buildings

MDPI

Article

Qualitative Assessment of Collaborative Behavior Based on Self-Perception Personality Tests for BIM Staff

Fatemeh Biabani [1], Ju-Hyung Kim [1] and Namhyuk Ham [2,*]

[1] Department of Architectural Engineering, Hanyang University, Seoul 04763, Korea; fatemeh994@hanyang.ac.kr (F.B.); kcr97jhk@hanyang.ac.kr (J.-H.K.)
[2] Department of Digital Architecture and Urban Engineering, Hanyang Cyber University, Seoul 04763, Korea
* Correspondence: nhham@hycu.ac.kr

Abstract: Collaboration, such as communication and coordination, using BIM is the key to a successful BIM-based construction project. In spite of existing studies on BIM competency and the optimal arrangement of BIM staff, there have not been many studies on the tendencies of BIM staff in the humanities aspect. The purpose of this study is to qualitatively evaluate the collaborative behavior of BIM staff through a cognitive survey targeting BIM staff. For this, 13 tasks essential for collaboration were defined. The frequency of tasks performed by the BIM staff differed according to the role they are in charge of, and the frequency of tasks considered important to support the collaboration of project participants also appeared to be different. In addition, the personal behavior of the BIM staff, which is the core outcome of this study, was investigated by dividing it into two types: the importance level of personality traits and the required level of personality traits. A survey on the perception of BIM staff was conducted through three categories (leadership, communication, job performance) and a total of 17 personality traits. The research findings, visualized through a correspondence analysis, strongly suggest that it is necessary to consider the personality traits of the BIM staff to improve collaboration performance.

Keywords: BIM staff; collaborative behavior; personality trait; qualitative assessment

Citation: Biabani, F.; Kim, J.-H.; Ham, N. Qualitative Assessment of Collaborative Behavior Based on Self-Perception Personality Tests for BIM Staff. *Buildings* **2022**, *12*, 426. https://doi.org/10.3390/buildings12040426

Academic Editor: Carlos Oliveira Cruz

Received: 15 February 2022
Accepted: 29 March 2022
Published: 1 April 2022

1. Introduction

In a construction project, the process of realizing the requirements of the client, according to the characteristics of the project size and type, is very complex and fragmented [1]. In addition, the final product of the project, the building, is created through the repeated and continuous collaboration and coordination of various stakeholders [2]. BIM has been actively introduced to solve various problems that arise in the decision-making process [3]. BIM, in fact, is "an ICT supported process that uses digital modeling of a building that is able to facilitate communication, collaboration, and coordination" [4]. By using BIM, project participants can exchange information efficiently to improve collaboration, coordination, and communication [5,6].

The method of performing BIM in a construction project is achieved by strengthening the capabilities of the internal staff or outsourcing the BIM service [7]. As such, BIM services are provided by BIM staff who have accumulated competency through training, and Succar et al. (2013) focused on individual BIM competency and conducted a study on the BIM competency that should be measured to improve project performance [8]. In addition, research to optimize the allocation of BIM staff, which accounts for most of the BIM investment cost, was conducted. Ham et al. (2020) conducted a study, focusing on part of the BIM staff, to reduce the waiting time for the request for information (RFI) of project participants, and through this, the decision-making on the optimal BIM staff arrangement was supported [9]. As such, studies are being actively conducted to support the collaboration of project participants through the technical capabilities of BIM or to

allocate the optimal staff in consideration of the economic aspect of the project. However, it is difficult to find studies on how the personal disposition of the BIM staff, who supports the project participants' collaboration, affects the project performance improvement and that can be referred to when allocating the BIM staff to the project [10].

According to the humanities approach, collaboration goes beyond technical capabilities [11]. In other words, collaboration is based on human behavior [12], and it is revealed that various characteristics of individuals, such as attitudes, behaviors, and characteristics, can include trust and commitment between individuals [13]. In order to comprehensively improve performance through collaboration in BIM-based construction projects, human-focused research is also required, along with consideration of the process, information, and technical aspects [14]. Therefore, the purpose of this study is to perform a qualitative evaluation of collaborative behavior, based on a propensity test, for BIM staffs.

2. Literature Review

2.1. Collaborative Characteristics of BIM-Based Construction Projects

BIM helps project stakeholders visualize what is to be built, make decisions, and identify the possible problems prior to the actual construction. According to Azhar (2011), BIM carries all information related to the building, from its physical characteristics to the life cycle information of the project [1]. BIM has also proved its technical capabilities for offering a quiet collaborating environment, which can be counted as one of the biggest motivators for practitioners for adopting it in their projects [14,15]. Numerous scholars have pointed out, in previous studies, that effective BIM-collaboration showed definite benefits, leading to better decision-making, project performance, and value [16]. With construction being very fragmented, and in need of the participation of various parties with different backgrounds and professions, avoiding problems and obstacles is almost impossible. Through collaboration, these parties can find remedial solutions and go beyond the limited vision of each other [17]. Hence, Gassel et al. (2014) believes that collaboration is the core element for successful construction projects [18], as it lets the independent stakeholders come together [19], negotiate, and make decisions on rules, structures, and the mutually beneficial relationships for all the involved parties [20].

Despite all the benefits of BIM mentioned by various scholars, about collaboration, specifically, evidence shows that BIM-enabled projects keep facing various problems in terms of collaboration [21]. This author points out that, although there are a lot of stakeholders that apply BIM to their projects, there are only a few that can work collaboratively. According to Scharge (1995), the author centralized human factors as the elements with the most influence on collaboration [22]. Shelbourn et al. (2007), believes that human factors, rather than technology, can influence collaboration [23]. They illustrated that focusing on the soft issues (organizations' people) is more effective than focusing on hard aspects (technology). The authors mentioned that the approaches fully focused on technology are likely to be less successful unless organization and people issues are considered as well. Through their research, they showed that the most important aspect for a successful collaboration is people, followed by the business process and technology, respectively, as chosen by practitioners.

The collaborative work in BIM-based projects, within the design phase, involves a wide range of activities, including BIM-model creation, decision-making, BIM-model adjustment, and the collaboration management process [24]. During the design stage, the largest number of information is defined. This happens right from the preliminary phase, until reaching the executive project. Throughout this process, the BIM approach can offer clear advantages, which includes supporting the project participants in a way that no problem, such as omission or duplication of information, happens [24]. Regarding this, various participants, namely the client, architect, engineers, contractors, and sub-contractors, should get involved to be able to finish a project. The client, as the key role, should lay the rules, standards, and requirements for other project participants, which should later be reflected in BIM execution plan [25]. However, since tthe client's decision-making stage is not a part of

this research scope, it will be omitted from literature review. The general contractor, as the party who mostly leads BIM implementation, should write and check on the BIM execution plan, which includes project goals, the design process, and BIM deliverables. In projects with early contractor involvement (ECI), the role of contractors become very crucial, as they develop a long-term relationship with project participants, from clients to designers, help collaborate, and exchange information in initial stages where both time and waste can be reduced [26]. Here, allocation of proper employees, with suitable behavior patterns in groups, becomes very important as, according to Huemann at al. (2007), this can affect both work and the employees' relationship [27]. When all decisions are made, architects, engineers, and MEP sub-contractors are supposed to design and generate their separate models, which helps with both visualization and coordination with others [28]. Designers are also responsible for updating their models with the changes throughout the whole design process [3]. During this stage, the contractor should continuously review the models to make sure they are generated based on the design criteria and the costumer's requirements [24]. To do so, weekly coordination sessions should be held, which enhance the communication and collaboration among project parties. Borrowing from Leite (2019), through these coordination sessions, opinions, ideas, and the changes that need to be performed are discussed and recorded [3]. After the coordination meetings, discussed changes are supposed to be implemented on the models and be updated until the next coordination session.

Individual models created during the design phase not only make the visualization of the end product feasible and easier but also can help throughout the simulation and scheduling process (4D BIM), with cost estimation (5D BIM), and with generating quantity take-off diagrams [25], which are a part of the contractor's responsibility [24]. To prevent cost and time waste, each discipline checks possible interferences for each model and makes sure that the model is generated based on the standards and rules defined within the BIM execution plan [3]. The regular interference-checking and constructability analysis sessions include both the identification of problems and suggesting solutions for them, and they are performed for both internal and external coordination. For internal coordination, clash detection's aim is to make sure the discipline model is clash free, while in external coordination, clash detection is performed with each discipline model, as well as the federated one, to check the overall interferences, which is directed by the general contractor [3]. Any changes performed according to clash detection should be written and recorded later [25].

All processes above are performed as the basic functions of BIM, and any other function needed to be performed should be added to the BIM execution plan based on project requirements [25]. The fact that a successful collaboration is depending on clear communication makes it very important to state a collaboration strategy in the BIM execution plan beforehand [3].

2.2. Role and Responsibility of BIM Staff

To perform the mentioned tasks, different roles with specific responsibilities are defined within BIM-based teams. These roles and responsibilities have been extracted from the previous studies, and each discipline must employ them based on their project needs. However, based on the results of the conducted survey in this research, in most cases, all of the following roles are required, for every discipline, during the design phase. These roles are as follows (since this study is having a behavioral approach, the software skill expectations have been omitted):

2.2.1. BIM Manager

BIM manager, in general, is a professional in charge of most BIM-related tasks, such as managing people for the implementation, maintenance of the BIM team, and training, when required [9,29]. To be more specific, he/she is responsible for setting goals for the project, making the plans for achieving them, identifying the demands of the client and conditions of the contract, and leading different parties through decision-making. In other words,

BIM managers organize, plan, schedule, direct, control, monitor, and evaluate the whole BIM process [30]. Borrowing from Davis et al. [31], the BIM manager should assure the quality of the project, maintain oversight over BIM responsibilities and deliverables, and guide the collaborative process, which includes arranging and organizing meetings and the project record. The latter is feasible through coordination meetings. There is a BIM manager assigned to each of the disciplines, as they are the contact point between different disciplines for communicating BIM issues [3]. Even a client can hire a BIM manager that acts as his/her representative for communication with other stakeholders and attending coordinating sessions. The BIM manager, as the contact point among different disciplines, is supposed to run design coordination meetings, prepare the federated model for these meetings, perform the initial clash detection analysis, and manage file sharing and coordination software to make sure the meetings run smoothly. This proves that a large part of the BIM manager's responsibility is to facilitate effective collaboration between different stakeholders, which makes this role the center of BIM job groups [32]. This makes the BIM manager a vital role in decision-making and collaboration among BIM teams.

2.2.2. BIM Coordinator

According to Davis et al. (2017), the BIM coordinator is the second role under the leadership of the BIM Manager [31]. In other words, the BIM coordinator is a smaller scale BIM manager, and one is needed for each discipline. His/her responsibility is to exchange their disciple BIM model, check for the adjustment of the models with the discipline's guideline and standards, check the quality of their work, and provide guidelines for their team. In a research done by Jacobsson and Merdchbrock (2018), it is mentioned that BIM coordinators should also be responsible for clash detection [33]. Managing information and communication flows, monitoring and coordinating design changes, supporting new working procedures and technical development, and coming last, acting as a boundary spanner, are the other responsibilities of a BIM coordinator [33]. In Bosch-Sijtsema and Gluch (2019)'s research, it was mentioned that, although in some countries the role of BIM manager, and BIM coordinator is totally distinguished, this is not the case for every country [31,34]. These roles, at some locations, cannot be differentiated clearly, as it depends upon the size of the market and the BIM performing firms. Not to mention that it also depends on whether the roles are defined at organization level or just project level. Especially in the case of the BIM coordinator, by conducting some interviews, Jacobsson and Merdchbrock (2018) made it clear that, while all the respondents were agreed with the fact that BCs are responsible for a wide range of tasks, sometimes it is just a part-time job [33]. Needing a BC, and the scope of his/her responsibilities, totally depends on the scale of the project.

2.2.3. BIM Modeler

BIM modeler is a specialist in building with the fundamental information for all disciplines, including BIM software. He/she creates 3D visualization (3D model) for the team, can insert various information to it, as required, and should take responsibility for the created model [29,35]. The generation of the model is based on the agreements recorded in the BIM execution plan, where it should be updated throughout the design phase and coordinated with other project stakeholders [3]. Quoting Joseph (2011), BIM modeler needs high level of communication, as he/she has to report the workflow to BIM coordinator [29].

Abovementioned stakeholders need to work on separate parts of a project and, in most of the cases, are geographically dispersed members from different organizations [11]. BIM has made it possible for various stakeholders to overcome boundaries, such as communication among different construction industry fields working at different geographical locations, and make them able to share information, communicate, and find solutions for their project problems. When allocating staff to BIM projects, it is important to consider the skills and experiences of individuals. However, to get the best out of a team's collaboration, considering their behavior, characteristics, and interpersonal skills is vital as well [36].

According to Ham et al. (2020), when implementing BIM in a project, the goal is to get the most benefit out of BIM staff but not to sacrifice efficiency in terms of human resource costs [9]. The author believes BIM staffing should be studied as an important topic in the field of human resources allocation. Assigning optimal human resources to the projects, so that the participants can collaborate as much as possible, is an important task of the project manager [37]. However, as mentioned earlier, the individual's behavior and characteristics have remained unnoticed during previous studies. It is also difficult to find a study on the collaborative traits of BIM staff, especially the BIM manager, as the role in charge of BIM staff allocation. Many previous studies have expressed their opinion on the importance of identification of the behavior of individuals to improve the interaction and, eventually, the collaboration among team members, which brings motivation for further study of human characteristics and personality traits. Thus, this study aims to study the collaborative traits that are shown by BIM staffs in the BIM-based construction projects.

2.3. Importance of Human Resource Management

As mentioned earlier, construction is a very fragmented and project-based industry [38]. Various teams from different AEC organizations should associate to achieve satisfying end products. When it comes to allocating staff to each project, as a part of human resource management (HRM), project managers, generally, are the ones responsible for it [39]. There are a lot of factors that should be considered while managing the project participants. Numerous studies exist about the HRM within the literature. Based on a study done by Gurmu and Ongkowijoyo (2020), to achieve more productivity and success in a construction project, factors such as crew composition are the most important HRM elements [40]. Another scholar stated that, when allocating members to construction teams, experience, skills, and competencies of the prospective team members are the key factors for a project's success [41]. Prajapaty et al. (2015), believes that HRM gets affected by various external and internal factors, such as employee's performance, relation with each other, and even their behavioral patterns and attitude [42]. It has been stated, in the literature, that human behavioral factors and characteristics can leave a significant influence on the way individuals perform, which is directly connected to the result of a project [41,43].

Loosemore et al. (2003) believes that the numerous problems existing within the construction projects, resulting from human characteristics and behavioral factors, can be eliminated through human resource management [38]. Collaboration, indeed, is an effective human resource strategy, and a successful collaboration highly depends on the ability of human resource managers to select and create a team with suitable members, in terms of knowledge, skill, attitude, characteristics, and task-required behaviors [44]. According to Ballesteros Pérez et al. (2019), even though the current era is the era of technological advancement, most of the tasks are still done and handled by human beings [39]. BIM, as a widely used IT tool in construction projects, especially for how it supports and improves the collaboration and communication among construction, needs to go under study as it has become the "centerpiece of collaboration on construction projects" [10,45]. Borrowing from Ham et al. (2020), BIM staffing might be a major issue for difficulties in reaching the level of communication and collaboration required in BIM [9].

In the practice world, basically, composition of the members of a BIM-enabled team or any other team in construction, in general, is mostly based on who is available with the required experience, or sometimes, recommendations and connections also affect the decision-making of the project team member selections [46,47]. In the academic world, on the other hand, many scholars have already point out the importance of human behavior and characteristics when allocating members to teams [11–13]. Additionally, various researchers have studied the effects of human characteristics and personalities, on specific job performances, in the construction industry or other fields. To name a few: There are some research projects that studied human personality and characteristics' influence on design team structure [47], safety behavior in construction projects [48], project managers' performance, and the team working in general [49].

2.4. Human Personality Traits-Extracted from Self-Perception Tests

According to personality–job fit theory, there should be a match between the job characteristics and requirements and the characteristic of the person who performs the job [49]. Recently, the number of the studies that try to find how the personality can influence the job performance is increasing. For instance, Ma et al. (2021) has conducted research on the relationship between the human personality and safety behavior in a construction project [48]. In this study, the author stated that the human brain can affect the way they behave through psychological factors. One of these factors is personality, which can describe and predict the way that people act, behave, or even perform at a job [50–52]. Moreover, many studies have investigated various human personality traits to discover their relations with job performance, for which the results showed, not only, that personality traits affect the job performance but they are also important factors for personnel selection when forming groups [53].

There are numerous personality tests that define human characteristics and behavior. Most of the studies done on this area focus on only one personality test specifically. To investigate a wider range of human characteristics and personalities, this study analyzes five different self-perception personality tests, which are broadly known and reliable within the psychology field, consisting of: Belbin's team role Self-perception inventory [54,55], Big five personality model [56,57], Myers–Briggs Type Indicator Personality Test (known as MBTI) [58–61], DiSC model of human behavior [62–64], and Holland codes (also known as RIASEC) [65–69]. Here, the aim for choosing five different personality tests is to extract different personality traits that are defined for humans. Eventually, extracted personality traits are used for designing the questionnaire as one of the research methods of this study.

3. Research Method: Design and Conduct a Quantitative Questionnaire

The first research method of this study is a quantitative survey that targets a BIM-based project's team members, where the details of the process are shown in Figure 1.

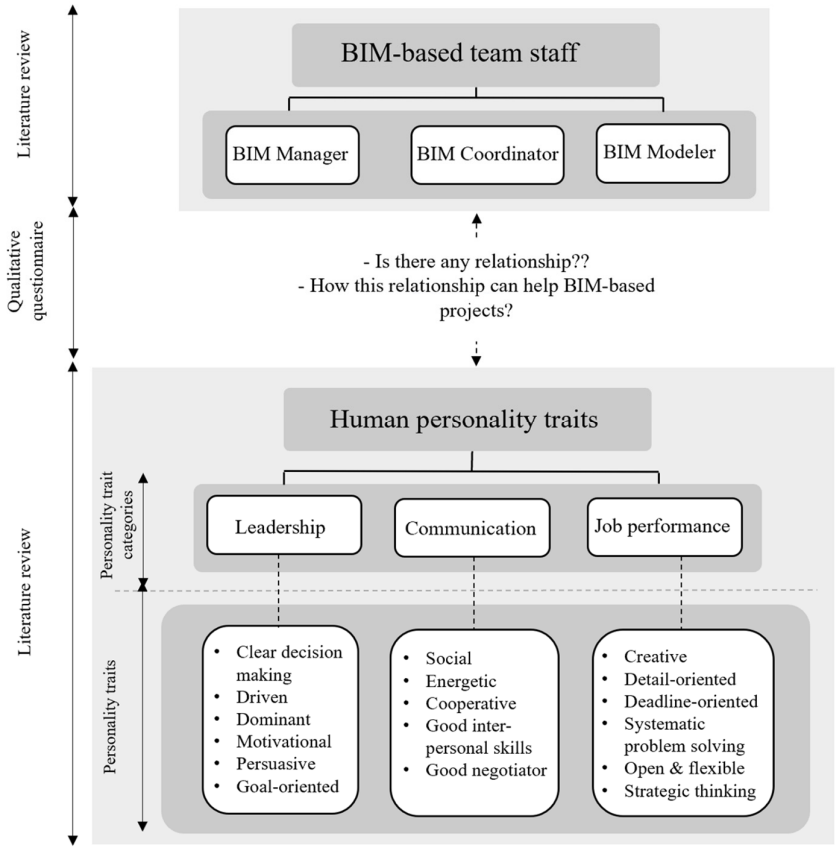

Figure 1. Research overview.

This survey aims to find out about the relation between personality traits and the R&Rs of BIM-team members. In this regard, it was decided for the questionnaire to include three parts: general information of the target companies, detailed information of the role and responsibilities of team members, and the personality traits-related questions. There are many studies done on the R&Rs of the BIM team members. These studies, which were mentioned in the previous section, were used to design the questions of this questionnaire, and the aim of this part is to help connect the responsibility of each role with the required personality traits. The results of this questionnaire, once again, can confirm the reliability of the existing literature about BIM team members' R&Rs. The last part of this research, personality trait questions, is the most important part of this questionnaire, and its designing process is as follow:

After selecting and analyzing human personality traits from five personality tests mentioned earlier, a variety of personality traits were extracted. Since there were a huge number of personality traits extracted and it was not possible to use them all, considering that many of these personality traits were similar to each other, it was decided to choose the traits that were mentioned the most in personality tests. To achieve this, all the personality traits were inserted at 'Word Cloud'. Word Cloud made it possible to recognize the most mentioned traits. Eventually, nineteen personality traits were extracted from Word Cloud. Since two pairs of these traits had quiet similar definitions (extravert and social, openness and flexibility), it was decided to combine the similar ones to prevent the confusion of the respondents. To categorize the final seventeen personality traits, each of these traits went under further study. The personality traits, derived based on the word cloud, are shown in Table 1. The overall details of each personality trait, extraction resources, categorization, and its theoretical evidence are summarized in the following Table 1. This study conducted an intensive literature review on the collaborative characteristics of BIM-based construction projects and the roles and responsibilities of the BIM staff, through Section 2.1 and 2.2, for a qualitative evaluation of the BIM staff's collaborative traits. Based on the literature review, these traits can be categorized into three groups under the names of leadership category, communication category, and job performance category.

Table 1. Personality traits extraction and categorization.

Personality Trait Categorization	Traits Extracted Based on Word Cloud	Personality Trait Test				
		Belbin	Big Five	MBTI	DiSC	RIASEC
Leadership	Firm decision making [70,71]	O		O	O	
	Driven [72]	O		O	O	O
	Dominant [73]	O		O	O	
	Motivational [74]		O	O	O	O
	Persuasive [75]	O			O	O
	Goal and achievement-oriented [76]	O		O	O	O
Communication	Social [77–79]	O	O	O	O	O
	Extravert and energetic [80]		O	O	O	
	Good interpersonal skills [81]		O	O	O	
	Cooperative [79]		O	O	O	
	Good negotiator [82]	O			O	O
Job performance	Creative [83,84]	O	O	O		O
	Detail-oriented [85]	O	O	O	O	O
	Deadline-driven [86,87]	O	O	O	O	
	Systematic problem solving [86]	O	O	O	O	
	Openness and flexibility [88]	O	O	O		
	Strategic thinking [89]	O		O		O

4. Data Collection and Analysis

The questionnaire was generated and sent out through Google forms. Its focus was experienced BIM professionals who are currently working in the industry, with the professions limited to BIM manager, BIM coordinator, and BIM modeler. There was no preference for age and gender. The questionnaire survey was done anonymously, and participants only chose the type of their companies within the construction industry. The questionnaire was distributed to 130 employees in several companies in South Korea, which included various fields such as Architecture firms, construction firms, general and sub-contractors, civil and infrastructure firms, etc. The questionnaire consisted of 71 questions, in total, and in three sections. Questions were based on the literature presented in the literature review section as well as personality traits extracted from self-perception personality tests. To prevent any confusion of future participants, a pilot survey was conducted. The questionnaire was sent to five BIM professionals, and based on their feedback, effective changes in the questions' structures and the definitions of roles and responsibilities were performed. The first part of the questionnaire focused on the general information regarding the organization that respondents are currently working at. It includes the role of the company in the construction industry, its size, total number of employees, and the BIM team number of employees, as well as the size and type of its projects and application level of BIM for them. The second part is about the role and responsibilities of the participants as BIM manager, BIM coordinator, or BIM modeler, their experience in the field based on years, and the required competencies to perform each role's specific tasks. Responsibility-related questions in the second part are divided into two sub-questions, asking about the frequency of each task's performance and their importance, on a scale of 1–5. The third part specifically asked about the personality traits of BIM staff, and questions of this part are divided into two sub-questions as well. These questions ask about the importance and required level of each personality trait, on a scale of 1–5. The third part is made of three categories: the leadership category, communication category, and job performance category.

The participant companies were selected because of their mature usage in BIM in South Korea while not only using BIM as a 3D modeling tool. In total, 81 responses to questionnaire were received (81/130, 62.3% response rate). Considering the history of BIM application in South Korea's construction industry, 81 responses from 81 BIM staff, who work at mature South Korean construction companies, seem fair and reliable. The responses were collected from various firms: designing firms, with 31.3% of the response rate, was the field with the most participation rate. Following designing firms, general contractors, BIM specialist and construction management firms had the highest participation rate with 16.0%, 9.8%, and 9.8%, respectively. The majority of the response rate belonged to small-sized companies, followed by major companies. The participation rate was 52.5% for the former and 28.8% for the latter. While medium-sized companies had around a quarter (17.5%) of the received responses, private companies had the lowest rate with only one response. One of the general questions was about the scale of the projects that are likely to apply BIM; however, due to difficulties in estimating civil and infrastructure projects' scale, the mentioned question was excluded from the surveys sent out to civil and infrastructure firms.

As mentioned earlier, a total number of 81 answers were gathered. Among those, 35 of the answers were from BIM managers, and the equal number of 23 answers were for BIM coordinators and modelers. To gain better insight from the participants and their roles in the industry, two questions were designed to find out about the experience of each participant based on years and the competencies they should meet to be able to work as their specific roles. The answers can be found in Table 2.

This information shows that the staff with the lowest experience are likely to work as modelers, while the more experienced they get, they can promote to coordinator position, followed by a BIM manager spot. Furthermore, according to the required competencies' table, by comparing the results, BIM are managers need to meet the most competency requirements, followed by coordinators.

Table 2. Detailed information on the BIM staff years of experience and required competencies.

Indicator	Details	Number of Responses		
		BIM Manager (*n* = 35)	**BIM Coordinator (*n* = 23)**	**BIM Modeler (*n* = 23)**
Years of experience	Under 5yeras	6	10	18
	Above 5years-under 10 years	10	9	5
	Above 10yeras-under 15 years	11	4	0
	Above 15years-under 20 years	8	0	0
Required competencies	• Ability to analyze order documents, e.g., understanding bidding documents and BIM requirements, etc.	30	13	4
	• Modeling skills. e.g., Revit, Navisworks, Rhino, Sketchup, etc.	30	18	22
	• Analysis and interpretation capabilities by field. e.g., Structural Analysis, MEP Simulation, etc.	22	7	7
	• Integrating models, e.g., interference check, design error review, etc.	33	33	15
	• Documentation competencies, e.g., BEP, Report, submittal, deliverable, etc.	29	12	4
	• Smart construction competencies, e.g: Drone, MR, AR, laser scanning, etc.	25	8	3

All in all, based on the answers, a BIM manager almost needs to meet all these requirements, while a BIM coordinator should mostly focus on integrating models, modeling abilities, and the ability to analyze documents, respectively. For a BIM modeler, however, modeling abilities is the most important one.

As mentioned above, to connect the R&Rs of the participants and their required personality traits, there were two sets of questions, representing R&Rs and the personality traits categories. There are various criteria in both R&Rs and the personality traits categories. Thus, to find the most important ones, for each of the BIM roles, there is a need to put these criteria in some sort of ranking indicator. According to Fallahnejad (2013), who has done many studies on ranking factors, using a relative index would be ideal [90]. Here, in this research, the Relative Importance Index (RII) is used to rank the responses according to their relative importance. The Equation (1) is as follow:

$$RII = \sum Wi/A \times N \quad (1)$$

In this equation, Wi is the weight given to each criterion from the scale of one to five by each participant, where one is the lowest and five is the highest in each question. A is the highest weight, which is five in this research. N is the total number of responses which is different for each role: BIM manager = 35, BIM Coordinator = 23, and BIM modeler = 23.

The highest number of RII determines the most relative criterion, and the lowest number of RII determines the least relative one.

After this, to compare the importance of personality traits for each of the BIM-based roles, the author performs correspondence analysis. Correspondence analysis is a comprehensive principal component analysis that is used for analysis of qualitative data [91]. This analysis helps find the relation between different factors of a data tables' information. This relation can become important in different ways, such as a relation between row categories, column categories, or the relation between the row and column category factors. Based on the importance of the relations, different types of settings or normalizations can be defined for this analysis. Here, in this research, symmetrical normalization was chosen, as it correctly shows the relation between row and column coordinates: BIM roles (row) and personality traits (column). To find the relation between row and column coordinates, it is important to interpret the graph correctly. To do so, it is required to:

- Look at the length of the collecting line between row factor and the origin point, where longer lines indicate high association.

- Look at the length of the collecting line between column factor and the origin point, where longer lines indicate high association.
- Look at the angle formed between these two lines, where small angles indicate high association.

Although all the personality traits were ranked by the participants separately, the result of the correspondence analysis shows that each of these traits are important to different roles within different degrees.

5. Report the Findings

5.1. Qualitative Analysis of BIM Role and Responsibility

5.1.1. The Frequency Degree of BIM Role and Responsibilities Ranked by BIM Staff

To design the questionnaire, a total number of 13 tasks were extracted through a literature review. These tasks were later used as the criteria that the participants had to rate. There were two types of questions for this part. The first type asked the participants to rate the frequency of performing each of the tasks provided. They were asked to answer these questions only based on their own roles and responsibilities. The results of the responses are presented in Table 3.

Table 3. The performance frequency of BIM-related tasks, ranked by questionnaire participants.

Defined Tasks	BIM Manager		BIM Coordinator		BIM Modeler	
	RII	Ranking	RII	Ranking	RII	Ranking
• Communication contact point	0.903	1	0.843	1	0.722	5
• Arrange coordination meetings	0.629	9	0.791	4	0.687	7
• BEP develop	0.766	6	0.643	9	0.522	11
• Train the staff	0.766	6	0.617	10	0.548	8
• Control model quality	0.829	4	0.791	4	0.730	4
• Coordination and collaboration	0.886	2	0.722	7	0.704	6
• Monitor and control design changes	0.817	5	0.817	2	0.765	2
• Check clashes and design Constructability	0.851	3	0.800	3	0.765	2
• BIM Model Authoring	0.754	8	0.774	6	0.922	1
• Architectural design	0.531	10	0.670	8	0.548	8
• Structural engineering	0.526	11	0.548	11	0.513	12
• MEP systems design and analysis	0.451	12	0.443	13	0.374	13
• Cost estimation	0.451	12	0.470	12	0.548	8

According to results, being a communication point for the stakeholders was ranked as number one, the most frequent task to perform for both BIM managers and coordinators. While it was ranked as fifth for BIM modelers and as a less common task for this role, BIM modeler, on the other hand, ranked BIM model authoring as the first and most frequent task for this role. The same task was ranked as eighth and sixth for BIM managers and coordinators, respectively. The second most frequent task for BIM managers was coordination and collaboration among different disciplines, while coordinators and modelers selected monitor and control design changes as their second frequent task. BIM modelers also ranked clash detection and design constructability alongside as their second frequent task. Based on BIM managers' responses, check clashes and design constructability, control model quality, and monitor and control design changes were ranked from third to fifth, respectively. BIM coordinators put a little more emphasis on the check clash and design constructability, as they ranked this task as the third frequently performed task by them. They also ranked arranging coordination meetings and controlling model quality in the same place, as they selected them as the fourth main tasks for the coordinator role.

5.1.2. The Importance Degree of BIM Role and Responsibilities Ranked by BIM Staff

In the second type of question, the participants were asked to rate the roles based on their importance level for them to finish a BIM-based project successfully. Here, respondents

had to consider each task in the entire process of projects. It could be their own task or somebody else's. The results of the responses are presented in Table 4.

Table 4. The importance level of BIM-related tasks, ranked by questionnaire participants.

Defined Tasks	BIM Manager		BIM Coordinator		BIM Modeler	
	RII	Ranking	RII	Ranking	RII	Ranking
• Communication contact point	0.966	1	0.948	1	0.957	1
• Arrange coordination meetings	0.949	2	0.904	3	0.887	4
• BEP develop	0.823	11	0.783	12	0.748	13
• Train the staff	0.874	8	0.864	8	0.809	11
• Control model quality	0.914	4	0.887	7	0.843	8
• Coordination and collaboration	0.909	5	0.896	5	0.896	3
• Monitor and control design changes	0.891	7	0.904	3	0.861	6
• Check clashes and design Constructability	0.949	2	0.913	2	0.887	4
• BIM Model Authoring	0.903	6	0.896	5	0.904	2
• Architectural design	0.834	9	0.817	11	0.774	12
• Structural engineering	0.834	9	0.826	10	0.852	7
• MEP systems design and analysis	0.811	12	0.843	9	0.843	8
• Cost estimation	0.789	13	0.748	13	0.843	8

The result of this type of question shows that all three groups of BIM managers, BIM coordinators, and BIM modelers have a similar opinion on the importance of each task regarding their influence on a construction project's success. All the three groups selected being a communication point for the stakeholders as the first and most important task. While BIM managers chose both arranging coordination meetings and check clashes and design constructability as the second, as well as control model quality as the next most important task, BIM coordinators have a very close selection to BIM managers. They ranked check clashes and constructability as their second choice, as well as arranging coordination meetings alongside monitor and control design changes as their third choice. Based on the results, BIM managers and BIM coordinators seem to have a similar opinion on ranking the important tasks, as both chose coordination and collaboration, among disciplines, as the fifth important task. BIM coordinators also chose BIM model authoring as the fifth one alongside coordination and collaboration, which was chosen as the sixth important task by BIM managers. BIM modelers on the other hand chose BIM model authoring as their second choice, followed by coordination and collaboration among disciplines as third, both arranging coordination meetings and checking clashes and design constructability as fourth, and monitor and control design changes as their sixth choice. These results show that, despite some difference in the rankings done by three groups, all the mentioned tasks are ranked as the top most important tasks, which seem to leave the greatest effect on a BIM-based project's final product.

5.2. Qualitative Analysis of Personality Traits

5.2.1. The Importance Degree of Personality Traits Ranked by BIM Staff

As mentioned earlier, a total number of 17 personality traits were extracted from selected self-perception personality tests. Later, based on the literature review, these traits were divided into three categories: leadership, communication, and job performance. The categorized personality traits were used to design the questionnaire of this research. The author decided to split personality traits-related questions into two type of questions as well. The first type of question is designed to determine the importance degree of each trait for performing the responsibilities of each role successfully. In this type of question, BIM staff were asked to consider the relation of each trait only with their own role and the defined tasks for it. The results of the calculations, regarding the importance of each personality trait for BIM staff roles and their rankings, are presented in Table 5.

Table 5. The importance level of personality traits in relation with roles and responsibilities, ranked by BIM staff.

Categories	Personality Traits	BIM Manager		BIM Coordinator		BIM Modeler	
		RII	Rank	RII	Rank	RII	Rank
Leadership	Clear decision making	0.897	1	0.913	1	0.861	1
	Driven	0.874	2	0.870	3	0.774	5
	Dominant	0.800	6	0.774	6	0.626	6
	Motivational	0.857	4	0.861	4	0.843	4
	Persuasive	0.829	5	0.852	5	0.861	1
	Goal-oriented	0.863	3	0.878	2	0.852	3
Communication	Social	0.737	5	0.791	5	0.835	5
	Energetic	0.794	3	0.809	4	0.843	4
	Cooperative	0.846	1	0.913	1	0.904	2
	Good interpersonal skills	0.794	3	0.843	3	0.913	1
	Good negotiator	0.840	2	0.870	2	0.896	3
Job performance	Creative	0.817	4	0.809	6	0.730	4
	Detail-oriented	0.817	4	0.878	3	0.913	2
	Deadline-oriented	0.920	1	0.896	2	0.922	1
	Systematic problem solving	0.880	2	0.904	1	0.904	3
	Open and flexible	0.817	4	0.835	5	0.904	3
	Strategic thinking	0.880	2	0.878	3	0.904	3

The results of the leadership category show that all the BIM managers, coordinators, and modelers agree that being able to make clear decisions plays the most important role as a personality trait in BIM-based projects. Modelers selected persuasive, alongside clear decision-making, as the most important personality trait as well. While coordinators selected goal-oriented criterion as the second important one, BIM managers and modelers decided that the same criterion should be ranked as third. As for the fourth feature, all three groups of participants showed the same pattern, choosing motivational for the spot. According to results, BIM managers and coordinators showed similar rankings for the rest of the criteria, as they ranked persuasive and dominant in fifth to sixth place respectively. BIM modelers, however, showed different results by choosing driven and dominant as the fifth and sixth important personality traits, respectively.

According to the results of the communication category, BIM managers and coordinators chose being cooperative as the most important personality trait, for their own BIM role, to finish their BIM-based project successfully. BIM modelers, on the other hand, seem to believe that this feature is the second important, and the first spot belongs to good interpersonal skills. BIM managers and coordinators, however, selected this feature as the third important one. BIM managers selected energetic in company with good interpersonal skills. Likewise, BIM managers and coordinators showed the same pattern for choosing the second important trait by selecting good negotiation, while BIM modelers put the emphasis of being the third important feature on this trait. Thus, they chose being a social person as the least important personality type. BIM coordinators and modelers' rankings showed quite similar patterns by choosing energetic and social, respectively, as the least important features needed for BIM coordinators.

Based on the results of the job performance category, BIM managers and modelers picked deadline-oriented as the first and most important personality feature. BIM coordinators chose systematic problem solving for the same spot. As for the second place, managers chose both systematic problem-solving and strategic thinking, while BIM coordinators and modelers chose deadline-oriented and detail-oriented as their second choice, respectively. BIM managers picked the rest of the criteria as their third choice, including creative, detail-oriented, and open and flexible. BIM coordinators, on the other hand, chose detail-oriented and strategic thinking as the third, open and flexible as the fourth, and creative as the fifth important personalities that are most likely to affect their task performance. In the case of BIM modelers, they ranked systematic problem solving, open and flexible, and strategic thinking as the third and creative as the least important personality trait.

5.2.2. Comparison between the Importance Degree of Personality Traits among BIM Staff Roles

In the case of the leadership category, while the dominant trait was ranked as one of the least important factors that can influence a project's outcome, the results show that, among the three defined roles, BIM managers can receive the biggest influence by this trait, followed by BIM coordinators. As for driven, it seems to play the biggest role for both BIM coordinators and BIM managers, while both driven and dominant have a very small influence on the performance of BIM modelers. Clear decision-making was ranked as the first and the most important trait for all three roles earlier; however, among all, it is the most important factor for the coordinators, followed by BIM modelers. Being goal-oriented and persuasive are two features that are likely to affect the BIM modelers' performance. As for motivational, the trait is the most important for BIM modelers too. See Figure 2 for details.

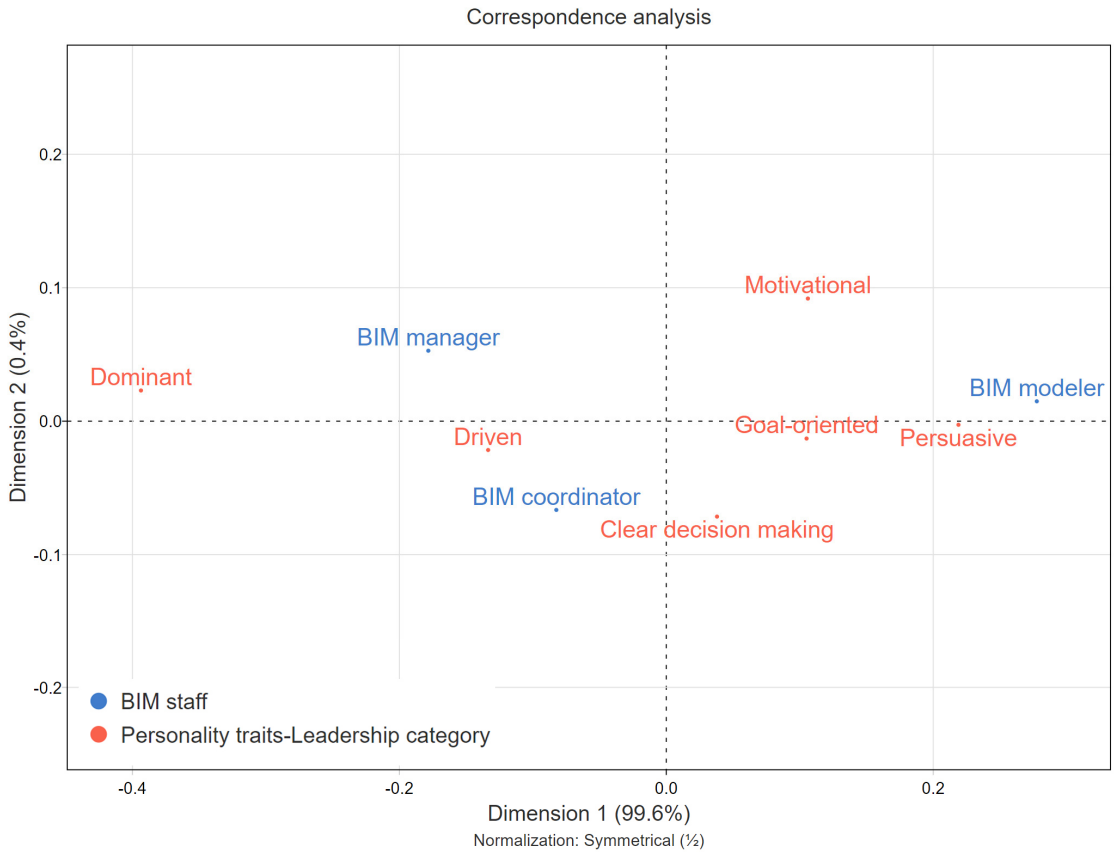

Figure 2. Comparison of the importance degree of personality traits (leadership category) between BIM staff roles—Correspondence analysis.

The result of the correspondence analysis for the communication category shows that, while being energetic can have a small impact on the performance of BIM staff, this trait can influence BIM managers the most among all. Being a good negotiator, as one of the most important personality traits, is a more supreme personality feature for BIM managers in comparison with the other two. According to the results, being cooperative obviously plays a more important role for BIM coordinators when compared to BIM managers and modelers. As could be predicted from the results of the questionnaire, having good interpersonal skills is the most important factor for BIM modelers, while it has less influence on BIM coordinators and BIM managers, respectively. Lastly, although social was chosen as the least important personality trait for all the three BIM roles, it can have a higher influence on BIM modelers when compared to the two other staff members. The detailed result is illustrated in Figure 3.

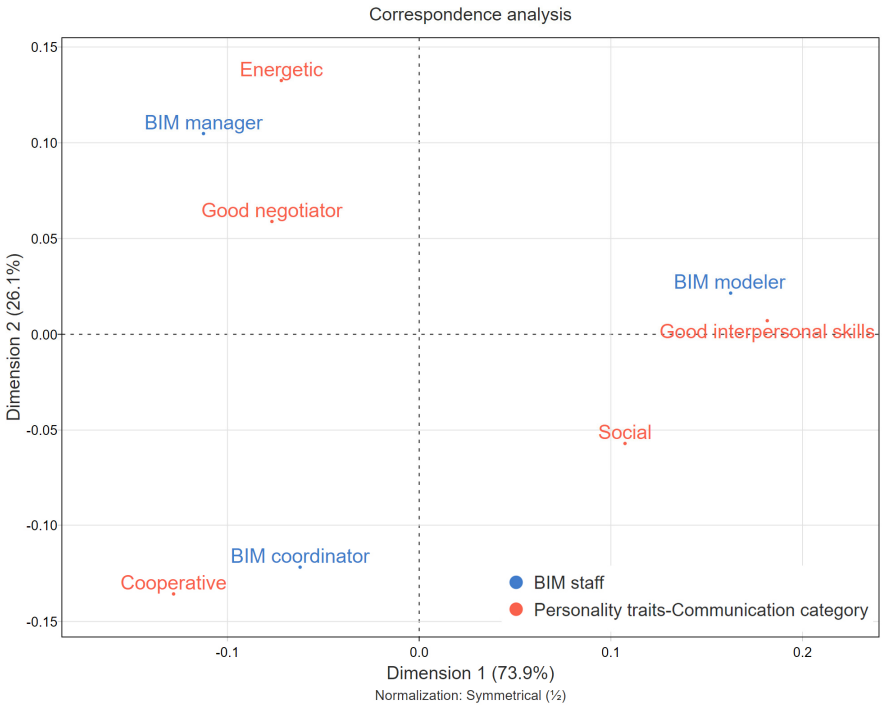

Figure 3. Comparison of the importance degree of personality traits (communication category) between BIM staff roles—Correspondence analysis.

According to the results of the ranking, being creative is one of the less important factors for successful performance of BIM staff. However, according to the correspondence analysis results, among all the defined roles, creativity can influence BIM managers and BIM coordinators the most. On the other hand, while deadline-oriented was chosen as one of the most important personality traits by all the participants, it seems that being deadline-oriented plays a more important role for BIM managers in comparison with the other two roles. The same goes for strategic thinking, as it is also another important feature for BIM managers compared to the others. As it is shown in Figure 4, BIM coordinators are the ones that might perform their responsibilities better when associated with more systematic problem-solving abilities. In addition, while being detail-oriented can be helpful for all the staff, BIM coordinators can benefit the most from this feature, followed by modelers and managers, respectively. Lastly, being open and flexible to new/different situations can be most beneficial to the BIM modelers, as expected, based on the results of the questionnaires.

5.2.3. The Required Degree of Personality Traits Ranked by BIM Staff

The second type of question asks about the required degree of each personality trait to form the BIM staffs. This means that BIM staff had to answer in what degree they should show these personality traits while considering their own role and its defined responsibilities. The detailed answers of participants are shown in Table 6.

As for the leadership category, according to the results, BIM managers decided that being goal-oriented is the feature that is required the most, followed by being able to making clear decisions. Motivational, driven, persuasive, and dominant were ranked from third to sixth, respectively. BIM coordinators on the other hand, chose clear decision-making as the most required personality trait for performing tasks. They also chose the goal-oriented trait as the second required personality, followed by persuasive as the third one. They decided that driven, motivational, and dominant traits are less required and ranked them from fourth to sixth, respectively. BIM modelers, like BIM managers, decided that being goal-oriented is needed the most in their job for performing their tasks, followed by clear decision-making and persuasive both ranking as second. Driven, motivational, and dominant were ranked from fourth to sixth, respectively.

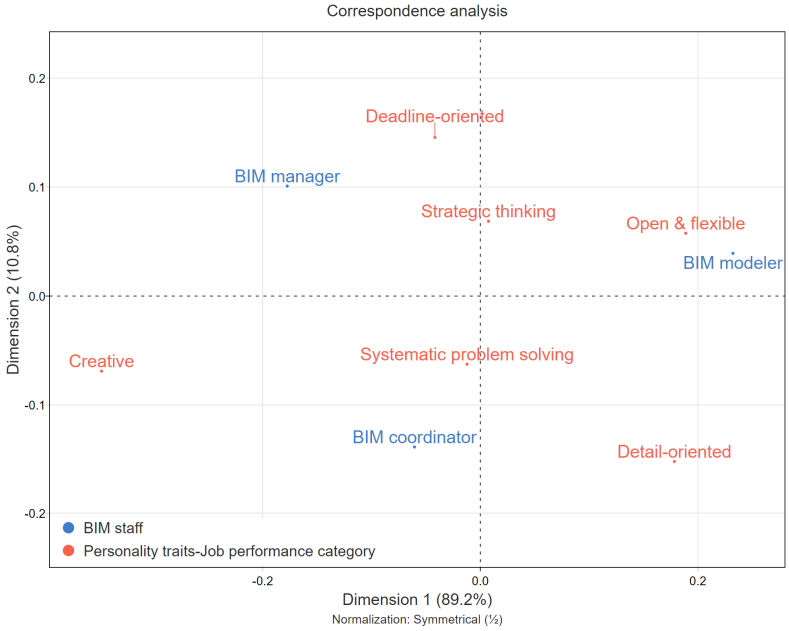

Figure 4. Comparison of the importance degree of personality traits (job performance category) between BIM staff roles—Correspondence analysis.

Table 6. The required level of personality traits, in relation with role and responsibilities, ranked by BIM staff.

Categories	Personality Traits	BIM Manager		BIM Coordinator		BIM Modeler	
		RII	Rank	RII	Rank	RII	Rank
Leadership	Clear decision making	0.869	2	0.904	1	0.843	2
	Driven	0.851	4	0.861	4	0.783	4
	Dominant	0.777	6	0.783	6	0.600	6
	Motivational	0.863	3	0.852	5	0.774	5
	Persuasive	0.783	5	0.878	3	0.843	2
	Goal-oriented	0.880	1	0.887	2	0.852	1
Communication	Social	0.737	5	0.800	5	0.800	4
	Energetic	0.777	3	0.843	4	0.783	5
	Cooperative	0.846	1	0.922	1	0.913	1
	Good interpersonal skills	0.771	4	0.861	3	0.852	3
	Good negotiator	0.806	2	0.904	2	0.870	2
Job performance	Creative	0.800	6	0.809	6	0.774	6
	Detail-oriented	0.817	5	0.913	1	0.878	3
	Deadline-oriented	0.886	1	0.896	3	0.922	1
	Systematic problem solving	0.857	2	0.913	1	0.887	2
	Open and flexible	0.823	4	0.843	5	0.835	5
	Strategic thinking	0.857	2	0.886	4	0.861	4

The results of the communication category illustrate that all the participants, including BIM managers, BIM coordinators, and BIM modelers, selected cooperative as the number one trait that is required the most for their task performance. They all also chose being a good negotiator as the trait that is needed the most after the cooperative trait. While BIM coordinators and modelers decided that having good interpersonal skills should be ranked as the third one, BIM managers seem to believe that this position belongs to being energetic. For the fourth spot, all the groups chose different traits, with BIM managers choosing good interpersonal skills, BIM coordinators choosing energetic, and BIM modelers choosing social. For the social trait, BIM managers and coordinators believed that it is the least required trait; however, BIM modelers chose energetic as the least needed personality trait.

Based on the results of data analysis for the job performance category, BIM managers and modelers believed that having a deadline-oriented personality is required the most for them in a BIM team staff. Alongside deadline-oriented, BIM modelers choose detail-oriented as well. However, BIM coordinators showed different opinions, selecting systematic problem-solving and detail-oriented as the first and most required personality traits. As for the second trait, once again, BIM managers and modelers showed similar opinions by choosing systematic problem solving. However, BIM managers selected strategic thinking as the second most required as well. BIM coordinators on the other hand, choose deadline-oriented for the next most required trait. BIM managers ranked open and flexible, detail-oriented, and creative as the fourth to sixth, respectively. BIM coordinators' results show some similarities with modelers' rankings by choosing strategic thinking as the fourth, open and flexible as the fifth place, and creative as the sixth for the required degree of each personality trait. BIM modelers ranked detail-oriented, strategic thinking, open and flexible, and creative from third to sixth, respectively, which shows some similarities with two other rankings as well.

5.2.4. Comparison between the Required Degree of Personality Traits among BIM Staff Roles

The same correspondence analysis was performed on the results of the required degree of personality traits for the BIM staff. The results show that, while the dominant feature of the leadership category is one of the least searched features in all the staff, if required, it should be founded equally in both BIM managers and the coordinators. In the case of driven, it is required the most by BIM modelers, while it seems to be needed for the other roles equally. Out of all the staff, BIM managers are the most expected to have motivational features. As shown in Figure 5, BIM modelers are required to have the most outstanding features of being persuasive and goal-oriented among three defined BIM roles. Finally, while clear decision-making was chosen as one of the most needed personality traits through the questionnaire, based on the results of the correspondence analysis, this feature is searched for the most in BIM coordinators and the modelers.

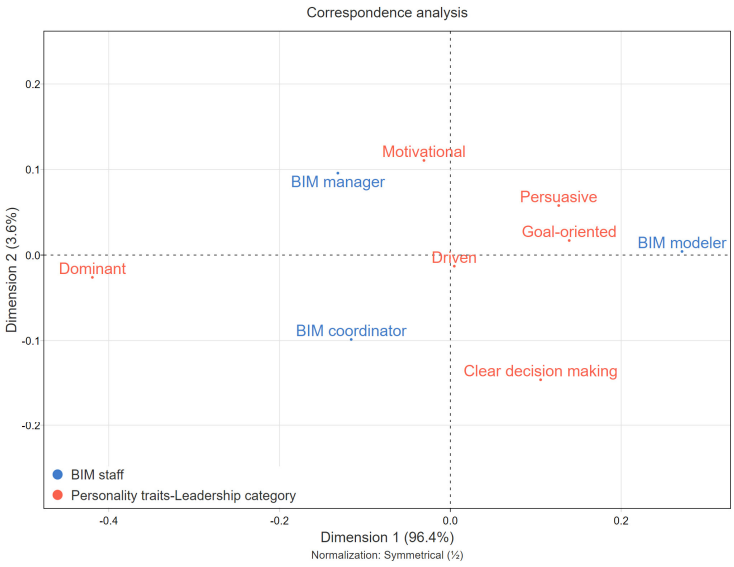

Figure 5. Comparison of the required degree of personality traits (leadership category) between BIM staff roles—Correspondence analysis.

The results of the communication category show that, while being cooperative is the most required feature for BIM team members, this personality trait is mostly required for managers and modelers. According to the ranking results, being a good negotiator is the second most required personality trait. However, the correspondence analysis shows that coordinators are the one who can get the most benefit of this feature. As it can be

seen in Figure 6, BIM manager is the role that is mostly required to perform energetically in projects among all the BIM staff. In addition, BIM coordinators need to have the best interpersonal skills among all, even though this feature was ranked as one of the least required personality traits. As for social, BIM modelers could benefit the most from being social in comparison with two other BIM-based roles.

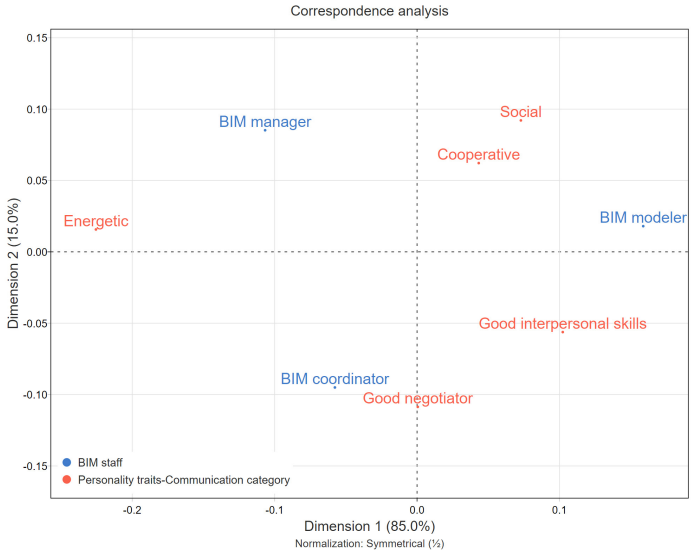

Figure 6. Comparison of the required degree of personality traits (communication category) between BIM staff roles—Correspondence analysis.

Based on the results of the job performance category, while deadline-oriented was one of the most required personality traits for all the BIM-based roles, BIM modelers are needed to keep the deadline the most. Systematic problem-solving, as one of the most needed personality features, seems to be required the most for the coordinators, followed by modelers. Creativity, on the other hand, is one of the least required features; however, when compared, BIM managers should show the most creativity when performing in projects. As shown in Figure 7, strategic thinking, as well as open and flexible, are the personality traits that are expected from BIM managers the most, followed by BIM modelers for the former and BIM coordinator for the latter.

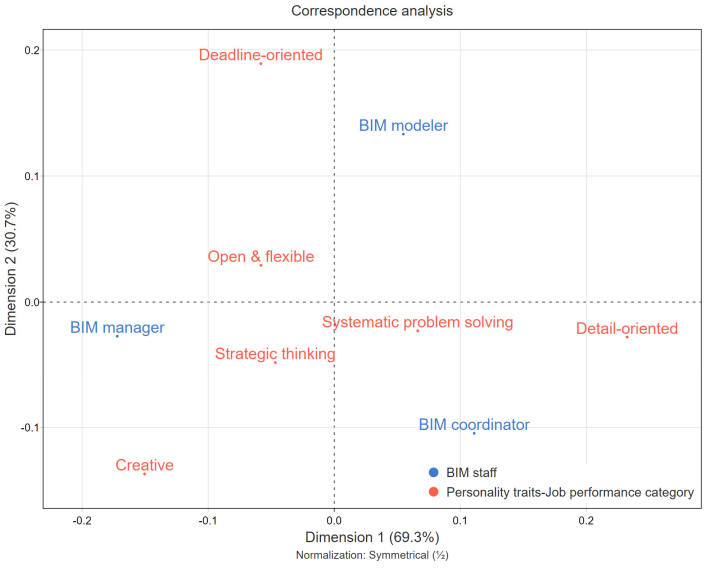

Figure 7. Comparison of the required degree of personality traits (job performance category), between BIM staff roles, in a correspondence analysis.

6. Discussion

This study performed a qualitative evaluation between tasks that require collaboration and individual personality traits for various BIM staff who have accumulated experience in performing BIM-based construction projects. The survey on the roles and responsibilities of the BIM staff's cooperative tendencies was targeted for 13 defined tasks. Depending on the roles (BIM manager, BIM coordinator, BIM modeler) performed in a BIM-based construction project, the frequency of performing defined tasks in the project was different (Table 3). In addition, the research results on defined tasks, recognized as important to successfully complete a BIM-based construction project, showed a different aspect from the role currently performed by the BIM staff (Table 4). In the case of existing studies, a study on the evaluation of BIM competency was conducted in a macroscopic approach [8]. On the other hand, this study focused on the BIM staff, who are the direct actors of collaboration. This study not only shows that each BIM staff member has their own roles and responsibilities in a BIM-based construction project, where collaboration is important, but can also suggest the direction of education and training to strengthen the capacity to perform defined tasks required for BIM staff.

The study on the personality traits of the BIM staff, which is the core of this study, was divided into three categories: leadership, communication, and job performance. The subdivided personality traits, collected through literature review, were placed in three categories, and the importance level (Table 5) and required level (Table 6) for individual tendencies were investigated for BIM staff. According to the roles (BIM manager, BIM coordinator, BIM modeler) performed by the BIM staff in a BIM-based construction project, the tendency to perceive it as important and the tendency to perceive it as necessary were different. This was visualized through correspondence analysis, and it was found that a different pattern was shown (Figures 2–7). Existing research conducted quantitative research on how many BIM staff should be put into the field by simply classifying them by position [9]. However, the results of this study show that the personal disposition of the BIM staff can affect the collaboration performance. Therefore, it suggests that it is necessary to consider personal inclinations in the humanities, as well as economic aspects, when deploying BIM staff who perform important roles and responsibilities in BIM-based construction projects.

7. Conclusions

This study contributes to the human resource management of BIM-based construction projects, and it influences BIM project management in several ways. First, the study extracts the roles and responsibilities of BIM staff (here, limited to BIM manager, BIM coordinator, and BIM modeler) from available resources and through the literature review. In addition, to find some of the most important human personality traits, the author selected five of the most reliable self-perception tests within the psychology field and extracted the most mentioned personality features. Secondly, a quantitative survey was designed based on the withdrawn role and responsibilities and personality traits to find the relationship between BIM staff R&Rs and their personality traits, and then, the questionnaire was sent out to some of the most mature construction companies in South Korea. The results of this questionnaire show a ranking of personality traits from the most to the least important ones for different BIM team staff to perform their jobs properly and successfully. Furthermore, performed correspondence analysis illustrates the comparison of the importance and the required degree of each personality trait for BIM staff, when working together as a team. This analysis identifies, while being in the same team and situation, which role can be affected by a certain personality trait, which draws a picture for better future teamwork.

Findings of this research can help the practitioners of the real world with the following expected benefits:

- Select and place the best fit for BIM staff to the projects not only based on their competencies but also the behavior patterns they show while working in groups.

- This research can help the managers to train the staff based on the needs of their roles because finding the right staff with the required skills and behavior is not easy, if not impossible.
- Considering the hierarchy of BIM staff, training BIM staff with the required experience and qualifications for the future roles (e.g., BIM modeler to BIM coordinator, BIM coordinator to BIM manager) can be achieved.

From this perspective, this study is unique in providing a comprehensive list of personality traits and behavioral patterns extracted from reliable sources (existing literature and real-world practitioners).

Notwithstanding the study's contributions, the following limitations should be considered when referring to study findings. The sample size can be considered as small, knowing the fact that a number of participants were a few from firms in South Korea that implement BIM in their projects, which can result in a medium level of reliability. In addition, the responses of participants were gathered and analyzed all together, regardless of their companies' roles within the industry. The employees who work at different disciplines of the construction industry, such as architecture firms, structure firms, MEP firms, and so on, have different responsibilities, which lead to different behaviors in job performance. Considering this, separating BIM staff based on their companies' role would bring more accurate results. Furthermore, knowing that each BIM-based project is unique in its way and has specific characteristics, it might be hard to generalize findings of this research to all the construction projects.

These limitations however, can provide areas for future research projects. Validating the findings of this research through in-depth interviews with BIM staff, especially managers as the leaders of projects, in various countries and for different types of projects is a new research area generated through this study. Complementary studies could extend the findings of this research through defining models or frameworks for training BIM staff according to projects' needs and/or assigning the right staff to the right role and project.

Author Contributions: Conceptualization, F.B., J.-H.K. and N.H.; Formal analysis, F.B.; Investigation, F.B.; Methodology, F.B.; Resources, J.-H.K. and N.H.; Supervision, J.-H.K. and N.H.; Visualization, F.B.; Writing—original draft, F.B.; Writing—review & editing, F.B. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2021R1F1A1052050).

Institutional Review Board Statement: Not applicable.

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Azhar, S. Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadersh. Manag. Eng.* **2011**, *11*, 241–252. [CrossRef]
2. Shen, F.-Y.; Chang, A.S. Exploring Coordination Goals of Construction Projects. *J. Manag. Eng.* **2011**, *27*, 90–96. [CrossRef]
3. Leite, F.L. *BIM for Coordination: A Virtual Design and Construction Guide for Designers, General Contractors, and Subcontractors*; Wiley: Hoboken, NJ, USA, 2019.
4. Paik, S.M.; Leviakangas, P.; Choi, J. Making most of BIM in design: Analysis of the importance of design coordination. *Int. J. Constr. Manag.* **2020**. Available online: https://www.tandfonline.com/doi/abs/10.1080/15623599.2020.1774837 (accessed on 21 October 2021). [CrossRef]
5. Farnsworth, C.B.; Beveridge, S.; Miller, K.R.; Christofferson, J.P. Application, Advantages, and Methods Associated with Using BIM in Commercial Construction. *Int. J. Constr. Educ. Res.* **2014**, *11*, 218–236. [CrossRef]
6. Grilo, A.; Jardim-Goncalves, R. Value proposition on interoperability of BIM and collaborative working environments. *Autom. Constr.* **2010**, *19*, 522–530. [CrossRef]
7. Lee, G.; Park, H.K.; Won, J. D3 City project—Economic impact of BIM-assisted design validation. *Autom. Constr.* **2012**, *22*, 577–586. [CrossRef]

8. Succar, B.; Sher, W.; Williams, A. An integrated approach to BIM competency assessment, acquisition and application. *Autom. Constr.* **2013**, *35*, 174–189. [CrossRef]
9. Ham, N.; Moon, S.; Kim, J.-H.; Kim, J.-J. Optimal BIM staffing in construction projects using a queueing model. *Autom. Constr.* **2020**, *113*, 103123. [CrossRef]
10. Oraee, M.; Hosseini, M.R.; Papadonikolaki, E.; Palliyaguru, R.; Arashpour, M. Collaboration in BIM-based construction networks: A bibliometric-qualitative literature review. *Int. J. Proj. Manag.* **2017**, *35*, 1288–1301. [CrossRef]
11. Oraee, M.; Hosseini, M.R.; Edwards, D.J.; Li, H.; Papadonikolaki, E.; Cao, D. Collaboration barriers in BIM-based construction networks: A conceptual model. *Int. J. Proj. Manag.* **2019**, *37*, 839–854. [CrossRef]
12. Eriksson, P.E.; Westerberg, M. Effects of cooperative procurement procedures on construction project performance: A conceptual framework. *Int. J. Proj. Manag.* **2011**, *29*, 197–208. [CrossRef]
13. Amuda-Yusuf, G. Critical Success Factors for Building Information Modelling Implementation. *Constr. Econ. Build.* **2018**, *18*, 55–73. [CrossRef]
14. Bassanino, M.; Fernando, T.; Wu, K.-C. Can virtual workspaces enhance team communication and collaboration in design review meetings? *Arch. Eng. Des. Manag.* **2013**, *10*, 200–217. [CrossRef]
15. Cao, D.; Li, H.; Wang, G.; Zhang, W. Linking the motivations and practices of design organizations to implement Building Information Modeling in construction projects: Empirical study in China. *J. Manag. Eng.* **2016**, *32*, 04016013. [CrossRef]
16. Poirier, E.A.; Forgues, D.; Staub-French, S. Understanding the impact of BIM on collaboration: A Canadian case study. *Build. Res. Inf.* **2017**, *45*, 681–695. [CrossRef]
17. Gray, B. Conditions Facilitating Interorganizational Collaboration. *Hum. Relations* **1985**, *38*, 911–936. [CrossRef]
18. van Gassel, F.; Láscaris-Comneno, T.; Maas, G. The conditions for successful automated collaboration in construction. *Autom. Constr.* **2014**, *39*, 85–92. [CrossRef]
19. Wood, D.J.; Gray, B. Toward a Comprehensive Theory of Collaboration. *J. Appl. Behav. Sci.* **1991**, *27*, 139–162. [CrossRef]
20. Thomson, A.M.; Perry, J.L.; Miller, T.K. Conceptualizing and Measuring Collaboration. *J. Public Adm. Res. Theory* **2007**, *19*, 23–56. [CrossRef]
21. Cao, D.; Wang, G.; Li, H.; Skitmore, M.; Huang, T.; Zhang, W. Practices and effectiveness of building information modelling in construction projects in China. *Autom. Constr.* **2015**, *49*, 113–122. [CrossRef]
22. Schrage, M. *No More Teams!: Mastering the Dynamics of Creative Collaboration*; Currency Doubleday: New York, NY, USA, 1995.
23. Shelbourn, M.; Bouchlaghem, N.; Anumba, C.; Carrillo, P. Planning and implementation of effective collaboration in construction projects. *Constr. Innov.* **2007**, *7*, 357–377. [CrossRef]
24. Korea Institute of Construction Technology National BIM Center. Basic Guidelines for BIM-Construction Industry. 2020. Available online: https://www.molit.go.kr/USR/policyData/m_34681/dtl.jsp?search=&srch_dept_nm=&srch_dept_id=&srch_usr_nm=&srch_usr_titl=Y&srch_usr_ctnt=&search_regdate_s=&search_regdate_e=&psize=10&s_category=&p_category=&lcmspage=1&id=4516 (accessed on 18 November 2021).
25. Latiffi, A.A.; Brahim, J.; Syazli Fathi, M. *Roles and Responsibilities of Construction Players in Projects Using Building Information Modeling (BIM)*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 173–182. [CrossRef]
26. Ferme, L.; Zuo, J.; Rameezdeen, R. Improving Collaboration among Stakeholders in Green Building Projects: Role of Early Contractor Involvement. *J. Leg. Aff. Disput. Resolut. Eng. Constr.* **2018**, *10*, 04518020. [CrossRef]
27. Huemann, M.; Keegan, A.; Turner, J.R. Human resource management in the project-oriented company: A review. *Int. J. Proj. Manag.* **2007**, *25*, 315–323. [CrossRef]
28. US Army Corps of Engineers. *Civil Works Directorate. Engineering and Construction Branch. The US Army Corps of Engineers Roadmap for Life-Cycle Building Information Modeling (BIM)*; ERDC SR-12-2; Engineer Research and Development Center (U.S.): Washington, DC, USA, November 2012.
29. Joseph, J. DL4436: BIM Titles & Job Descriptions: How Do They Fit in your Organizational Structure? Autodesk University. 2011. Available online: https://aucache.autodesk.com/au2011/sessions/4436/class_handouts/v1_DL4436_Joseph_BIM_Titles_Job_Descriptions_JJ.pdf (accessed on 18 October 2019).
30. Hosseini, M.R.; Martek, I.; Papadonikolaki, E.; Sheikhkhoshkar, M.; Banihashemi, S.; Arashpour, M. Viability of the BIM Manager Enduring as a Distinct Role: Association Rule Mining of Job Advertisements. *J. Constr. Eng. Manag.* **2018**, *144*, 04018085. [CrossRef]
31. Davies, K.; Wilkinson, S.; McMeel, D. A review of specialist role definitions in BIM guides and standards. *J. Inf. Technol. Constr.* **2017**, *22*, 185–203.
32. Uhm, M.; Lee, G.; Jeon, B. An analysis of BIM jobs and competencies based on the use of terms in the industry. *Autom. Constr.* **2017**, *81*, 67–98. [CrossRef]
33. Jacobsson, M.; Merschbrock, C. BIM coordinators: A review. *Eng. Constr. Arch. Manag.* **2018**, *25*, 989–1008. [CrossRef]
34. Bosch-Sijtsema, P.; Gluch, P. Challenging construction project management institutions: The role and agency of BIM actors. *Int. J. Constr. Manag.* **2021**, *21*, 1077–1087. [CrossRef]
35. Building and Construction Authority (BCA). *Singapore BIM Guide Version 2*; Building and Construction Authority: Singapore, August 2013.
36. Constructing Excellence. *Effective Teamwork: A Best Practice Guide for the Construction Industry*; Technical Report; Constructing Excellence: Watford, UK, 2014.

37. Anvuur, A.M.; Kumaraswamy, M.M. Effects of Teamwork Climate on Cooperation in Crossfunctional Temporary Multi-Organization Workgroups. *J. Constr. Eng. Manag.* **2016**, *142*, 04015054. [CrossRef]
38. Loosemore, M.; Dainty, A.; Lingard, H. *Human Resource Management in Construction Projects, Strategic and Operational Approaches*; Tyalor & Francis: New York, NY, USA, 2003.
39. BallesterosPérez, P.; Phua, F.T.T.; MoraMelià, D. Human resource allocation to multiple projects based on members' expertise, group heterogeneity and social cohesion. *J. Constr. Eng. Manag.* **2019**, *145*, 04018134. [CrossRef]
40. Gurmu, A.T.; Ongkowijoyo, C.S. Predicting Construction Labor Productivity Based on Implementation Levels of Human Resource Management Practices. *J. Constr. Eng. Manag.* **2020**, *146*, 04019115. [CrossRef]
41. Chan, A.P.C.; Scott, D.; Chan, A.P.L. Factors Affecting the Success of a Construction Project. *J. Constr. Eng. Manag.* **2004**, *130*, 153–155. [CrossRef]
42. Prajapati, N.; Pitroda, J.; Vyeas, M.C. A critical literature review on integrated framework for assign factors affecting human resource management in construction. *J. Int. Acad. Res. Multidiscip.* **2015**, *2*, 114–123.
43. Xu, X.; Zou, P.X.W. System dynamics analytical modeling approach for construction project management research: A critical review and future directions. *Front. Eng. Manag.* **2021**, *8*, 17–31. [CrossRef]
44. Bedwell, W.; Wildman, J.; DiazGranados, D.; Salazar, M.; Kramer, W.S.; Salas, E. Collaboration at work: An integrative multilevel conceptualization. *Hum. Resour. Manag. Rev.* **2012**, *22*, 128–145. [CrossRef]
45. Chen, H.-M.; Hou, C.-C. Asynchronous online collaboration in BIM generation using hybrid client-server and P2P network. *Autom. Constr.* **2014**, *45*, 72–85. [CrossRef]
46. Fryer, B.G.; Fryer, M.; Ellis, R.; Egbu, C. *The Practice of Construction Management: People and Business Performance*; Blackwell Publishing: Oxford, UK, 2004.
47. Senaratne, S.; Gunawardane, S. Application of team role theory to construction design teams. *Arch. Eng. Des. Manag.* **2013**, *11*, 1–20. [CrossRef]
48. Ma, L.; Guo, H.; Fang, Y. Analysis of Construction Workers' Safety Behavior Based on Myers-Briggs Type Indicator Personality Test in a Bridge Construction Project. *J. Constr. Eng. Manag.* **2021**, *147*, 04020149. [CrossRef]
49. Dvir, D.; Sadeh, A.; Malach-Pines, A. Projects and Project Managers: The Relationship between Project Managers' Personality, Project Types, and Project Success. *Proj. Manag. J.* **2006**, *37*, 36–48. [CrossRef]
50. Ones, D.S.; Dilchert, S.; Viswesvaran, C.; Judge, T.A. In Support of Personality Assessment in Organizational Settings. *Pers. Psychol.* **2007**, *60*, 995–1027. [CrossRef]
51. Shuck, B.; Reio, T.G. Employee engagement and well-being: A moderation model and impactions for practice. *J. Leadersh. Organ. Stud.* **2013**, *21*, 43–58. [CrossRef]
52. Tan, J.K.; Lee, N.K.; Bong, C.H.; Sofian, S.A. Identification of personality traits for recruitment of unskilled occupations using Kansei engineering method. *J. Telecomm. Electron. Comput. Eng.* **2017**, *9*, 141–146.
53. Florez, L.; Cortissoz, J.C. Using workers compatibility to predict labor productivity through cluster analysis. *Procedia Eng.* **2017**, *196*, 359–365. [CrossRef]
54. Batenburg, R.; Van Walbeek, W.; Der Maur, W.I. Belbin role diversity and team performance: Is there a relationship? *J. Manag. Dev.* **2013**, *32*, 901–913. [CrossRef]
55. Belbin, R.M. *Team Roles at Work*; ButterworthHeinemann: London, UK, 1993.
56. Rhee, J.; Parent, D.; Basu, A. The influence of personality and ability on undergraduate teamwork and team performance. *SpringerPlus* **2013**, *2*, 16. [CrossRef]
57. Bar, M.A.; Leurer, M.K.; Warshawski, S.; Itzhaki, M. The role of personal resilience and personality traits of healthcare students on their attitudes towards interprofessional collaboration. *Nurse Educ. Today* **2018**, *61*, 36–42. [CrossRef]
58. Jafrani, S.; Zehra, N.; Zehra, M.; Abuzar Ali, S.M.; Abubakar Mohsin, S.A.; Azhar, R. Assessment of personality type and medicalspecialty choice among medical students from Karachi; using Myers-Briggs Type Indicator (MBTI) tool. *J. Pak. Med. Assoc.* **2017**, *67*, 520–526. [PubMed]
59. Fabio, C.; Bruno, L. Is Big Five Better than MBTI? A Personality Computing Challenge Using Twitter Data. In Proceedings of the Fifth Italian Conference on Computational Linguistics (CLiC-it 2018), Torino, Italy, 10–12 December 2018.
60. Bharadwaj, S.; Sridhar, S.; Choudhary, R.; Srinath, R. Persona Traits Identification based on Myers-Briggs Type Indicator(MBTI)—A Text Classification Approach. In Proceedings of the 2018 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Bangalore, India, 19–22 September 2018; pp. 1076–1082.
61. Johnson, H.M.; Singh, A. The Personality of Civil Engineers. *J. Manag. Eng.* **1998**, *14*, 45–56. [CrossRef]
62. Kamtar, P.; Jitkongchuen, D.; Pacharawongsakda, E. Multi-Label Classification of Employee Job Performance Prediction by DISC Personality. In Proceedings of the 2nd International Conference on Computing and Big Data, Taichung, Taiwan, 18–20 October 2019; pp. 47–52. [CrossRef]
63. Rohm, R.A. A Powerful Way to Understand People Using the DISC Concept. Technical Report [Online]. 2013. Available online: https://www.discoveryreport.com/downloads/understanding-people-disc-personality-traits.pdf (accessed on 30 September 2021).
64. Price, L.A. *DISC Instrument Validation Study*; PeopleKeys: Boardman, OH, USA, 2015.
65. Aljojo, N.; Saifuddin, H. A Study of the Reliability and Validity of Holland's RIASEC of Vocational Personalities in Arabic. *Am. J. Inf. Syst.* **2017**, *5*, 33–37. [CrossRef]

66. Zainudin, Z.N.; Rong, L.W.; Nor, A.M.; Yusop, Y.M.; Othman, W.N.W. The Relationship of Holland Theory in Career Decision Making: A Systematic Review of Literature. *J. Crit. Rev.* **2020**, *7*, 884–892.
67. Armstrong, P.I.; Day, S.X.; McVay, J.P.; Rounds, J. Holland's RIASEC model as an integrative framework for individual differences. *J. Couns. Psychol.* **2008**, *55*, 1–18. [CrossRef]
68. Usslepp, N.; Hübner, N.; Stoll, G.; Spengler, M.; Trautwein, U.; Nagengast, B. RIASEC interests and the Big Five personality traits matter for life success—But do they already matter for educational track choices? *J. Pers.* **2020**, *88*, 1007–1024. [CrossRef] [PubMed]
69. Holland, J.L. *Making Vocational Choices: A Theory of Vocational Personalities and Work Environments*, 3rd ed.; Psychological Assessment Resources: Odessa, FL, USA, 1997.
70. Paul, R. *Lawrence, Driven to Lead, Good, Bad, and Misguided Leadership*; Jossey-Bass: San Francisco, CA, USA, 2010.
71. Victor, H.V.; Philip, W. *Yetton, Leadership and Decision-Making*; University of Pittsburg Press: Pittsburgh, PA, USA, 1981.
72. Kirkpatick, S.A.; Locke, E.A. Leadership: Do traits matter? *Acad. Manag. Perspect.* **1991**, *5*, 48–60. [CrossRef]
73. Kim, J.-Y.; Hsu, N.; Newman, D.A.; Harms, P.; Wood, D. Leadership perceptions, gender, and dominant personality: The role of normality evaluations. *J. Res. Pers.* **2020**, *87*, 103984. [CrossRef]
74. Adair, J.E. *The Fifty-Fifty Rule and the Eight Key Principles*; Kogan: London, UK; Philadelphia, PA, USA, 2006.
75. Mumford, T.V.; Campion, M.A.; Morgeson, F.P. The leadership skills strataplex: Leadership skill requirements across organizational levels. *Leadersh. Q.* **2007**, *18*, 154–166. [CrossRef]
76. DeGeest, D.; Brown, K.G. The role of goal orientation in leadership development. *Hum. Resour. Dev. Q.* **2011**, *22*, 157–175. [CrossRef]
77. Knapp, L.; Mark, D.; John, A. *The Sage Handbook of Interpersonal Communication*; SAGE Publications: Thousand Oaks, CA, USA, 2011.
78. Juhász, M. Influence of personality on Teamwork behaviour and communication. *Period. Polytech. Soc. Manag. Sci.* **2010**, *18*, 61. [CrossRef]
79. Sonnentag, S. Excellent Performance: The Role of Communication and Cooperation Processes. *Appl. Psychol.* **2000**, *49*, 483–497. [CrossRef]
80. Bakker-Pieper, A.; de Vries, R. The Incremental Validity of Communication Styles Over Personality Traits for Leader Outcomes. *Hum. Perform.* **2013**, *26*, 1–19. [CrossRef]
81. Duffy, F.D.; Gordon, G.H.; Whelan, G.; Cole-Kelly, K.; Frankel, R. Assessing Competence in Communication and Interpersonal Skills: The Kalamazoo II Report. *Acad. Med.* **2004**, *79*, 495–507. [CrossRef]
82. Čulo, K.; Čulo, V. Communication in the Process of Negotiation. *Informal* **2012**, *45*, 323–327.
83. Walberg, H.J.; Stariha, W.E. Productive human capital: Learning, creativity, and eminence. *Creat. Res. J.* **1992**, *5*, 323–340. [CrossRef]
84. Harari, M.B.; Reaves, A.C.; Viswesvaran, C. Creative and innovative performance: A meta-analysis of relationships with task, citizenship, and counterproductive job performance dimensions. *Eur. J. Work Organ. Psychol.* **2016**, *25*, 495–511. [CrossRef]
85. Mount, M.K.; Oh, I.-S.; Burns, M. Incremental Validity of Perceptual Speed and Accuracy over General Mental Ability. *Pers. Psychol.* **2008**, *61*, 113–139. [CrossRef]
86. Rothmann, S.; Coetzer, E.P. The big five personality dimensions and job performance. *SA J. Ind. Psychol.* **2003**, *29*, 68–74. [CrossRef]
87. Tett, R.P.; Burnett, D.D. A personality trait-based interactionist model of job performance. *J. Appl. Psychol.* **2003**, *88*, 500–517. [CrossRef]
88. Yang, C.-L.; Hwang, M. Personality traits and simultaneous reciprocal influences between job performance and job satisfaction. *Chin. Manag. Stud.* **2014**, *8*, 6–26. [CrossRef]
89. Yousefi, H.; Mousavi, S.A. Investigating Strategic Thinking of Managers and its Impact on Optimism and Improving Job Performance of Employees at the Terminal. *Int. Acad. J. Innov. Res.* **2018**, *5*, 39–59. [CrossRef]
90. Fallahnejad, M.H. Delay causes in Iran gas pipeline projects. *Int. J. Proj. Manag.* **2013**, *31*, 136–146. [CrossRef]
91. Abdi, H.; Williams, L.J. Correspondence analysis. In *Encyclopedia of Research Design*; Salkind, N.J., Ed.; Sage Publications: Thousand Oaks, CA, USA, 2010.