation
7. Interaction & Communication
8. Translation & Transformation
9. Autonomous
10. Stable & Consistent
11. Reliable & Controllable
12. Adaptable & Adjustable
13. Dispassionate & Emotionless

**Stage 2**

**Human B&A**

1. Experimentations.
2. Risky issues debated.
3. Wider options considered.
4. Personal feelings raised.
5. More listening.
6. Concern for others.

**GenAI C&A**

1. Content Creation
2. Learning & Training
3. Computation & Processing
4. Prediction
5. Decision & Solution
6. Assistance & Recommendation
7. Information Recollection
8. Situational Analyzation & Interpretation
9. Interaction & Communication
10. Translation & Transformation
11. Integrated & Interoperable
12. Reliable & Controllable
13. Dispassionate & Emotionless
14. Customized & Personalized
15. Accurate
16. Smart & Innovative
17. Transparent
18. Logical

**Stage 3**

**Human B&A**

1. Experimentations.
2. Risky issues debated.
3. Wider options considered.
4. Personal feelings raised.
5. More listening.
6. Concern for others.
7. Methodical working.
8. Agreed procedures.
9. Established groundrules.

**GenAI C&A**

1. Content Creation
2. Learning & Training
3. Computation & Processing
4. Prediction
5. Decision & Solution
6. Assistance & Recommendation
7. Information Recollection
8. Situational Analyzation & Interpretation
9. Interaction & Communication
10. Imitation
11. Translation & Transformation
12. Autonomous
13. Integrated & Interoperable
14. Stable & Consistent
15. Reliable & Controllable
16. Adaptable & Adjustable
17. Dispassionate & Emotionless
18. Customized & Personalized
19. Accurate
20. Smart & Innovative
21. Transparent
22. Logical

**Stage 4**

**Human B&A**

1. Experimentations.
2. Risky issues debated.
3. Wider options considered.
4. Personal feelings raised.
5. More listening.
6. Concern for others.
7. Methodical working.
8. Agreed procedures.
9. Established groundrules.
10. High flexibility.
11. Appropriate leadership.
12. Maximum use of energy and ability.
13. Essential principles & social aspects considered.
14. Needs of all met.
15. Development a priority.

**GenAI C&A**

1. Categorization
2. Content Creation
3. Learning & Training
4. Computation & Processing
5. Prediction
6. Decision & Solution
7. Assistance & Recommendation
8. Information Recollection
9. Situational Analyzation & Interpretation
10. Interaction & Communication
11. Imitation
12. Translation & Transformation
13. Autonomous
14. Integrated & Interoperable
15. Stable & Consistent
16. Reliable & Controllable
17. Adaptable & Adjustable
18. Dispassionate & Emotionless
19. Customized & Personalized
20. Accurate
21. Smart & Innovative
22. Transparent
23. Logical

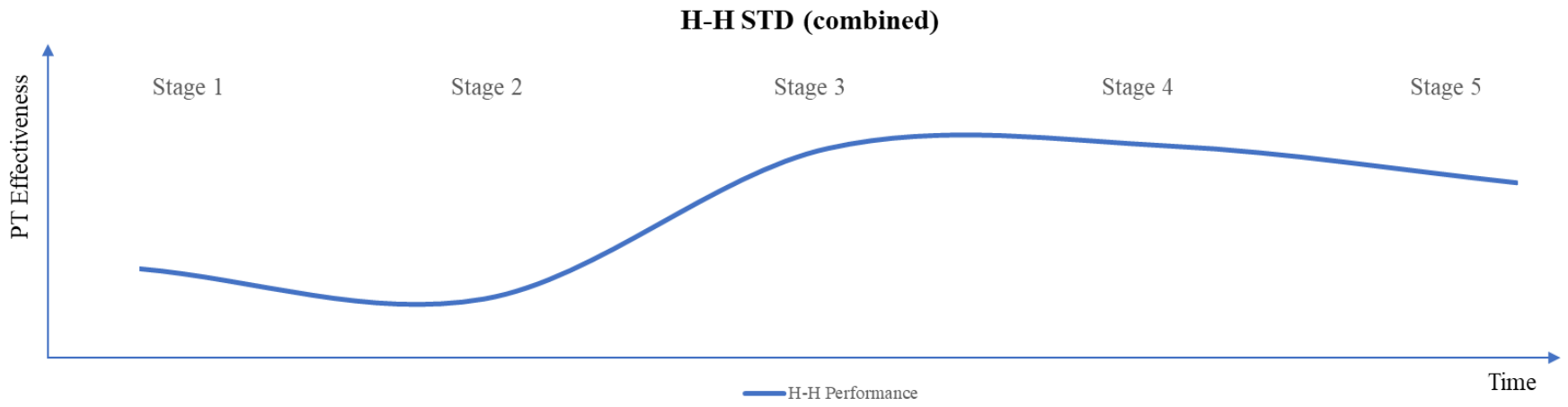



Fig. 62: H-H STD Combined Model

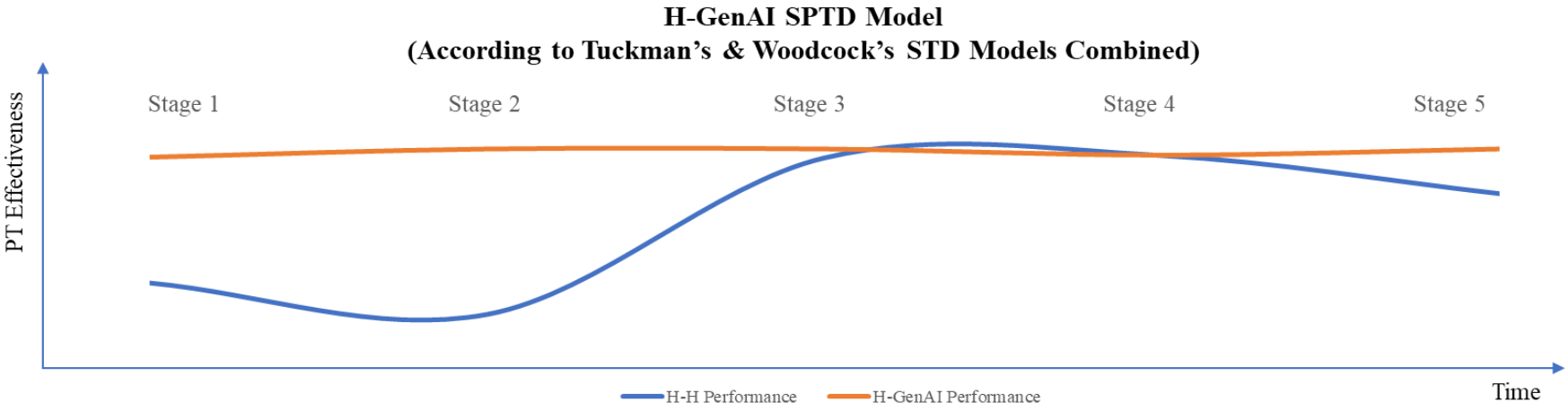



Fig. 63: H-GenAI SPTD Model (According to Tuckman's & Woodcock's STD Combined Models)

Table (76): H-GenAI SPTD Model

| PERFORMANCE OF H-GENAI THROUGHOUT THE STAGES OF PROJECT TEAM DEVELOPMENT ACCORDING TO TUCKMAN'S & WOODCOCK'S MODELS COMBINED | | | | | |
|---|---|---|---|---|---|
| STAGES | STAGE 1 | STAGE 2 | STAGE 3 | STAGE 4 | STAGE 5 |
| HUMAN BEHAVIORS & ATTITUDES | 1. Orientation.<br>2. Testing.<br>3. Dependency.<br>4. Excitement.<br>5. Unclear objectives.<br>6. Uninvolvement.<br>7. Uncommitted members.<br>8. Confusion.<br>9. Hidden feelings.<br>10. Politeness.<br>11. Displaying eagerness.<br>12. Socializing.<br>13. Sticking to safe topics.<br>14. Unclear about how one fits in.<br>15. Some anxiety and questioning.<br>16. Feelings not dealt with.<br>17. Workplace is for work.<br>18. Established line prevails.<br>19. No "rocking the boat".<br>20. Poor listening.<br>21. Weaknesses covered up.<br>22. Unclear objectives.<br>23. Low involvement in planning.<br>24. Bureaucracy.<br>25. Boss takes most decisions. | 1. Conflict.<br>2. Polarization around interpersonal issues.<br>3. Emotional responding.<br>4. Lack of cohesion.<br>5. Subjectivity.<br>6. Confrontation.<br>7. Frustration.<br>8. Volatility.<br>9. Inconsistency.<br>10. Failure.<br>11. Some resistance.<br>12. Lack of participation.<br>13. Competition.<br>14. Experimentations.<br>15. Risky issues debated.<br>16. Wider options considered.<br>17. Personal feelings raised.<br>18. More listening.<br>19. Concern for others. | 1. Overcome resistance.<br>2. Develop ingroup feeling & cohesiveness.<br>3. New standards evolve.<br>4. New roles are adopted.<br>5. Intimate, personal opinions are expressed.<br>6. Performance questioning.<br>7. Objectives review/clarification.<br>8. Roles confirmation.<br>9. Assertiveness.<br>10. Listening.<br>11. Testing new grounds.<br>12. Strengths & weaknesses identification.<br>13. Purpose and goals are well-understood.<br>14. More confident.<br>15. Improved commitment.<br>16. Members are engaged and supportive.<br>17. Relief (lowered anxiety).<br>18. Experimentations.<br>19. Risky issues debated.<br>20. Wider options considered.<br>21. Personal feelings raised.<br>22. More listening.<br>23. Concern for others.<br>24. Methodical working.<br>25. Agreed procedures.<br>26. Established groundrules. | 1. Roles become flexible and functional.<br>2. Group energy is channeled into the task.<br>3. Resolved structural issues.<br>4. Supportive structure of task performance.<br>5. Creativity.<br>6. Initiative.<br>7. Flexibility.<br>8. Open relationships.<br>9. Pride.<br>10. Learning.<br>11. Confidence.<br>12. High morale.<br>13. Success.<br>14. High motivation, trust and empathy.<br>15. Individuals defer to team needs.<br>16. Effectively producing deliverables.<br>17. Consistent performance.<br>18. Demonstrations of interdependence and self-management.<br>19. Experimentations.<br>20. Risky issues debated.<br>21. Wider options considered.<br>22. Personal feelings raised.<br>23. More listening.<br>24. Concern for others.<br>25. Methodical working.<br>26. Agreed procedures.<br>27. Established groundrules.<br>28. High flexibility.<br>29. Appropriate leadership.<br>30. Maximum use of energy and ability.<br>31. Essential principles & social aspects considered.<br>32. Needs of all met.<br>33. Development a priority. | 1. Termination.<br>2. Separation.<br>3. Disbandment.<br>4. Potential sadness.<br>5. Recognition of team and individual efforts. |

| | | | | | |
|---|---|---|---|---|---|
| **GENERATIVE AI CHARACTERISTICS & ABILITIES** | 1. Content Creation<br>2. Learning & Training<br>3. Computation & Processing<br>4. Prediction<br>5. Decision & Solution<br>6. Assistance & Recommendation<br>7. Information Recollection<br>8. Situational Analysis & Interpretation<br>9. Interaction & Communication<br>10. Translation & Transformation<br>11. Autonomous<br>12. Integrated & Interoperable<br>13. Stable & Consistent<br>14. Reliable & Controllable<br>15. Interactive & Reactive<br>16. Adaptable & Adjustable<br>17. Dispassionate & Emotionless<br>18. Customized & Personalized<br>19. Smart & Innovative<br>20. Transparent<br>21. Logical | 1. Content Creation<br>2. Learning & Training<br>3. Computation & Processing<br>4. Prediction<br>5. Decision & Solution<br>6. Assistance & Recommendation<br>7. Information Recollection<br>8. Situational Analysis & Interpretation<br>9. Interaction & Communication<br>10. Translation & Transformation<br>11. Autonomous<br>12. Integrated & Interoperable<br>13. Stable & Consistent<br>14. Reliable & Controllable<br>15. Interactive & Reactive<br>16. Adaptable & Adjustable<br>17. Dispassionate & Emotionless<br>18. Customized & Personalized<br>19. Accurate<br>20. Smart & Innovative<br>21. Transparent<br>22. Simple<br>23. Logical | 1. Categorization<br>2. Content Creation<br>3. Learning & Training<br>4. Computation & Processing<br>5. Prediction<br>6. Decision & Solution<br>7. Assistance & Recommendation<br>8. Information Recollection<br>9. Situational Analysis & Interpretation<br>10. Interaction & Communication<br>11. Imitation<br>12. Translation & Transformation<br>13. Autonomous<br>14. Integrated & Interoperable<br>15. Stable & Consistent<br>16. Reliable & Controllable<br>17. Interactive & Reactive<br>18. Adaptable & Adjustable<br>19. Dispassionate & Emotionless<br>20. Customized & Personalized<br>21. Accurate<br>22. Smart & Innovative<br>23. Transparent<br>24. Simple<br>25. Logical | 1. Categorization<br>2. Content Creation<br>3. Learning & Training<br>4. Computation & Processing<br>5. Prediction<br>6. Decision & Solution<br>7. Assistance & Recommendation<br>8. Information Recollection<br>9. Situational Analysis & Interpretation<br>10. Interaction & Communication<br>11. Imitation<br>12. Translation & Transformation<br>13. Autonomous<br>14. Integrated & Interoperable<br>15. Stable & Consistent<br>16. Reliable & Controllable<br>17. Adaptable & Adjustable<br>18. Dispassionate & Emotionless<br>19. Customized & Personalized<br>20. Accurate<br>21. Smart & Innovative<br>22. Transparent<br>23. Logical | 1. Stable & Consistent<br>2. Dispassionate & Emotionless<br>3. Transparent |

### 4.2.3 Phase 3: KPIs for H-GenAI Project Teams

This Section addresses SRQ4 and SRQ5. It presents the findings of qualitative data collection on evaluating the performance of PTs when GenAI is integrated into them, as revealed by the 16 interview respondents, under two successive sub-sections: Efficiency and Effectiveness. The third sub-section presents a summary of the KPIs in H-GenAI Collaboration.

It is essential to mention that the interview respondents referred to AI and GenAI interchangeably.

Figure 64 illustrates the structure of the KPIs section for the H-GenAI PTs.

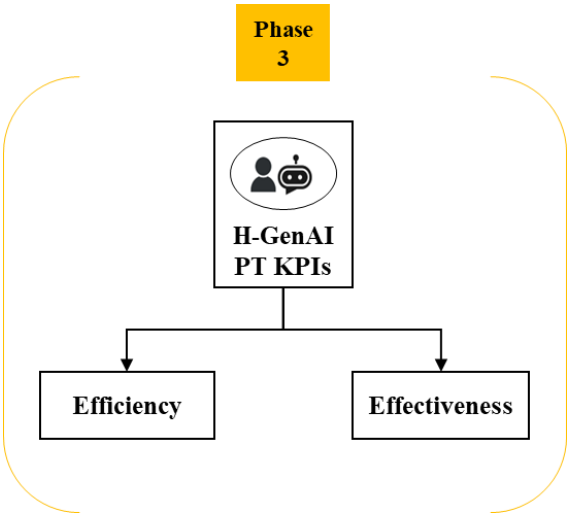



Fig. 64: H-GenAI PT KPIs section (Phase 3)

#### 4.2.3.1 Efficiency

GenAI is an added value in PM because it can enhance efficiency when integrated into PTs. In this context, respondent AIR4 said, *"AI can improve efficiency in project management and any other job-related work."*

Efficiency can be measured in several ways. As remarked by AIR6, *"In a project environment, to me, efficiency means that things move on schedule, that timelines and deadlines happen as planned. It also means that the*

*people involved in the team, and certainly the project leaders and project support people, are spending as minimal, as feasible amount of time in the project."* The following sub-section will present a discussion of how efficiency can be measured according to the respondents.

***1) Time***

Respondents agree that GenAI is time-efficient when it comes to delivering tasks in less than the time required and delivering projects on time as scheduled, without the need for project time variations.

According to AIR2, *"When it comes to time, it's the AI model that is faster in coming up with the result than humans. So that's reducing the time."* AIR3 added, *"These machines run on transistors, so they're faster than us."* AIR5 remarked, *"AI will have quicker decision-making," and* AIR8 said, *"You'll be shortening the time for decision-making".* AIR8 added, *"So instead of taking all this time, in a fraction of a second, one can see the next step."*

Some emphasized the ability of GenAI to automate specific tasks of the project, reducing the time that is spent on repetitive tasks. In this context, AIR5 said, *"AI will lessen the time that we waste on specific tasks."* AIR3 stated, *"The time we cut, basically doing rudimentary stuff, such as building reports, doing slides, we've actually built tools that can speed up the whole operation. We don't manually do these things anymore."*

Moreover, it is worth mentioning the effect of GenAI being time-efficient on humans; it frees up team members to focus on other important aspects of PM, and team members will have more time for creativity and innovation. GenAI can offload people from having to do undesired tasks, and by offloading people from such insignificant tasks, people can become creative and think outside the box. In this context, AIR1 remarked, *"AI can*

*automate routine tasks of documentation, freeing up team members to focus on more complex and creative aspects of the project.*" AIR5 added, *"It will give you more time,"* and continued, *"You will have all the time in the world when you automate repetitive tasks."* AIR6 remarked, *"It can offload a lot of the kinds of tasks that they potentially don't want to do. I mean, let's face it, we all have what I call motivated skills, i.e. the things that we really enjoy doing or the things that we do just because we need to do it. AI can in many cases offload people from the things that fall in that second category, allowing people to do more with what they really enjoy."* AIR6 continued, *"And by offloading to AI the things that are not our motivated skills, the things that require detail, that require repetition, that allows us to use a lot more of the capacity in our brain, which is well designed for creativity, innovation, thinking big."* AIR6 added, *"Our brains are designed, just like children are born, to be open and to think differently and to question and to do things, and that's what AI, I believe, can free us, so that our brains can do what they were designed to do, to ask those big questions, to think outside the box."*

GenAI avoids delays when executing tasks due to its speed. In this context, AIR16 remarked, *"I believe the speed is one of the biggest advantages."* According to AIR2, *"If you compare it with humans, they have their many reasons that stop them. Sometimes they are not in the mode of working. However, the AI is like delivering, no matter what condition it's in."* In this context, AIR6 remarked, *"I've seen statistics that say that today, pre-AI utilization, let's say average projects were delayed anywhere from 20% to 50% of the time. So, delays. So, I think with AI, that number should come down significantly. Maybe it's more like a 10 to 20% average delay period. When there are humans, there will always be human things that come up that cause delays, but I think that should be able to be mitigated*

*over time more to the 10 to 20%."* AIR6 continued, *"People are sick, people are confused, people get pulled into a different project, and people get upset with the boss. There's so much business, a global problem. At least I anticipate it's a global problem."*

GenAI saves the time that is spent on tasks. According to AIR6, *"Integrating AI in project teams is important in a couple of ways. One is to save time; if project teams have any consistent challenge, it's meeting the schedules, because teams are made up of multiple people and things can go wrong. So, it can be a significant time saver,", "Whether that is writing up project plans, maybe that's summarizing notes, which used to take people's time. That's all done through technology that can then be reviewed in five minutes instead of the hour to write up the notes."* AIR8 added, *"One of the main advantages of AI is to reduce the time taken by an expert."*

Besides, saving time is also due to task automation, as highlighted by AIR5, *"Think about any repetitive task that can be automated using AI. Even chatbots, whatever it is using; text, videos, or images, can be utilized with AI to simplify the process.* AIR6 continued, *"AI can certainly increase efficiency, i.e. taking those routine, time-consuming tasks away from the people and allowing them to do other tasks and to do it much more quickly."*

GenAI may function under any circumstances and without stopping. According to AIR2, *"Humans after a certain number of hours, will get tired. AI can function 24/7 and these factors will add plus value to the model or the outcomes."*

***2) Cost***

Regarding cost in terms of the project budget, respondents agreed that GenAI is cost-efficient. GenAI reduces costs in several ways. According to

AIR7, it is considered cost-effective in the long run, *"AI is more cost-effective in the long run."*

GenAI reduces the cost of employees. In this context, AIR5 commented, *"It will also lower the costs because you will have fewer team members."* AIR6 remarked, *"I certainly think it can reduce the employee cost in that fewer people are being used for less time."* According to AIR2, *"For sure AI is cheaper than humans because if you have a problem and you need an expert, maybe you need three, or four experts to come up with a solution and they are paid by hour. However, the AI will cost you only the model, then you can run it as much as you can. So, the ROI is a very exponential difference between both of them."* AIR6 added, *"The cost of having an AI agent on board depends on what type of project it is and what type of agent or tool is needed. From what I see today, the initial elements of utilizing AI for the things that we've talked about here in this session are not hugely costly. And when you balance out the increased efficiency, the reduction in potentially employee cost, especially with overruns and other issues, and you balance that against the software or the tool cost, I mean, you should be able to be near to a flat bottom line impact."*

Some respondents emphasized the importance of delivering a project on time and as scheduled and its effect on project cost or budget. In this context, respondent AIR6 mentioned, "*There's extension cost, and depending upon the type of project, I mean, there could even be contingency fees that are built into the contract."* AIR6 explained further, *"When projects run over, that leads to a lot more cost, because either space or technology or other things that are paid for, if you will, around the project, they need to move out, or penalties."* AIR8 commented, *"It's clear that time is money."*

### *3) Resources*

GenAI is efficient in optimizing a team's effort and size and team's resources by minimizing resource waste, whether human or non-human. Respondent AIR1 said, *"AI ensures efficient use of resources that would minimize waste and maximize productivity."*

Waste can be minimized by reducing the number of experts and the amount of time these experts are required to stay on duty, as AIR8 said, *"We need an expert, but an expert that will not spend a lot of time, who'll be very fast, and will gain a lot of time."* Besides, respondents highlighted the positive influence of GenAI on the team's size, which results in reducing the number of members in the team, as stated by AIR5, *"Teamwork is becoming more efficient, fewer people are able to do the same amount of tasks."* AIR7 added, *"By using GenAI, fewer members will be in teams."*

However, to ensure GenAI's efficiency in optimizing the team's effort and size, as well as minimizing resource waste, one should use GenAI in the most efficient way possible, as suggested by AIR3, *"As of today. There's a lot of emphasis on building your own AI models, which is not the way to go, if we're being honest, and it's extremely expensive, it requires a lot of experience. Commercial businesses like Amazon Web Services, Microsoft, and all these things, they're all building what they call foundational models, and they do the hard work for you. It's basically 90% of your application. And then when you build an AI, it's only the 10% on top of this model. This 90% has already been spent only once, and it's been spent only once. And then people can, you know, use this basically creation and do their own things. When this happens, you're going to have economies of scale and you do it once and you grow and everybody grows with you and you don't spend that much."*

#### 4.2.3.2 Effectiveness

GenAI ensures PM effectiveness when integrated into PTs. In this context, the respondents agree with the meaning of the term "effective" in general in terms of better usability and outputs or results.

According to AIR2, *"Effectiveness, when it comes to usability, how that will be effective in performing the duty."* AIR7 added, *"AI helps in achieving objectives in a better way."*

Effectiveness can be measured in several ways, and this sub-section will discuss how it can be measured according to the respondents.

***1) Accuracy***

GenAI is accurate in its outcomes and the integration of GenAI in PTs will positively affect tasks as well as the project as a whole. According to AIR4, *"It will improve accuracy."* AIR5 added, *"It will enhance accuracy, much higher accuracy because you are building your decisions."*

Several respondents mentioned that GenAI supersedes humans in its ability to provide correct and precise results in a shorter period of time, as highlighted by AIR2*, "The accuracy is way better than what humans can deliver."* In this context, respondent AIR8 added*, "The decision is more accurate, and then you can reach an accuracy that you never dreamed about because you cannot do it by yourself. Or maybe you can take months to reach that."* As mentioned by AIR8, *"It is faster and more accurate because it can handle more certain data, and more historical data to make a decision."*

***2) Quality***

GenAI enhances the quality of work by accomplishing tasks with pleasing results. In this context, AIR1 remarked, *"AI can significantly enhance*

*project outcomes, manage expectations, and maintain high satisfaction levels."* AIR4 commented, *"It will improve even the quality of work,"* and added, *"My job gets more efficient, and much better, even the quality of the slides is much better."*

Respondent AIR4 also emphasized the extent to which GenAI is capable of providing better results compared to humans, and said*, "ChatGPT can give you ten "x" the result of the normal person without ChatGPT. So, it's way advanced,"* and added, *"When you can get ten "x" the result, of course, you will be satisfied."*

***3) Transparency & Clarity***

GenAI enhances the transparency of project status and the clarity of communication. According to AIR4, *"It will improve the clarity, especially in project management."* AIR4 continued, *"It will improve clarity and that will improve accuracy and communication."*

In this context, AIR2 highlighted the importance of clarifying the status of projects in PM in terms of transparency and visibility of project status so that the management can build their decisions based on accurate information, and commented, *"When it comes to big projects, people, let's say, try to hide the facts or the actual progress when it comes to delivery or completing milestones. When you integrate it with the AI model, or let's say feed it to the AI model, they will be all clear, visibility clear, what is actual, which is not giving the higher management fake information or results that they build their strategic decision in it. So, it's very crucial, and this will help the leadership to decide or build their assumption on actual data, which is directly fed to the model, and of course, the model will work on analyzing it and come up with the right measures that help the leadership to make their strategic decision."*

Moreover, integrating GenAI in PTs enhances the clarity of communication between the team members. According to AIR4, *"AI can help a lot to make the conversation or the communication much, much clearer,"* and *"It will improve the clarity of communication between the team and the project manager."* AIR5 added, *"AI will facilitate communication among multi-language, multinational teams."* AIR5 continued, *"Using AI helped me with project communication between members."* Furthermore, AIR3 mentioned the difficulty of dealing with people at times, and how GenAI can enhance conversations and the level of communication, and said, *"It's always hard to deal with different kinds of people. A developer might have a different mode, you know, an engineer, data engineer, and HR is going to do something different."* AIR3 added, *"There are cases where, for example, you need to deal with hard people, socially, social-wise, let's say, in that case, GenAI can change its attitude. If you have a hard engineer to work with, somebody who's moody, GenAI can also tailor its own tone and language to cater to that guy or that lady. With GenAI, we have a lot of use cases that are really good fits for project management."*

#### 4.2.3.3 Summary of Phase 3

Based on the empirical results of this study, the study establishes KPIs or the success indicators when integrating GenAI with humans in PTs, as presented in Figure 65.

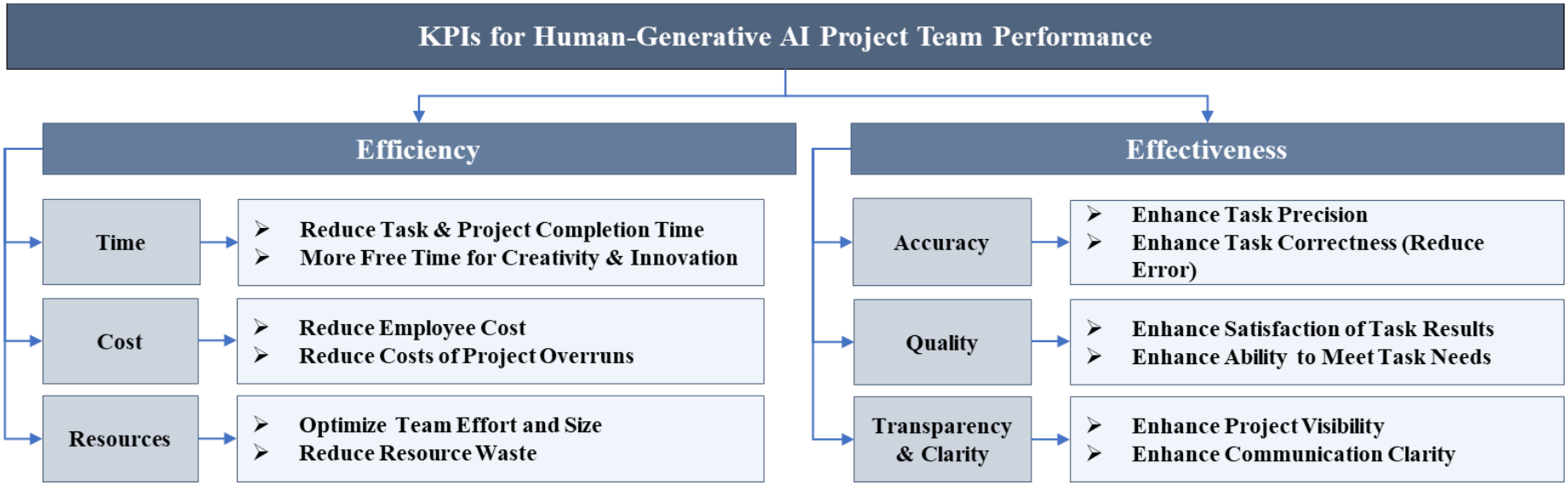



Fig. 65: Key Performance Indicators for Human-Generative AI Collaboration

### 4.2.4 Summary of Results: All 3 Phases

This study contributes to knowledge in GenAI and project management. Aiming to meet its first objective, which is to develop a model for H-GenAI collaboration for PTs in project management within the service industry, the study builds a model for H-GenAI PTF and H-GenAI SPTD.

In achieving the first objective of the study, the study first builds a model for H-GenAI PTF by solving the TFP when GenAI is integrated into PTs. In doing so, the study explored theories supporting TF by conducting an SLR to study how H-AI teams are formed, identified the influential factors that affect PTF from previous models, and assigned weights to the main factors by employing the BWM of the MCDM methods to solve the TFP as follows: Skills & Competencies (0.22), Personality (0.17), Work Experience (0.17), Expertise & Proficiency (0.15), Teamwork (0.14), Education & Knowledge (0.1), and Characteristics (0.05). The study contributes to the H-H TFP in project management within the service industry. In solving the H-GenAI TFP, the study explored the GenAI capabilities that support humans in PTs and impact project management through its integration into PTs by conducting semi-structured interviews with 16 AI experts and practitioners. Following the ML Clustering Framework, the study revealed 13 main GenAI characteristics and 12 main GenAI abilities. The study then utilized the factors that contributed to the formation of H-H PTs to re-evaluate the factors when considering GenAI as a team member in PTs and employed the BWM of the MCDM approach to assign their weights, and ranked the factors as follows: Skills & Competencies (0.22), Work Experience (0.18), Education & Knowledge (0.17), Expertise & Proficiency (0.15), Teamwork (0.14), Personality (0.09), and Characteristics (0.05). The study contributes to the H-GenAI TFP in project management within the service industry. Also, by analyzing

the semi-structured interviews, the study revealed 13 GenAI enablers that aid GenAI in functioning and 16 factors that support the collaboration of humans with GenAI when GenAI is a team member in a PT with its human partner. Consequently, the study builds a model for H-GenAI PTF.

Then, the study builds a model for H-GenAI SPTD by exploring models of Tuckman's and Woodcock's for the STD for traditional H-H teams and determines the extent to which the capabilities of GenAI enhance the performance of H-GenAI PTs compared to H-H PTs throughout the STD. In doing so, the study listed the human behaviors and attitudes in the two models, for a comprehensive traditional model of STD, and then assessed the effectiveness of the H-H teams by quantifying all human behaviors and attitudes that appeared in the two models according to the human behaviors' and attitudes' positive or negative influence on the performance of PTs. The study measured the performance of H-H teams throughout each stage of STD by taking the value of the total number of positive influences of both models for each stage and dividing it by the total number of behaviors and attitudes of each stage in the two models.

Then, the study examined the applicability of the characteristics and abilities of GenAI to those behaviors and attitudes of humans to measure the extent to which GenAI can compensate for the behaviors and attitudes of humans with its characteristics and abilities. The study assessed the performance of H-GenAI PT by measuring its effectiveness throughout the STD, compared its performance with the performance of the traditional H-H teams, and illustrated how humans and GenAI progressed throughout the STD when working on a project by substituting all human behaviors and attitudes that appeared in Tuckman's and Woodcock's models with those characteristics and abilities of GenAI, first for each model separately and then combined.

Then, the study quantified all GenAI main characteristics and abilities that correspond to the human behaviors and attitudes that appear in Tuckman's and Woodcock's models according to the positive or negative influence the main characteristics and abilities have on the performance of PTs. After that, the study measured the performance of H-GenAI teams and illustrated H- GenAI progress throughout each stage of STD according to the combined models of Tuckman's and Woodcock's. The study reveals the difference in performance level between H-H teams and H-GenAI teams in each of the stages and the percentage of their differences as follows: stage 1= 5.6, which represents 140%, stage 2= 7.4 (284.62%), stage 3= 0.4 (4.17%), stage 4= 0 (0%), and stage 5= 2 (25%). The study also reveals the successive performance growth of H-GenAI teams throughout STD: 240%, 384.62%, 104.17%, 100%, and 125%.

Then, aiming to meet the study's second objective, which is to determine KPIs for measuring the performance of H-GenAI PTs, the study investigates how H-GenAI PTs are evaluated. In doing so, the study conducted semi-structured interviews with 16 AI experts and practitioners and determined two parameters for measuring H-GenAI PT performance, as follows: (1) Efficiency; which is measured by Time, Cost, and Resources, and (2) Effectiveness; which is measured by Accuracy, Quality, and Transparency & Clarity. The study contributes to knowledge in project management by establishing KPIs to measure the performance of H-GenAI PTs in the service industry.

## 4.3 Discussion

This Section presents a discussion of the analysis of the study's findings concerning the study's model, as presented in the previous "Results" Section: (1) H-GenAI Project Team Formation and (2) Stages of H-GenAI Project Team Development. These sub-sections link the study's findings with those from the literature and provide an explanation, interpretation, and significance of the results in relation to the concerning RQs.

### 4.3.1 H-GenAI Project Team Formation

This sub-section presents a discussion of the H-GenAI PTF, which corresponds to Phase 1 of the study and addresses SRQ1.

According to the literature, the most important factors that are utilized for traditional H-H TF are presented in Table 25 in the previous Section, after employing the TF-IDF followed by the Pareto principle. To compare the results of the literature with the perspectives of the PMs, it is important to acknowledge the fact that the study has employed ML clustering algorithms to group similar factors that appeared in the literature -89 factors- and then employed the BWM of the MCDM method to weigh the factors -7 main factors- that influence the performance of PTs according to the PMs. In doing so, the study ranked the 7 factors that are most important to PMs when forming PTs in the previous Section as follows: Skills & Competencies, Personality, Work Experience, Expertise & Proficiency, Teamwork, Education & Knowledge, and Characteristics.

When it comes to factors that support traditional PTs, the literature-based ranking and PMs' viewpoints show a significant difference between the theoretical and practical, real-world priorities when forming PTs. Comparing the two information sources, both agree that "Skills" are the most important factor, demonstrating a common belief that technical and

non-technical capabilities are required for successful collaboration between team members when working on projects within the service industry. However, beyond this point, variations become increasingly evident. In the literature, the focus is placed on “Knowledge” after “Skills” since this study excludes the factor “Projects” as the project attributes influence the human attributes when forming PTs. This suggests that the educational background of the candidates is important for better PT performance and project success. On the contrary, PMs rank the factors “Education & Knowledge” sixth among the seven given factors. This could imply that, in practice, the educational background is not important when working on projects. However, it may be important during the recruitment process but not when the candidate is already hired. The same thing applies to the factors “Characteristics”. While the literature places quite a high importance on “Characteristics” when selecting candidates for projects, PMs consider “Characteristics” as their least important factor for forming traditional PTs. Another noteworthy difference is the emphasis PMs placed on “Personality,” followed by “Work Experience”. According to PMs, “Personality” is ranked the second-best factor that influences TF for H-H PTs, and “Work Experience” is ranked the fourth-best. In the literature, “Personality” appears to be less important than “Experience” but more important than “Characteristics”. However, “Personality” has almost an equal weight to “Characteristics” in the literature, according to the TF-IDF results. Furthermore, in the literature, the factor “Team” or “Teamwork” is more important than the factor “Experts” or “Expertise”, while the PMs view “Expertise & Proficiency” as more important factors than “Teamwork” when selecting project candidates.

Overall, the literature appears to develop a more theory-based model, whereas PMs use a practice-based approach. This difference highlights the

need for more integrated approaches that link theoretical frameworks with real-world situations and challenges encountered by practitioners in project environments, specifically within the service industry.

In addition, the results of the study reveal that "Skills & Competencies" are the most important factors that affect TF for traditional PTs according to PMs within the service industry, as presented in Figure 31 and Figure 32. This explains the necessity of having soft skills and hard skills or technical skills to be able to add value to PTs and, hence, deliver successful projects. "Personality" is the second-best factor that affects selecting project team members in the service industry. It is essential to highlight that the personality of a person matters in the service industry, where the nature of the projects is mainly affected by humans, whether forming teams for the sake of designing and construction projects or conducting sales and marketing campaigns. In addition, the personality of team members is key to grasping and acquiring new skills and working to gain more experience in general. However, the personality traits of humans will play a big role here since the personality of team members will affect the team dynamics and hence the team's decision-making process to address the customers' requirements, i.e., understandable and honest team members will sell the most suitable properties to customers considering their needs, gaining customer's trust and satisfaction. Moreover, "Work Experience" is also the second-best factor that influences the TF process in the service industry. This explains the need for experienced employees who can contribute to building and shaping the project from inception and utilize their accumulated experiences in the work environment in different domains to support the project and attain project success. Besides, with work experience, team members can acquire the necessary skills and competencies for a particular project, which is necessary for the PT and,

hence, project success. Furthermore, “Expertise & Proficiency” is the third-best factor that influences the TF process in the service industry, for it is important to have a wide range of technical skills and experience in a specific domain to elevate the performance of the PT in the service industry.

Moreover, “Education & Knowledge” appear to be among the least influential factors for forming PTs, followed by “Characteristics”, which is the least important factor in the TF process of a project team in the service industry. It is noticed that when considering the Pareto Principle, as shown in Figure 32, the factors “Characteristics”, “Education & Knowledge”, and “Teamwork” will be excluded. This could be justified by the fact that the selection of team members to work on projects is not based on specifications that may be very important when hiring. i.e., the educational background of a candidate and his demographic factors are considered at the recruitment level, but not when the candidates are already employed. Besides, “Teamwork” is a skill that may be acquired by the team members through work experience, depending on their personalities.

Moving forward to forming H-GenAI PTs, according to PMs within the service industry, as presented in Figure 44 and Figure 45, “Skills & Competencies” are the most important factors that influence the selection of human teammates to work with GenAI teammates on projects. This explains the necessity for human teammates to have the necessary skills, especially technical skills, to be able to deal with the GenAI teammate and enhance the performance of the H-GenAI PT and, hence, achieve project success. According to the results of the study, “Work Experience” is the second-best factor that influences the team formation process in the service industry. This explains the necessity of having experienced employees on projects who can work on different projects depending on the nature of the

project and its requirements. Besides, the accumulated experience of the human teammate that has been acquired over the years through working on different projects will help in steering the project in the right direction, achieving project success. Moreover, “Education & Knowledge” are the third-best factors that affect the formation of H-GenAI PT, for it is important for the human teammate to be well-educated and knowledgeable about the business context of the project in which GenAI will be participating, so that the human will be able to validate the GenAI outputs. “Characteristics” is the least important factor in the team formation process of selecting human teammates for H-GenAI PTs in the service industry. It is noticed that when considering the Pareto Principle, as shown in Figure 45, the “Characteristics” factor will be excluded. This could be justified by the fact that the selection of team members to work on projects is not based on human demographics or specifications that may be very important when hiring. i.e. demographic factors of candidates are considered at the recruitment level, but not when the candidates are already employed. In addition, it is also noticed that when considering the Pareto Principle, as shown in Figure 45, the “Personality” and “Teamwork” factors will also be excluded for teams that GenAI integrates into. Although human behaviors and attitudes affect the performance of traditional teams when working on projects, the “Personality” of a person becomes less important to consider when selecting human teammates to collaborate with GenAI since the human will be working with a GenAI agent rather than a human counterpart. Besides, “Teamwork” is a skill that a person can acquire through work experience.

The previous Section presented the difference between the factors that affect the formation of H-H and H-GenAI PTs. It showed that the percentage of the factors remains close to one another when forming the

two types of PTs, as presented in Figure 46, although the ranking of the factors differs when considering them for the formation of H-H PTs or H-GenAI PTs. Yet, this does not apply to the factors “Personality” and “Education & Knowledge”, where the type of PT, whether H-H or H-GenAI, tremendously affects the two factors. It is noticed that the “Personality” factor is extremely important in H-H PTs, while it is considered one of the least important factors for forming PTs that consider GenAI a teammate. This can be explained by the fact that projects are mainly achieved through collaboration, and human interaction with one another is remarkably important for attaining effective teamwork and, hence, project success. In addition, the study revealed in the previous Section that “Education & Knowledge” are among the most influential factors that affect the formation of H-GenAI PTs while it is considered one of the least important factors for forming traditional H-H PTs. This can be explained by the fact that humans must be well-educated, knowledgeable, and fully aware of the business context when working with GenAI to be capable of validating the output generated by the GenAI teammate.

### 4.3.2 Stages of H-GenAI Project Team Development

This sub-section presents a discussion of the H-GenAI SPTD, which corresponds to Phase 2 of the study and addresses SRQ2 and SRQ3.

According to the results of the study, GenAI enhances the performance of PTs when integrated into them and compensates for humans' performance drawbacks. As revealed in the previous Section, the performance of H-GenAI teams is enhanced when the GenAI characteristics and abilities have a positive influence on the team, while the human behaviors and attitudes have a negative influence on the team. Moreover, the H-GenAI TP appears to have an equal value of performance in comparison with the

H-H TP when either the GenAI characteristics and abilities have a positive influence on the team and the human behaviors and attitudes also have a positive influence on the team, or when the GenAI characteristics and abilities have a negative influence on the team and the human behaviors and attitudes also have a negative influence on the team. Furthermore, the H-GenAI TP worsens when the GenAI characteristics and abilities have a negative influence on the team, while the human behaviors and attitudes have a positive influence on the team.

In this study, there are two incidents where the GenAI characteristics and abilities appear to have a negative influence on the team while the human behaviors and attitudes have a positive influence on the team, meaning, the characteristics and abilities of the GenAI do not compensate for the human behaviors and attitudes which seem to be important throughout the STD in the scenario of H-GenAI collaboration, such as “Excitement” in Stage 1 and “High morale” in Stage 3. Even though GenAI is “Dispassionate & Emotionless”, it is important for the human counterpart within the H-GenAI team to psychologically feel the excitement of the teammate and deal with a teammate with high morale.

## 4.4 Further Findings of the Study

This Section presents further results obtained from the AI experts or practitioners during the semi-structured interviews followed by discussions in 2 sub-sections: (1) Generative AI Supporting Project Management and (2) A Hybrid Setup for Successful Project Management.

### 4.4.1 Generative AI Supporting Project Management

According to the respondents, the integration of GenAI in PTs in the domain of project management is highly beneficial and vital. With GenAI,

we have a lot of cases that are a good fit for project management. This goes back to not only the abilities that GenAI possesses but also to its characteristics and strengths. In addition, GenAI supports PTs throughout project management. Some respondents highlighted that GenAI can be used in every phase of the project lifecycle. Other respondents added that GenAI enhances the project lifecycle by providing tools and insights that will improve decision-making, optimize resource use, mitigate risks, and streamline processes. In this context, AIR1 highlighted, *"AI can be used in every phase of the project from initiation to closing."* Respondent AIR5 adds, *"It enhances the project lifecycle by providing tools and insights that will improve decision-making, optimize resource use, mitigate risks, and streamline processes."* AIR3 said, *"It's going to be very functional and very helpful across the whole journey. But it's only as good as you feed it legit stuff. But again, it depends on how much you want to delegate to it."* According to AIR6, *"I believe that technology, GenAI in particular, can be a huge benefit in being more accurate, efficient, and effective in doing repetitive tasks."*

The following are some aspects of the support that GenAI may provide for PTs in the domain of project management, as revealed by the interview respondents:

***1. Project Functionalities***

GenAI can do the project functionalities by utilizing its abilities. In project management, the majority of the workload spans contacting people, following up like a PM per se, summarizing the work, and figuring out the financials of the operation, budgets, and resourcing. Since all of these tasks and the whole operation can be scripted, it is a huge fit for GenAI. Thus, it is advised to put all the main tasks on GenAI, to learn from humans and gradually transfer the knowledge, and then let the PMs oversee the

functionality of GenAI. In this context, AIR1 said, *"Put all the main tasks on AI, to learn from humans, to gradually transfer, and then you let all of the project managers oversee the functionality of the AI."* AIR3 said, *"Especially in project management, and for being extremely honest, the majority of the workload spans contacting people, making sure that everybody's doing their job, following up like a project manager per se, figuring out the financials of the operation, we're talking budgets, resourcing, and all of these things can be scripted, if we're being honest again, and this is what people don't want to hear about. But since the operation, the whole operation can be scripted, it is a huge fit for AI."* AIR3 added, *"If we're talking about programming, we also rely on AI."* AIR4 said, *"AI can summarize, making your work better."*

***2. Recourse Allocation***

GenAI can be used for resource allocation, not just for TF, but also for other resources to ensure efficiency, detect potential bottlenecks, and advise improvements to ensure effective use of resources that minimize waste and maximize output. According to AIR6, *"I would use AI as a tool to research the backgrounds of the people, what their preferences are, and how they have performed best in other teams."* AIR1 said, *"It can be used for resource allocation not only for forming teams but also for other resources to ensure efficiency, identify potential bottlenecks, and suggest adjustments to ensure efficient use of resources that would minimize waste and maximize productivity."*

***3. Risk Management***

GenAI can be used to manage project risks. It can anticipate future threats by studying patterns and historical data and giving early warnings and mitigation techniques to address concerns before they arise. According to AIR1, *"Another area is the risk management of projects. It can predict*

*potential risks by analyzing patterns and historical data and providing early warnings and mitigation strategies to address issues before they escalate."*

***4. Performance Monitoring and Feedback***

GenAI can enhance performance monitoring and feedback by delivering real-time insights on important performance parameters, which can help projects stay on track. In this context, AIR1 explained, *"It can also support performance monitoring and feedback by providing real-time insights on key performance metrics, and this can keep projects on track."*

***5. Consultancy & Lessons Learned Source of Knowledge***

GenAI can serve as a project management consultant, verifying work and bridging any gaps that humans may create along the route, particularly in large projects. It enables us to see things from a different perspective. Furthermore, in project management itself, the lifespan of the project and all the activities that have been done from the commencement of the project to its closure can be used by GenAI as a learning mechanism; GenAI can provide feedback and comments. In this context, AIR3 emphasized the role of GenAI as a consultant in project management, *"In project management, strictly project management, it's a great way to have another consultant, another harsh consultant should really verify your work and basically bridge all the gaps that you make along the way, especially in big projects."* In this context, AIR3 continued, *"It allows you to really view things from a fresh eye and a fresh point of view, let's say. It's going to tell you if you're missing out on something, or if this thing has not been done."* AIR5 remarked, *"When you're looking at the project management itself, the lifecycle of the project itself, and all the events that have been done from the beginning of the project till the closing, you can use this as a learning*

*method, and once you apply the AI, the AI will come back with feedback and comments."*

### 4.4.2 A Hybrid Setup for Successful Project Management

The majority of the interview respondents emphasized the necessity of collaboration between humans and GenAI and its tremendous importance in the domain of project management. The reasons behind the call for H-GenAI collaboration correspond to the many abilities that GenAI can perform due to its unique characteristics and strengths, as well as the strengths and limitations of human beings. Although GenAI can help a lot in every stage of the project, it cannot do everything independently. So, human intervention is important here, as there must be someone behind its setup to make it function. In this context, AIR4 remarked, *"AI can help a lot in every stage of the project, but it cannot do everything on its own. So, there must be someone to make it work, to fine-tune it, to filter it. So, there will always be someone, let's say, who is handling it. Until now, we cannot run a project end-to-end using AI."* AIR3 mentioned, *"As of now, the way forward is you have a hybrid setup where humans can do one thing, and they can delegate the really daunting stuff to the machine."* AIR3 continues, *"The best way to use it, I think when you have a combination of both, humans can steer the AI to do very specific things, and then they can get the results and bridge their gaps."*

The following are some reasons why PTs consisting of both humans and GenAI are important for better project management, as revealed by the interview respondents:

***1. A Human Project Manager***

The important role that the PM plays in steering the project cannot be neglected, as emphasized by the respondents. Although GenAI has many

different capabilities that support PTs in performing tasks and keeping things on track, it cannot perform the duties of a PM. According to AIR4, *"AI can replace the scrum master, but it cannot replace the PM. Let's say it can keep things on track, can organize things. It can do the capacity, for example, but not as a PM."* AIR1 adds, *"Having certain tasks for the AI and the human will be the higher level, to supervise and monitor."* AIR1 continued, *"We'll let the AI do the functionalities, but we'll have one or two or whatever number of supervisory characters required to oversee the performance of AI in managing that project."*

***2. Humans' Creative Minds***

Creativity is human nature, no matter how much creative GenAI can get. Some respondents mentioned that the greatest formula is to have a hybrid setup where humans can focus on the creative aspect of the project. AIR3 mentioned, *"The ultimate formula is basically to have a hybrid setup, getting humans for now, at least for now, they're really good when it comes to the creative stuff; when it comes to the analysis, their chain of thought is much more, let's say, realistic or practical. With AI, we're not there yet."* AIR3 continued in the context of creativity, *"If it requires a lot of creative work, then in this case, I would argue that AI might not be the best fit for now."*

***3. Humans' Critical Thinking***

Critical thinking is important when dealing with GenAI. Humans need to use their reasoning and think critically about the outcomes of GenAI systems and verify them. According to AIR2, *"Humans can maneuver out of the programmed things. With AI, you need to come up with a mature AI model to reach that level."*

### *4. GenAI Complements Human Limitations*

It is important to integrate GenAI in PTs for many reasons that fall under human limitations. Humans have limitations and must recognize their constraints. As a result of those limitations, humans are unable to make some accomplishments. People forget and get tired, which negatively affects their performance. GenAI can compensate for humans' shortcomings. Humans have limited capacity in terms of attention, memory, and power, and this capacity can be constrained. People become distracted as things come up, and they lose track of things. A human will not be able to recall, for example, a discussion from years ago. They must browse through their emails and waste a lot of time to arrive at their desired result. Furthermore, there are occasions when people have unpleasant days, which affect their mood. So, having a GenAI as a coworker in PTs helps compensate for human limits and the numerous downsides in their behavior.

In this context, respondent AIR3 remarked, *"We humans, again, have limitations. We have to respect our limitations. And so, some of the breakthroughs that we did not get through are due to our limitations. People forget, people don't do things well, and they get tired. And now we have the ultimate creation, that even though it runs on transistors, might not be the best fit, these things that we created can really complement our mishaps or our shortcomings."* AIR3 elaborated, *"Human beings have a limited capacity in terms of their attention, in terms of their memory, in terms of their power, and in their capacity can go basically limited."* AIR6 added, *"We as people, get distracted, we have things that come up, and we lose track of things."* AIR3 explained, *"A human being is not going to be able to remember, for example, a conversation that occurred, I think, three years ago. They have to go through their emails and spend a lot of hours, waste*

*those hours, in order to get to what they want."* AIR6 continued, *"AI is much better than people in repetitively and routinely checking in on trends, "Where are we?", monitoring technologies, monitoring markets, customer reactions, and customer behaviors to allow the people involved to most effectively manage that, and lead into the future."* Besides, there are times when humans face bad days which effect their mood, as AIR2 highlighted, *"The mood of the human, AI will not have such problems with feelings."*

# Chapter Five

# Conclusion

## 5.1 Introduction

This Chapter consists of four main Sections. Section 2 addresses the research questions, Section 3 presents the research contributions, Section 4 presents the limitations of the study, and finally, Section 5 presents the study's recommendations and directions for future research.

## 5.2 Addressing Research Questions

This study aimed to develop a model for H-GenAI collaboration for PTs in project management within the service industry and determine KPIs for measuring the performance of H-GenAI PTs. This section explains how the study addresses its MRQs, **MRQ1** and **MRQ2**, as follows:

***MRQ1: How to develop a H-GenAI collaboration model for PTs in project management within the service industry?***

***MRQ2: What are the KPIs that can be utilized to measure the performance of H-GenAI PTs?***

To address **MRQ1** and **MRQ2** and achieve the study's objectives, the following explains how each of the two MRQs is addressed by addressing the SRQs, from SRQ1 to SRQ5, as follows:

***SRQ1: How to build a model for H-GenAI PTF?***

Phase 1 addresses **SRQ1**. The objective was to build a model for H-GenAI PTF mainly through solving the TFP when GenAI is integrated into PTs. In the first part of Phase 1, the study aimed to explore the theories that support the dynamics of TF to better comprehend the basis on which H-AI

teams are formed and investigate areas requiring further study concerning the various forms of H-AI teams. In doing so, the study reviewed prior studies by conducting SLR following the three suggested stages: planning, conducting, and reporting the review. Following the PICOC components, two RQs were formed to achieve the study's objectives. The study employed the inclusion and exclusion criteria and selected 20 scientific papers from ScienceDirect, ACM, and IEEE Xplore/Access, published between 2018 and 2023. A quality assessment of the study was conducted using a checklist consisting of five questions to evaluate the chosen scientific papers. The study reveals 30 theories that are utilized for TF, 11 of which apply to H-AI teams, namely the Intuitionistic Fuzzy Soft Set theory, the theory of Expectation Violation, the theory of Complex Systems, the Dynamical Systems theory, the theory on Trust Development, the theory of Interactive Team Cognition, the Social Identity Theory, Social Facilitation Theory, Distraction-Conflict Theory, Graph theory, and Social Categorization Theory. The study provides 17 considerations for future research within the domain of H-AI collaboration, which the study categorizes into the following 9 themes: Trust, Reliability, Stabilisability, Transparency, Communication and Cognition, Team Composition, Mental Models, Team Formation Models, and Experimentation. The findings of this part of the study revealed that the theories surrounding H-AI are not widely recognized, which might be viewed as a novel area that requires further investigation. Also, the findings of this study emphasized the necessity of further investigation into the 9 themes for H-AI collaboration.

In the second part of Phase 1, the primary objectives were to identify the influential factors that affect PTF and assign weights to the main factors to solve the MCDM problem of TFP. The study developed the TMF, a hybrid approach of AI (NLP and ML) with MCDM-BWM, consisting of three

successive phases: Data Preprocessing, Data Processing, and Data Post-processing. The Data Preprocessing phase of the TMF explored factors from literature that affect the TF process and prepared a list of all the factors that influence TF which previous publications considered for their results or developed models without eliminating redundant factors. In the Data Processing phase, the study applied text mining techniques of the NLP approach, specifically the TF-IDF, followed by the Pareto Principle, to evaluate the importance of the factors for TF, which resulted in the identification of 89 factors. Then, the study examined the adoption of ML clustering algorithms, specifically the K-Means and Hierarchical clustering, and consequently adopted the Hierarchical clustering algorithm to cluster the 89 pre-defined factors, which resulted in clustering the factors into 8 main factors under 3 themes, namely: (1) Human-related factors: Personality and Characteristics, (2) Project-related factors: Project Characteristics, and (3) Team-related factors: Teamwork, Skills & Competencies, Work Experience, Education & Knowledge, and Expertise & Proficiency. In the Data Postprocessing phase, the study considered the 7 main factors of both human-related and team-related themes and employed the BWM of the MCDM approach to assign their weights by conducting structured interviews with 25 PMs from 5 sectors in the service industry: FS, TS, RS, ES, and GS. Consequently, the study ranks these factors based on their level of influence on project teams according to their weights as follows: Skills & Competencies (0.22), Personality (0.17), Work Experience (0.17), Expertise & Proficiency (0.15), Teamwork (0.14), Education & Knowledge (0.1), and Characteristics (0.05). According to the study, “Skills & Competencies” is the most important factor that affects TF when considering PTs in the project management domain of the service industry, while “Characteristics” is the least important. The study

contributes to knowledge and understanding of the TFP in project management within the service industry.

As for the third part of Phase 1 of the study, the study's main objective was to solve the H-GenAI TFP by, first, exploring GenAI capabilities when collaborating with humans in PTs and determining the main capabilities of GenAI that impact project management through its integration into PTs, and, then, by considering the same factors that support H-H PTF in project management within the service industry. The study conducted semi-structured interviews with 16 AI experts and practitioners and uncovered 64 capabilities of GenAI for PTs. The study split the capabilities into characteristics and abilities of GenAI and followed the Clustering Framework, which was developed by the authors of the study, for the clustering process. The study employed the hierarchical clustering algorithm, followed by the Silhouette and t-SNE plots, and, as a result, determined 27 characteristics and clustered them into 13 main clusters under 13 developed themes, namely: (1) Autonomous, (2) Integrated & Interoperable, (3) Stable & Consistent, (4) Reliable & Controllable, (5) Interactive & Reactive, (6) Adaptable & Adjustable, (7) Dispassionate & Emotionless, (8) Customized & Personalized, (9) Accurate, (10) Smart & Innovative, (11) Transparent, (12) Simple, and (13) Logical. The study also determined 34 abilities and clustered them into 12 main clusters under 12 developed themes, namely: (1) Categorization, (2) Content Creation, (3) Learning & Training, (4) Computation & Processing, (5) Prediction, (6) Decision & Solution, (7) Assistance & Recommendation, (8) Information Recollection, (9) Situational Analysis & Interpretation, (10) Interaction & Communication, (11) Imitation, and (12) Translation & Transformation. The study then utilized the factors that contribute to the formation of PTs to re-evaluate the factors when considering GenAI as a team member in

PTs and employed the BWM of the MCDM approach to assign their weights. By conducting structured interviews with 15 PMs out of the 25 PMs from FS, TS, RS, ES, and GS, the study ranks these factors based on their level of influence on project teams according to their weights as follows: Skills & Competencies (0.22), Work Experience (0.18), Education & Knowledge (0.17), Expertise & Proficiency (0.15), Teamwork (0.14), Personality (0.09), and Characteristics (0.05). According to the same PMs, "Skills & Competencies" is still the most important factor that affects TF when considering GenAI in PTs in the project management domain of the service industry, and "Characteristics" remains the least important, while the other factors differ in importance. The study contributes to knowledge in the area of GenAI for project management when GenAI is integrated into PTs and contributes to knowledge and understanding of the H-GenAI TFP in project management within the service industry.

The fourth part of Phase 1 aimed to explore the GenAI enablers that enable GenAI to function the way they do and the factors that support the collaboration of humans with GenAI when GenAI is a team member in a PT with its human partner. As a result of the semi-structured interviews that were conducted with 16 AI experts and practitioners, the study discovered 13 GenAI enablers, which are: (1) Deep Learning Models (DL), (2) Large Language Models (LLMs), (3) Transformer Models, (4) Generative Adversarial Networks (GANs), (5) Gated Recurrent Unit (GRU), (6) Long Short-Term Memory (LSTM) & Bidirectional Long Short-Term Memory network (BiLSTM), (7) Autoencoders, (8) Machine Learning Models, (9) (Artificial) Neural Network Models (ANN), (10) Natural Language Processing (NLP), (11) Statistics, (12) Processing Powers: Central Processing Unit (CPU), Graphical Processing Unit (GPU), Tenser Processing Unit (TPU), and Language Processing Unit (LPU), and (13)

GenAI Eco System. As for the factors that aid in achieving successful H-GenAI collaboration, the study discovered 16 factors, which are: (1) General Understanding of GenAI, (2) Realization of GenAI Capabilities, (3) User-friendly GenAI, (4) Acceptance & Adoption of GenAI, (5) Reskill & Upskill Human Skills, (6) Prompt Engineering: the Chain of Thoughts, (7) Context & Business Understanding, (8) Governance, (9) Security & Privacy, (10) Reliable Data, (11) Well-designed GenAI Models: GenAI Model Learning, GenAI Model Training, and GenAI Model Testing & Validating; GenAI Explainability (Explainable AI), (12) Trust & Ethics, (13) Humans & GenAI Roles, (14) Tasks Delegation & Assignment, (15) Critical Thinking, and (16) Monitor Collaboration Performance.

Phase 1 of the study builds a model for H-GenAI PTF by considering its four parts, addressing **SRQ1**.

Moving forward, the objective of Phase 2 was to build a model for H-GenAI SPTD and determine the extent to which the capabilities of GenAI enhance the performance of H-GenAI PTs compared to H-H PTs throughout the STD by examining how humans and GenAI develop while collaborating in PTs. The objectives of Phase 2 are achieved by addressing the two following SRQs:

***SRQ2: How to build a model for H-GenAI stages of project team development?***

***SRQ3: To what extent do the capabilities of GenAI enhance the performance of humans in H-GenAI PTs compared to H-H PTs throughout the STD?***

To address **SRQ2** and **SRQ3**, first, part 1 of Phase 2 explored two models of STD for traditional H-H teams: Bruce Tuckman's and Mike Woodcock's models. The study listed the human behaviors and attitudes in the two

models and then assessed the effectiveness of the H-H teams by quantifying all human behaviors and attitudes that appear in Tuckman's and Woodcock's models using the "+ / -" scale according to how "positive" or "negative" influence the human behaviors and attitudes have on the performance of PTs, where "+1" corresponded to positive influence while the "-1" corresponded to negative influence. The study then calculated the number of positive and negative behaviors and attitudes in each of the STD. The study measured the performance of H-H teams and illustrated H-H's progress throughout each stage of the STD according to Tuckman's model by taking the sum of positive influences in Tuckman's model for each stage and dividing it by the total number of human behaviors and attitudes of each stage. Then, the study measured the performance of H-H teams and illustrated H-H's progress throughout each stage of the STD according to Woodcock's model by taking the sum of positive influences in Woodcock's model for each stage and dividing it by the total number of human behaviors and attitudes of each stage. For a comprehensive traditional model of STD, the study combined the two models of Tuckman's and Woodcock's, and measured the performance of H-H teams throughout each stage of STD for both models combined by taking the value of the total number of positive influences of both models for each stage and dividing it by the total number of behaviors and attitudes of each stage in the two models. The findings revealed that the percentage of the performance level of H-H teams in each of the stages, according to Tuckman's model, is as follows: stage 1= 47%, stage 2= 7.7%, stage 3= 100%, stage 4= 100%, and stage 5= 80%. The percentage of the performance level of H-H teams in each of the stages, according to Woodcock's model, is as follows: stage 1= 30%, stage 2= 83%, stage 3= 88%, and stage 4= 93%. As for the combined models, the percentage of the performance level of H-H teams in each of

the stages is as follows: stage 1= 40%, stage 2= 32%, stage 3= 96%, stage 4= 97%, and stage 5= 80%.

Then, in part 2 of Phase 2, the study examined the applicability of the characteristics and abilities of GenAI to those behaviors and attitudes of humans in the two models combined, to measure the extent to which GenAI can compensate for the behaviors and attitudes of humans with its characteristics and abilities in a cooperative context. The study assessed the performance of H-GenAI PT by measuring its effectiveness throughout the STD, compared its performance with the performance of the traditional H-H teams, and illustrated how humans and GenAI progressed throughout the STD when working on a project by substituting all human behaviors and attitudes that appeared in Tuckman's and Woodcock's models with those characteristics and abilities of GenAI, first for each model separately and then combined. Then, the study quantified all GenAI main characteristics and abilities that correspond to the human behaviors and attitudes that appear in Tuckman's and Woodcock's models using the "+ / -" scale, according to the "positive" or "negative" influence the main characteristics and abilities have on the performance of PTs, where "+1" corresponded to positive influence while the "-1" corresponded to negative influence. The study then calculated the number of positive and negative characteristics and abilities in each of the stages. The study measured the performance of H-GenAI teams and illustrated H-GenAI progress throughout each stage of the STD according to Tuckman's model by taking the sum of positive influences of GenAI main characteristics and attitudes in Tuckman's model for each stage and dividing it by the total number of human behaviors and attitudes of each stage. Then, the study measured the performance of H-GenAI teams and illustrated H-GenAI progress throughout each stage of the STD according to Woodcock's model by

taking the sum of positive influences of GenAI main characteristics and attitudes in Woodcock's model for each stage and dividing it by the total number of human behaviors and attitudes of each stage. After that, the study measured the performance of H-GenAI teams and illustrated H- GenAI progress throughout each stage of STD according to the combined models of Tuckman's and Woodcock's by taking the value of the total number of positive influences of GenAI main characteristics and attitudes in both models for each stage and dividing it by the total number of behaviors and attitudes of each stage in the two models.

The findings revealed that the percentage of the performance level of H- GenAI teams in each of the stages, according to Tuckman's model, is as follows: stage 1= 93%, stage 2= 100%, stage 3= 100%, stage 4= 94%, and stage 5= 100%. The study reveals the difference in performance level between H-H teams and H-GenAI teams in each of the stages and the percentage of their differences as follows: stage 1= 4.6, which represents 97.87%, stage 2= 9.93 (14186%), stage 3= 0 (0%), stage 4= -0.6 (-6%), and stage 5= 2 (25%). The study also reveals the successive performance growth of H-GenAI teams throughout STD: 198%, 14286%, 100%, 94%, and 125%. The percentage of the performance level of H-GenAI teams in each of the stages, according to Woodcock's model, is as follows: stage 1= 100%, stage 2= 100%, stage 3= 100%, and stage 4= 100%. The study reveals the difference in performance level between H-H teams and H-GenAI teams in each of the stages and the percentage of their differences as follows: stage 1= 7, which represents 233.3%, stage 2= 1.7 (20.48%), stage 3= 1.2 (13.64%), and stage 4= 0.7 (7.53%). The study also reveals the successive performance growth of H-GenAI teams throughout STD: 333%, 120%, 114%, and 108%. As for the combined models, the percentage of the performance level of H-GenAI teams in each of the stages

is as follows: stage 1= 96%, stage 2= 100%, stage 3= 100%, stage 4= 97%, and stage 5= 100%. The study reveals the difference in performance level between H-H teams and H-GenAI teams in each of the stages and the percentage of their differences as follows: stage 1= 5.6, which represents 140%, stage 2= 7.4 (284.62%), stage 3= 0.4 (4.17%), stage 4= 0 (0%), and stage 5= 2 (25%). The study also reveals the successive performance growth of H-GenAI teams throughout STD: 240%, 384.62%, 104.17%, 100%, and 125%.

Phase 2 of the study builds a model for H-GenAI SPTD by considering its two parts and confirms its enhanced performance compared to the STD for traditional H-H teams.

By considering the two built models from Phase 1 and Phase 2, the study develops the H-GenAI Collaboration Model for PTs in project management (H-GenAI Collab). This addresses **MRQ1** of the study.

Moving forward to Phase 3, the study's primary aim was to establish KPIs for assessing the performance of PTs when GenAI is integrated into them along with their human counterparts, which addresses **MRQ2**. The objectives of Phase 3 are achieved by addressing the two following SRQs:

***SRQ4: How can we measure the efficiency of H-GenAI PTs?***

***SRQ5: How can we measure the effectiveness of H-GenAI PTs?***

To address **SRQ4** and **SRQ5**, first, the study conducted semi-structured interviews with 16 AI experts and practitioners and determined two parameters along with their dimensions for measuring H-GenAI PT performance: (1) Efficiency; which is measured by Time, Cost, and Resources, and (2) Effectiveness; which is measured by Accuracy, Quality, and Transparency & Clarity. The study contributes to knowledge by

establishing KPIs to measure the performance of H-GenAI PTs for the domain of project management in the service industry.

Considering all 3 Phases of the study, the study achieves its two main objectives by, first, developing the H-GenAI Collaboration Model (H-GenAI Collab) as a combination of the two built models, H-GenAI PTF model in Phase 1 (**SRQ1**) and the H-GenAI SPTD model in Phase 2 (**SRQ2** and **SRQ3**), and then establishing H-GenAI KPIs to measure the performance of PTs in Phase 3 (**SRQ4** and **SRQ5**).

## 5.3 Study Contribution to Research & Practice

The study's main contribution is the development of a model for H-GenAI collaboration, which contributes to the concept of team formation for H-GenAI PTs and the concept of stages for H-GenAI project team development. The study adds knowledge to the domain of H-GenAI collaboration and contributes to the field of project management through the integration of GenAI in PTs, highlighting the significance of GenAI integration into PTs as teammates with their human counterparts. To the best of the authors' knowledge, there is no existing model that provides insight into the formation of a PT when GenAI is considered a teammate with its human counterpart and the development of such a PT throughout the stages of team development when humans and GenAI collaborate on a project.

Moreover, the study not only proposed a technique for project team formation that allows PMs in the service industry to select their PTs based on a hybrid approach of AI (NLP and ML) and MCDM but also developed a model for H-GenAI project team formation, which allows PMs in the service industry to select their PTs based on a hybrid approach of AI (NLP

and ML) and MCDM. To the best of the authors' knowledge, there is no existing model for H-GenAI project team formation.

Furthermore, the study not only proposed a general model for traditional teams characterizing the stages of team development for H-H teams but also developed a model for the stages of H-GenAI project team development, which allows PMs in the service industry to enhance their PTs through the integration of GenAI in PTs. To the best of the authors' knowledge, this H-GenAI SPTD model is the first model to capture the H-GenAI team dynamics throughout the stages of team development when working on a project, showcasing how GenAI characteristics and abilities compensate for human behaviors and attitudes when working in teams. Through this model of H-GenAI SPTD, the study draws the boundaries for human and GenAI cooperation while collaborating to improve H-GenAI communication and team cohesion and hence improve PT performance in project management within the service industry.

In addition, the study establishes KPIs for H-GenAI PTs in the field of project management that will assist project-based businesses in evaluating the performance of their PTs when integrating GenAI into their teams as teammates. Besides, having a clear understanding of how teams are being evaluated will help detect the project’s drawbacks and ensure project success.

Moreover, the study contributes to the domain of active learning in the context of H-GenAI collaboration in PTs. By introducing active learning mechanisms into the suggested models of TF and SPTD through integrating GenAI as teammates in PTs and its application within project management, the study allows GenAI agents to learn continually from human input, interaction uncertainty, and changing team dynamics. As a result, GenAI continuously increases its effectiveness as a team member in

a dynamic collaboration model, leading to PTs that are more receptive, contextually aware, high-performing, and, hence, productive.

## 5.4 Limitations of the Study

Although the study meets its objectives, it has some limitations. As for the SLR that was conducted on TF, the study does not evaluate the 30 theories that arise from the literature. It rather lists the theories supporting TF that previous studies -selected for the SLR- have mentioned in their studies, regardless of (1) the type of teams that the studies have formed or aimed to form (i.e. project teams, study groups, etc.), and (2) the type of teammates being humans or agents (i.e. H-H, H-AI, AI-AI). In addition, the study did not assess the applicability of the 11 theories to H-AI teams. Besides, the study does not expose which theories are best used for TF, nor the most suitable for teams involving H-AI for H-GenAI collaboration. Moreover, the results of the SLR are constrained by the research methodology; the study created quality questions for SLR to evaluate the quality standard of the chosen studies based on the authors' judgment, possibly limiting the way the selected papers are evaluated. Furthermore, the selected previous studies for the SLR were only searched in three databases, namely ScienceDirect, ACM, and IEEE Xplore/Access; additional papers from other different online sources may have been included in this study. Besides, the study only considered papers published in the period from 2018 to 2023; earlier or later studies might have utilized different theories.

In solving the TFP for H-H PTs, the study explored the factors that influence TF within the study's selected papers, while other important factors might have been neglected as a result. Besides, the factors were extracted from previous literature without being validated. Moreover, the study has prioritized the list of factors that appeared in the literature as the

results of the previous studies using the TF-IDF technique, while other unsearched methods might be more appropriate for this purpose. In addition, the study used the TF-IDF on the entire list of factors from the literature without categorizing the PTs into types, which might be inappropriate to generalize as each project has its own set of characteristics and requirements. Besides, the factors were not categorized according to the type of their influence on TF, whether positive or negative. Furthermore, after applying the Pareto principle to the TF-IDF results, the study clustered the most important (high-weighted) unique factors and then ranked the main or key factors by assigning them weights using the MCDM-BWM, without comparing the results of other MCDM weighing methods.

As for solving H-GenAI TFP and forming H-GenAI PTs, the study conducted semi-structured interviews with 16 AI experts and practitioners to identify the capabilities of GenAI and discover how much it serves the project and impacts project management. Interviewing PMs per se as well could have supported this study by confirming the practical requirements of projects throughout the project lifecycle phases. Moreover, although the number of interviewees for the semi-structured interviews with AI experts was selected based on the saturation principle, other AI experts might likely have had additional input, and some of the GenAI capabilities might have been overlooked as a result. Moreover, other AI experts might likely have had additional input on the factors that support the collaboration between humans and GenAI, which might have been overlooked as a result. Furthermore, for the identified GenAI capabilities, the authors created their own split of the GenAI capabilities into two groups, characteristics and abilities, and then followed the Clustering Framework, shown in Figure 23,

instead of directly following the Clustering Framework and employing the ML clustering algorithms for this purpose.

For the STD models for H-H teams, the study explored 9 models and thoroughly investigated 2 models, which are the models of Tuckman and Woodcock, for their similarity of stages characteristics and suitability for traditional teams, when other models for STD could have been explored and investigated as well. In addition, in the combined H-H STD model of Tuckman's and Woodcock's models, there are some similarities or intersections between the human behaviors and attitudes that appear in equivalent/parallel stages (i.e. the "Forming" stage of Tuckman's and the "Undeveloped Team" of Woodcock's, the "Storming" stage of Tuckman's and the "Experimenting Team" stage of Woodcock's, etc.), which created redundant behaviors and attitudes in equivalent stages of the models. This limitation will be addressed in the future.

Finally, for establishing means for evaluating the performance of H-GenAI PTs, the study determined the KPIs of the PT considering GenAI integration into it from the lens of AI experts without validation of these KPIs from PM experts per se. Besides, the study interviewed 16 AI experts or practitioners while other AI experts might have additional KPIs to share.

## 5.5 Recommendations & Directions for Future Research

This study suggests several directions for future research. While investigating the TF theories, the study recommends focusing on a field of study (i.e., project management) to specifically investigate the type of team (i.e., project teams) most suitable for that specific domain. The study also recommends categorizing teams into 3 types of teammates: H-H, H-AI, and AI-AI. Moreover, investigating the 11 theories that apply to H-AI or H-GenAI teams, as resulted from the SLR, is important to understand the

basis on which H-GenAI teams are formed. Besides, it is necessary to further explore all the theories of TF that this SLR study reveals (30 theories) and evaluate their suitability for H-AI and H-GenAI teams, to provide a comprehensive list of theories that could apply to H-AI and H-GenAI collaboration.

In solving the TFP for H-H teams, the study recommends conducting further research to explore other factors that affect TF, besides those found in this current study, and validating the factors by conducting empirical research or interviewing project management experts to verify the adaptability of the identified factors (i.e. to conduct semi-structured interviews with PMs) before conducting the structured interviews with PMs to assign weights to the clustered factors (criteria). Also, the study recommends verifying the sub-criteria, in our study called the sub-factors consisting of attributes, by interviewing project management experts to build a comprehensive TF model, with factors and sub-factors of PTs. Moreover, the study suggests investigating other ML clustering algorithms as well as looking at alternative approaches for allocating weights to the main or key factors, including other MCDM methods for weight allocation. Besides, as every project has a unique set of requirements, the study suggests classifying the PTs before allocating weights based on the project domain. Furthermore, the study recommends categorizing the factors' influence on TF into positive and negative influences. In addition, the BWM that was applied focused only on assigning weights to the factors (criteria) in correspondence to the research's objectives without ranking the PT members (alternatives) according to their priority value after being compared with one another. The study recommends conducting a comprehensive study with PMs until the team candidates are ranked to satisfy the ultimate goal which is to form an ideal PT.

The study recommends implementing the TF model in real scenarios in the service industry, whether to form H-H PTs or H-GenAI PTs, taking into consideration the nature of the sector and the project requirements, and evaluating the model in terms of its applicability and limitations. In addition, the study recommends implementing the model by building software that will use human attributes as input by creating a profile for each employee (project team candidates) and GenAI capabilities, and the software will generate the optimal PT for the project based on the project requirements. Moreover, the study suggests enhancing the TF model, whether for H-H PTs or H-GenAI PTs, by integrating an optimization technique to select the optimal team.

In exploring GenAI capabilities to benefit PTs, the study recommends interviewing additional AI experts and also interviewing PMs to determine the requirements of the phases of the project lifecycle and verify the findings of this study, in terms of evaluating the importance of the 27 characteristics and 34 abilities of GenAI in PTs before clustering them using ML clustering algorithms by following the Clustering Framework, shown in Figure 23.

In determining the factors that contribute to the success of H-GenAI collaboration, the study recommends validating the factors -that resulted from the semi-structured interviews- with PMs in project management in a specific domain within the service industry. Furthermore, this study recommends tackling human teammates' challenges and discomfort when working with GenAI teammates for future research in the area of H-GenAI collaboration.

In addition, the fact that GenAI technologies continually evolve is a major constraint of this research. Fundamental elements, including factors such as the underlying models of the tools, human skills and training strategies,

as well as their architectural frameworks, are probably going to change as these technologies develop. The enablers of the tools under study may also change as a result of the ongoing development of the underlying technologies, which include deep learning, machine learning, and integrated AI ecosystems. Meanwhile, it is anticipated that these tools' capabilities—such as their degree of automation, processing capacity, and contextual awareness—will advance considerably over time. To stay up to date with technology developments and guarantee continued relevance and efficacy in H–GenAI collaboration within project environments, future research should constantly review and modify the suggested models and frameworks.

As for the STD combined model, the study recommends eliminating the redundant behaviors and attitudes of humans that appear in the same stage of Tuckman's and Woodcock's models. Moreover, in this study, we assume that all the human behaviors and attitudes, as well as the GenAI characteristics and abilities, are with the same weight "1". However, as for future work, the study recommends assigning weights for the GenAI characteristics and abilities that compensate for the human behaviors and attitudes for more accuracy. Furthermore, the study recommends validating the proposed model by conducting a simulation, an experiment, or a survey.

In addition, future studies are urged to investigate a multi-agent simulation method that considers the nature of the project environment and assigns unique attributes and capabilities to both human and GenAI agents. These simulations could use techniques like Deep Reinforcement Learning to examine the interactions and behaviors of agents over time. This approach could enable the development of more flexible models for collaboration and make it possible to determine which GenAI configurations are most suited for various project types and environments.

In establishing KPIs for measuring the performance of H-GenAI PTs, the study recommends validating the determined KPIs for PTs when considering GenAI as a team member with PMs to confirm the findings of this study. The study recommends collecting quantitative primary data from businesses that integrate GenAI into their PTs by conducting surveys and obtaining the users' input on how efficient or effective GenAI is in PTs. In addition, considering the KPIs for measuring the efficiency and effectiveness of H-GenAI PTs, it would be interesting to determine which KPIs are more fundamental than others while assessing the level of satisfaction towards the integration of GenAI in PTs.

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# Appendices

## Appendix (A): A sample of the semi-structured interview transcripts.

**Interviewer:** What do you think are the challenges in general of collaboration that we face today in PTs, causing project failure?

**AIR13:** Communications, no respect for the timings and deadlines, the issue of forgetting some items or some of the tasks on a daily basis, and maybe the overestimate of any projects or the low estimate of projects.

**Interviewer:** Have you ever used GenAI in PTs in your entity?

**AIR13:** Yes, we are using GenAI, Copilot.

**Interviewer:** Great. If we were to include GenAI to solve some of these issues that you've mentioned, what do you think we should do to ensure good collaboration? How can we ensure a good collaboration between humans and GenAI in teams in a project setting?

**AIR13:** Basically, we can use it as assistants to help us enhance this collaboration, to put, for example, some reminders, to also measure the timings that basically we work with. It can help us to summarize the actions discussed and then share it with the people and with the teams. So, these are the tasks that GenAI can help us with. Not to replace us, but to help and assist us in finalizing the tasks.

**Interviewer:** Great. And what are the factors that you think would support the use of GenAI in PTs, as in H-GenAI collaboration?

**AIR13:** Between humans and GenAI, we cannot say trust because definitely every GenAI should be controlled by humans, whether tasks or summary or any of the activities that will be shared. However, we can

coexist and try to use it and not rely on it 100%, but try to use it in order to be more efficient. Let's say you have an assistant and you're trying to use this assistant in order to get your information or accomplish your tasks. So, this is one point. The second is trying to minimize the role of GenAI on the things that you need help with. So, if you don't need help with, for example, summarizing the data or getting into specific ones, specific data and not the others, so you can control this. And then you can set the roles between you and GenAI to make it happen. We don't want the GenAI to be intrusive, let's say, and get into our daily things. But if you want to ensure good collaboration, we need help with its integration with the different tasks and with different data sets and information that you want to get data from.

**Interviewer:** And what qualifications do you think a human should have to deal with GenAI?

**AIR13:** Actually, human beings need to know how to interact with GenAI. Like for example, ask the right questions, use the right models, ensure that you have the right data sets basically to interact with, put on the right protocols and policies from compliance and security perspective. And also, they need to have the knowledge in interacting with. This will not let GenAI replace us, but again it is an assistant that needs help in getting the needed specific data, on specific information. We don't need to blindly rely, but also need to know how to deal with it. So, for example, if you want to use Copilot or ChatGPT, you need to ask the right questions and then the human being needs to have knowledge in the art of prompting. You know, when you have this art, when we start chatting with the bots or when we chat with people via WhatsApp or via Facebook or via messenger or others, any other communication or social media communication, we need basically to know how to use it and so on. It is also the same, it's not just as answering questions and so on. And we need to be mindful about

whatever data we need to share because there is difference between public models and training models. And then people that train their models need to be aware of that and then have to get the art of prompting very well and understand it very well and use it as per the best practices of each tool.

**Interviewer:** And what enables GenAI to function the way they do? What makes them so generative?

**AIR13:** Okay, so it's basically based on the models that the tools are using and the different models that are in place. And there are different models, for example, we have LLMs that are based on GenAI and there is kind of interaction with humans. It is not interaction with data only, but it's also interaction with a human where we use human language, whether by typing or by dragging and dropping or by voice or speech to voice. And there is a kind of cognitive search or cognitive understanding and learning, which is part of the GenAI.

**Interviewer:** What are the advantages of GenAI in PTs? And when we say advantages, we mean all the capabilities of GenAI, their abilities, characteristics, and strengths.

**AIR13**: There are a lot of advantages for GenAI. First of all, it helps in accelerating the daily tasks, it helps us to get more efficiency in terms of you doing the daily task. So instead of spending a full day drafting some information or drafting documents, it will take a few minutes to do this. It unleashes creativity. It helps in creating creativity. As people will not focus on the basic stuff, they will be more creative. It also helps with the productivity part; it makes us more productive. Also, it helps us in getting more learning, to have more ideas on some subjects and some projects.

**Interviewer:** What are the disadvantages of GenAI in PTs?

**AIR13:** When it comes to the disadvantages of GenAI, basically, if we don't validate the data coming from GenAI, we will have some quality issues. We see people that just copy the same text from ChatGPT or wherever and they copy the data, and they keep the note: “If you want to learn more, you can ask different questions or if you want to get data or you want to understand further, you can click on this link.” This is very bad; it’s one of the disadvantages. And also, from a data perspective, we will be depending hugely on GenAI. So, we will miss the authenticity of the information, and the document generated. So, then it will not be very helpful in validating the knowledge of the person itself. If we basically are submitting to, we're having a thesis, or we are basically having an exam and so on. And it can be also risky from security perspective and policy and policy and compliance perspective and knowing that whatever we're having as a data and information can be misused. Like for example, we're seeing companies, they open ChatGPT so people use the internal documents and put them in a ChatGPT or any other solution to get the data from it. So, we will be fully dependent on technology, GenAI, and we will not be autonomous. And then this dependency will be one of the disadvantages for this GenAI technology.

**Interviewer:** Is there anything else you would like to add for the contribution of GenAI to PTs, specifically in the project management domain?

**AIR13:** There are a lot of good scenarios when it comes to PTs. For example, when we are using GenAI for example for Pts, we are also getting better understanding and the risk management, all potential risk that our project will face, especially when it comes to the sizing, the over estimation or the underestimation of the tasks and so on. Also from a communication perspective, I already mentioned that it helps a lot in enhancing

communication and improving communication between the different PTs. And also, one of the big things that basically will help with monitoring and also predicting, if there is any issues going to happen or if there is any lack or if any time it is going over or under. And also, with a lot of monitoring, it helps on to taking some decisions. Because if you are using GenAI with actions, it will also somehow take the decisions in from project management. So, there are some solutions that help in taking decisions on, for example subscriptions on adding more resources to the project or reducing the number of people, adding more documentation or adding more tasks to the team, etc. And also, we'll be using it especially at the beginning we are using it from ideation by brainstorming about different aspects or even by closing and also preparing the final documentation to the customers or to the people or to internal team to carry on with the projects.

**Interviewer:** Now since you're using GenAI in PTs in your entity, how can you evaluate the gap between a team that's using GenAI and a team that's not using GenAI? What's the difference in performance between the two teams?

**AIR13:** The GenAI will help the people in the teams to get to the same level, even without expertise. It will help with getting people at the same level of understanding. The team that are using GenAI are using some tools to get them to a good level, and then to effectively manage the project through some support, through some assistance and then they will be full automations or a lot of agents that will support with not getting into a lot of misunderstanding or identifying the risk from the beginning, putting in the right resources with the same estimations. So, we will have a lot of support from GenAI in terms of performance changing dynamics, and team needs. It is kind of continuous learning about the current PT and project

management and improvement at the same time, and it’s an ongoing thing. It's kind of agile. When you are basically working with the support of GenAI, the other teams will basically use the lesson learned actually more than getting every time they will learn and listen. But they cannot change whatever happened, but they will consider this in the upcoming projects. And also, I mean with GenAI, you can do a lot of stimulation from potential outcomes, planning, any measures of risk or something that you can take care of, depending on the input that we are basically putting in place. The people that don't use GenAI will be using their knowledge, their previous experience to solve it. It can lead to the same thing. But with GenAI, I mean learning from a lot of projects, even if you're not experts in managing the projects, it will have the same impact.

**Interviewer:** Speaking of performance, what are the KPIs for measuring efficiency and effectiveness of H-GenAI PTs?

**AIR13:** Usually from project management it is the time of completion of this project. So, usually what we have as a performance is, if we are using GenAI, how long this task will take and how long this task will take without GenAI. So, it is basically time to complete the tasks that we are having. Second of all, it is the time frame not only with the task, but also with the whole project. So, for example, if a project is taking two months but when we're working with GenAI, it will reduce it to one. Then, the efficiency of the people, the resources, the executions of resources, if it helps in reducing the resources’ number of hours, which will then help also in cutting costs for us. So, if we need three resources to finalize the project with GenAI, we will need only two, because ChatGPT, for example, will help with the reporting, will help with communicating, it will help sharing the minute meeting. So, we'll not need an assistant to do this. So, we will use it as assistants, right? And then from this, this is one of the KPIs that we are

aiming for. And then the KPI is also the customer satisfaction rate. Is it going to improve or not with GenAI.

**Interviewer:** So, for efficiency, we have the time, cost, and resources, to ensure an efficient project team. Now for the effectiveness, how do you think we can measure effectiveness?

**AIR13:** Effectiveness will come from customer satisfaction basically. And then when we said that the project would be on time, we would be, for example, cutting costs, we will basically be getting outcomes from the meetings and the minute of meeting, that's also one of the effectiveness' KPIs within the customer companies. And then customer satisfaction can be basically part of the effectiveness. And if basically for effectiveness perspective, whenever we're putting money on GenAI, we need to see ROI part of it, that will help in measuring the effectiveness. Maybe also we can see from the HR perspective that or from the manager's perspective, if we're saving time for people and then we are increasing their productivity. The purpose of GenAI is to unleash productivity and creativity. We're seeing more creative people and more people within the company are productive. This is also can be measured as part of the effectiveness of our GenAI solutions.

**Interviewer:** Great. And how about the accuracy of the PT when using GenAI, do you think effectiveness can also be measured by precision or accuracy in terms of having less errors?

**AIR13:** Yes, yes. So basically, with this from error perspective, we'll have definitely less errors. Maybe also we can have some quality measurement or feedback measurement whether from customers or from the internal teams. Right. So, we are using a lot of manuals internally with the company as part of the ISO certification, we are using a lot of let's say tools to

measure the accuracy of our project, using a lot of forms and feedback forms. GenAI can help us with a lot of dashboards that we can put in place to get a lot of information like error rates that can happen or that is happening within customers. We also have very good tools within our company that also help us to see project management with GenAI in a similar environment. It's a comparison between whatever we're having within our company and other companies that are using the same GenAI. Since we are using Copilot, it helps us to measure whether we are using it perfectly compared to the other companies with the same size, with the same, let's say, type of activities and so on.

**Interviewer:** And how about the quality? Can we measure effectiveness by having quality as a KPI?

**AIR13:** Yeah, the quality is part of the effectiveness, as it also can be part of the accuracy. So, we can use some outputs like, for example, some scoring, some metrics, some numbers, some feedback that we share with the customers or with the internal teams.

**Interviewer:** How can you describe the satisfaction of a PT in a project? How would the human teammate feel? How can you measure the satisfaction of the human teammate that is using GenAI?

**AIR13:** See from our side since we are using Copilot, we have a dashboard that basically shows us if really people internally are using GenAI, first of all, we help them with a lot of training to understand how to use it because it's not straightforward and especially understanding the art of prompting, which is very important. And then we get a lot of feedback from their perspective, right. So, internally it helped a lot in improving the response rate to questions, to feedback, to emails and so on. Especially me, I'm getting like hundreds of emails on a daily basis. So, I'm trying to keep up

with the email response. So, I'm now able to get the summary of my emails, for example, on a daily basis. I can also get GenAI help me in responding to some emails or to have automation and to my emails, etc. And then from a feedback perspective, also we get some feedback on the tools that basically we are launching from GenAI perspective or deploying from GenAI perspective and then also the level of engagement whether using the dashboard that we're having internally, what are the usage number out of the number of people that they have their GenAI tools, how frequent they are using it on a daily basis per tool, per environment, per data etc.? So, we're getting this information to evaluate in a regular manner the effectiveness and the usage of these tools.

**Interviewer:** Okay, great. We're done with the interview. Is there anything else you would like to add?

**AIR13:** No, but thank you so much for this opportunity. I really appreciate and like the subject. Let me know if you need any further information, if you want some reports to share with you to see how we are evaluating, how we are using, and even some experience with the customers. Because also we're helping customers elaborate or put in place GenAI tools like Copilot. So, this is one of the things that we are helping people with as we are officially Jumpstart Copilot partner from Microsoft. So, we have the capabilities and the tools to help customers do this on a daily basis.

**Interviewer:** Thank you so much. Yes, definitely. I would really love to have your advice and your help in several ways.

# Thesis Abstract (Arabic)

يعد ظهور التعاون بين البشر والذكاء الاصطناعي نهجاً واعداً لتعزيز أداء الفريق. تعمل هذه الدراسة على تطوير نموذج تعاون بين الإنسان والذكاء الاصطناعي التوليدي لفريق العمل في إدارة المشاريع بقطاع الخدمات وتحديد معايير لقياس أداء فريق العمل المتكون أعضائه من الإنسان والذكاء الاصطناعي التوليدي.

تم إجراء الدراسة على 3 مراحل. في المرحلة الأولى، اعتمدت الدراسة أساليب مختلطة، بدءاً من إجراء مراجعة منهجية للأدبيات لاستكشاف نظريات التعاون. ثم استخدمت الدراسة العديد من التقنيات الكميّة من خلال تطوير واتباع إطار التنقيب في النصوص لتحديد العوامل الرئيسية لتشكيل فريق العمل وترتيب أولوياتها، وبالتالي حل مشكلة تشكيل فريق العمل للفِرق التقليدية. علاوة على ذلك، استكشفت الدراسة قدرات الذكاء الاصطناعي التوليدي الداعمة لفريق العمل من خلال المنهجية النوعية، وحددت القدرات الرئيسية له من خلال الطريقة الكميّة وذلك عن طريق توظيف خوارزميات تجميع التعلم الآلي. من خلال النظر في كيفيّة حل مشكلة تكوين فريق العمل للفِرق التقليدية ومعرفة القدرات الرئيسية للذكاء الاصطناعي التوليدي الداعمة لفريق العمل، تحل الدراسة مشكلة تكوين فريق العمل المتكون من الإنسان والذكاء الاصطناعي التوليدي وبالتالي تقترح نموذجاً لتشكيل فريق عمل الذكاء الاصطناعي التوليدي البشري.

في المرحلة الثانية، ومن خلال اعتماد منهجية الأساليب المختلطة، استكشفت الدراسة أولاً نماذج لمراحل تطوير فريق العمل لتحديد السلوكيات والمواقف البشرية أثناء التعاون في فريق العمل، ودرست كيفيّة دعم الخصائص والقدرات الرئيسية للذكاء الاصطناعي التوليدي للبشر والتعويض عن عيوبهم في الأداء في كل مرحلة. تقترح الدراسة نموذجاً لمراحل تطوير فريق العمل المتكون من الإنسان والذكاء الاصطناعي التوليدي وتقارنه بنماذج مراحل تطوير الفريق للفرق التقليدية. من خلال تحديد السلوكيات والمواقف البشرية بالإضافة إلى الخصائص والقدرات الرئيسية للذكاء الاصطناعي التوليدي وفقاً لتأثيرها الإيجابي أو السلبي على أداء فريق العمل، تؤكد الدراسة أن أداء الفِرق المتكونة من الإنسان والذكاء الاصطناعي التوليدي يتفوق على أداء الفِرق البشرية التقليدية خلال التعاون في العمل على المشاريع.

من خلال الجمع بين النموذجين المقترحين للمرحلة الأولى والمرحلة الثانية، تطور الدراسة نموذج تعاون بين الإنسان والذكاء الاصطناعي التوليدي لفريق العمل لتعزيز التعاون بين البشر والذكاء الاصطناعي عند العمل معاً ضمن فريق عمل في إدارة المشاريع، وذلك لتعريز أداء الفريق وبالتالي تحقيق نجاح المشروع.

وأخيراً، في المرحلة الثالثة، تم جمع البيانات النوعيّة لوضع مؤشرات الأداء الرئيسية لقياس أداء فريق العمل المتكون من الإنسان والذكاء الاصطناعي التوليدي من حيث الكفاءة والفعالية.

تكمن المساهمة الرئيسية للدراسة في تطوير نموذج التعاون الأمثل بين الإنسان والذكاء الاصطناعي التوليدي، والذي يعد بمثابة إطار موسّع لدعم وتعزيز العمل الجماعي بين البشر والذكاء الاصطناعي التوليدي في المشاريع، بدءاً بتشكيل فريق العمل ومروراً بمراحل تطويره، وإنشاء مؤشرات الأداء الرئيسية لتقييم أداء فرِق العمل التي تجمع الإنسان مع الذكاء الاصطناعي التوليدي في مشروع عمل.

جامعة البحرين

كلية إدارة الأعمال

برنامج دكتوراه تحليل الأعمال في الإدارة

# تعزيز أداء إدارة المشاريع من خلال التعاون الأمثل بين الإنسان والذكاء الاصطناعي

رسالة دكتوراه قدمت استكمالا لمتطلبات درجة الدكتوراه في الفلسفة

تقديم

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مايو 2025