Framework for Measuring and Assessing Team Alignment in Construction Projects Based on Target Value Design

by

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Abstract

Providing value to customers is vital to a construction project's success. To guide projects toward their target value, team alignment is necessary. The circumstance when the right people are working together on a project to create and realize values that are consistently stated and accepted can be characterized as alignment. Teamwork challenges are an inevitable part of the architectural engineering and construction industry. The team's existence does not guarantee project success; a dysfunctional team can lead to project failure, wasting money, energy, and time. Team alignment is more challenging in cross-functional teams because members are from different firms with diverse organizational cultures. Teams must be effectively formed, trained, managed, and motivated to avoid performance problems. Lean management is a system that emphasizes continuous improvement, removing non–value-adding (waste) activities, and reducing and enhancing variance, quality, and flow. The foundation of lean project delivery is establishing a learning organization that can effectively adapt and improvises for team performance. Target value design (TVD) is a lean approach that drives the design and construction phases to deliver project goals within the project and team constraints. Different circumstances, facts, or influences that contribute to team alignment improvement (factors) vary within each project based on their values. Also, an aligned team has specific qualities or features regarded as a characteristic (attributes). Measuring and assessing team performance based on TVD using factors is complex and uncertain. This research is filling the gap in the literature review with respect to measurement and assessment of team alignment. The process and its results could help construction project leaders regularly assess and identify team strengths and weaknesses to improve team alignment. A case study is also presented to apply the team alignment measuring framework to measure team alignment on a construction project.

Acknowledgments

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I could not have done this without the support of my friends and family. To my incredible parents for nurturing my curiosity and confidence. Thank you for always believing in me.

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List of Abbreviations

ABBREVIATION	EXPLANATION
AEC	architectural engineering and Construction
AI	Artificial intelligence
IPD	Integrated project delivery
TVD	Target Value Design
AT	Attribute
F	Factor
TA	Team Alignment
AIA	The American Institute of Architects
BIM	Building Information Modelling
TPS	Toyota Production System
TPDS	Toyota Product Development System
LPD	Lean product Development
LC	Lean Construction
VM	Value Management
VE	Value Engineering
TFV	Transformation, flow, and value
AI	Artificial Intelligence
P2SL	Project Production Systems Laboratory

Chapter 1: Introduction

1.1 Background and Problem Statement

The architectural engineering and construction (AEC) industry is a collaborative endeavor (Scott & Neilson, 2021) that has grown more multi-disciplinary, complicated, and interdependent. Creating a virtual organization for construction projects presents several obstacles. The first barrier is that the AEC sector has a long history of being individualistic and adversarial. People have collaborated on projects in groups rather than in teams. Furthermore, many people wrongly believe they have engaged in collaboration since the term “team” is casually used (Ashcraft, 2011). The fundamental difference between teams and groups is that teams require personal and social responsibility. Teams are dedicated to a single goal, procedure, and result for which they keep each other accountable (Katzenbach, 2005). Transitioning groups into teams necessitate a significant change in individuals’ collaboration and the reorganization of work and hierarchy. “Successful deployment of multifunctional teams necessitates a fundamental rethink of the entire company,” stated in a software context (Larman, 2008). The performance necessary determines if these endeavors worthwhile.

Construction clients worldwide are increasingly demanding the industry for continuous improvement (Oke & Ogunsemi 2011). Construction is a vital industry that generates substantial outputs and outcomes. Low output in such a crucial industry could have a negative influence on the national economy. Lean thinking has been used effectively in the construction sector for years, resulting in better project planning and execution (Daoud et al.,2019).

According to a previous study, stakeholder satisfaction and effective outcomes have been achieved in the construction industry by value creation (Salvatierra-Garrido et al.,2009).

Client/user satisfaction has been assigned to the discovery and delivery of value parameters, according to Emmitt et al. (2005), since value creation is the end aim of all construction projects. The value of a building project is not determined from the outset; it will be difficult to realize it afterward (Drevland & Lohne 2015).

Disappointments occur because of a lack of collaboration between designers, subcontractors, and other specialist groups, who prefer to work in isolation in their respective disciplines, and the unpredictability of cost, time, and quality standards during the design phase, reports usually following the construction phase reports. Rework, change orders, and repricing are the outcome, making it costly and off-target for clients (Oliva et al., 2016; Oke & Ogunsemi2011; De Melo et al., 2016).

Miron et al. (2015) have also recognized target value design (TVD), which is (a lean approach) method for generating value in projects with favorable characteristics. Team alignment (TA) and value alignment (VA) are the backbones of successful implementation of TVD (Ashcraft, 2016). Also, TVD is used to increase collaboration by using the client's perceived value as a design driver, aiming to eliminate waste, if not exceed, the client's expectations (Obi & Arif, 2015; Olivaet al., 2016; Kim & Lee, 2010).

The failure of AEC projects is primarily due to a lack of team performance monitoring methodologies, a lack of collaboration between actors from many disciplines, fragmented work, conflicts of interest, poor communication, work in isolated silos, and imprecise definition of the project value (Achell, 2020). Team alignment (TA) is poor causes many challenges and barriers during implementing TVD, leading to project failure (Griffith, 2001). By the literature review, there is minimal (almost none) research on using TVD to measure and assess TA.

This research proposes a method to measure team alignment in construction projects based on the principles derived from TVD. Based on the literature review, team alignment factors are circumstances, facts, or influences that affect a team's performance. Team alignment attributes are qualities or features regarded as a characteristic or natural part of the alignment. The measurement method simulated to test the framework by relationships and correlations between factors, attributes, and team alignment is a measurable variable affected by the correlation and relationship between team alignment factors and attributes. The experiment involves the application of two methods for modeling the correlation and measurement: the correlation coefficient Pearson test and the fuzzy inference system (FIS).

This research also validates the measurement method on a construction project. Participants filled out the prepared survey and data analysis methods applied to the survey results to understand factors and attributes relationship and measure the team alignment. Based on the result, suggestions for team alignment improvements are presented.

1.2 Purpose of Study

The primary objectives of this research are to:

1. Develop a framework to measure team alignment in construction projects based on TVD
2. Investigate whether the proposed method of measuring the degree of team alignment can be applied on real projects
3. Identify possibilities for providing recommendations for improving team alignment

1.3 Expected Contributions

This study provided the following academic contributions:

- Providing a methodology for developing a measuring and assessing framework for team alignment.
- Developing correlations between factors, attributes, and team alignment degree.

This study's industrial contributions include:

- Demonstrating the application of team alignment measuring tool to analyze team performance in AEC projects; and,
- Providing analyses with a roadmap for assessment outcomes to performance team threats and improvement opportunities

1.4 Research Methodology

The research methodology for this thesis is Design Science Research and is as follows:

- Conduct a literature review to identify (1) team alignment barriers and challenges in TVD, (2) team alignment influential factors, (3) aligned team attributes in target value design, (4) methods of data analysis and measure qualitative data
- Prepare a survey, apply for the survey approval, validate survey questions with an expert panel
- Rank factors and attributes importance and prevalence
- Propose a team alignment framework
- Validate proposed measurement method on a construction project team
- Analyze the applied method's outcomes, know the areas of strengths and weaknesses, and provide recommendations to improve team alignment.

The research methodology is explained in Chapter 3.

1.5 Thesis Organization

This thesis consists of six chapters: Chapter 1 introduces the background and problem statement, the purpose of study, expected contributions, research methodology and thesis organization. Chapter 2 includes a review of the literature relating to lean management, TVD, and team alignment importance in construction projects. Chapter 3 describes methods and steps are taken in the research. Chapter 4 discusses team alignment barriers, influential factors in successful alignment and attributes and proposes the research framework and techniques. Chapter 5 applies the current framework in the case study. Chapter 6 summarizes the research, research contribution to academia and industry, limitations of the recent research, and discussions about future works.

Chapter 2: Literature Review

2.1 Introduction

The literature review is an excellent method for understanding a particular issue and the conclusions and methodological elements associated with the topic. The literature study is implemented by applying recent academic papers and websites worldwide.

2.2 Definition

This section includes definitions for integrated project delivery (IPD), lean, TVD, and TA, which provides context for using these terms throughout this thesis.

2.2.1 Definition of integrated project delivery

IPD is a project implementation delivery strategy intended to reduce construction waste and result in optimum or sub-optimum schedule, cost, and quality improvements (Matthews & Howell, 2011; Singleton & Hamzeh, 2011). AIA (2014) notes that IPD approach involves people, systems, business structure, and practices:

- Instant involvement of owners and key designers, and contractors from the start of the project to the finish
- “Shared risk and reward,” may include risky financial gains tied to project outcomes and aligning business interests
- Collaborative project control by key participants like the owner and key designers and builders
- A multi-party agreement or equal overlapping clauses
- Limited accountability among owners, key designers, and builders

All successful IPD projects have a core team that includes the client, contractor, and architect as equals determined to make decisions together based on the project's best interests. While working cooperatively toward mutual objectives, the major responsibility of the core team is to foster a culture of openness, trust, and mutual respect among all project participants. This can be accomplished in several ways, but establishing a project charter and guidelines, which set both the project's values and team conduct standards, can give a template for success. They are, however, the glue that holds the team together with a single purpose (Richardson & Laurie, 2017). IPD projects must overcome various cultural, financial, legal, and technological barriers to be extensively embraced by the construction industry (Ghassemi & Becerik-Gerber, 2011). The following Table shows the differences between traditional project delivery methods and IPD that were presented by the AIA (2007):

Table 2.1: The differences between traditional project delivery method and IPD

Area	Traditional project delivery	Integrated project delivery
Teams	Fragmented, assembled on a "just-as-needed" or "minimum-necessary" basis, bureaucratic, and regulated	An integrated team entity formed of key project stakeholders, assembled at the beginning of the process, open, collaborative
Process	Linear, distinctive, segregated; knowledge gathered "just-as-needed"; information hoarded; silos of knowledge and expertise.	Concurrent and multi-level; early inputs of skills and knowledge; open sharing of information; stakeholder trust and respect
Risk	Individually controlled and transferred as much as feasible	Collectively managed and equitably distributed
Compensation/ reward	Individually pursued; minimum work for most significant profit; (usually) expense first	Project success is linked to team success; value-based

Communications/technology	Paper-based, 2 dimensional; analog	Digitally based, virtual, building information modeling (BIM) (3, 4, and 5 dimensional)
Agreements	Encourage individuals to work alone; distribute and transfer risk, and not share	Encourage, foster, promote and support multi-lateral open sharing and collaboration as well as risk-sharing

IPD methods delivery method that considers the organization, operational systems, and commercial terms regulating the project to match all project stakeholders' interests, aims and practices (including the architect, key technical consultants, and subcontractors). They claimed that IPD enables a company to implement the lean project delivery system's concepts and practices (Tommelein & Ballard, 2016). IPD aims to capitalize on expertise while transforming the various stakeholders into a virtual organization aligned with the project values by TVD (Ashcraft, 2011).

2.2.2 Definition of lean project delivery system

Lean project delivery system (LPDS) is a form of integrated project delivery (Mossman et al., 2013). The application of lean thinking to the design and production of capital projects, or delivery and projects in general, is known as lean construction (LC) or lean project delivery (P2SL, 2016). Lean projects are temporary production systems that deliver the product with maximum value and minimize waste. The stages, the interaction between phases, and the participants in each phase are the primary distinctions between traditional and lean project delivery (Ballard & Howell, 2003). “Project Definition,” “Lean Design,” “Lean Supply,” “Lean Assembly,” and “Use” are the phases of LPDS. According to Ballard (2008), LPDS was created in 2000 because of theoretical and practical study, and it is continuously being refined through global testing. Figure 2.1 shows an LPDS.

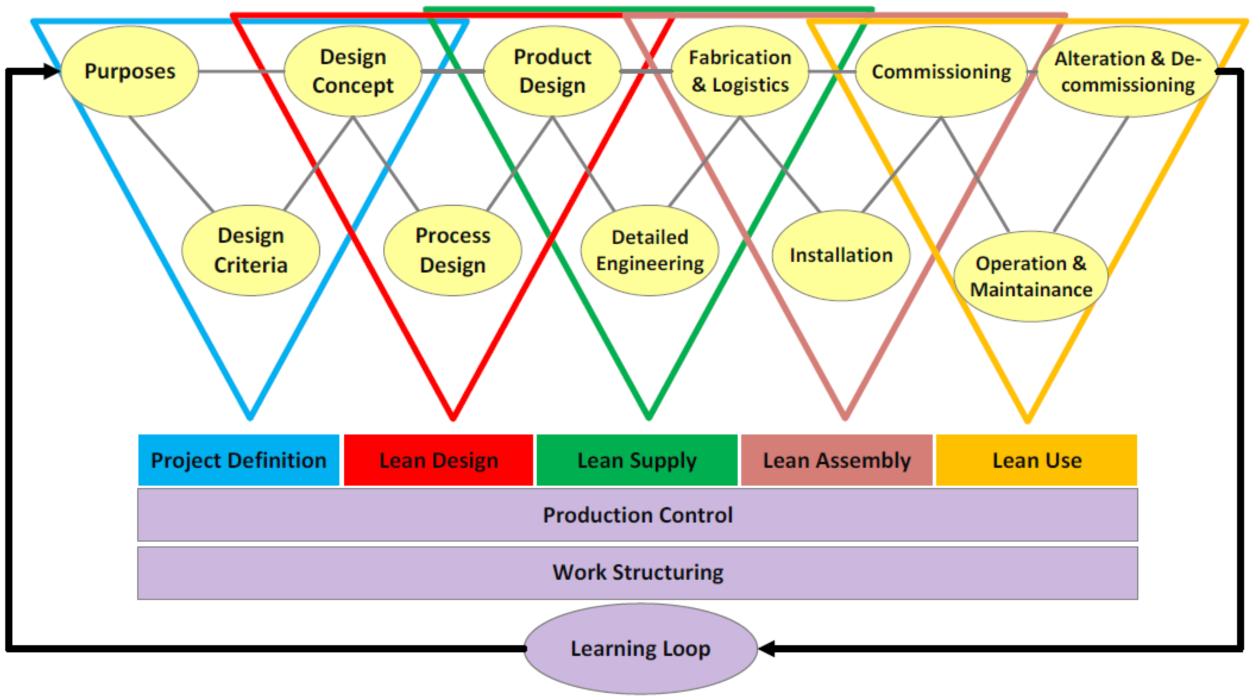


Figure 2.1: Lean project delivery system (Ballard, 2008)

Lean construction (LC) refers to improving construction processes with the lowest cost and highest value by applying lean principles derived from the Toyota Production System (TPS) (Gao & Low, 2013). Construction organizations consider the LC concept a vital strategy for improving their performance (Egan, 1998, Ballard & Howell, 2003). In recent years, many studies have correlated construction with lean principles, creating effective implementation methods and advanced tools and techniques relevant to the construction industry. Constructors are beginning to change their operations due to the LC paradigm, which alters their traditional view of the project as transformation (Jørgensen & Emmitt, 2008).

2.2.3 Definition of target value design

TVD is a management practice and a design technique that aims to deliver customer value within the constraints of a project (Kaushik & Koskela, 2015; de Melo et al., 2016). Projects have been completed under market costs because of employing lean project delivery with TVD - so far, 19 percent below market cost - and the predicted cost has reduced as design and construction advance (Mossman et al., 2010).

A Target Value Design Process Benchmark was developed by University of California at Berkeley's Project Production Systems Laboratory (P2SL) in 2011 (Ballard, 2011). It includes the following components:

- Determine the clients' values and constraints by conducting a feasibility study at the commencement of the project.
- The target cost is set according to the amount that the client is eager and afford to pay, and the project is designed and constructed based on the target cost.
- Only the customer can modify the target cost in the project. This is a fundamental rule for the project team.
- The customer is a permanent, active participant in the project.
- During the design phase, downstream trade partners are engaged to leverage their construction expertise and cost estimation capabilities.
- For the project participants to align their commercial interests, a relational contract is used with shared pains and gains.
- Tools and methods of LC are used to manage the project.

Researchers may view TVD differently. Kim and Lee (2010) defined it as a management strategy that uses a design-to-cost method to eliminate waste and deliver value. Morêda Neto et al. (2016) defined it as a management method that uses principles of target costing and applies them to the construction industry. TVD's goal, according to them, is to make the client's value a key driver of design by enhancing project description during programming and thereby streamlining the design process. According to the literature review, TVD is:

- A management tool, strategy, approach, or practice; and
- A management tool, strategy, approach, or practice.
- Emphasizes cost, time, quality, and stakeholder value as the primary design objectives; and
- Success necessitates both face-to-face and virtual cooperation.

"Rather than being a form of agreement or a cost-control strategy, TVD is a management practice" (Zimina et al., 2012). The concept of designing to objectives rather than designing and then reviewing if budgets, deadlines, and other constraints have been surpassed is critical to TVD. Although it is progressively being used for lean–IPD processes, primarily in the medical facility sector, Rybkowski et al. (2016) argue that the basic principles of TVD take time to understand and can appear discouraging when executed for the first time on real projects.

2.2.4 Definition of team alignment

The alignment between appropriate project participants can be described as a situation where they work within tolerable limits to give rise to and achieve uniformly defined and acknowledged project values (Griffith, 2001).

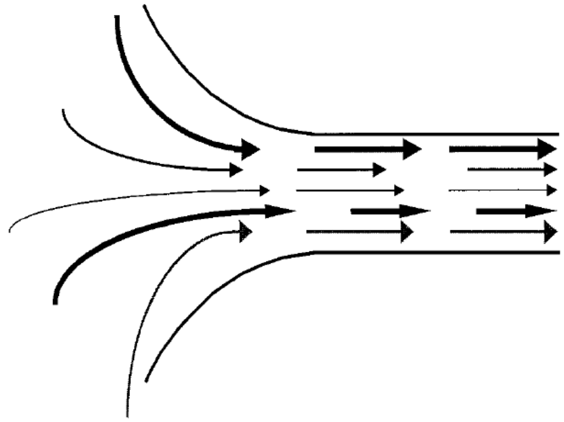


Figure 2.2: Graphical representation and definition of alignment (Griffith, A. F, 2001)

Groups can align even if they work differently but share a common goal. The alignment of the project team has a direct influence on the project's outcomes. These direct relationships also investigated whether alignment mediates the links between the antecedents and project results (Griffith, 2001).

According to CII (1997), the difference between alignment and teamwork is as follows:

- Alignment regards whether the team members are working towards the correct goal. During a capital project, the primary goal is to achieve business or mission success. It is possible that a team is performing well together but has the wrong objectives set.
- Working as a team depends on how well members interact, cooperate, and support each other.
- In general, teamwork refers to close relationships among people working together.

2.3 Lean Management

Automotive manufacturing, transport and logistics, retail, medicine, construction, administration, and government are just a few of the industries that have successfully applied lean management (Lean Enterprise Institute, 2012). Lean management may be summarized as maximizing value for the client/customer while minimizing waste for the company. To put it another way, lean

Management aims to provide more excellent value to clients/customers while utilizing fewer resources (Womack et al., 1990; Womack & Jones, 1996).

2.3.1 The origins of lean thinking

Lean production was born when researchers at Toyota established the Toyota Production System in the 1950s (Womack & Jones, 1996). Womack and Jones (1990) described how mass manufacturing replaced craft production in the automobile industry, because it delivered cheaper automobiles by employing low-skilled labor and specialized machinery.

El Reifi (2016) mentioned that customers, benefit from decreased costs due to mass manufacturing, but at the cost of indirect labour through engineering, production planning, and administration. Toyota's "Do It Right the First Time" concept blended the benefits of both artisan and mass manufacturing by keeping inventory low and delegating decision-making to line employees. Toyota pioneered producing high-quality automobiles at a cheap cost and shorter time by using a waste-reduction system. The "Toyota approach" became known for its cross-utilization of standardized components, quick machinery change-over periods, and just-in-time logistics. This approach gained notoriety and was dubbed the Toyota Production System, also referred to as *lean production*.

In comparison to the extensive study on lean production (Haque & James-Moore, 2004; Baines et al., 2006; Morgan and Liker, 2006b; Ballard et al., 2007), lean product development (LPD), the form of a concept of the Toyota Product Development System (TPDS), is a developing topic of research. TPDS comprises procedures and processes unique from those related to Lean Production, even though they go together and have many commonalities. It is sometimes stated that lean product development is a holistic system rather than a set of methodologies and that attaining "lean" is a journey rather than a destination (Liker et al., 1996; Karlsson and Ahlström, 1996; Sobek II et al., 1999; Ballé & Ballé, 2005; Morgan and Liker, 2006b). As a result, Morgan, and Liker (2006a) presented the TPDS as a framework consisting of procedures, tools, people, and technology, subdivided into 13 principles to explain the system. They stated that the efficient process could not stand alone without skilled people and appropriate tools and technology. However, in Haque and James-Moore (2004) and Baines et al. (2006), LPD is primarily presented as a collection of concepts and methodologies that should be integrated, with some assistance in organizing the structuring of the idea in an extensive application pattern. Womack and Jones (1996) outlined five lean principles (Figure 2.3):

1. Determine the customer's desired value.
2. Allow the product to flow continuously through the remaining value-added procedures to create flow.
3. Create a value stream for each product.
4. Generate a pull between all processes where continuous flow is feasible; and
5. Aim for excellence by minimizing the number of processes, time, and information needed to service the consumer.

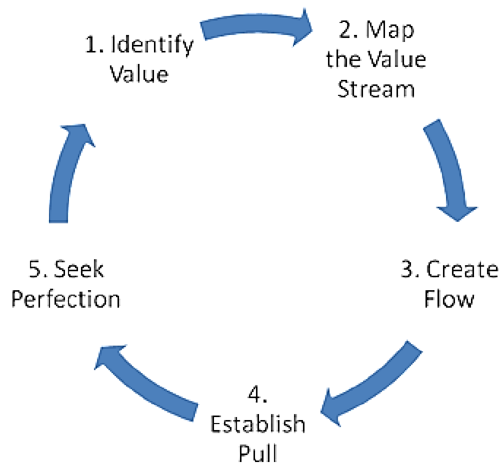


Figure 2.3: Lean Principles (Source: Lean Enterprise Institute, 2012)

The requirement to remove waste to provide additional value to external parties (i.e., clients or customers) and internal entities (i.e., the following person(s) in the process) is the critical motivation for implementing Lean principles inside a process (Womack et al., 1990; Womack & Jones, 1996; Ballard, 2000). In contrast, Liker (2004) proposed the concept of the 4Ps, reflected in the pyramid displayed in Figure 2.4:

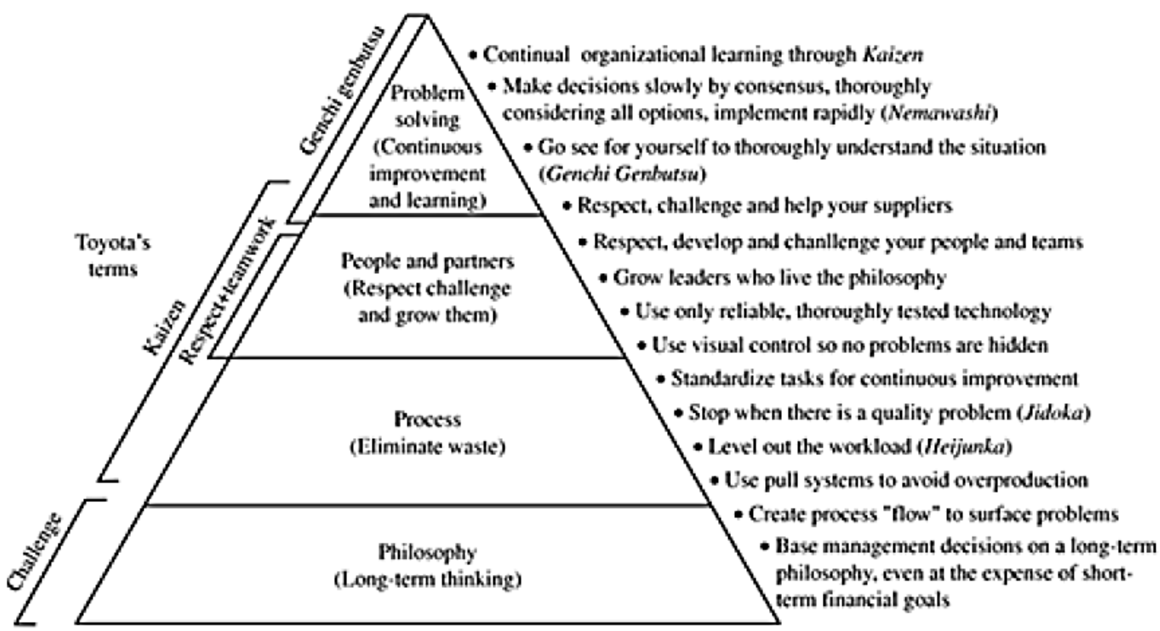


Figure 2.4: The 4P's Model (Source: Liker, 2004)

Liker (2004) mentioned that most businesses are solely concerned with the “process aspect” of the network (i.e., operations management). Unlike commercial manufacturing, which focuses on the efficiency of operation and uses large batches to work with misalignment of activities, ‘Lean’ companies focus on the procedure, trying to make the product ‘flow’ by scheduling and balancing all the phases in the process from the perspective of the output itself. According to Poppendieck (2002), presented in figure 2.5, not all process stages contribute value. It is debatable if actions like error repair and patience provide value in a new context.

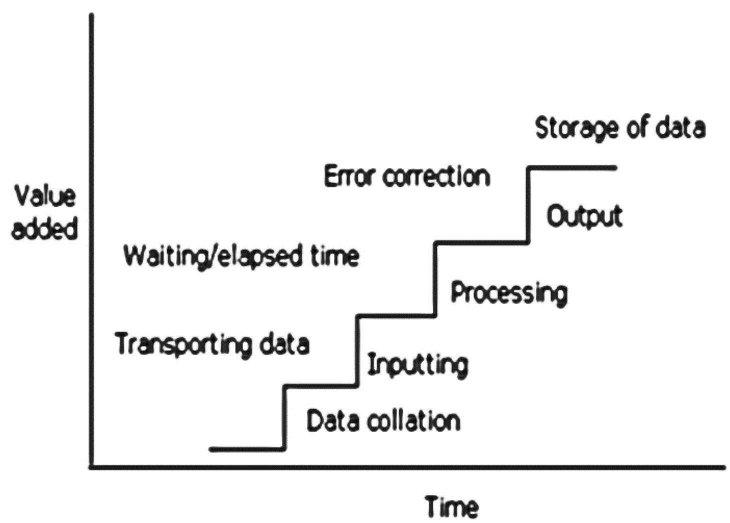


Figure 2.5: Processes Steps (Source: Audit Commission, Cited in Poppendieck, 2002)

As a result, the cornerstones to ‘thinking lean’ and implementing lean concepts in a process are quantifying waste and precisely stating what is of value inside the process. That is, precisely what actions and supplies are required. It is critical to examine just those required, as including others would be deemed waste (Poppendieck, 2002; Koskela et al., 2013). It is vital to maintain development by applying what you have learned (Schmidt et al., 2014). The main goal of lean principles is how to put them into practice.

2.3.2 Lean construction approach to value generation

In the LC community, there are numerous explanations and interpretations of the notion of value, according to the research literature. Some scholars believe that reducing waste is a crucial method of creating value, while others believe profit from a project is valuable. For example, the first and last value model established by Salvatierra-Garrido and Pasquire (2011) has been frequently used to visualize value in the construction industry. A three-step model (value/process/operation) and the identification of six value variables are two other models that have been offered (Emmitt et al., 2005). Furthermore, according to Macomber and Howell (2004), a fundamental need for comprehending value is a thorough grasp of waste.

Meanwhile, according to Lindfors (2000), value is a product or service that generates profit for the organization, saves time and money, improves quality, and creates profit/value for the consumer. Since, value-based management has enhanced the construction industry's effectiveness and efficiency by examining various values (Wandahl & Bejder 2003). Owners, users, and society have been grouped to represent distinct interests and values at different points during the project's lifetime (Bertelsen and Emmitt 2005). Others have classified value as internal and external (Emmitt et al., 2005), while Brimson and Antos (1999) believe value is determined by supply chain synchronization. It may be argued that the LC community has made significant and sustained contributions to the advancement of value over time through various pertinent studies and research.

The concept of value creation has been analyzed from both LC and value management (VM) perspectives to identify a tool or practice like both disciplines and might potentially be an avenue for boosting value generation. *Target value design* was defined as a methodology whose concepts are founded in both disciplines while incorporating their strengths, with a range of parallels and distinctions between LC and VM highlighted. Cell and Arratia (2003) stated that both the LC and

VM techniques have potential and that integrating them might provide significant synergy in value generation.

When analyzing their mutual misapplication as cost reduction approaches, this research found several parallels between the two disciplines that show LC and VM are interchangeable, with the same objective of producing value. However, research has revealed a variety of philosophical and scope disparities in various areas, including practitioners' responsibilities, practice areas, project timing and application, and practitioners' domains, among others. In talks at conferences in the UK and the US, there has been a continuous trend of integrating VM and lean processes (IVM, 2014; LCI UK 2015; SAVE International 2015a; SAVE International 2015b).

Both disciplines have similar origins and practices from the industrial industry in the past (IVM, 2015a). In the manufacturing industry, value analysis and value engineering, known subsets of VM, have been utilized in target costing to achieve additional cost cuts, according to Womack et al. (1990). Both VE and LC have been discovered to meticulously apply approaches to services/methods to improve the output, which meets customers' expectations in a cost-effective and timely manner and maximizes value and minimizes waste. According to Lehman and Reiser (2004), LC activities complement rather than compete with VE techniques.

However, LC is a larger philosophy than VM, including more areas and resulting in more developments in value ideas over time by depending less on other construction value-related professions like VM, VE, and partnership. Despite improvements in value study in the LC literature, the idea of value remains perplexing, with many interpretations providing the foundation of its comprehension.

Furthermore, while no one approach from the two disciplines is superior to the other, others suggest that approaches, strategies, and ideas from the two disciplines may complement each other when used together (Nayak, 2006), adding value to the delivery of suitable solutions. Some data show that target value design, which Macomber et al. (2007) coined as a lean name for the application of target costing, is a technique whose principles have roots in both disciplines and incorporate the strengths of LC and VM. TVD effectively maintains a predictable project cost and manages cost overruns, delivering projects up to 20% below market pricing without sacrificing timetable or quality; assures early engagement of key stakeholders; and facilitates cooperation (Do et al., 2014).

Previous researchers have confirmed the findings. TVD incorporates methods that improve value from a variety of disciplines, such as value engineering for building projects and VM for the client business case, and a value approach throughout the design process (Novak, 2012). TVD is a "team-based, process-driven technique" that matches the definition of value management (Male et al., 2007). It has been stated that TVD enhances the project environment in general by adding beneficial features that produce value (Miron et al., 2015). In one sense, TVD could be a platform that promotes better collaboration by using the client's perceived value (specific design criteria, cost, and schedule). As a design driver, reduce waste and meet or exceed the client's expectations (Oliva et al., 2016; Obi & Arif, 2015; Kim & Lee, 2010).

Clients are increasingly demanding the construction sector because it is perceived as inefficient and lacking value delivery. As an outcome, this research aims to investigate TVD as a vehicle for creating value and addressing some of the NCI's difficulties. TVD aims to provide maximum value to clients while decreasing waste in the delivery process (Reiser, 2003); as a result, it has been proven to produce a variety of social, financial, and quality advantages in projects.

2.4 Target value design

According to Oliva et al. (2016), TVD can benefit from the early inclusion of critical stakeholders through IPD procedures. Economic rewards, the development of collaborations, and other contract techniques, according to Morêda Neto et al. (2016), can spawn results regarding the collaboration required for the TVD approach. TVD may be carried out using a variety of project delivery techniques; nevertheless, it is ideally suited to IPD, as tight co-ordination is essential between the stakeholders, which include the contractor, designer, and client (De Melo, 2015).

TVD is a part of the strategic project delivery, from start to finish, and is built on the lean management philosophy. It consists of a series of tools linked to each other in an ongoing process (Daria Zimina et al., 2012). Figure 2.6 presents the TVD process.

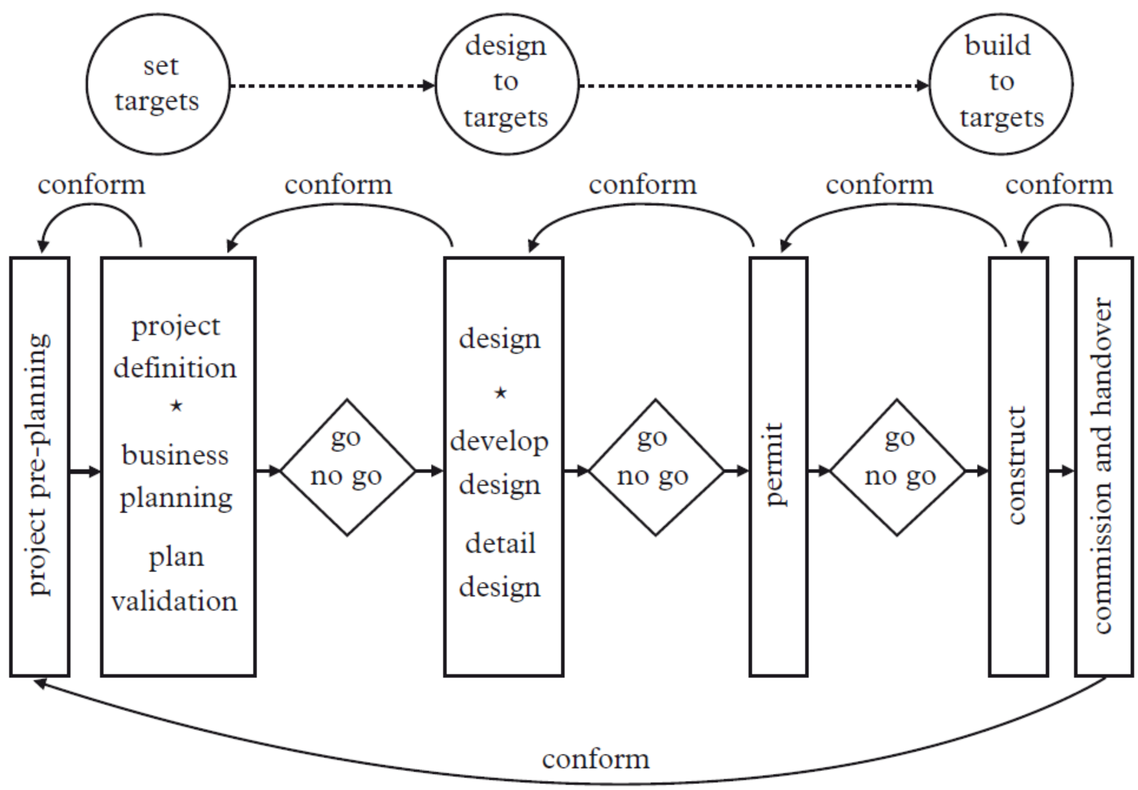


Figure 2.6: Target value design process (Daria Zimina et al., 2012)

2.4.1 History of target value design

To understand TVD, one must first understand its roots, which are found in target costing. TVD is a manufacturing-based modification of target costing (Kaushik et al., 2014; Namadi et al., 2017; Tillmann et al., 2017; Cooper & Kaplan, 1999; Ballard et al., 2015; Morêda Neto et al., 2016; Cooper and Slagmulder 1997; Do et al., 2015). According to Zimina et al., 2012, the target cost for a project is the number that the design team will strive toward because of the feasibility study; they refer to it as the objective established to be the final construction cost. “The goal cost is what the team pledges to produce, sometimes contractually and sometimes ‘only’ ethically, and is often estimated below the projected cost to stimulate innovation beyond existing professional standards,” states Ballard (2008) and Ballard (2009). Emuze and Mathinya (2016), on the other hand, suggest that getting the working precision of the target cost is exceedingly challenging. Do et al. (2015b) indicated that the target cost is calculated by deducting the product's estimated profit from the expected selling price. Tang (2015) cites several researchers (Ansari et al., 2006; Dekker & Smidt, 2003; Ellram, 2006; Okano & Suzuki, 2006) who claim that the target cost is determined by the gap between the actual retail price (based on the price rate of existing products/services or competitors' offerings). In addition, an organization's strategic profit strategy determines the predicted profit margin.

TVD emerged from the manufacturing industry's target costing by changing target costing's ideas, procedures, and practices. It is a more advanced variant of target costing that incorporates stakeholder value generation as a design and construction motivator. Target pricing focuses on setting "cost" objectives, whereas target value design expands the notion to include time, quality, and value targets, among other things. Since its launch in 2002, it has grown in popularity and acceptance within the construction companies in the United States (Do et al., 2014).

2.4.2 TVD benchmarks and principles

TVD research and practices have been focused on the lean mindset and rely on the benchmarks and techniques listed below. The Project Production Systems Laboratory at the University of California, Berkeley, released and revised the TVD benchmarks twice. The current TVD benchmark, a version of the original issued in November 2005, reveals that the benchmark focuses primarily on project predesign and design, with minimal attention paid to project construction and completion. Ballard (2011) presented TVD process standards based on theoretical and empirical investigations of TVD projects; they reflect practices that have been demonstrated to result in favorable outcomes on TVD projects (Do et al., 2015). Seventeen benchmarks are particular to the US construction industry, including IPD and multiparty collaborative contracts like IFOA (Kaushik et al., 2014). Furthermore, the benchmarks are more focused on project conceptualization, planning, and design stages. Martin (2015) recognized three TVD principles:

1) The Cardinal Rule – The facility's entire target cost must not be exceeded.
2) The Corresponding Rule – The buyer's pleasure with the result is equally crucial; and
3) The Fundamental Challenge – Anything that is not necessary to produce value is deemed waste.

These concepts are critical in leading a TVD project team: the purpose of having a set of objectives is negated if the project’s aim is consistently exceeded. Zimina et al. (2012) identified two key concepts of TVD:

1) To find the optimal project-level investment, money must be encouraged to flow across organizational and contractual barriers.
2) All design conditions for generating, assessing, and choosing a product and process design alternatives must be applied at the same time.

Concurrently creating the product and process in design sets, cooperating in small and varied groups, and meeting often in a “big room” environment of co-location to improve communication and foster innovative interactions are among the core concepts of TVD (Suhr 1999). The objective of TVD is to cooperate and work as a virtual team while designing to specified targets, backed by unique ideas that allow you to meet the targets without limiting the scope or sacrificing the quality of standards or the value of stakeholders.

Macomber et al. (2007) and Kaushik et al. (2014) defined the commonly acknowledged TVD procedures, which they dubbed the essential principles of TVD:

1. Build a close relationship with the client to determine the target-value
2. Lead the learning and innovation design effort
3. Design according to a precise budget
4. Plan and re-plan the project in a collaborative manner
5. Design the product and the process in parallel in design sets
6. Design and detail in the order in which the consumer intends to use it
7. Small and diverse groups of people to work with
8. Work in a Big Room; and
9. Throughout the process, do retrospectives.

By exposing employees to many disciplines while boosting their understanding of the entire process, TVD impacts not only the construction process but also the result and, most significantly, the mentality of those participating in the project.

2.4.3 Target value design approach to value

When evaluated through the LC perspective, the notion of value generation in the context of TVD is best understood. The LC Institute’s core objective and goal, according to LCI (2016), is to deliver value through attaining both customer and stakeholder value throughout the project life cycle. For example, Ballard and Howell (1998) believe value is generated through a compromise between the customer's aims and resources. Koskela, another well-known LC expert, devised a transformation flow value-generation model (2000). Each of these three concepts (last model, flow, and value) focuses on different elements of the manufacturing process:

- The notion of transformation handles Value-adding conversion.
- The flow principles handle non-value-adding tasks.
- The value-generation concept handles production control from the customer's perspective.

These notions represent Koskela's value-generation viewpoint and have significantly impacted the LC perspective on value (Salvatierra-Garrido et al., 2012). According to Salvatierra-Garrido et al. (2012), research has shown that the discussion on the delivery of value is concentrated more in the project phase, with the subjective aspect of value given more weight. However, their overall conclusion is that value is still unclear because it has no single definition.

Despite the importance of addressing the demands of many stakeholders, several obstacles prevent optimizing project value and aligning the various needs (Khalife & Hamzeh, 2019). Tillmann et al. (2013) suggested that to enhance value generation, key stakeholders should be involved in value definition activities to capture their requirements, develop the necessary circumstances for them to participate, and define targets consistent with the company plan. It is also critical to have suitable tools for tracking the creation of value or measuring results.

2.4.4 Target value design approach to collaboration

Remote and Face-to-face collaboration are not alternatives in the TVD approach; they are necessary for project success. Collaboration's unifying function and numerous benefits have increased its popularity in industries such as information technology, organizational growth, construction, and service offering. “The transition towards new collaborative project delivery systems is among the most significant concern in the construction industry and research.” (Ismail et al., 2014)

Collaboration is “the process of shared creativity involving two or more persons with complementary talents interacting to develop a common knowledge that none of them had previously shared or could have arrived at on their own,” according to Schrage (1990). Collaboration is often founded on the notion of beneficial contact between two parties. Collaboration implies that the project teams are appropriately integrated to achieve the overall project objectives (Daniel, 2017). Collaboration is not restricted to two or more organizations working together but also involves having shared common knowledge, ensuring plans are developed based on the provided information, and completing the planned job jointly rather than separately (Attaran & Attaran, 2007). Individual goals and activities are subordinate to a common aim in a collaborative atmosphere.

Different levels of collaboration are readily misconstrued and misused, although they have significant differences. The interdependence and different needs of networking, cooperation, co-ordination, coalition, and collaboration are studied since collaboration is the backbone of effective TVD implementation. Cooperation has been mistakenly interpreted as collaboration, failing in specific ostensibly joint endeavors. This is because the companies or teams attempt to collaborate rather than genuinely collaborate. *The Oxford Advanced Dictionary defines cooperation* as "the process or activity of working together toward a common goal." The three essential aspects of collaboration described by Attaran and Attaran (2007) are not included in this formulation. According to Mattessich and Monsey (1992), cooperation is built on informal associations and frequently lacks a specified objective, framework, and clearly defined responsibilities for the people involved. Cooperation might allow information to be exchanged across organizations, such as the architect giving the main contractor the working drawing or the principal contractor supplying information to the subcontractor. However, each organization could still operate independently of the other. As a result, such a relationship cannot be called collaboration because individual organizations retain control and reward (Shelbourn et al., 2012; Mattessich & Monsey, 1992).

Furthermore, because collaboration is an informal agreement, no risk-sharing considerations will be considered, and the organizations will be less committed to the process. On the other hand, collaboration necessitates a high level of commitment and risk because each organization must adhere to the teams or organizations (Mattessich and Monsey 1992).

Co-ordination is one of the essential management principles. A project with many tasks, participants, or organizations manages and unites specific activities or agencies (O'Brien et al., 1995; Malone & Crowston, 1991). Co-ordination is used to specify a formal way of organizing how an operation or activity should be carried out, implying that co-ordination is still founded on the command-and-control concept. Even if the technique is formal, the shared mutuality part of collaboration is still missing. In co-ordination, unlike collaboration, roles and line of communication processes must be followed; nonetheless, the power or decision on how work should be done remains with the team or organization. The necessity of co-ordination in construction projects cannot be overstated due to the nature of construction operations at both the project and organizational levels.

On the other hand, Iyer and Jha (2005) claim that researchers have neglected to address concerns that may aid project collaboration. This implies that project failure can still occur when activities are coordinated without a clear purpose to the agreement. It is worth mentioning that this strategy carries more risk than cooperation; nonetheless, the approach still lacks the core features of collaboration.

2.5 Team Alignment

Team alignment and value alignment are prerequisites of TVD. “Organizations develop alliances, often termed networks or constellations, to match their own goals with stakeholders' interests and to decrease environmental uncertainty,” according to Barringer and Harrision (2000). Page (2018) believes that networking enhances business connections, promotes innovative ideas, facilitates the acquisition of new viewpoints, and fosters long-term partnerships. However, Gaida and Koliba (2007) believe that networking is the weakest operational form of relational collaboration. A group of individuals who exchange information and connections for business or social goals is the networking definition according to the Oxford Advanced Dictionary (2018). The practice of networking fosters the flow of information and ideas among members or organizations that share a common interest (Investopedia, 2017).

“A coalition of persons representing several organizations, groups, or constituencies who agree to work together to achieve a similar purpose,” according to Feighery and Rogers (1990). Lerbinger (2005) substantiates this by defining the coalition as an interconnected set of organizational actors who:

(a) agree to work together toward a common objective.

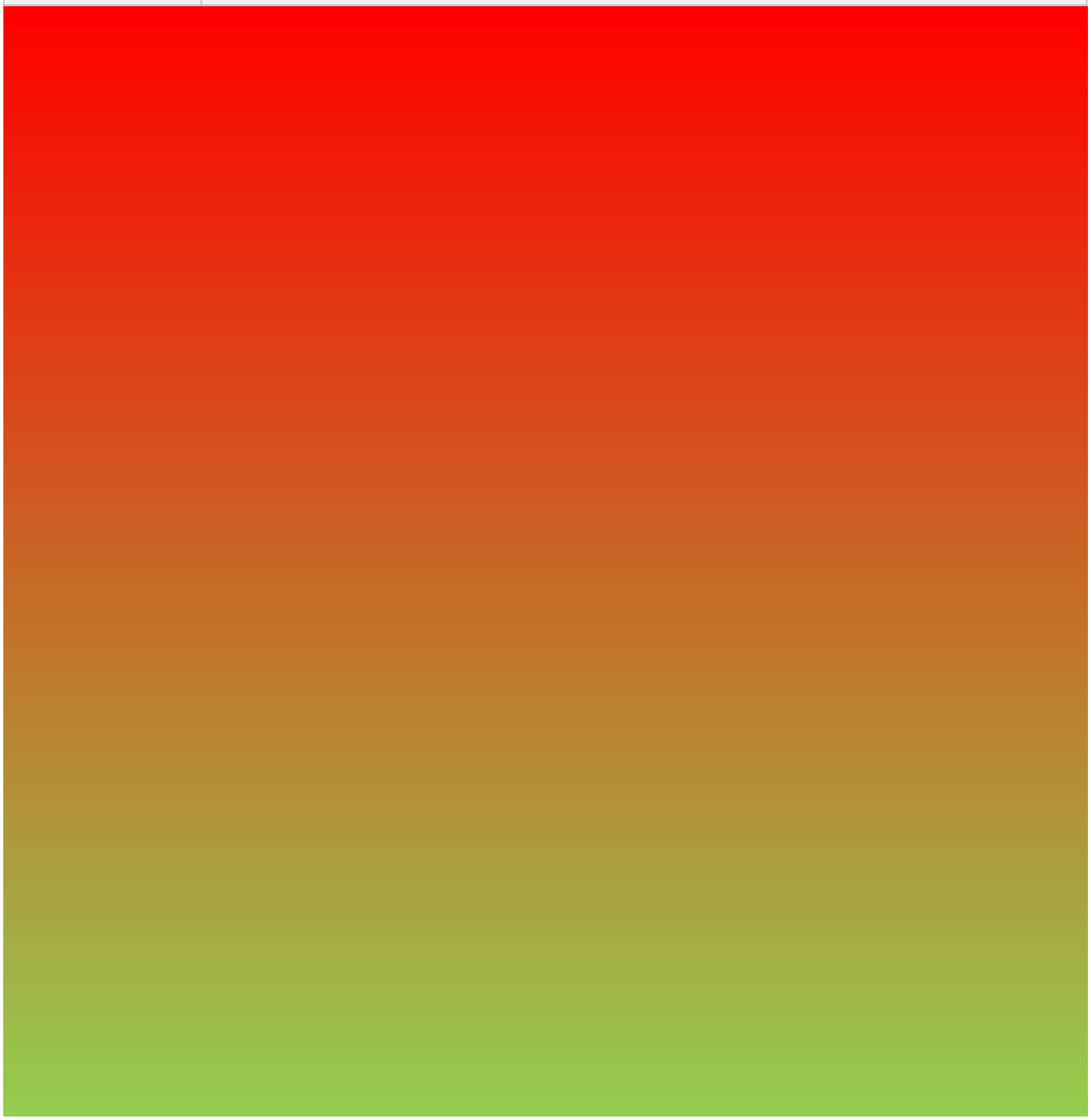
(b) manage their assets in a bid to achieve this single aim; and

(c) pursue this goal using a joint approach.

Coalitions encourage a variety of behaviours and practices that have been shown to improve application quality, including collaboration across local agencies, shared decision-making, and communication (Durlak & DuPre, 2008). According to Foster-Fishman et al. (2001), one of the essential goals of a coalition is to build collaborative capability between coalition members through the coalition's organizational structure and programming. Coalitions provide strength in numbers, enhanced legitimacy, networking and alliances, media attention, and access to legislators (Kochhar, 2013). He says that the level to which members are engaged, satisfied, loyal, devoted, and contributing to the coalition's work allows it to conduct its tasks. According to Frey et al., 2006 the link between the levels of team relationship is mentioned in Table 2.2, the current research writer adds the alignment row. Three primary categories for these partnerships ranging from low to elevated levels of alignment are misaligned (networking and cooperation), poorly aligned (co-ordination and coalition), and aligned (collaboration and alignment).

Table 2.2: Team relationships level (Frey et al., 2006)

	Relationship characteristics



2.5.1 Disadvantages of misalignment and advantages of team alignment

The company's specialist fragmentation causes misalignment among team members and project stakeholders (Ashcraft, 2011). IPD strives to use knowledge while changing a wide range of stakeholders into a virtual organization aligned with TVD's project values. Due to misalignment, well-intentioned leaders may squander countless hours pursuing activities that, while productive ideas are not the most important goals at the time (Kochhar, 2013). Even worse, if the company's culture is unsure to operational employees, they may lose trust in its vision, objective, and value proposition. This gap may impede their desire and willingness to give their best to the project, resulting in a negative impact on the company's culture and bottom line. Strategically linked firms perform more effectively and deliver more substantial outcomes because team members create action plans focused on achieving comparable goals and objectives. (Ashcraft, 2011). If people are not strategically linked, they get confused about their priorities, make fewer effective judgments, and are more likely to engage in conflict. People lose their excitement and motivation to do their best work because of this, and they get exhausted. People want to be a part of something meaningful to them.

In the current research, the team alignment assessments will focus on project success in the level of commitment to the team and project value, morale among team members, ability to overcome challenges and provide the right knowledge and information at the right time and level of creativity. In a prior study of project planning and execution, Gibson, and Hamilton (1994) employed budget, schedule, percentage of design capacities, and production capacities at the startup of facilities construct to quantify project success successfully. According to Gibson, Tortora, and Wilson (1994) and Gibson and Hamilton (1994), project success was significantly correlated with the level of the pre-project planning effort. This planning effort includes establishing project objectives and developing the consensus required for project team alignment. They also discovered that project participants on the same project often had different objectives and focus on success, which they referred to as poor alignment. According to the findings, this imbalance can lead to conflict and communication failures.

2.5.2 Team alignment issues

Griffith (1997) broke down team alignment issues into five categories – execution process, tools, information, barriers, and company culture – as presented in Table 2.3:

Table 2.3: Team alignment issues (Griffith, 1997)

Category	Alignment issue
Execution process	▪ Capital project approval process ▪ Process for identifying project objectives ▪ Process for communicating project objectives ▪ Early in the project, the project manager should be named. ▪ Naming the operations manager early in the project ▪ Staffing the pre-project planning team with the representative of groups that have a significant stake in the project ▪ Team building programs ▪ Charter for the pre-project planning team ▪ Budget for project planning prior to the start of the project ▪ Procedure for communicating and handling changes during pre-project planning ▪ Involvement by design and/or construction contractors in the pre-project planning process
Tools	▪ Risk management analysis software ▪ Project cost control software ▪ Scheduling software ▪ Budgets ▪ Lessons learned from previous projects ▪ Constructability programs ▪ Value engineering programs

	▪ Partnering agreements with outside contractors and suppliers ▪ Scope definition checklist ▪ Work processes flow diagrams ▪ Project team in-progress-review meetings
Information	▪ Project resources requirements and sources ▪ Project schedule constraints ▪ Project budget constraints ▪ Codes and standards to be used ▪ Priority ranking of schedule, cost, and required features ▪ The financial model used to justify the project ▪ Project reliability, maintenance, and operating philosophies ▪ Products to be produced by the facility ▪ Required production capacities ▪ Future expansion considerations for the facility ▪ Facility's expected life cycle ▪ Social issues related to the facility ▪ The project's use of new or existing technologies ▪ Production processes to be used in the new facility ▪ Project site selection criteria ▪ Environmental criteria
Barriers	▪ Reward and recognition system that does not support the project's goal ▪ Many changes in the project's objectives, schedule, budget, or other information ▪ Insufficient time for proper pre-project planning ▪ Unclear definition of team member's duties and tasks ▪ Lack of team experience with an innovative technology ▪ Turnover of high-level team members during pre-project planning ▪ Poor communications between team members ▪ Lack of proper skills for the project among the pre-project planning team ▪ Releasing the project for execution before pre-project planning is fully complete

	▪ Confusion in strategic planning for pre-project ▪ Team members not geographically located near one another ▪ Inadequate budget for pre-project planning ▪ Poorly established priorities between cost, schedule, and required features trade-offs ▪ Lack of leadership ▪ Restrictive confidentiality requirements that impacted communications ▪ Ineffective or incompatible information technology systems
Company culture	▪ Trust ▪ Customer focus ▪ Honesty ▪ Mutual respect ▪ Focus on the solution of problems and not on blame ▪ Teamwork ▪ Open communications ▪ Environment for creativeness and innovation ▪ Clear corporate mission and vision ▪ Empowerment of team members to make appropriate decisions at lower levels of the organization ▪ Uniform and clear approach to risk ▪ Long-term view (rather than short-term focus)

Griffith's (1997) study reduced a list of 66 alignment issues to the ten important ones that have the most significant influence on team alignment and project performance. The following are the ten critical alignment issues:

1. The pre-project planning team should be appropriately staffed with all primary project stakeholders.
2. Develop and support effective team leadership.

3. Determine and explain to all pre-project team members the priority of the project's budget, timetable, and needed features.
4. Establish open and effective communication among all pre-project planning team members.
5. Conduct regular and fruitful project meetings to inform and solicit feedback from the team.
6. Cultivate a culture of openness and loyalty among your team.
7. Build and adhere to a project's pre-project planning procedure.
8. Develop and execute a method for recognizing and rewarding team members and outside contractors who contribute to the project's overall goals.
9. Formal and informal team-building activities can help you foster a sense of belonging and teamwork.
10. Develop and present the project structure, scope, timeline, estimate, and work processes using the different planning tools available.

2.5.3 Factors that promote team alignment

In the TVD process, face-to-face and virtual interaction is not a choice; it is required. According to Hyun (2012), the TVD process necessitates engagement among project participants and the "Big Room" was created to facilitate teamwork, and it would have been difficult to function without colocation. One of the most potent IPD tools is colocation. It boosts participation, teamwork, and creativity while also making administering an IPD project easier. Colocation also allows the appropriate people to be in the right place at the right time (Ashcraft, 2016).

Early involvement of stakeholders can foster teamwork: According to Kaushik et al. (2014), it is critical to ensure that all essential expertise is available. They say that this allows the team to set the proper objectives based on the client's needs and allows for a collaborative design approach to meet target pricing and design criteria. Although tools can be beneficial and essential, participation requires a shift in how work is done and a shift in behaviour and attitude (Zimina et al., 2012).

Contractual agreements, using some IPD principles, shared objectives, the best value contractor selection, colocation, big room meetings, and shared governance. Critical project personnel training is among the factors required to achieve the degree of alignment needed for TVD implementation (De Melo, 2015, Neto et al., 2016, Chan et al., 2012, Do et al., 2015b). This promotes more positive outcomes regarding the required teamwork for the TVD method.

Similarly, Ismail et al. (2014) claimed that a successful team has nine characteristics that promote cooperation, creativity, and production. These characteristics are colocation, dedication, interdisciplinary work, decision authority, a productive workplace, training, responsibility, fast feedback, and consensus leader selection. Kellar Guenther and Betts (2011) classified the elements that promote alignment into structural and interpersonal components. Structural factors are political and social atmosphere, clear roles and policies, specific, achievable aims and goals, sufficient funds, personnel, materials, time, high-level, prominent leaders' commitment and engagement and interim Achievements. Interpersonal factors are open and frequent communication, established and unofficial relationships and communication links, altruism, adaptability, shared vision, flexibility, and trust.

2.5.4 Lessons learned from implementing TVD and assessing team performance

Various aspects of TVD procedures, particularly team alignment, are intensively discussed in the literature. The literature focuses primarily on measuring and analyzing team alignment, particularly in TVD. As stated in Table 2.4, many researchers have addressed using TVD and evaluating team collaboration.

Table 2.4: Implementing TVD to evaluate team collaboration

Researcher	Research topic
Musa, 2019	A framework for implementing target value delivery to enhance value creation in the construction industry
Griffith, A. F, 2001	Team alignment during pre-project planning of capital facilities
Do et al., 2014	Alignment and misalignment of commercial incentives in IPD and TVD
Ismail et al., 2014	Developing a framework of metrics to assess collaboration in IPD
Che Ibrahim et al., 2013	Development of a conceptual team integration performance index for alliance projects
Che Ibrahim et al., 2015	Key indicators influencing the management of team integration in construction projects

The above research studies focus on implementing TVD, team alignment and influential factors for promoting team alignment. However, none of them have proposed a method and framework to measure team alignment based on TVD.

Chapter 3: Methodology

3.1 Introduction

This section introduces the research approach and data collection methods and then describes the main objectives of the thesis.

3.2 Design Science Research

Design science research (DSR) is the approach followed in this study. Hevner et al. (2004) noted that DSR aims to gain knowledge and understanding of a problem area by creating and deploying a designed artifact. DSR seems to be suitable for research in LC, according to Smith (2015), because of its "applied" character. It may be considered a practical approach for TVD research work as this is an LC approach. The goal of DSR has been established as developing credible and reliable knowledge to be used in design problem-solving solutions and as contributing significantly to the act and theory of the discipline in which it is applied; this is the justification for using design science as a research method (Brady et al., 2013; De Melo, 2015; Lukka, 2003).

March and Smith (1995) maintained that DSR has two main goals: developing artifacts that can address real-world issues and assessing the efficacy of the artifact (s) in use. Koskela (2008) states that construction management provides solutions to managerial problems; it argues that design science research is not about describing and explaining the nature of the world but about creating something new for it.

DSR was chosen for this study because it entails the creation and assessment of a solution offered to solve real-world issues, has practical value, and contributes to the theory of the subject in which it is used. According to Hevner (2007), encompasses three primary cycles in DSR:

1. The relevance cycle, in which the new artifact attempts to improve an environment's practices and where field testing is essential

2. The rigor cycle uses existing knowledge, skills, and artifacts in the application area to assure innovation beyond the known.

3. The core design cycle facilitates iterations in the design and assessment of the artifact until a satisfying product is obtained. As Figure 3.1 is illustrated the methodology used in the research, three main stages of this research are problem identification, solution development, results, and recommendation. A framework for evaluating, ranking, and analyzing data is also presented.

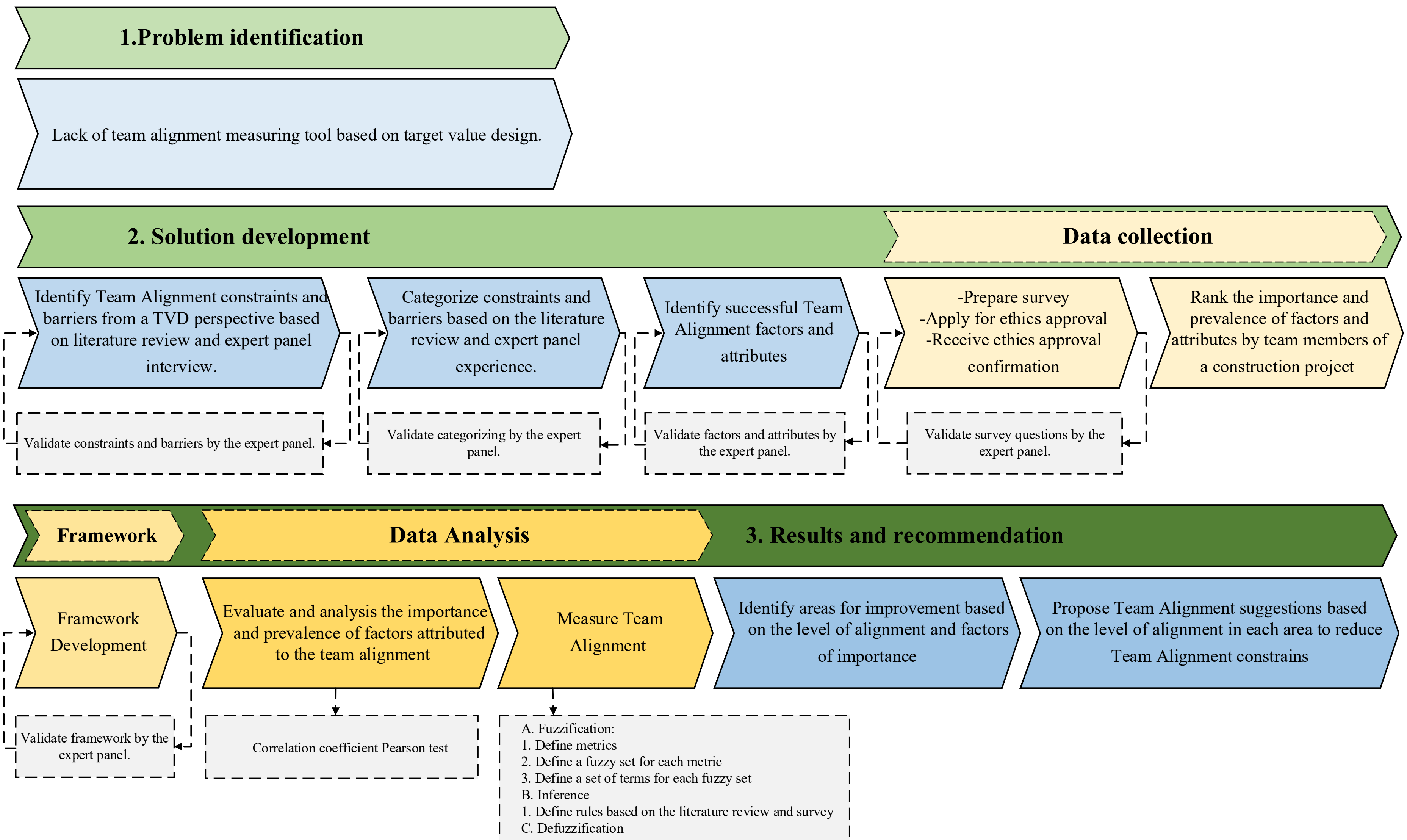


Figure 3.1: Research methodology

3.3 Problem Identification

Value alignment and team alignment are the cornerstones of TVD. Any problem and deficiencies in the catching value during steps of the project will lead to project failures. Hence, consistent evaluation of the team performance in TVD will help deliver value. DSR research methodology starts with problem identification which is the research motivation.

Interdisciplinary and multidisciplinary team alignment, directly and indirectly, affects target value design in IPD projects. From the target value design perspective, specific factors and conditions cause team alignment, and an aligned team has attributes. Knowing team alignment obstacles and drivers will help improve and prepare for future challenges. Based on the literature review, there is a need for a team alignment tool based on the target value design principles. Filling this gap by consistently assessing and measuring team alignment will help leaders identify the team's strengths and weaknesses.

3.4 Solution Development

Solution development consists of three parts. It starts with identifying team alignment constraints, barriers, factors, and attributes based on the TVD principles. The second part is developing a framework. The next step in solution development is data collection. The mentioned steps are explained in the following sections.

3.4.1 Team alignment challenges in IPD from a TVD perspective

The first step in filling a gap is to know it comprehensively and entirely from different aspects. In the solution development section, TA challenges are known based on the literature review and are verified by the expert panel. After based on the roots of the challenges, the author classified them into five categories: personal characteristics, training, leadership, culture, and environment. The second step is to know the factors that can cause TA and the attributes of the aligned team. Knowing the team alignment challenges helped to identify influential factors in team alignment and the attributes of the aligned team.

3.4.2 Identify successful team alignment factors and attributes in TVD

Factors contain the values, information, or conditions that promote team alignment. IPD team leaders may increase alignment by being aware of, evaluating, and spending time and money on enhancing the most important and impactful variables. Team alignment attributes are qualities or features considered part of the alignment. The difference between team alignment attributes and factors, is that factors cause and prepare the situation that team alignment promotes, while attributes are the features of the aligned team. Each team and project have its notion of alignment as it is a qualitative abstract term. A team that is aligned will be defined by its attributes. Based on the team and the project values, team leaders and members identify these qualities. These characteristics are multi-dimensional in the IPD project to satisfy the needs of the available cross-functional and multidisciplinary construction teams. This research has created a list of essential factors and attributes for successful team alignment based on the TVD principles from the literature. The inputs, factors, and attributes are validated by the team leader.

3.4.3 Data collection

The survey was prepared to rank the factors and attributes of team alignment in importance and prevalence by the project expert panel. The survey aims to validate and measure the importance (factors and attributes' value in team alignment) and prevalence (the existence of factors and attributes in the project's current situation) of team alignment factors and attributes. The difference between prevalence and importance is that the level of importance shows the factor and attribute priority and the team's expected value, while the prevalence is the current level of assessment of factors and attributes in the team project. In this context, importance can be more or less fixed value while prevalence can change regularly with each update or new assessment. Before sharing the survey, the writer applied for the University of Alberta ethics approval. The request is submitted and approved in Pro00119771 ID. After getting the ethics approval, an experienced manager in the construction field validated the survey questions. Survey participants have several years of experience implementing lean project management principles in IPD construction projects. 18 construction project team members out of 20 participated in the survey.

A Likert scale is a psychometric scale commonly used in surveys to measure participants' opinions. Respondents are asked to rate their levels of agreement with a proposition or set of statements (Bertram, 2007). A Likert scale is a non-comparative, one-dimensional technique to scaling. The Likert five-point scale used in the present study consist of 5 points, where 1 = Least prevalence or important, 2 = Less prevalence and important, 3 = prevalence and important, 4 = more prevalence and important and 5 = Most prevalence and important. In this research, the Likert scale is used for ranking factors and attributes by the expert panel in the validation part.

3.5 Results and Recommendations

The last step of DSR is results and recommendations that start with framework development, continue with data analysis and end with the team performance improvement proposal.

3.5.1 Framework development

The entire performance of a team is heavily influenced by team alignment. It increases comprehension of the end goals and explains the procedures and techniques used to achieve them, which improves human talent management performance. As a result, team members collaborate and communicate more openly, resulting in enhanced efficiency and production. An aligned team shares a shared vision, understands the values, and comprises individuals who know how to make the most of their talents. When people are aligned to do what must be done, things will get done much more quickly and easily (Ashcraft, 2011). This research tests the framework, implements the research methodology on data from the survey. The framework development is a creative process based on the existing scientific knowledge and practical experiences in construction projects. The framework is based on the relationship and correlation between factors, attributes, and team alignment. (Figure 3.2).

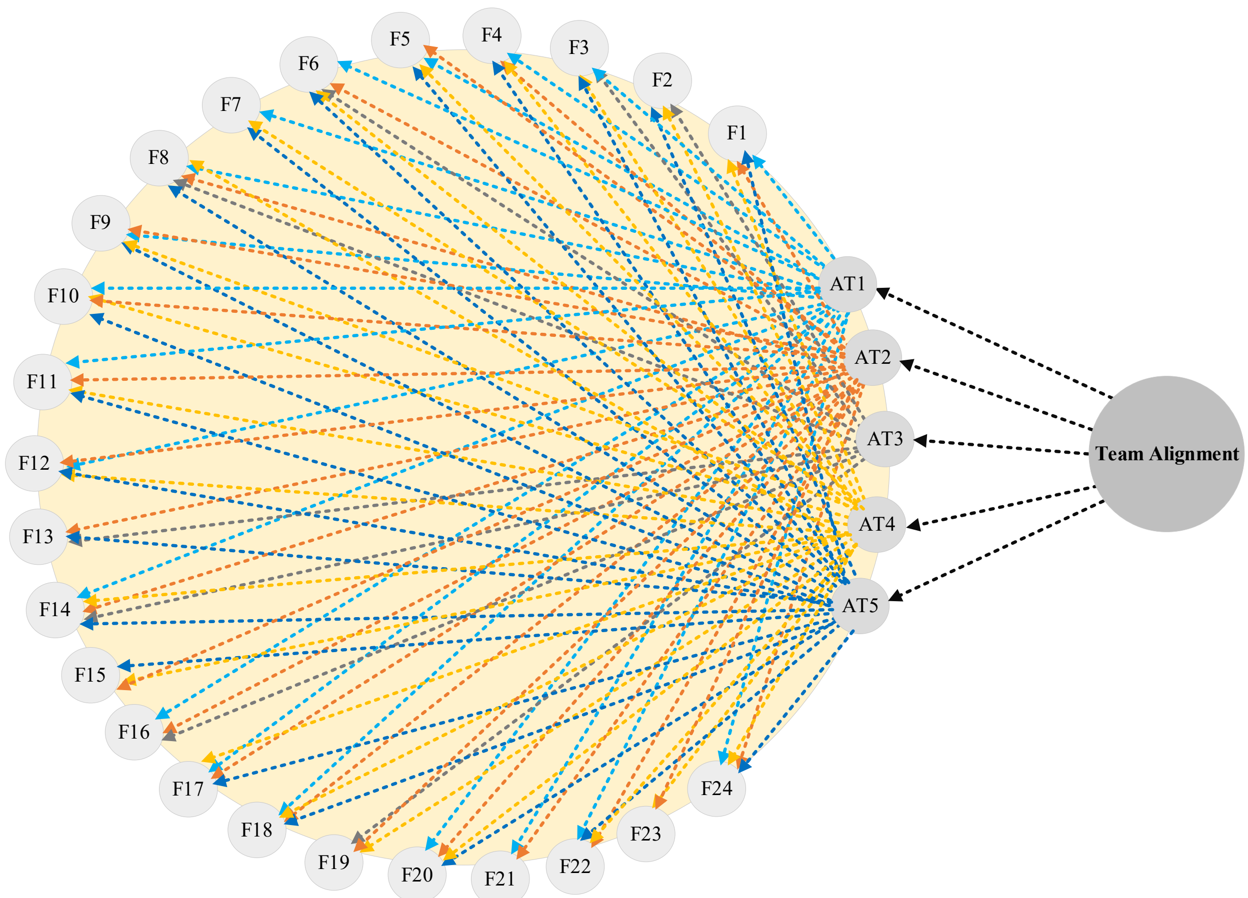


Figure 3.2: Research assumptions

3.5.2 Data analysis

Data collected from the survey (Appendix A) evaluate this study's proposed team alignment factors and attributes. According to the result, all participants have less than ten years of experience in construction projects; hence there is no need to consider work experience in data analysis. Factors' mean is calculated by $\overline{X} = \frac{\sum X}{N}$ formula which X is ranking value (1-5) for each factor and N is the number of participants.

A statistical measure of the linear correlation between two variables is the Pearson correlation coefficient. The covariance of two variables divided by the sum of their standard deviations is known as Pearson's correlation coefficient. A product-moment is the mean of the product of the mean-adjusted random variables (Rodgers & Nicewander, 1988). The following is the equation for calculating the Pearson correlation coefficient:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

where r = correlation coefficient,

X_i = values of the x-variable in a sample,

$\overline{X}$ = mean of the values of the x-variables,

y_i = values of the y-variable in a sample, and

$\overline{y}$ = mean of the values of the y-variable.

In this research, the direct and reverse relationships and correlations between factors and attributes are confirmed by the Pearson's test, the results of the correlation coefficient Pearson test showed that all the attributes and factors do not have positive values. Therefore, the author decided to ignore the degree of positive values because its intensity and weakness are not significant in this step.

3.5.3 Measuring team alignment

Team alignment is a subjective qualitative variable which cannot measure with quantitative methods. According to Nguyen, 1985, “Zadeh created the fuzzy set theory to describe the ambiguity that comes with human perception and subjective probability estimations.” This research uses fuzzy logic and fuzzy inferences systems (FISs) to model the relationships between factors and attributes to measure and assess team alignment.

The modelling approach employed in this study to predict the measure of team alignment is fuzzy logic. In construction research, fuzzy logic has become a standard modelling method. Fuzzy logic and fuzzy expert systems are becoming more common in situations where there is a shortage of dependable data (Knight et al., 2002). Fuzzy logic provides for the ranking or subjective grading of factors and facilitates the use of language variables such as “high experience” or “poor weather.”

Fuzzy systems are different forms of artificial intelligence (AI). AI is an area of computer science that deals with the automation of intelligent behaviour (Luger & Stubblefield, 1990). It is the art of making machines that can accomplish tasks that would need intelligence if done by humans (Kurzweil, 1990). AI is the automation of tasks associated with human thinking, such as learning and decision-making (Bellman, 1978). We employ AI to solve issues that are not amenable to algorithmic solutions and instead necessitate thinking and heuristic searches. Rather than depending solely on numerical approaches for situations including inexact, missing, or poorly defined information, capture and alter crucial qualitative elements. We also utilize it to get solutions that are neither accurate nor optimum but are “adequate” –heuristic problem-solving strategies when optimal or actual outcomes are too expensive or impossible to achieve: often used in the construction industry (Bellman, 1978, Kurzweil, 1990, Luger and Stubblefield, 1990).

An FIS is a computer-based system that simulates the inferring process of a human expert inside a specific domain of learning by using a collection of membership functions and rules to reason or reach a conclusion. It allows a non-expert in the field to benefit from the problem-solving abilities of experts.

The idea of a fuzzy set is the foundation of fuzzy logic. The fuzzy set theory was established to model complicated systems in unpredictable and imprecise situations. A fuzzy set is an extension of a set with items that may or may not belong. If *X* is the universe of discourse (input space), then a fuzzy set *A* in *X* is defined as a collection of ordered pairings.

$A= \{x, \mu_A(x) \mid x \in X\}$

In *A*, the membership function (μ_F) of *x* is termed $\mu_A(x)$. μ_F is a function that specifies how each element x in the input space is translated to a membership value (or degree of membership) that ranges from 0 to 1. An FIS is one of the most valuable methods offered within the domain of fuzzy set theory for dealing with nonlinear yet ill-defined mappings of input variables to certain output variables. FIS is a framework that replicates a system's behaviour as IF-THEN rules based on expert knowledge or previously known data. It applies fuzzy logic to translate a group of standard input variables into output variables. The component of an FIS is made up of five functional blocks, as follows (Kazeminezhad et al., 2005):

1. A fuzzification inference which converts the crisp inputs into the degree of match with linguistic values.
2. A rule base contains several fuzzy IF-THEN rules.
3. A database defines the fuzzy sets' membership functions used in the fuzzy rules.
4. A decision-making unit which performs the inference operations on the rules.
5. A defuzzification interface transforms the inference’s fuzzy results into a crisp output.

3.5.4 Identify improvement room

The degree of team alignment will measure on a percentage scale in FIS. The gap between team alignment and the maximum level of alignment is an opportunity for team alignment improvement. The difference between attribute importance and attribute prevalence represents room for improvement. As mentioned in the previous section, attributes' importance shows the team's expectation of attributes. In other words, the team expected this degree of attributes in the possible ideal situation. The attribute prevalence presents the degree of each attribute in the current situation. The difference between these two attributes shows that attributes can be improved to meet team expectations.

3.5.5 Propose team alignment suggestion

With the help of Pearson's test, each attribute's related factors will be recognized. Team leaders can select factors related to the attribute they need to enhance in each project step. With the help of test results, the most critical, effective, and impressive factors will be known. The test result is the analysis of team member's perception of the current and ideal situation of the team performance. The test result is trustworthy because it is not based on one-person judgment. Team members are the best judges in knowing the team's strengths and weaknesses.

Chapter 4: Solution development

To solve a problem, it must work to overcome obstacles and reach goals. The steps of solution development involve identifying the issue, organizing it using various kinds of representation, and seeking potential solutions, frequently including divergent thinking strategies.

4.1 Team alignment challenges in IPD from a TVD perspective

According to the previous studies and research in Lean construction, TVD's successful application is challenging (Oliva et al., 2016; Do et al., 2015; Antti, 2017; Miron et al., 2015; Emuze & Mathinya, 2016; Kron & Von der Haar, 2016; De Melo, 2014; Do et al., 2014; Jacomit et al., 2008; Ballard, 2006; Nanda et al., 2014; Koladiya, 2017). Some of these problems impacted team alignment, resulting in decreased team efficiency in value alignment, overcoming the natural desire to design and make decisions from a silo perspective. It is effortless to slip into old mindsets; the team requires extensive training to understand the TVD/IPD process; develop trust within the project environment; people outside the risk pool did not want to go to the big room meeting, and some people did not collaborate so well and ended up leaving the project are some of the barriers mentioned in the technical report 'The Application of Target Value Design in the Design and Construction of the UHS Temecula Valley Hospital' by Do et al., (2015). Conflicts of interest, mistrust, and prejudice were barriers to co-design. Some people left the project because they did not cooperate reasonably within the project, as Do et al. (2015b) reported.

Moreover, Do et al. (2015), and Tillman et al. (2017) refer to collaboration issues with non-risk pool consultants; they reported that people outside the risk pool were unwilling to come to the big room or coordinate meetings negatively impacted their ability to collaborate. The fishbone diagram presents root cause analysis, six main categories of challenges reported in the literature hinder team alignment in TVD implementation. The major groups include personal characteristics, training, management, culture, and environment.

4.1.1 Personal characteristic

When selecting team members, personality should be considered. Some people are not naturally collaborative (Benkler, 2011), while others dislike working in groups and would refuse to participate if given the opportunity (Robbins, 2011). Employees educated in command-and-control systems may struggle to adapt to team structures since they want to be told what to do or tell others what to do. They might not have the patience for IPD teams' more methodical methods. Corporate culture is widespread, and the impact of a team member's home roots on their performance in a collaborative team may be detrimental (Ashcraft, 2011).

4.1.2 Training

Training should occur at regular intervals during the project and should be used to supplement the team's self-evaluation and improvement activities (Hackman, 2011). Incomplete and inconsistent training has a negative impact as lack of training. Many team members, for example, have a faulty or inadequate knowledge of Lean principles. Team members should actively participate in project-related duties and training rather than lecturing on Lean practices. Such as pulling scheduling to a project phase, mapping the value stream of a complex process, reaching a collective choice using a structured decision method, or documenting a root cause analysis using a PDCA (plan, do, check and act) Cycle, A3 format (Ashcraft, 2011). Working together with the help of a skilled coach improves the team's baseline capacity while fostering the required relationships to work together—and, unlike "ropes course" bringing closer, the team generates something meaningful to them and the project (Ashcraft, 2011).

4.1.3 Leadership

In any long-term project, leaders should be evaluated for team performance by the team members (Ashcraft, 2011). Leaders who do not represent the project objectives must be counselled, improved, or replaced. Team leaders should analyze the team's early interactions in all circumstances to identify, train, and, if needed, remove those who are undermining team behaviour. Early monitoring and intervention are essential if the team leader has little influence over the team makeup. Also, Leadership encouragement recognizes the value of the team's effort and keeps them interested, even if results are not visible immediately.

Furthermore, the leader must not allow criticism to kill or hinder the sharing of valuable ideas before they can be fully developed and assessed. Great leaders, according to Collins, initiate change by getting together the right team before deciding where their businesses should go (Collins, 2001). One of the most critical choices a team leader can make is matching employees and assignments (Amabile, 1998). However, employees are frequently defined depending on who is available, a prevalent practice that should be vigorously opposed (Hackman, 2011).

4.1.4 Culture

The teams are made up of people from diverse firms with varied corporate cultures, management systems, and incentive packages. Because most workers operate in accordance with their company's culture, culture may have a significant impact on performance. In some instances, this helps to strengthen the team. In other cases, the differences in company cultures will hinder teamwork. Employees are forced to comply with contradicting norms if the project and business culture are not compatible. For example, if you cannot pick partner firms based on compatibility– and some IPD member firms are unlikely to have supportive cultures–you must devote more work to developing a project culture. Because team members will be stuck between two cultures, this will never be flawless, but it will be preferable to enable them to bring their diverse cultures into the same workplace. Transparent, compassionate, and ethical leadership creates trust among team members.

4.1.5 Environment

Employees’ effective performance will be influenced by a supportive atmosphere with proper tools, equipment, and supplies. Employee efficiency is also affected by favourable working environment, helpful coworkers, supportive work norms and procedures, sufficient knowledge to make job-related decisions, and appropriate time to accomplish an excellent job. There is a clear correlation between how people feel about their work's social sphere and their overall happiness. with Interrelationship, feedback, social benefits, and participation with coworkers outside of the workplace are all significantly associated with job satisfaction after accounting for work aspects. (Robbins, 2011).

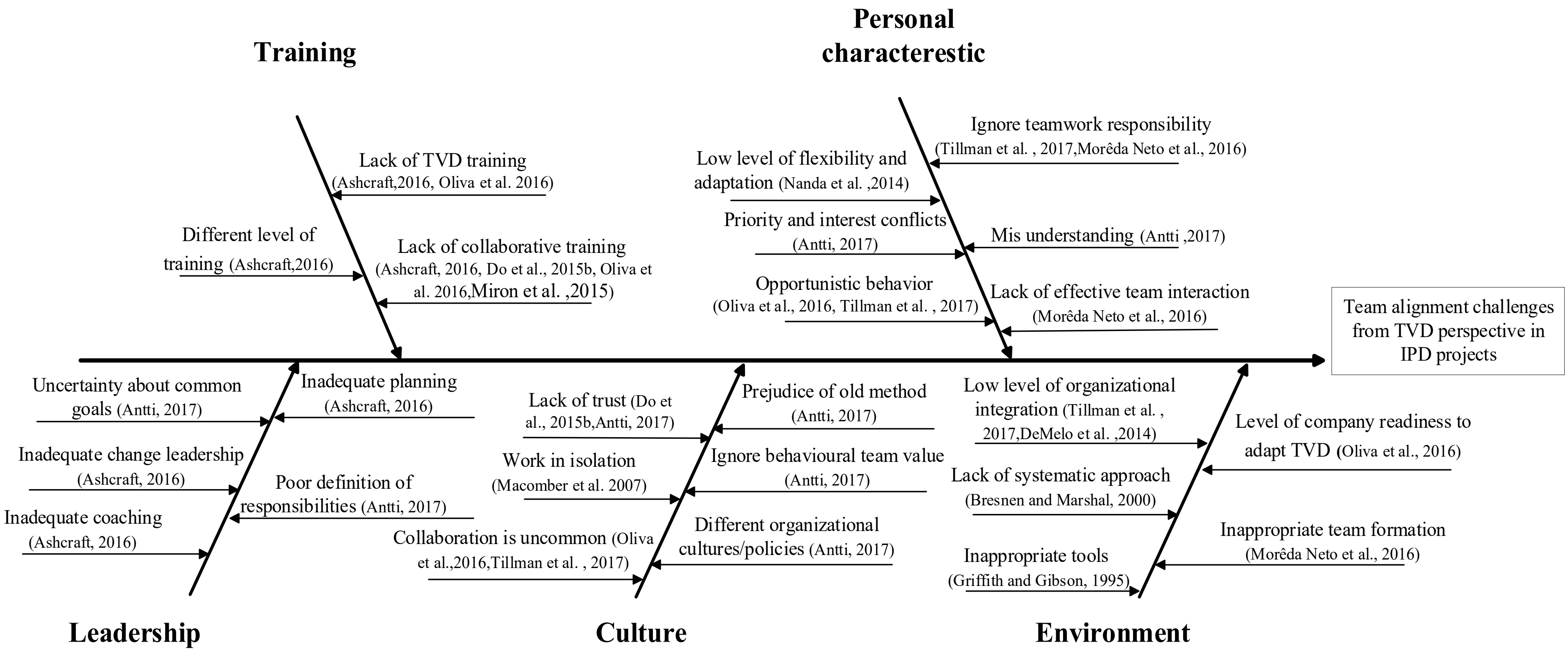


Figure 4.1: Team alignment challenges from TVD perspective in IPD projects

4.2 Identifying Successful Team Alignment Factors in TVD

Factors are circumstances, facts, or influences that contribute to team alignment. Knowing, assessing, and investing time and money in strengthening essential and most influential factors can help IPD team leaders increase alignment. The Researchers have compiled a list of critical factors from the literature that must be in place for successful team alignment in TVD. According to Antti (2017), equality, trust, similar interests and goals, structured support systems, and continuity, all of which might foster cooperation, are necessary for TVD to succeed.

Most research highlights collaboration and cooperation as success elements in TVD implementation, which positively impacts a positive impact on team alignment (Antti, 2017; Oliva et al., 2016; Kaushik et al., 2015). Multidisciplinary teams – a collaboration between departments - are required for team alignment success, according to Mendes and Machado (2012). To enable the successful operation of the techniques, certain conditions, including voluntary participation, managerial support, a good research team, and an experienced facilitator, must consider (Perera et al., 2003). Table 4.1 provides an overview of successful Team alignment factors in TVD.

Table 4.1: Successful Team alignment factors overview based on the literature review

Successful team alignment factors	References
Members with adequate skills in problem-solving and decision making	Do et al., 2014
Ability to Resolve conflict or Dispute resolution skills	Ashcraft, 2011 Katzenbach, 1993 Malaeb and Hamzeh, 2021 Robbins, 2010
Level of acceptance of constructive criticism (Ashcraft, 2011)	Ashcraft, 2011
Clear, honest, and open communication and negotiation	Katzenbach, 1993; Ashcraft, 2011, Robbins, 2010

Trust and a sense of safety	Robbins, 2010
Getting to know each other	Ashcraft, 2011, Malaeb and Hamzeh, 2021
Team members are motivated to work on the project.	
Conscientious members	Robbins, 2011
Focus and commitment on team behaviour and project value	Griffith, 2001, Malaeb and Hamzeh, 2021
Level of team education and knowledge in IPD, lean and TVD	Do et al., 2014
Methods of transfer and receiving knowledge	Ashcraft, 2011
The team trained in effective communication	Ashcraft, 2011
Adequate and equal accessibility resources of information and equipment	Griffith, 2001, Ashcraft, 2011, Malaeb and Hamzeh, 2021
Lean mentor or leader	Ashcraft, 2011, Malaeb and Hamzeh, 2021
Interdisciplinary and multidisciplinary members and team management	Ashcraft, 2011, Laurent et al., 2019, Malaeb and Hamzeh, 2021
Right team assembling	Amabile, 1998
Team strengths and weaknesses assessment	Do et al., 2014, Ashcraft, 2011
Clear definition of project scopes and values	Ashcraft, 2011, Griffith, 2001
Pain and gain sharing	Malaeb and Hamzeh, 2021
Risk and reward management	Malaeb and Hamzeh, 2021
Corporate and collaborative culture	Ashcraft, 2011, Malaeb and Hamzeh, 2021
Harmonious and respectful interpersonal relationship	Griffith, 2001, Malaeb and Hamzeh, 2021
Compatibility culture	Ashcraft, 2011, Malaeb and Hamzeh, 2021

Creativity and innovation incentive	Do et al., 2014
Enhance team culture by Co-location	Ashcraft, 2011, Malaeb and Hamzeh, 2021
Heterogeneous members (owner, builder, and designers)	Do et al., 2014
Number of team members (Team size)	Robbins, 2011
Stable team members	Hackman, 2011
Early involvement of key participants	Ashcraft, 2011, Malaeb and Hamzeh, 2021

4.2.1 Team alignment factors in TVD

This research presents 24 factors (Table 4.2) based on the literature review and expert panel verification. Factors are the variables that will affect team alignment, and attributes are the characteristics of an aligned team. These variables are extracted from a literature review and expert panel interview. They can change and update based on the company and IPD project value. Prevalence means the existence of factors and attributes in the project's current situation, and importance means the value of each factor and attribute.

Table 4.2: Research successful Team alignment proposed factors

No.	Factors descriptions
F1	Team members have good problem-solving and decision-making skills.
F2	Team members listen effectively and empathize with each other. They share constructive feedback transparently.
F3	Team members trust each other to speak up-phycological safety.
F4	The team learns about each other's past professional project collaboration experience.
F5	Team members are encouraged to work on the project.
F6	The team focuses on the project's goals and objectives.
F7	Team members are knowledgeable and are constantly trained to work on IPD projects and use Lean techniques and TVD.
F8	Team members benefit from training approaches and methods.

F9	Team members are trained in effective and frequent communication.
F10	Team leaders ensure that members have equal access to information, equipment, and technology.
F11	Lean mentors are available to guide and train team leaders.
F12	Team leaders collaborate with other cross-functional teams and provide cross-disciplinary expertise for successful communication.
F13	Leaders assign tasks that fit team members' strengths and capabilities.
F14	The team members’ strengths and weaknesses are regularly assessed by management.
F15	The project scope and value are clearly defined by team leaders and communicated visually.
F16	Leaders and team members know and understand the risks and rewards of the project on which they are working.
F17	A collaborative culture exists among team members.
F18	Members respect the teams’ diversity; accept and treat each other fairly and equally. Diversity, Equity, and Inclusion (DEI).
F19	Leaders and team members express and apply innovative ideas to projects.
F20	Team members attend face-to-face meetings in the big room.
F21	Members come from different educational and professional backgrounds.
F22	Leaders size their teams properly according to the project’s workload, size, and nature.
F23	Leaders and team members are satisfied with their collaboration and hope to continue it.
F24	Key participants are involved early in the project.

4.3 Identifying Successful Team Alignment Attributes in TVD

Team alignment attributes are characteristics or aspects considered to be a feature of the alignment. As team alignment is a qualitative abstract concept, each team and project have their definition of alignment. Attributes will clear the definition of an aligned team. Team leaders and members define these attributes based on team and project values. In the IPD project, these attributes are multi-dimensional to fulfill the desire of multidisciplinary and cross-functional construction teams of available teams and environments. Based on the literature review and expert panel dissections, the following attributes are chosen, and they will assess in this research:

Table 4.3: Successful Team alignment attributes

Attribute no.	Attribute description
AT1	Level of commitment to team and project value
AT2	Level of morale among team members
AT3	Ability to overcome challenges
AT4	Provide the right knowledge and information at the right time
AT5	Level of creativity

4.3 Proposing a Team Alignment Framework

The team alignment measuring framework (Figure 4.2) applies to all construction projects. It has three stages, gathering data, data analysis and recommendation. The framework can use as a regular team alignment assessment tool. The periodic results can be compared to monitor the performance of the team's strengths and weaknesses. Also, the results will help the project leaders to focus on particular factors and attribute improvement based on the project's needs.

4.3.1 Gathering data

Each construction project based on several features like function, number of team members, budget and time has its challenges from a TVD perspective. Identifying the project constraints and barriers to monitoring them in regular assessment is necessary. In addition, knowing the team alignment promoter factors and alignment characteristic is critical. Factors and attributes need to be confirmed by team members and team leaders. The next stage is preparing a survey based on the project team factors and attributes. The survey should rank all factors and attributes based on their prevalence and importance. The factor and attribute importance represent their value to the team members. The factors and attributes' prevalence represents the level of their existence.

4.3.2 Data analysis

Two methods are used in survey data analysis: FIS and Pearson's correlation coefficient test. With the help of attributes prevalence ranking results, the numerical value of team alignment can be measured in FIS. On the other hand, Pearson's test helps to identify the related factors to each attribute. The coefficient test result will help project leaders to identify factors to improve a critical attribute based on the project phase. For example, in the design phase, the level of creativity plays a crucial role in project success, so the assessment results will help project leaders to identify dependent factors to enhance creativity.

4.3.3 Recommendation

The data analysis result shows team members' performance based on the TVD. The different levels of attributes, importance, and prevalence, represent team strengths, weaknesses, opportunities, and threats. The improvement suggestions can be based on this value. The most critical attribute has the highest difference between importance and prevalence. Also, the difference value presents the team performance room for improvement. Each team in each phase of the project has recommendations based on the team performance and project phase requirements.

$$\textit{Attribute prevalence} - \textit{attribute importance} = \textit{room for improvement}$$

Factors related to the highest value of attribute prevalence and importance difference with the lowest level of prevalence are the most influential factors in team alignment improvement. Team leaders can create a considerable change in team alignment by improving these factors.

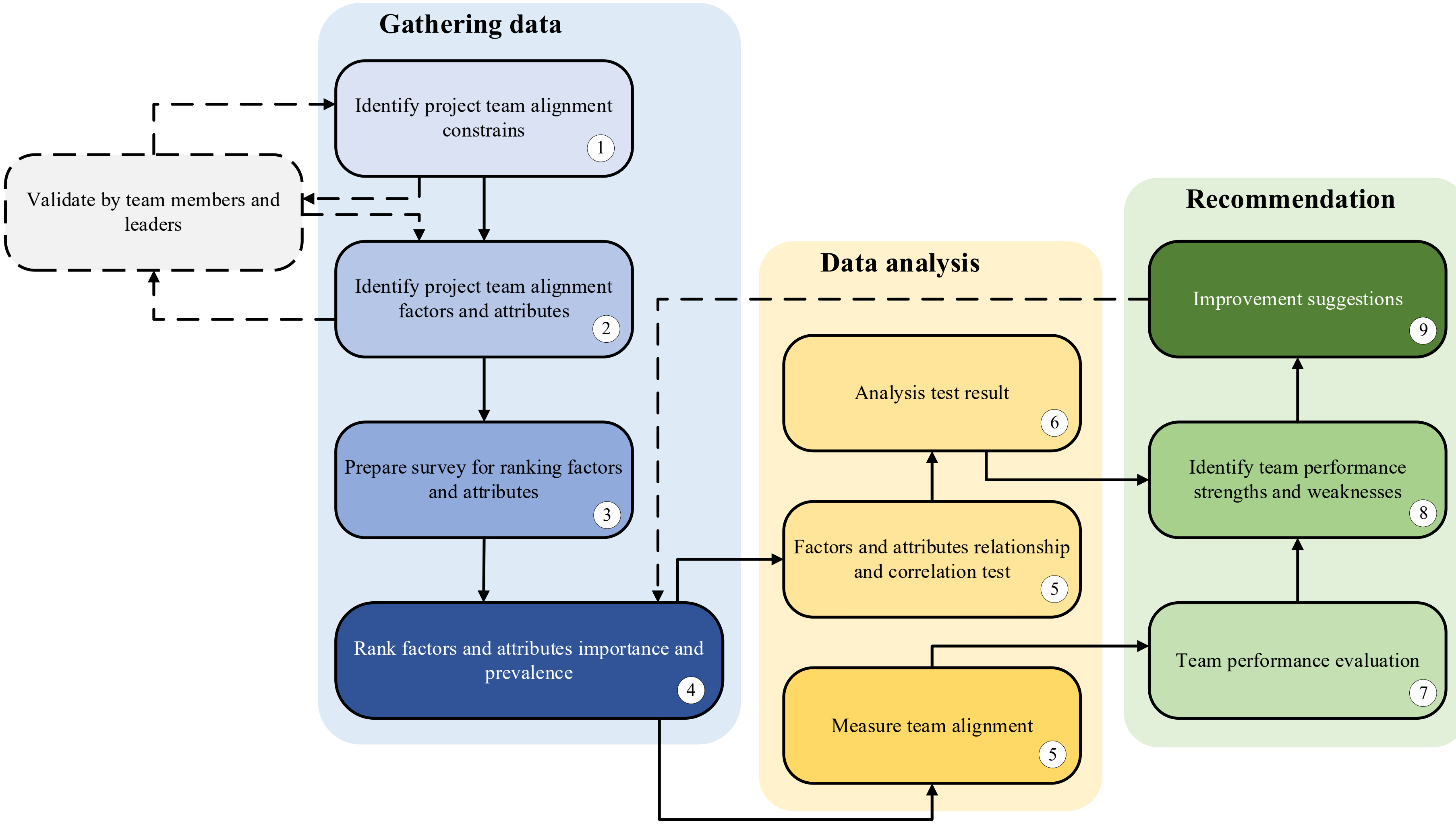


Figure 4.2: Team alignment measuring framework

Chapter 5: Application of Current Modelling Method on a Case Study Project

As shown in Figure 5.1, this study presents a technique for evaluating team effectiveness and monitoring team alignment on construction projects. This application aims to keep track of team members' performance and progression based on team, project, and company values. The technique can be used on construction projects, and influential factors and aligned team characteristics can be defined for each project based on the project value. It will assist team leaders in identifying the team's strengths and shortcomings and setting monthly and annual goals to improve team performance. This study evaluates the tool using a case study of an IPD project at a construction company. The three critical parts of the assessment process are preparing process inputs, the evaluation process, and the process outputs.

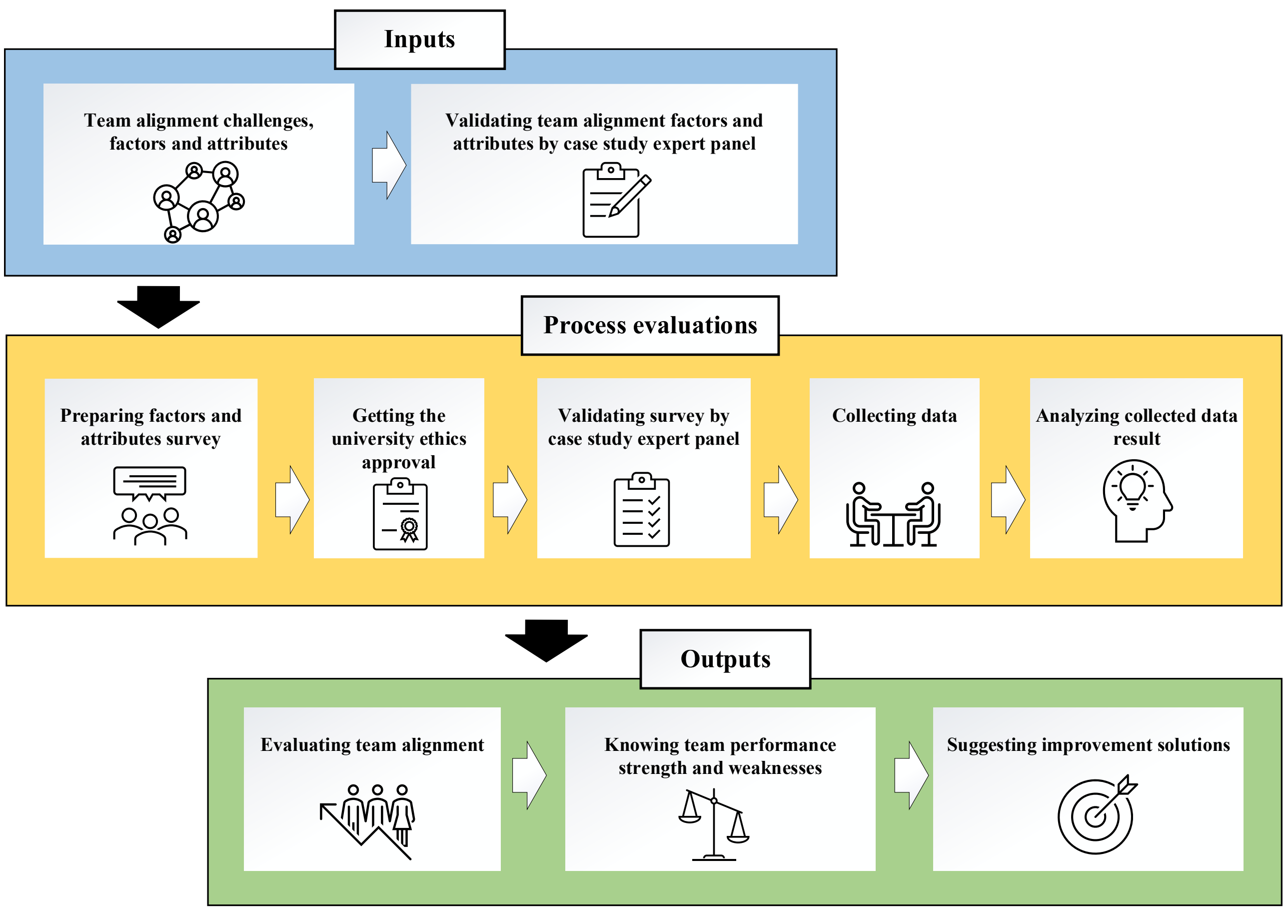


Figure 5.1: Team alignment measuring application process

5.1 Case Study Information

The project name and client are New Mechanical Wastewater Treatment Facility and city of Lloydminster. The project budget is $81,500,000 and is it still on budget and the project managers are tracking to complete the project at budget. (CHANDOS, 2022)

Figure 5.2: Mechanical Wastewater Treatment Facility of Lloydminster (CHANDOS, 2022)

As of July 1, 2017, Lloydminster must build a new wastewater treatment plant to meet Canadian environmental effluent water quality standards. The facility cannot be modified to comply with current federal and provincial rules since the wastewater treatment system was set up more than 30 years ago. The project finish date is mandated by Environment and Climate change

Canada on December 1, 2023. The project is municipal wastewater treatment facility with an Average Daily Demand (capacity) of 42,000 m3/day treatment comprised of: two course screens, influent pump station, three primary clarifiers, two fine screens, intermediate pump station, three bioreactors, six membranes, sludge digestion lagoon, two stormwater management lagoons and an effluent pump station. (CHANDOS, 2022)

Figure 5.3: Mechanical Wastewater Treatment Facility of Lloydminster (CHANDOS, 2022)

As chosen project vendors gathered to become familiar with the IPD approach and establish the project management team (PMT) in January 2020, planning for the new facility officially started in earnest (PMT). Not only for the present and future generations of Lloydminster, but also the downstream cities, towns, villages, and Indigenous communities that depend on the North Saskatchewan River for drinkable water and recreation, the construction of a new facility will have significant social and environmental benefits. (CHANDOS, 2022)

5.2 Preparing Process Inputs

The evaluation application inputs are factors (Table 4.2), attributes (Table 4.3), and discussed in Chapters 4 and 5. A set of interviews with an expert in this field was conducted to ensure that the mentioned factors and attributes (variables) are the reasons and results for team alignment in the construction projects. The participant was asked to evaluate and add variables. The general factors and attributes used for evaluating team alignment based on TVD in the construction project have been selected. The TA will evaluate by the framework based on the meaningful relationships and correlations between factors and attributes and meaningful relationships and correlations between attributes and team alignment, which is a measurable variable.

5.3 Process Evaluations

The evaluation process has five steps, preparing factors and attributes survey, validating survey by case study expert panel, getting university ethics approval, collecting data, and analyzing collected data result.

5.3.1 Validating factors and attributes survey

A survey (Appendix A) is prepared according to the approved variables. Each statement in the survey is related to one factor or attribute, the total numbers of statements are 29. Statements are ranked based on their prevalence and importance on the Likert scale by the case study project team members. As it is explained in Chapter 3, the term "prevalence" refers to factors and attributes in the project's present state, while "importance" refers to the value of each factor and attribute.

5.3.2 Getting the university ethics approval

The author requested ethics approval from the University of Alberta before disseminating the survey. For research involving human subjects as well as study, teaching, and testing involving animals, the Research Ethical Office oversees every aspect of the ethics assessment and approval process. The request is filed with the Pro00119771 ID, and it is approved.

5.3.3 Validating survey by case study expert panel

After getting the ethics approval, the survey questions and statements presented to the case study project manager. He has suggested minor edits based on his experiences and after several online meetings he validated the survey questions.

5.3.4 Collecting data

Survey participants have several years of experience implementing lean project management principles in IPD construction projects. 18 team members of the New Mechanical Wastewater Treatment Facility city of Lloydminster project out of 20 participated in the survey. All the participants have less than 10 years' experience in IPD projects.

5.3.5 Analyzing survey result

Data collected from the survey (Appendix A) evaluate this study's proposed team alignment factors and attributes. According to the result, all participants have less than ten years of experience in IPD construction projects; hence there is no need to consider work experience in data analysis. Factors' mean is calculated by $\overline{X} = \frac{\sum X}{N}$ formula which X is ranking value (1-5) for each factor and N is the number of participants. The comparison of factors' Mean importance and prevalence is shown in Figure 5.4.

The Figure shows that all factors' importance is ranked as more and the most important factors by the expert panel, demonstrating the literature review results in knowing influential factors of team alignment in TVD.

Factors 14 and 20 (the team members' strengths and weaknesses are regularly assessed by management, and team members attend face-to-face meetings in the big room) have the most negligible prevalence value in the team's current situation among all factors. Factor 5 and 3 (Members respect the teams' diversity; accept and treat each other fairly and equally. Diversity, Equity, and Inclusion (DEI)) has the highest prevalence value. Also, comparing these two different perspectives presents that all factors' importance is higher than their prevalence or the difference is negligible.

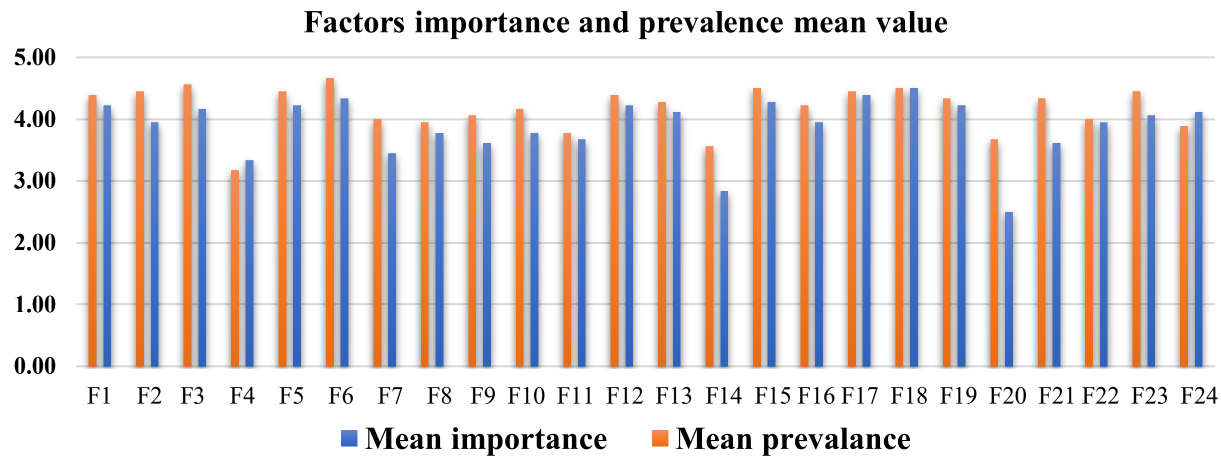


Figure 5.4: Comparison factors importance and prevalence ranking result

The standard deviation is a measure of the amount of variation or dispersion of a set of values. A low standard deviation indicates that the values tend to be close to the mean (also called the expected value) of the set, while a high standard deviation indicates that the values are spread out over a wider range (Bland, 1996). Figure 5.5 presents factors importance and prevalence standard deviation.

σ = population standard deviation

N = the size of the population

X_i = each value from the population

μ = the population mean

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$$

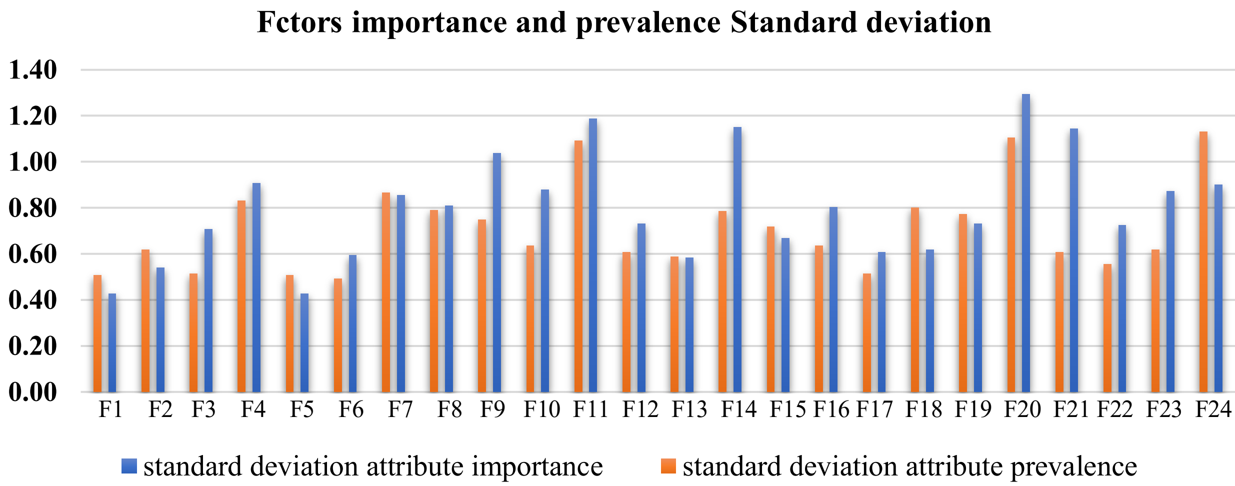


Figure 5.5: Factors importance and prevalence Standard deviation

The comparison of attributes' Mean importance and prevalence is depicted in Figure 5.6. The Figure shows that all attributes' importance is ranked as the most critical attributes except attribute five (level of creativity), which is ranked as more important by the expert panel, illustrating the literature review results in knowing the aligned team attributes in TVD. The mean difference between all attributes' importance and prevalence is less than 0.2 except for attribute four (Provide the right knowledge and information at the right time) which is 0.39.

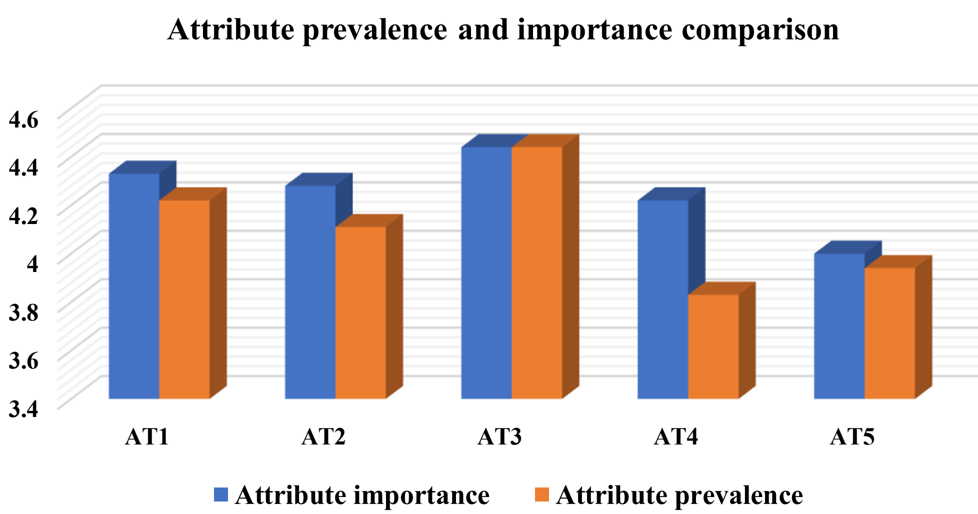


Figure 5.6: Comparison attributes importance and prevalence ranking result

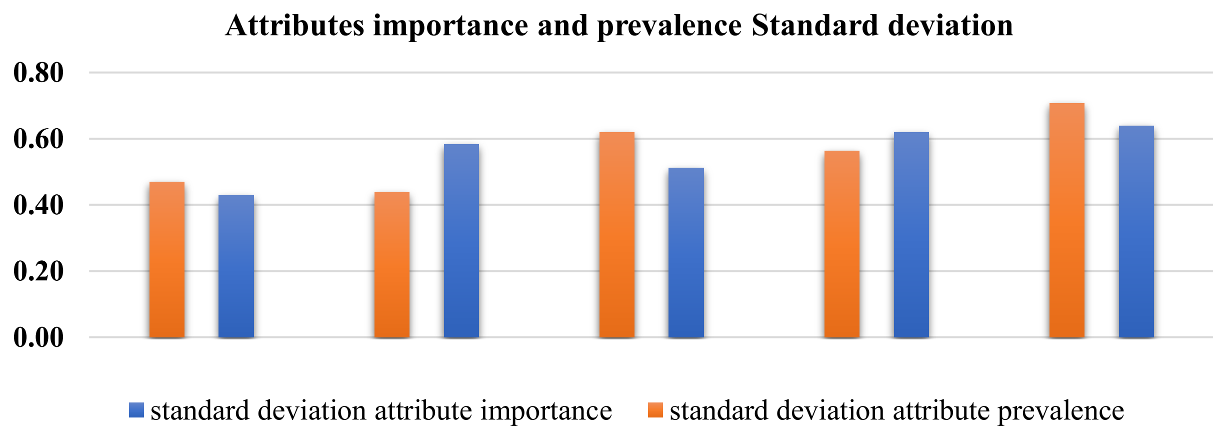


Figure 5.7: Attributes' importance and prevalence Standard deviation

Figure 5.7 presents attributes' importance and prevalence standard deviation. All the standard deviation values are between 0.40-0.8.

Table 5.1 presents the correlation coefficient Pearson test on survey results. While positive correlation improve attribute, the negative contribution on the team alignment. The positive value indicates the positive effect of a factor in the attribute prevalence, while the negative value indicates the factor that needs improvement. In other words, the negative value of factors presents that factor's critical situation, which decreases the team alignment measure. For example, F5, which is team members are encouraged to work on the project, has negative value in AT1 (Level of morale among team members), AT2 (Ability to overcome challenges) and AT3 (Provide the proper knowledge and information at the right time) which cause to decrease team alignment measure. If team members and leaders work on the F5, team alignment will improve significantly. The most critical factors (red color) are factors five and 20 (Team members are encouraged to work on the project and team members attend face-to-face meetings in the big room) with three negative correlations, which negatively affect the value of attributes. The most influential factors are 1, 6, 7, 8, 10, 13, 17, 18, 21 and 22 (green color), which are mentioned in Table 5.1.

Table 5.1: Correlation coefficient Pearson test results for survey data for factors and attributes

	AT1	AT2	AT3	AT4	AT5
F1	0.357	0.131	0.598	0.148	0.048
F2	0.057	-0.166	0.095	-0.029	0.332
F3	0.454	0.381	0.271	0.471	-0.108
F4	-0.051	-0.185	0.296	0.419	0.237
F5	0.036	-0.341	-0.209	-0.074	0.263
F6	0.154	0.057	0.452	0.160	0.207
F7	0.036	0.131	0.194	0.037	0.478
F8	0.491	0.055	0.395	0.039	0.544
F9	-0.059	-0.022	0.012	0.168	0.498
F10	0.296	0.396	0.626	0.253	0.291
F11	-0.077	-0.028	0.258	0.000	0.594
F12	0.209	0.490	0.664	0.087	-0.098
F13	0.367	0.308	0.417	0.054	0.018
F14	-0.040	0.292	0.133	0.455	0.467
F15	-0.023	0.369	0.478	0.261	0.176
F16	0.724	0.391	0.207	0.099	-0.006
F17	0.327	0.203	0.547	0.562	0.362
F18	0.445	0.326	0.558	0.231	0.074
F19	0.021	0.077	0.506	-0.173	0.531
F20	-0.212	0.000	-0.267	0.184	0.462
F21	0.187	0.333	0.112	0.402	0.290
F22	0.232	0.155	0.546	0.634	0.120
F23	0.123	0.218	0.601	0.236	-0.100
F24	-0.373	-0.249	0.142	0.352	0.318

* Red color indicates critical factors, yellow color indicates less critical factors, light green indicates influential factors and dark green color indicates the most influential factors.

Table 5.2: Survey results of Positive correlation results for factors and attributes

RELATED FACTORS	ATTRIBUTES				
	AT1	AT2	AT3	AT4	AT5
1	x	x	x	x	x
2	x		x		x
3	x	x	x	x	
4			x	x	x
5	x				x
6	x	x	x	x	x
7	x	x	x	x	x
8	x	x	x	x	x
9			x	x	x
10	x	x	x	x	x
11			x	x	x
12	x	x	x	x	
13	x	x	x	x	x
14		x	x	x	x
15		x	x	x	x
16	x	x	x	x	
17		x	x	x	x
18	x	x	x	x	x
19	x	x	x		x
20				x	x
21	x	x	x	x	x
22	x	x	x	x	x
23	x	x	x	x	
24	x		x	x	x

Table 5.2 presents each attribute's positive factors, which means the attribute will enhance by improving the related factors and will have considerable change if the negative factors improve.

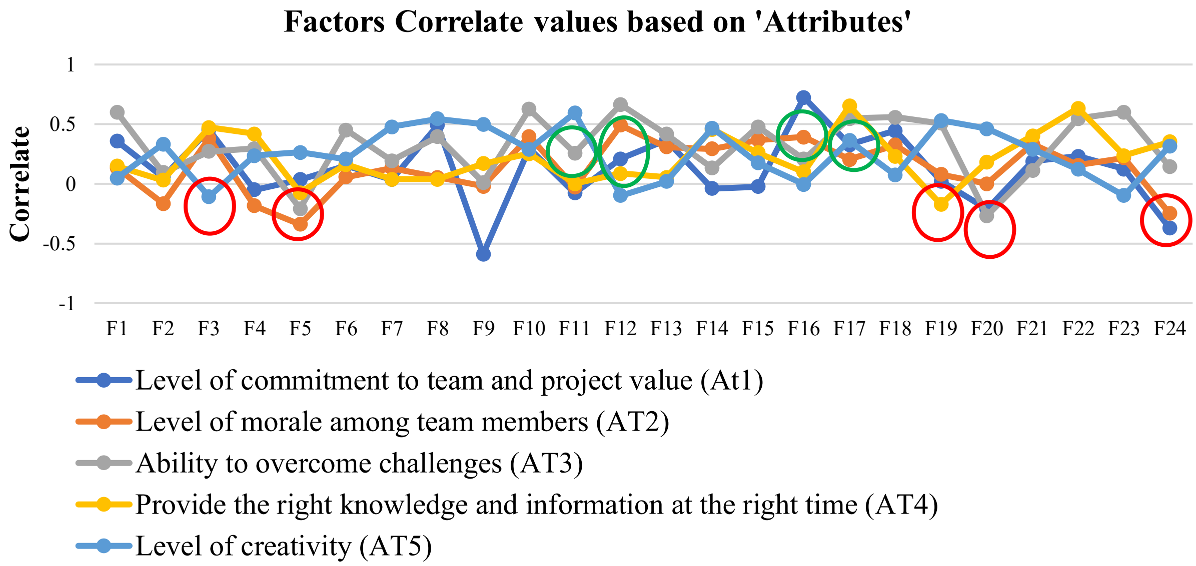


Figure 5.8: Factors correlate values based on attributes for survey result

Figure 5.8 compares different correlation values for each attribute based on the factors. Figure 5.9 presents and mentions the most influential factors in the increase and decrease of each attribute.

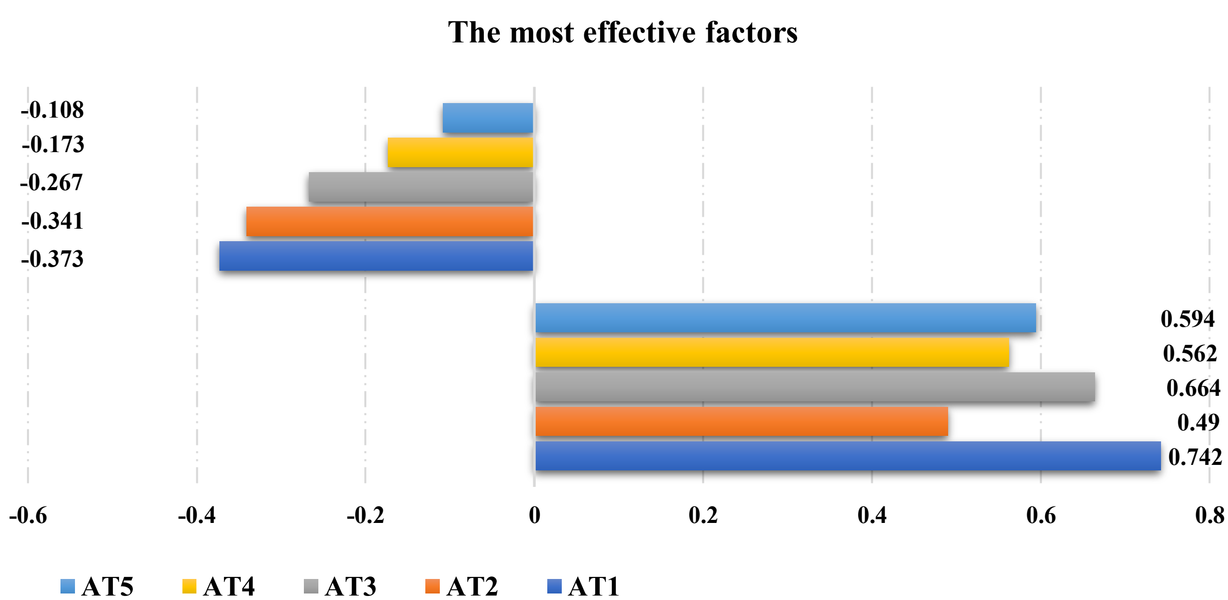


Figure 5.9: The most effective factors with positive and negative coefficient correlation Pearson test result of survey result based on attributes

5.4 Process Output

The process output phase has three steps: team alignment evaluation, knowing team alignment strengths and weaknesses and improvement suggestions. The ranking and correlation coefficient Pearson tests result are used in these steps.

5.4.1 Team alignment evaluation

As mentioned, aligned team attributes are characteristics or aspects that are components of the alignment. Each construction project team can change, moderate, or adjust more accurate attributes based on the team, company, and project values. Table 5.3 contains the data collection results for ranking TA attributes by expert panels on the Likert scale. The expert panels ranked AT1, AT2 and AT3 as the most prevalent and AT4 and AT5 as prevalent and more prevalent attributes in the team project.

Table 5.3: Attributes mean value ranking result

	ATTRIBUTE	MEAN VALUE
AT1	Level of commitment to team and project value	4.22
AT2	Level of morale among team members	4.11
AT3	Ability to overcome challenges	4.44
AT4	Provide the right knowledge and information at the right time	3.83
AT5	Level of creativity	3.94
TOTAL ATTRIBUTE MEAN		4.10

The fuzzy Inference system is used to measure team alignment; this method measures subjective variables collected from experts. This method is used to measure the team alignment in the case study with the help of survey results and the Mean value of 18 participants for each attribute in MATLAB software. The measuring process has three steps: fuzzification, inference, and defuzzification. In fuzzification step five inputs (attributes) with five MFs (according to the Likert scale, the least prevalence, less prevalence, prevalence, more prevalence and the most prevalence) and one output (team alignment) with ten MFs defined. The degree of team alignment will measure in the percentage scale. This section will explain the three-step process: fuzzification, defining rules and defuzzification. In MATLAB software, FUZZY and the fuzzy logic designer will pop up in the command window. In the edit tab, add the variable section, five input variables, five attributes, and one output variable, team alignment (Figure 5.10). For input variables, the defuzzification type is the centroid. For each attribute in membership functions (MFs), the editor window five MFs (based on the Likert scale most prevalence to least prevalence) in the "trimf" type chosen. The range number should also adjust [1 5] (Figure 5.11).

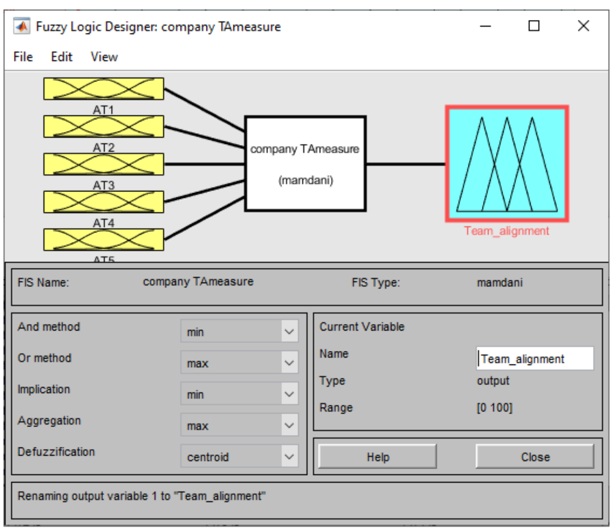


Figure 5.10: Fuzzy logic design window in MATLAB software

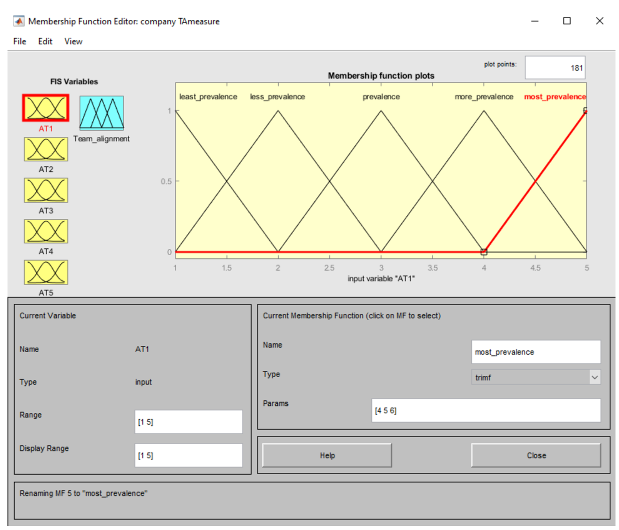


Figure 5.11: Membership function window in MATLAB software

Following is the example of input explanation:

```
[Input1]
Name='AT1'
Range= [1 5]
```

```
NumMFs=5
MF1='least_Pre':'trimf’, [0 1 2]
MF2='less_pre':'trimf’, [1 2 3]
MF3='Pre':'trimf’, [2 3 4]
MF4='More-Pre':'trimf’, [3 4 5]
MF5='Most-Pre':'trimf’, [4 5 5]
```

In the membership functions (MFs) editor window, five MFs in the “trimf” type chose for the output variable. The rang number should also adjust [1 100] because the team alignment value should measure on a percentage scale, and the defuzzification type is the centroid. Following is the example of output explanation:

```
[Output1]
Name='Team_Alignment'
Range= [0 100]
NumMFs=5
MF1='mf1':'trimf’, [-25 -2.22e-16 25]
MF2='mf2':'trimf’, [0 25 50]
MF3='mf3':'trimf’, [25 50 75]
MF4='mf4':'trimf’, [50 75 100]
MF5='mf5':'trimf’, [75 100 125]
```

The second step is defining rules in the rule editor window, rules define based on the mean value of each attribute data will test all output values. For example, if an attribute value is 3.5 three rules defines based on the three neighborhood values which are 3, 3.5 and 4.

```
[Rules]
3 3 4 4 3, 4 (1): 1
3 3 4 4 3, 3 (1): 1
3 3 3 3 3, 3 (1): 1
3 3 3 3 3, 4 (1): 1
4 3 4 4 3, 4 (1): 1
4 3 4 4 3, 3 (1): 1
4 3 4 3 3, 3 (1): 1
4 3 3 4 3, 4 (1): 1
```

```
4 3 3 4 3, 3 (1): 1
3 3 3 3 3, 3 (1): 1
3 3 3 3 3, 4 (1): 1
3 3 3 3 4, 4 (1): 1
3 3 3 3 4, 3 (1): 1
3 3 3 3 3, 4 (1): 1
3 3 3 3 3, 3 (1): 1
3 3 4 3 3, 4 (1): 1
```

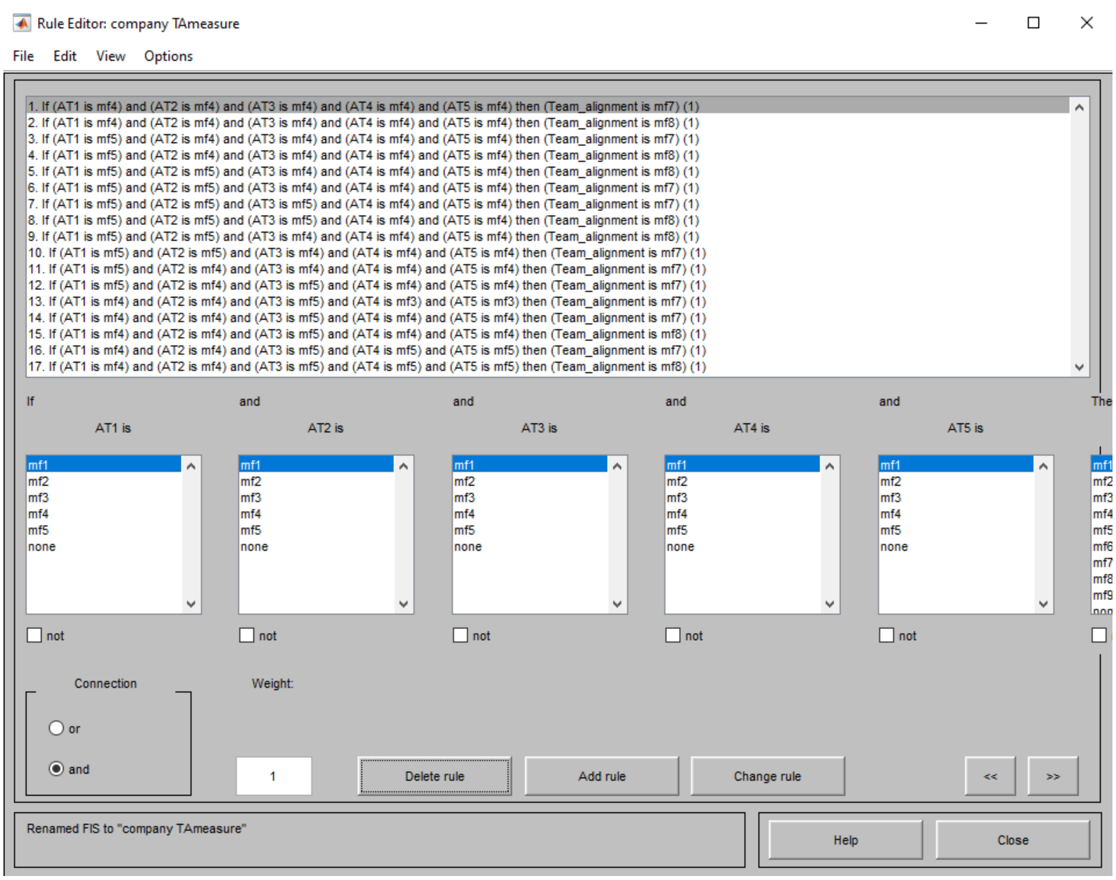


Figure 5.12: Rule editor window MATLAB software

For example: IF level of commitment to team and project value is the most prevalent and,

IF level of morale among team members is the most prevalent and,

IF ability to overcome challenges is the most prevalent and,

IF provides the right knowledge and information at the right time is more prevalent and, IF the level of creativity is more prevalent, THEN team alignment will be 3. (Figure 5.12)

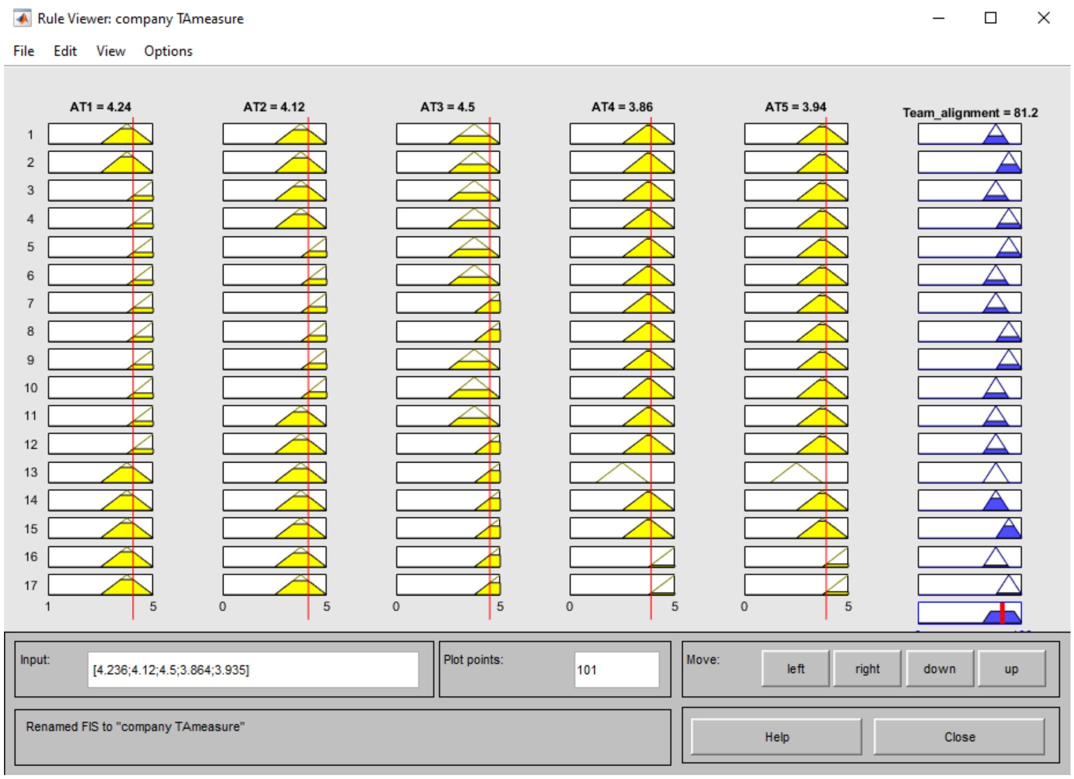


Figure 5.13: Rule viewer window in MATLAB software

The actual attribute value can adjust in the rule viewer window. The rule viewer window's red line presents each attribute's mean value. (Figure 5.13) After adjusting the actual attribute value in the rule viewer window to the mean value for each attribute, the team alignment measure will be **81.2** percent in the last step. The team is well-aligned, but there is room for improvement. This number indicates that the case study team members have met 81.2 percent of their target value to becoming aligned. This number varies from one project to another based on the attribute importance team members define by their own ranking. If team members set the target value too low, this will not help them to improve team performance, and this framework will not be helpful for them. If team members rank the team alignment attributes importance too low, this means that team members probably need more training on lean concepts, target value delivery, and team alignment.

5.4.2 Identifying TA strengths and weaknesses

The team alignment measurement tool assesses team performance based on ranked attributes by the expert panel. It helps construction companies' leaders know team members' strengths and weaknesses by root cause analysis, which is the low ranked and low coefficient correlation test results. Regular team project monitoring weaknesses will help team leaders prevent project failure and increase team efficiency. The team project ranked TA factors and attributes based on their prevalence and importance; the first significant output of this evaluation is to monitor team alignment and team progression by TA value. Based on the project phase, the team's top priority attributes are changed, which is the second important outcome that can be concluded from the important result. Attributes' importance and prevalence comparison will show team strengths and weaknesses. If attributes' prevalence value is as important as its importance (the difference will be zero), team members' effort is based on the team project priority.

Table 5.4: Team alignment attribute importance and prevalence comparison

	AT1	AT2	AT3	AT4	AT5
Attribute importance	4.33	4.28	4.44	4.22	4.00
Attribute prevalence	4.22	4.11	4.44	3.83	3.94
Difference	0.11	0.17	0	0.39	0.06

For example, the case study's significant ranking results show (Table 5.4) that AT3 is the top priority attribute. AT3 importance and prevalence value are also the same, representing team strength; meaning team members performed based on the team's priority. The results of the importance and prevalence comparisons show that the attributes' prevalence for AT1, AT2, AT4 and AT5 are lower than importance. Team members' weaknesses are not to perform based on the team priority. The difference amount of attribute importance and prevalence represents team improvement criteria. AT4, Providing the right knowledge and information at the right time, is the most critical attribute based on the difference value, and AT5, Level of creativity, is the least critical attribute.

According to the data collection results, team members admitted that the ability to overcome challenges is the most prevalent attribute. This attribute affected by F1, F2, F3, F4, F6, F7, F8, F9, F10, F11, F12, F13, F14, F15, F16, F17, F18, F19, F21, F22, F23 and F24. Among these factors first five with the highest value of correlation coefficient (which means improving them will increase AT3 and consequently team alignment) are team leaders collaborate with other cross-functional teams and provide cross-disciplinary expertise for successful communication, team leaders ensure that members have equal access to information, equipment, and technology, leaders and team members are satisfied with their collaboration and hope to continue it, team members have good problem-solving and decision-making skills and members respect the teams' diversity; accept and treat each other fairly and equally (DEI). Two last mentioned factors also have the highest-ranking mean value.

The least prevalent attribute is AT4, providing the right knowledge and information at the right time in the team alignment. Knowing the factors with negative correlation coefficient results will help control and lessen the negative effect on this attribute. Because these factors' improvement will decrease the attribute prevalence. Factors with the lowest value of correlation coefficient results are F19, F5 and F2 which are leaders and team members express and apply innovative ideas to projects, team members are encouraged to work on the project and Team members listen effectively and empathize with each other. They share constructive feedback transparently.

5.4.3 Improvement suggestions

In each phase of the construction project, the IPD team requires specific attributes to be more aligned because of the team, project, and company values. For example, team creativity plays a crucial role in construction projects compared to other attributes in the design phase. In this regard, this section's suggestions are based on the case study team's current situation, priority, and level of alignment. The importance of ranking results and their comparison to prevalence rate in each project phase will help the project leaders know critical attributes, related factors, and potential team alignment for improvement. The SWOT analysis of the Figure 5.9 which is the difference value of attribute importance and prevalence is presented in Table 5.5.

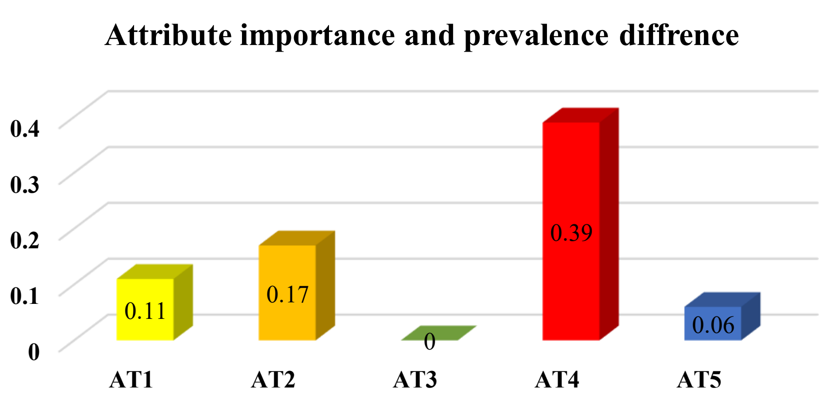


Figure 5.14: Attribute importance and prevalence difference

Table 5.5: Comparing the mean value of attributes important and prevalence

	Strengths	Weaknesses	Opportunities	Threats
Comparison results	AT3 mean importance is as much as its prevalence	AT1, AT2, AT4 and AT5 prevalence mean value is lower than the importance mean value	The gaps between attributes mean importance and prevalence.	AT4 has the greatest value of difference between importance and prevalence.
Consequences, effect and required actions	The team members are successful in adjusting their efforts to their priority. Improving AT3 does not affect team alignment measure.	The difference will affect the value of team alignment	Knowing and improving factors related to top priority attribute with positive efficiency test's result	Team concentrates on this attribute
	-Team members should consider AT3 related factors with positive coefficient test's result -Avoid improving the factors with negative coefficient test's result	Team members should improve factors with highest positive correlation coefficient results	Knowing and improving factors related to top priority attribute with positive efficiency test's result	Team members should improve factors with highest positive correlation coefficient results

Low prevalence ranked attributes will decrease team alignment measurement while high ranked attributes will increase it. One way to improve the team performance is to improve factors with the positive correlation coefficient Pearson test with low ranked attributes. Figure 5.10 presents the case study's factors and attributes with the positive correlation coefficient Pearson test result.

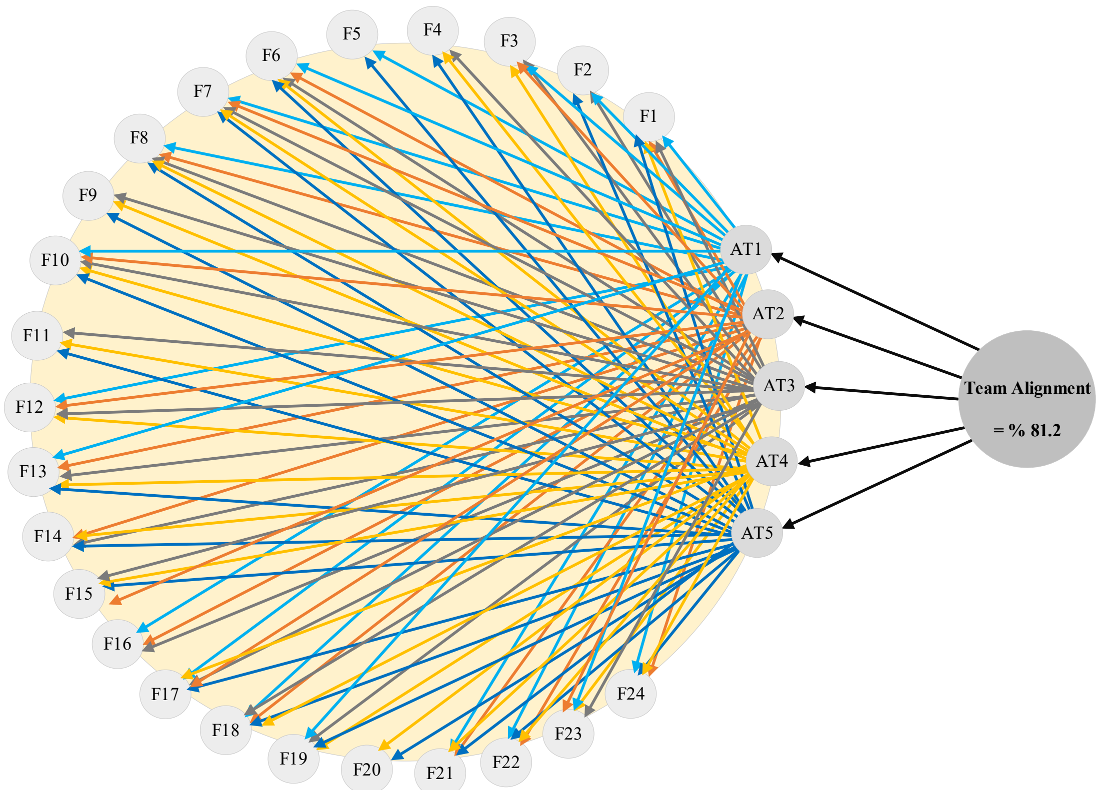


Figure 5.15: Case study's factors and attributes with the positive correlation coefficient Pearson test result and team alignment percentage

According to the expert panel ranking result, the least prevalent attribute in TA is providing the right knowledge and information at the right time. Table 5.6 presents attributes from the most critical to the least critical and their five most effective factors with high correlation results value, improving team alignment based on the team priority. The psychological safety factor is the most repeated high correlation value meaning trust is the prerequisite for building functional relationships among team members. Knowing and understanding the risks and rewards of the project and training are the second most repeated factors. To observe significant changes in team performance, the writer suggests team start from the most repeated factors to improve.

Table 5.6: The most critical attributes and related factors

ATTRIBUTE		FACTORS		PEARSON TEST RESULT
AT4 =0.39	**provide the right knowledge and information at the right time**	F22	Leaders size their teams properly according to the project's workload, size, and nature.	0.634
		F17	A collaborative culture exists among team members.	0.562
		F3	Team members trust each other to speak up-psychological safety.	0.471
		F14	The team members' strengths and weaknesses are regularly assessed by management.	0.455
		F4	The team learns about each other's past professional project collaboration experience.	0.419
AT2 =0.17	**Level of morale among team members**	F12	Team leaders collaborate with other cross-functional teams and provide cross-disciplinary expertise for successful communication.	0.490
		F10	Team leaders ensure that members have equal access to information, equipment, and technology.	0.396
		F16	Leaders and team members know and understand the risks and rewards of the project they are working on.	0.391

		F3	Team members trust each other to speak up-phycological safety.	0.381
		F15	The project scope and value are clearly defined by team leaders and communicated visually.	0.369
AT1 =0.11	**Level of commitment to team and project value**	F16	Leaders and team members know and understand the risks and rewards of the project on which they are working.	0.724
		F8	Team members benefit from training approaches and methods.	0.491
		F3	Team members trust each other to speak up-phycological safety.	0.454
		F18	Members respect the teams' diversity; accept and treat each other fairly and equally. Diversity, Equity, and Inclusion (DEI).	0.445
		F13	Leaders assign tasks that fit team members' strengths and capabilities.	0.367
AT5 =0.06	**Level of creativity**	F11	Lean mentors are available to guide and train team leaders.	0.594
		F8	Team members benefit from training approaches and methods.	0.544
		F19	Leaders and team members express and apply innovative ideas to projects.	0.531
		F9	Team members are trained in effective and frequent communication.	0.498
		F7	Team members are knowledgeable and are constantly trained to work on IPD projects and use Lean techniques and TVD.	0.478

Chapter 6: Conclusions

6.1 Thesis Summary

The AEC industry is rife with teamwork constraints and barriers at all phases of the construction projects. Team members' conflicts and misalignments can lead to project failures. Due to the cultural diversity and conflicts of interests, the challenges are more complicated in the IPD method. TVD provides an enormous advantage to Lean and IPD projects in team alignment challenges. However, even though the adaptation of TVD has yielded benefits for construction IPD projects, if adequate alignment between the designers, constructors, and stakeholders does not occur, the project may experience many problems like delays and cost overruns. Therefore, the team leaders must specify the project, team, and company values with which team members will be aligned. The big room's regular meetings can help IPD team members brainstorm to find out the common ground of the project's values in the initial steps of the project. Ambiguities and confusion in value definition may also mislead the IPD project's members in case the owner misstates the project requirements, which leads to misalignment.

Lessons learned from the current challenges can assist the team leaders in establishing proper factors and attributes to monitor and evaluate team performance. The evaluation is based on the team members' ranking and all members are equal. It also develops a reasonable practice for improving the current state by identifying factors related to challenges and constraints throughout the construction project.

This research intended to know Team Alignment practical factors and alignment attributes also establish a method of team performance evaluation and remedy deficiencies in current practice that contributes to using TVD. This thesis began with an introduction of a comprehensive literature review on the importance of Team Alignment, identifying its challenges in TVD and analyzing the methods of team performance assessment. Regarding generating subjective probabilities and preserving correlation between model inputs and outputs, gaps were discovered in the IPD construction and TVD literature.

To address the former gap, this thesis sought to ascertain the potential effective factors and how they can improve through knowing their correlation with aligned team affection. Two relations are investigated which are relationships between all factors and each attribute and relationships between attributes and Team alignment

The literature review has been done to select an appropriate data analysis method to find the relationships, correlations, and values between mentioned variables. The correlation coefficient Pearson test was applied to factors, attributes, and team alignment analysis for generated random data. The test was applied twice, firstly for the relationship between factors and attributes and the second for the relationship between attributes and team alignment. With the assumption that team alignment is a measurable variable, the coefficient test between attributes and team alignment has been repeated for the second time.

The latter research gap is measuring team alignment. This gap defines as lack of team alignment measuring tool.

FIS opted to measure this subjective variable. It was applied to use the effects of possible correlation coefficient test results on the team alignment measure and assess effective factors to improve team alignment. The experiment involved defining factors and attributes, generating random sample data, applying a correlation test, and FIS to measure team alignment.

Finally, a case study was provided to demonstrate how experimental modelling approaches may be used in an actual project. The case study applied the two correlation modelling methods and the FIS experiment to measure the construction team project alignment.

6.2 Overall Conclusion

The FIS experiment proved that team alignment is affected by the correlation between model inputs. Modelling inputs dependently results in the underestimation of team alignment computability. Dependent modelling of inputs resulted in an underestimation of team alignment computability except where all factors must reverse correlation with attributes which is seldom case in context of team performance analysis.

1. Based on outcomes from the FIS experiment, recommendations for modelling team alignment measuring method are as follows:
2. Where possible, team's alignment factors and attributes should be defined and up to date based on the team, project, and company values. Each team, project and company have clear values which empower or forbid in a certain time.
3. Where possible, replace attributes with negative correlation coefficient Pearson test result because based on the initial definition attributes are team alignment characteristics which means by increasing the value of attributes the value of team alignment will increase.
4. Where possible, capture functional correlations (with positive Pearson test's result) between attributes and factors in the model to account for the team performance improvement. Correlations with higher value are more effective.
5. Where possible, capture functional correlations (with negative Pearson test's result) between attributes and factors in the model to avoid for the team performance improvement. Correlations with lower value are less effective.

6.3 Research Contributions

The established tool and technique can contribute to both academia and industry in that way it develops a quantitative method to measure a qualitative variable (Team Alignment). It develops a unique practice for evaluating IPD team members' performance based on the TVD in construction projects. The primary contributions from this research are summarized as follows:

1. Focusing on the role of team alignment in the effective implementation of TVD and identifying a connection between factors, attributes, and the level of team alignment; and
2. The thesis provided a methodology for assessing the performance of team. Creating a relationship map to measure and evaluate the degree of team alignment and developing a framework for evaluating and assessing different forms of correlation.
3. The Correlation Coefficient Pearson experiment demonstrated the value of team alignment produced by data analysis is related to the extent of correlation between factors and attributes. When correlation is present, but the subjective quality of attributes and factors are ignored in the measuring tool, team alignment value can significantly differentiate. The correlation is dynamic, and it will change based on the expert panel ranking
4. Highlighting the application of team alignment tool to assess team performance in AEC industry or any other team-based organization such as medicine and business; and,
5. Presenting a route for evaluation results to risks and process improvements for performance teams.

6.4 Recommendations for Further Research

The following are some study opportunities relating to this thesis:

1. Schedule team alignment analysis: This assessment tool can automate and be presented as a team alignment measuring dashboard. Dashboard reports, tracks, and compares the team performance regularly that, helps team leaders in doing the evaluation process and its analysis as fast as possible, involving all team members in the team improvement process, evaluating the team performance progress by comparing the team performance with the last evaluation results, identifying strengths and weaknesses of the aligned team attributes, identify related factors to improve or modify them
2. Team alignment improvement simulation tool: Establish the simulation tool to the visual content of the results of abstract concepts of improving a factor which help leaders understand based on the correlation of the factors which will proceed the improvement process.

References

Abdirad, H., & Pishdad-Bozorgi, P. (2014). Developing a framework of metrics to assess collaboration in integrated project delivery. In *Proceedings of the 50th Annual International Conference of the Associated Schools of Construction*. Virginia Polytechnic Institute and State University, VA, US.

Achell, J. F. (2020). Why traditional project management fails: Keys to success. Retrieved from Zigurat: https://www.e-zigurat.com/blog/en/why-traditional-project-management-fails-keys-to-success/

AIA (The American Institute of Architects). (2014). AIA-IPD-A-Working-Definition-FINAL.

Akoglu, H. (2018). User's guide to correlation coefficients. *Turkish Journal of Emergency Medicine*, *18* (3), 91–93.

Amabile, T. M. (1998). How to kill creativity. Retrieved from *Harvard Business Review*, 1–29: https://hbr.org/1998/09/how-to-kill-creativity

Ansari, S., Bell, J., & Swenson, D. (2006). A template for implementing target costing. *Cost Management*, *20* (5), 20–27.

Ashcraft, H. W. (2011). IPD teams: Creation, organization, and management. Retrieved from Hanson Bridgett, December 12, 2012: https://www.hansonbridgett.com/media/Files/Publications/IPD-Teams.pdf

Ashcraft, H. W. (2016). Location, Location, Co-location. Retrieved from Hanson Bridgett, [retrieval date]: https://www.hansonbridgett.com/Publications/articles/2016-04-ipd-location

Attaran, M., & Attaran, S. (2007). Collaborative supply chain management: the most promising practice for building efficient and sustainable supply chains. *Business process management journal*.

Baines, T., Lightfoot, H., Williams, G. M., & Greenough, R. (2006). State-of-the-art in lean design engineering: A literature review on white collar lean. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *220* (9), 1539–1547.

Ballard, G. (2000). Lean Project Delivery System: White Paper-8 (Revision 1).

Ballard, G., & Howell, G. (2003). Lean project management. *Building Research & Information*, *31*(2), 119-133.

Ballard, Glenn. "Rethinking Project Definition in Terms of Target Costing." Proceedings of the 14th Annual Congress, 22 May 2014, https://www.academia.edu/811536/Rethinking_project_definition_in_terms_of_target_costing.

Ballard, G. (2014, May 22). Rethinking project definition in terms of target costing. Proceedings of the 14th annual Congress. Retrieved August 3, 2022, from https://www.academia.edu/811536/Rethinking_project_definition_in_terms_of_target_costing

Ballard, G. (2008). The Lean Project Delivery System: An Update. *Lean Construction Journal*. https://leanconstruction.org/uploads/wp/media/library/id53/The_Lean_Project_Delivery_System_An_Update.pdf

Ballard, Glenn. (2009). “P2SL Report: Current Benchmark in Target Costing”. Project Production Systems Laboratory, University of California, Berkeley, November 28, 2005. https://p2sl.berkeley.edu/benchmarks/

Ballard, G. (2011). Target value design: current benchmark. *Lean Construction Journal*, 6(1), 79-84. http://p2sl.berkeley.edu/wp-content/uploads/2016/03/Ballard-2011-Target-Value-Design-Current-Benchmark-1.0-LCJ_11_009.pdf

Ballard, G., Dilsworth, B., Do, D., Low, W., Mobley, J., Phillips, P., & Wood, N. (2015). How to make shared risk and reward sustainable. In Proc. 23rd Ann. Conf. of the Int’l. Group for Lean Construction (pp. 257-266). https://www.iglc.net/Papers/Details/1193

Ballé, F., and Ballé, M. (2005), “Lean development”, Business Strategy Review, 16(3), pp.

17- 22. https://onlinelibrary.wiley.com/doi/10.1111/j.0955-6419.2005.00369.x

Barringer, B. R., & Harrison, J. S. (2000). Walking a tightrope: Creating value through interorganizational relationships. *Journal of management*, 26(3), 367-403.

Bellman, R. (1978). Artificial Intelligence: Can Computers Think? Course Technology.

Bertelsen, S., and Emmitt, S. (2005). “The client as a complex system.” *13th Ann. Conf. of the Int’l. Group for Lean Construction*, 73–79.

Bertram, D. (2007). Likert Scales… are the meaning of life: CPSC 681–Topic Report. Available from: https://www.academia.edu/8160815/Likert_Scales_are_the_meaning_of_life

Brady, D. A., Tzortzopoulos, P. and Rooke, J. (2013). The Development of an Evaluation Framework Based on the Design Science Approach. Proceedings *IGLC-21*, July 2013 |Fortaleza, Brazil, pp 579- 588.

Brinson J.A., & Antos, J. (1999). Driving value using activity-based budgeting. John Wiley, New York. https://books.google.com/books?id=uoYrAQAAMAAJ

Campbell, T. T., Judge, T. A., & Robbins, S. P. (2010). Organizational behaviour. Harlow: Pear. https://www.pearson.com/uk/educators/higher-education-educators/product/9780273719397.html

Chan, D. W., Lam, P. T., Chan, J. H. L., Ma, T., & Perkin, T. (2012). A comparative study of the benefits of applying target cost contracts between South Australia and Hong Kong. *Project management journal*, 43(2), 4-20.

Cell, C.L. & Arratia, B. (2003). Creating value with lean thinking and value engineering, *43rd Annual Society of American Value Engineers International Conference* Scottsdale AZ, USA 2003.https://www.researchgate.net/publication/306340030_WHERE_LEAN_CONSTRUCTION_AND_VALUE_MANAGEMENT_MEET

Che Ibrahim, C. K. I., Costello, S. B., & Wilkinson, S. (2013). Development of a conceptual team integration performance index for alliance projects. *Construction Management and Economics*, 31(11), 1128-1143.

Collins, J. (2009). Good to Great- (Why some companies make the leap and others don't). https://journals.sagepub.com/doi/abs/10.1177/0974173920090719?journalCode=nhra

Cooper, R., & Slagmulder, R. (2017). Target costing and value engineering. Routledge. https://www.routledge.com/Target-Costing-and-Value-Engineering/Cooper-Slagmulder/p/book/9781563271724

Cooper Robin–Kaplanrobert, S. (1999). Design of Cost Management Systems: Text–Cases and Readings.https://openlibrary.org/books/OL1532539M/The_design_of_cost_management_systems

Daniel, E. I. (2017). Exploratory study into the use of Last Planner® System and collaborative planning for construction process improvement. Nottingham Trent University (United Kingdom).

Daoud, Y., Ghannoum, C., Antar, S., & Hamzeh, F. (2019). Evaluating the Lean-Enabling Competencies of Clients. In Proc. *27th Annual Conference of the International Group of Lean Construction* (IGLC), Dublin, Ireland (pp. 889-900).

De Melo R. S. S. (2015). 'Guidelines for target costing introduction in the real estate products development process'. PhD Thesis, University of Campinas, Sao Paulo.

De Melo, R. S. S., Do, D., Tillmann, P., Ballard, G., & Granja, A. D. (2016). Target value design in the public sector: evidence from a hospital project in San Francisco, CA. Architectural Engineering and Design Management, 12(2), 125–137. https://doi.org/10.1080/17452007.2015.1106398

Dekker, H., & Smidt, P. (2003). A survey of the adoption and use of target costing in Dutch firms. *International Journal of production economics*, 84(3), 293-305.

Do, D., Ballard, G., & Tillmann, P. (2015). Part 1 of 5: The Application of Target Value Design in the Design and Construction of the UHS Temecula Valley Hospital. Project Production Systems Laboratory, University of California, Berkeley.

Do, D., Chen, C., Ballard, G., & Tommelein, I. D. (2014). Alignment and Misalignment of Commercial Incentives in Integrated Project Delivery and Target Value Design.

Durlak, J. A., & DuPre, E. P. (2008). Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. American journal of community psychology, 41(3), 327-350.

Egan, J. (1998). Rethinking construction: report of the construction task force on the scope for improving the quality and efficiency of UK construction.

Ellram, L.M. (2006). 'The implementation of target costing in the United States: theory versus practice', Journal of Supply Chain Management 42(1), 13–26.

El Reifi, M. H. (2016). A novel lean briefing process for effective design management (Doctoral dissertation, Loughborough University).

Emig, J. (1967). On teaching composition: Some hypotheses as definitions. Research in the Teaching of English, 1(2), 127-135.

Emmitt, S., Sander, D., & Christofferson, A. K. (2005). The value universe: defining a value-based approach to lean construction. In Proceedings IGLC (Vol. 13, pp. 57-64).

Emuze, F., & Mathinya, L. Assessing the feasibility and use of target value design in South African construction. In Annual Conference of the International Group for Lean Construction (Vol. 24, pp. 73-82).

Feighery, E., & Rogers, T. (1995). Building and maintaining effective coalitions. Health Promotion Resource Center.

Foster-Fishman, P. G., Berkowitz, S. L., Lounsbury, D. W., Jacobson, S. & Allen, N. A. (2001). Building Collaborative Capacity in Community Coalitions: A Review and Integrative Framework. American Journal of Community Psychology, Vol. 29, No. 2.

Gajda, R., & Koliba, C. (2007). Evaluating the imperative of intraorganizational collaboration: A school improvement perspective. American Journal of Evaluation, 28(1), 26-44.

Gao, S., & Low, S. P. (2014). Impact of Toyota way implementation on performance of sizeable Chinese construction firms. Journal of Professional Issues in Engineering Education and Practice, 140(3), 04013022.

Ghassemi, R, Becerik-Gerber B. (2011). "Transitioning to Integrated Project Delivery: Potential barriers and lessons learned", Lean Construction Journal, pp.32-52

Gibson, G. E., & Hamilton, M. R. (1994). Analysis of Pre-Project Planning Effort and Success Variables for Capital Facility Projects–Source Document 105. Austin, Texas: Construction Industry Institute, The University of Texas at Austin.

Gibson, G.E., Tortora, A.L., & Wilson, C.T. 1994. Perceptions of Project Representatives Concerning Project Success and Pre-Project Planning Effort - Source Document #102. Austin, Texas: Construction Industry Institute, The University of Texas at Austin.

Gomes Miron, L., Kaushik, A., & Koskela, L. (2015). Target value design: The challenge of value generation. IGLC. net.

Griffith, A. F., & Gibson Jr, G. E. (2001). Alignment during pre-project planning. Journal of Management in Engineering, 17(2), 69-76.

Grosse, H. Developing teamwork skills: AEC students writing reflective journals and using action research. In thirty-seventh annual conference (Vol. 553, p.553).

Hackman, J. R. (2011). Collaborative intelligence: Using teams to solve complex problems. Berrett-Koehler Publishers.

Haque, B., & James-Moore, M. (2004). Applying lean thinking to new product introduction. *Journal of Engineering design*, 15(1), 1-31.

Hevner, A. R. (2007). A three-cycle view of design science research. *Scandinavian journal of information systems*, 19(2), 4.

Howell, G., & Ballard, G. (1998, August). Implementing lean construction: understanding and action. In *Proc. 6 th. Ann. Conf. Intl. Group for Lean Constr*.

Ibrahim, C. K. I. C., Costello, S. B., & Wilkinson, S. (2015). Key indicators influencing the management of team integration in construction projects. *International Journal of Managing Projects in Business*. http://ijimt.org/papers/173-A10025.pdf

Investopedia. (2017). Networking. Dotdash publishing family.

Iyer, K. C., & Jha, K. N. (2005). "Factors affecting cost performance: evidence from Indian construction projects." *International Journal of Project Management*, 23, 283-295.

IVM (Institute of Value Management). (2014). *Value Analysis Practice In 2014 International Conference*, [Online] Available from: http://ivm.org.uk/blog/post.php?s=2014-01-14 value analysis- practice-in-2014-international-conference [Accessed: 20 December 2018].

IVM (Institute of Value Management). (2015) a. [Online] Available at http://ivm.org.uk/services/brand-enhancer [Accessed: 20 December 2018].

Jacomit, A. M., Granja, A. D., & Picchi, F. A. (2008). Target Costing Research Analysis: reflections for construction industry implementation. In Proc. *16th Ann. Conf*. of the Int'l. Group for Lean Construction (pp. 16-18).

Jørgensen, B., & Emmitt, S. (2008). Lost in transition: the transfer of lean manufacturing to construction. Engineering, construction, and architectural management.

Karlsson, C., & Ahlström, P. (1996). The difficult path to lean product development. *Journal of product innovation management*, 13(4), 283-295.

Katzenbach, J. R., & Smith, D. K. (2005). The discipline of teams. Harvard business review, 83(7), 162.

Kaushik, A. K., Keraminiyage, K. P., Koskela, L. J., Tzortzopoulos Fazenda, P., & Hope, G. (2014). Knowledge transfer partnership: implementation of target value design in the UK construction industry.

Katzenbach, J. R., & Smith, D. K. (2015). The wisdom of teams: Creating the high-performance organization. *Harvard Business Review Press*.

Kaushik, A., & Koskela, L. J. (2015). Target Value Design: The Challenge of Value Generation. https://www.researchgate.net/publication/280255088

Kazeminezhad, M. H., Etemad-Shahidi, A., & Mousavi, S. J. (2005). Application of fuzzy inference system in the prediction of wave parameters. Ocean Engineering, 32(14-15), 1709-1725.

Kellar-Guenther, Y., & Betts, B. (2011). Come Together Now: Measuring the Level of Collaboration. *In American Evaluation Association Annual Conference*, San Antonio, TX.

Khalife, S., & Hamzeh, F. (2019). A framework for understanding the dynamic nature of value in design and construction. In Proc. *27th Annual Conference of the International Group for Lean Construction* (IGLC) (Vol. 1, pp. 617-628).

Khalife, S., & Hamzeh, F. (2019). An Integrative Approach to Analyze the Attributes Shaping the Dynamic Nature of Value AEC. *In Lean Construction Journal* (Vol. 2019). www.leanconstructionjournal.org

Khalife, S., & Hamzeh, F. Developing a Value Dashboard for Tracking Value Alignment during Design. *In Construction Research Congress 2022* (pp. 513-523).

Kim, Y., & Lee, H.W. (2010). Analyzing User Costs in a Hospital: Methodological Implication of Space Syntax to Support Whole-life Target Value Design. *Lean Construction Journal*, 11, pp.55-63.

Knight, K., & Robinson Fayek, A. (2002). Use of fuzzy logic for predicting design cost overruns on building projects. *Journal of Construction Engineering and Management*, 128(6), 503-512.

Kochhar, S. (2013). A Conceptual Model for Measuring Coalition Building Effectiveness. A research paper submitted to Institute for Public Relations as part of the Ketchum Excellence in Public Relations Research Award.

Koladiya, B. (2017). Research trends of Lean Construction and its compliance with Toyota Production System for the year 2016.

Koskela, L. (2000). An exploration towards a production theory and its application to construction. Espoo: VTT Publications. www.inf.vtt.fi/pdf/publications/2000/P408.pdf.

Koskela, L., & Ballard, G. (2013). The two pillars of design theory: Method of analysis and rhetoric. https://usir.salford.ac.uk/29455/1/Koskela_Ballard_The_two_pillars_of_design_theory.pdf

Koskela, L. (2008). Which Kind of Science is Construction Management? Proceedings for the *16th Annual Conference of the International Group for Lean Construction*. Manchester. https://eprints.qut.edu.au/71034/1/71034.pdf

Kron, C., & Von der Haar, R. (2016). Target costing for the development of office buildings. *In Proceedings of the 24th Annual Conference of the International Group for Lean Construction, Boston*, MA, USA (pp. 20-22).

Kurzweil, R., Richter, R., Kurzweil, R., & Schneider, M. L. (1990). The age of intelligent machines (Vol. 580). Cambridge: MIT press.

Larman, C. (2008). Scaling lean & agile development: thinking and organizational tools for large-scale Scrum. Pearson Education India.

Lean Construction Institute (2015). http://www.leanconstruction.org.uk/lci-summit-2015/> (10 December 2015)

Lean Construction Institute. (2016). <http://www.leanconstruction.org /32> (20 March 2016).

Lean Enterprise Institute (2012), "Lean principles," Available at: http://www.lean.org/WhatsLean/Principles.cfm, (accessed in April 2012).

Lee Rodgers, J., & Nicewander, W. A. (1988). Thirteen ways to look at the correlation coefficient. The American Statistician, 42(1), 59-66.

Lee, H. W. (2012). Application of Target Value Design to energy efficiency investments (Doctoral dissertation, UC Berkeley).

Lehman, T., & Reiser, P. (2004). Maximizing Value & Minimizing Waste: Value Engineering & Lean Construction.

Lerbinger, O. (2006). Corporate public affairs: Interacting with interest groups, media, and government. Routledge.

Liker, J. K., Sobek, D. K., Ward, A. C., & Cristiano, J. J. (1996). Involving suppliers in product development in the United States and Japan: Evidence for set-based concurrent engineering. IEEE Transactions on Engineering Management, 43(2), 165-178.

Liker, J. K. (2004), The Toyota way, McGraw Hill: New York.

Liker, J. K., & Morgan, J. M. (2006). The Toyota way in services: the case of lean product development. Academy of management perspectives, 20(2), 5-20.

Lindfors, C. (2000). "Value chain management in construction: Controlling the housebuilding process". *IGLC 8 Conference*, Brighton, England.

Love, P. E., Li, H., Irani, Z., & Faniran, O. (2000). Total quality management and the learning organization: a dialogue for change in construction. Construction Management & Economics, 18(3), 321-331.

Luger, G. F., & Stubblefield, W. A. (1990). Artificial intelligence and the design of expert systems. Benjamin-Cummings Publishing Co., Inc.

Lukka, K. (2003) The constructive research approach. In Ojala, L. & Hilmola, O-P. (eds.) Case study research in logistics. Publications of the Turku School of Economics and Business Administration, Series B1: 2003, p.83-101.

Macomber, H. & Howell, G. A. (2004). Two Great Wastes in Organizations – A Typology for Addressing the Concern for the Underutilization of Human Potential. IGLC 12, Elsinore, Denmark.

Macomber, H., Howell, G. & Barberio, J. (2007). Target value Design: Nine foundational and six advanced practices for delivering surprising client value. Lean project consulting.

Macomber, H., Howell, G., & Barberio, J. (2012). Target value design: Nine foundational practices for delivering surprising client value. [White paper].

Male, S., Kelly, J., Gronqvist, M., & Graham, D. (2007). Managing value as a management style for projects. International Journal of project management, 25(2), 107-114.

Malaeb, Z., & Hamzeh, F. R. (2021). IPD-inspired framework for measuring stakeholder integration in public-private partnerships. Construction Innovation.

Malone, T. W., & Crowston, K. (1991). Toward an interdisciplinary theory of coordination.

March, S. T., & Smith, G. (1995). Design and Natural Science Research on Information

Martin, P. (2015). Target Value Design (TVD). Construction work zone. Available at www.constructionworkzone.com/articles/ target-value-design-tvd.

Mattessich, P. W., & Monsey, B. R. (1992). Collaboration: what makes it work. A review of research literature on factors influencing successful collaboration. Amherst H. Wilder Foundation, 919 Lafond, St. Paul, MN 55104.

Matthews, O, & Howell, G.A. (2011). "Integrated Project Delivery an example of relational contracting".

Melo, R. S. S. D., Kaushik, A., Koskela, L., Granja, A. D., Keraminiyage, K., & Tzortzopoulos, P. (2014). Target costing in construction: a comparative study. IGLC.

Mendes, H. R., & Machado, M. J. (2013). Target costing: Review of empirical studies in the automotive sector. Tourism & Management Studies, (3), 792-801.

Miron, L.I.G., Kaushik, A. & Koskela, L., (2015). Target Value Design: The Challenge of Value Generation. In: Proc. 23rd Ann. Conf. of the Int'l. Group for Lean Construction. Perth, Australia, July 29-31, pp. 815-825, available at www.iglc.net.

Morêda Neto, H. M., Costa, D. B., & Thomas, L. (2016). Target value design approach for real estate development. In ANNUAL CONFERENCE OF THE INTERNATIONAL GROUP FOR LEAN CONSTRUCTION (Vol. 24).

Morgan, J. M., & Liker, J. K. (2006a), The Toyota Product Development System – Integrating People, Process, and Technology, Productivity Press: New York.

Mossman, A., Ballard, G., & Pasquire, C. (n.d.). Lean Project Delivery-innovation in integrated design & delivery Last Planner System View project Design decisions for hybrid projects using integrated building information View project. https://doi.org/10.13140/2.1.2713.2804

Musa, M. M. (2019). A framework for implementing target value delivery to enhance value creation in the construction industry. Nottingham Trent University (United Kingdom).

Namadi, A., Pasquire, C., & Manu, E. (2017). Discrete costing versus collaborative costing.

Nanda, U., K. Rybkowski, Z., Pati, S., & Nejati, A. (2017). A value analysis of lean processes in target value design and integrated project delivery: Stakeholder perception. HERD: Health Environments Research & Design Journal, 10(3), 99-115.

Nayak, B. (2006). Lean Manufacturing and Value Management Convergence of Divergent Tools" SAVE International conference.

Novak, V. M. (2012). Managing Sustainability Value in Design: A Systems Approach. Unpublished PhD dissertation.

Obi, L.I. & Arif, M. (2015). A Case for Target Value Design Towards Effective Low-Cost Housing Project Cost Management and Performance in South-East Zone Nigeria. CIB Proceedings 2015: Going north for sustainability: Leveraging knowledge and innovation for sustainable construction and development, p.104.

O'brien, W. J., Fischer, M. A., & Jucker, J. V. (1995). An economic view of project coordination. Construction Management and Economics, 13(5), 393-400.

Okano, H., & Suzuki, T. (2006). A history of Japanese management accounting. Handbooks of Management Accounting Research, 2, 1119-1137.

Oke, A. E., & Ogunsemi, D. R. (2011). Value management in the Nigerian construction industry: Militating factors and the perceived benefits. In Second international conference on advances in engineering and technology (pp. 353-359).

Oliva, C. A., Granja, A. D., Ballard, G., & Melo, R. S. S. (2016). Assessing suitability of Target Value Design adoption for real estate developers in Brazil. In Proc. CONFERENCE OF THE INTERNATIONAL GROUP FOR LEAN CONSTRUCTION (Vol. 24).

Page, M. (2018). Top 11 benefits of networking. Michael Page International (Australia) Pty Ltd.

Pirinen, A. (2016). The barriers and enablers of co-design for services. International Journal of Design, 10(3), 27-42.

Poppendieck, M. (2002). Principles of lean thinking, Poppendieck. LLC, Eden Prairie, MN.

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests. Journal of statistical modeling and analytics, 2(1), 21-33.

Reiser, P. (2003). Target Costing and Value Engineering on Projects. The Boldt Companies, Appleton, Wisconsin.

Richardson, Canup, K. R. L. C. (2017). Integrated project delivery: Perspective and lessons learned. SRG. Retrieved October 10, 2017, from https://www.srgpartnership.com/ideas/white-papers/integrated-project-delivery.

Robbins, S. P. (2008). The truth about managing people. Upper Saddle River.

Rybkowski, Z. K., Munankami, M., Shepley, M. M., & Fernández-Solis, J. L. (2016). Development and testing of a lean simulation to illustrate key principles of target value design: A first run study. Proceedings of the 24th annual conference of the International Group for Lean Construction. https://iglc.net/Papers/Details/1279

Salvatierra-Garrido, J., Pasquire, C., & Thorpe, T. (2009). Value in construction from lean thinking perspective: current state and future development. In 17Th Annual Conference of The International Group for Lean Construction, Taipei.

Salvatierra-Garrido, J., & Pasquire, C. L. (2011). The first and last value model: Sustainability as a first value delivery of lean construction practice.

SAVE International. (2015a). 2015 SAVE Value Summit, Value Engineering – Driving Innovation, San Diego CA, https://custom.cvent.com/92CFB39BAB784058982EFC7894728ABF/files/event/43EC5B7E3E734095B9EA3C30E052AC52/45eb201675ae467ead8c6ad342a29867.pdf_ (20 July 2015).

SAVE International. (2015b). Value Management Practice 2016 International Conference Call for Papers,<http://www.value-eng.org/pdf_docs/events/04-26 15_Value_Management_Conference.pdf >(26 August 2015).

Salvatierra-Garrido, J., Pasquire, C., & Miron, L. (2012). "Exploring value concept through the IGLC community: Nineteen years of experience." *20th Ann. Conf. of the Int'l. Group for Lean Construction*, San Diego, CA, USA.

Schmidt, M. T., Elezi, F., Tommelein, I. D., & Lindemann, U. (2014). Towards recursive plan-do-check-act cycles for continuous improvement. *In 2014 IEEE International Conference on Industrial Engineering and Engineering Management* (pp. 1486-1490). IEEE.

Schrage, M. (1990). Shared minds: The new technologies of collaboration.

Singleton, M, & Hamzeh, F.R. (2011). "Implementing Integrated Project Delivery on Department of the Navy Construction Projects", Lean Construction Journal, USA, pp.17-31

Srinath, P., Gayani, K., & Kaushalya, S. (2003). Application of Value Management in Construction. Built-Environment-Sri Lanka, 4(01).

Suhr, J. (1999). The Choosing by Advantages Decision-making System, Quorum, Westport, CT, 293 p.

Tang, Y. (2015). A survey on target costing (TC) in New Zealand's Private Training Establishments (PTEs): the level of awareness among managers and the degree of adoption (Doctoral dissertation, Auckland University of Technology).

Technology, Decision Support Systems (15:4), pp. 251-266.

Tilley, P. A. (2005). Lean design management-A new paradigm for managing the design and documentation process to improve quality? Proceedings IGLC-13.

Tillmann, P., Tzortzopoulos, P., Formoso, C. T., & Ballard, G. (2013). "Contributions of existing practices to pursuing value in construction projects." Proc. *21st Ann. Conf. Int. Group for Lean Construction*, 359-368.

Tillmann, P. A., Do, D., & Ballard, G. (2017). A case study on the success factors of target value design. 25th Annual Conference of the International Group for Lean Construction (IGLC), 9-12 July 2017, Heraklion, Greece.

Tommelein, I.T & Ballard, G. (2016) Target Value Design: Manual of Practice Report: Project Production Systems Laboratory University of California, Berkeley Version I.5.

Wandahl, S., & Bejder, E. (2003). "Value-Based Management in the supply chain of construction projects." Proc., *11th Annual Conference on Lean Construction IGLC*, Virginia, USA, 1-14.

Womack, J. P., Jones, D. T., & Roos, D. (2007). The machine that changed the world: The story of lean production--Toyota's secret weapon in the global car wars that is now revolutionizing world industry. Simon and Schuster.

Womack, J., & Jones, D. (1996), Lean thinking, *Free Press*: New York. https://www.academia.edu/34563325/James_P_Womack_Lean_Thinking

Zimina, D., Ballard, G., & Pasquire, C. (2012). Target value design: using collaboration and a lean approach to reduce construction cost. Construction management and economics, 30(5), 383-

Appendix A

Team Alignment

Welcome to the survey.

This survey contains 30 questions, and it should take 12-15 minutes to complete.

Value Alignment and Team Alignment are prerequisites of Target Value Design in IPD projects.

The survey aims to validate and measure the importance (factors and attributes' value in team alignment) and prevalence (the existence of factors and attributes in the project's current situation) of Team Alignment factors and attributes.

There are 30 questions in this survey.

This survey is anonymous.

The record of your survey responses does not contain any identifying information about you, unless a specific survey question explicitly asked for it.

If you used an identifying token to access this survey, please rest assured that this token will not be stored together with your responses. It is managed in a separate database and will only be updated to indicate whether you did (or did not) complete this survey. There is no way of matching identification tokens with survey responses.

Next

General information

*How many years of experience in IPD and collaborative construction projects do you have?

Choose one of the following answers

Please choose...

Next

Assessing successful Team Alignment factors: Using a Likert Scale from 1 to 5, please rate to what extent the following statements are important for the team alignment and prevalence in your project/team (1: The Least important and 5: The most important).

*Team members have good problem-solving and decision-making skills.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team members listen effectively and empathize with each other. They share constructive feedback in a transparent fashion.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team members trust each other to speak up.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*The team knows about each other's past professional project collaboration experience.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team members are motivated to work on the project.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

Next

*The team focuses on the project's goals and objectives.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team members are knowledgeable and are constantly trained to work on IPD projects and use Lean techniques and TVD.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team members benefit from training approaches and methods.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team members are trained in effective and frequent communication.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team leaders ensure that members have equal access to information, equipment, and technology.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

Next

Leadership

* Lean mentors are available to guide and train team members.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team leaders collaborate with other cross-functional teams and provide cross-disciplinary expertise for successful communication.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

* Team leaders assign tasks that fit team members' strengths and capabilities.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*The team members' strengths and weaknesses are regularly assessed by leadership.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

* The project scope and value are clearly defined by team leaders and communicated visually.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

Next

Culture

*Team leaders and team members know and understand the risks and rewards of the project they are working on.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*A collaborative culture exists among team members.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Members respect the teams' diversity; accept and treat each other fairly and equally.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Leaders and team members express and apply innovative ideas to projects.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Team members attend face-to-face meetings in the big room.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

Next

Environment

*Leaders size their teams properly according to the project's workload, size, and nature.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Leaders and team members are satisfied with their collaboration and hope to continue it.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Key participants are involved early in the project.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Members come from different educational and professional backgrounds.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

Next

Assessing successful Team Alignment attributes: Using a Likert Scale from 1 to 5, please rate to what extent the following statements are important for the team alignment and prevalence in your project/team. (1: The Least important and 5: The most important).

*Level of commitment to team and project value

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Level of morale among team members

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Ability to overcome challenges

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Provide the right knowledge and information at the right time.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

*Level of creativity.

	1	2	3	4	5
Importance	○	○	○	○	○
Prevalence	○	○	○	○	○

Submit

Table A-1: Designed Survey

How many years of e	Team	Team	Team	Team	Team	Team	The te	The t	Team	Team	The te	The t	Team	Team	Team	Team	Team	Team	Team le	Team l	Lean r	Lean
	F1-IM	F1-P	F2-IM	F2-P	F3-IM	F3-P	F4-IM	F4-P	F5-IM	F5-P	F6-IM	F6-P	F7-IM	F7-P	F8-IM	F8-P	F9-IM	F9-P	F10-IM	F10-P	F11-IM	F11-P
Less than 10 years	4	4	5	4	5	4	2	2	5	4	5	4	4	3	3	2	4	4	4	4	4	3
Less than 10 years	5	4	5	4	4	3	3	3	4	4	5	5	3	3	4	4	3	3	4	2	3	3
Less than 10 years	5	5	5	5	5	4	4	4	5	4	4	4	4	4	5	5	5	5	5	5	4	4
Less than 10 years	5	4	4	4	4	5	2	2	4	4	5	4	4	3	4	4	4	3	4	4	4	3
Less than 10 years	4	5	5	3	4	5	3	2	5	4	5	5	5	3	4	4	4	2	4	4	3	2
Less than 10 years	4	4	5	4	5	3	2	3	4	5	4	4	3	3	3	4	3	3	3	3	2	5
Less than 10 years	5	4	5	4	5	5	3	5	5	5	5	5	4	4	5	5	4	4	4	4	5	5
Less than 10 years	4	4	4	4	5	4	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	4
Less than 10 years	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Less than 10 years	4	4	5	4	4	4	2	4	4	4	5	4	4	1	5	3	5	2	5	2	5	1
Less than 10 years	5	5	4	5	4	4	3	4	4	4	5	4	5	4	3	3	4	4	4	5	4	4
Less than 10 years	4	4	4	4	5	5	3	3	4	4	5	5	3	3	3	3	4	4	4	4	3	3
Less than 10 years	4	4	5	4	5	5	3	4	4	4	5	5	5	4	5	5	5	5	5	5	4	5
Less than 10 years	4	4	4	4	5	5	3	3	5	5	4	4	4	4	3	3	4	4	3	3	4	4
Less than 10 years	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	5	5	4	4	5
Less than 10 years	4	4	4	4	4	4	3	2	4	4	4	3	2	3	3	3	3	3	4	3	1	2
Less than 10 years	5	4	5	4	5	3	5	3	5	4	5	4	5	4	5	4	5	3	5	4	5	5
Less than 10 years	5	5	4	3	5	4	4	4	5	4	5	5	4	3	4	4	3	2	4	4	4	4

Team le	Team	Team	Team	The tea	The te	The pr	The p	Team le	Team	A collab	A colla	Membe	Memb	Leaders	Leade	Team n	Team	Leaders	Leade	Leaders	Leade
F12-IM	F12-P	F13-IM	F13-P	F14-IM	F14-P	F15-IM	F15-P	F16-IM	F16-P	F17-IM	F17-P	F18-IM	F18-P	F19-IM	F19-P	F20-IM	F20-P	F21-IM	F21-P	F22-IM	F22-P
5	5	4	5	2	1	5	4	5	4	4	3	5	4	5	4	3	2	4	3	3	2
4	3	4	3	3	2	3	3	4	3	4	4	4	4	5	4	4	2	5	3	4	4
5	5	5	5	4	4	5	4	5	5	5	5	5	5	5	5	3	3	5	5	4	4
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5	4	4	4	3	2	5	5	5	5	5	5	5	5	4	3	4	2	5	4	4	5
4	4	5	4	4	3	5	4	4	3	4	4	5	5	5	4	5	4	5	5	4	4
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4	4	4	4	4	4	4	4	3	3	5	5	5	5	5	5	4	4	5	5	5	5
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4	4	4	4	3	2	3	4	3	4	4	4	2	3	2	3	2	2	3	3	3	3
5	5	5	4	5	4	5	5	5	3	5	4	5	5	5	5	5	2	5	3	5	4
5	5	5	5	4	3	5	5	4	4	5	5	5	5	5	4	4	1	5	2	4	5

Key par	Key pa	Membe	Memb	Level of	Level c	Level of	Level c	Ability tc	Ability t	Provide	Provide	Level of	Level c
F23-IM	F23-P	F24-IM	F24-P	AT1-IM	AT1-P	AT2-IM	AT2-P	AT3-IM	AT3-P	AT4-IM	AT4-P	AT5-IM	AT5-P
5	4	5	4	5	4	5	4	5	4	4	3	4	3
5	4	4	4	4	4	4	3	4	4	4	3	4	4
5	5	5	5	5	5	5	4	5	5	5	4	5	5
4	3	5	3	4	5	4	5	5	4	4	4	5	4
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4	3	3	3	4	4	4	4	4	4	4	4	3	3
5	4	5	4	5	4	5	5	5	5	5	3	5	4
5	5	3	5	4	4	4	4	4	5	4	5	3	3

Table A-2: Survey Ranking Results

Descriptive Statistics

	Mean	Std. Deviation	N
Team members have good problem-solving and decision-making skills.	4.22	0.428	18
Team members listen effectively and empathise with each other. They share constructive feedback in a transparent fashion.	3.94	0.539	18
Team members trust each other to speak up.	4.17	0.707	18
The team know about each other's past professional project collaboration experience.	3.33	0.907	18
Team members are motivated to work on the project.	4.22	0.428	18
The team focuses on the project's goals and objectives.	4.33	0.594	18
Team members are knowledgeable and are constantly trained to work on IPD projects, use Lean techniques and TVD.	3.44	0.856	18
Team members benefit from training approaches and methods.	3.78	0.808	18
Team members are trained in effective and frequent communication.	3.61	1.037	18
Team leaders ensure that members have equal access to information, equipment, and technology.	3.78	0.878	18
Lean mentors are available to guide and train team members.	3.67	1.188	18

Team leaders collaborate with other cross-functional teams and provide cross-disciplinary expertise for successful communication.	4.22	0.732	18
Team leaders assign tasks that fit team members' strengths and capabilities.	4.11	0.583	18
The team members' strengths and weaknesses are regularly assessed by leadership.	2.83	1.150	18
The project scope and value are clearly defined by team leaders and communicated visually.	4.28	0.669	18
Team leaders and team members know and understand the risks and rewards of the project they are working on.	3.94	0.802	18
A collaborative culture exists among team members.	4.39	0.608	18
Members respect the teams' diversity; accept and treat each other fairly and equally.	4.50	0.618	18
Leaders and team members express and apply innovative ideas to projects.	4.22	0.732	18
Team members attend face-to-face meetings in the big room.	2.50	1.295	18
Members come from different educational and professional backgrounds.	3.61	1.145	18
Leaders size their teams properly according to the workload, size, and nature of the project.	3.94	0.725	18

Leaders and team members are satisfied with their collaboration and hope to continue it.	4.06	0.873	18
Key participants are involved early in the project.	4.11	0.900	18
Level of commitment to team and project value	4.22	0.428	18
Level of morale among team members	4.11	0.583	18
Ability to overcome challenges	4.44	0.511	18
Provide the right knowledge and information at the right time	3.83	0.618	18
Level of creativity	3.94	0.639	18

Table A-3:Mean value of Survey result

Level of commitment to team and project value	Pearson Correlation	0.357	0.057	0.454	-0.051	-0.040	-0.023	.724**	0.327	0.445	0.021	-0.212	0.187	0.232	0.123	-0.373	1	0.367	0.329	-0.074	0.263
	Sig. (2-tailed)	0.146	0.823	0.059	0.842	0.875	0.928	0.001	0.186	0.064	0.934	0.397	0.458	0.355	0.628	0.127		0.134	0.183	0.770	0.292
	N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Level of morale among team members	Pearson Correlation	0.131	-0.166	0.381	-0.185	0.292	0.369	0.391	0.203	0.326	0.077	0.000	0.333	0.155	0.218	-0.249	0.367	1	0.219	0.054	0.018
	Sig. (2-tailed)	0.604	0.510	0.119	0.462	0.239	0.132	0.108	0.419	0.186	0.763	1.000	0.177	0.540	0.384	0.319	0.134		0.382	0.830	0.945
	N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Ability to overcome challenges	Pearson Correlation	.598**	0.095	0.271	0.296	0.133	.478*	0.207	.547*	.558*	.506*	-0.267	0.112	.546*	.601**	0.142	0.329	0.219	1	0.248	0.080
	Sig. (2-tailed)	0.009	0.708	0.276	0.233	0.598	0.045	0.410	0.019	0.016	0.032	0.285	0.659	0.019	0.008	0.574	0.183	0.382		0.321	0.752
	N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Provide the right knowledge and information at the right time	Pearson Correlation	0.148	-0.029	.471*	0.419	0.455	0.261	0.099	.652**	0.231	-0.173	0.184	0.402	.634**	0.236	0.352	-0.074	0.054	0.248	1	-0.174
	Sig. (2-tailed)	0.557	0.908	0.049	0.083	0.058	0.296	0.697	0.003	0.357	0.492	0.466	0.098	0.005	0.345	0.152	0.770	0.830	0.321		0.491
	N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Level of creativity	Pearson Correlation	0.048	0.332	-0.108	0.237	0.467	0.176	-0.006	0.362	0.074	.531*	0.462	0.290	0.120	-0.100	0.318	0.263	0.018	0.080	-0.174	1
	Sig. (2-tailed)	0.851	0.179	0.668	0.344	0.051	0.485	0.980	0.140	0.769	0.023	0.054	0.243	0.636	0.694	0.198	0.292	0.945	0.752	0.491	
	N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Table A-4: Correlation coefficient Pearson test Results for survey result

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Type='mamdani'
Version=2.0
NumInputs=5
NumOutputs=1
NumRules=17
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='centroid'

[Input1]
Name='AT1'
Range=[1 5]
NumMFs=5
MF1='mf1':'trimf',[0 1 2]
MF2='mf2':'trimf',[1 2 3]
MF3='mf3':'trimf',[2 3 4]
MF4='mf4':'trimf',[3 4 5]
MF5='mf5':'trimf',[4 5 6]

[Input2]
Name='AT2'
Range=[0 5]
NumMFs=5
MF1='mf1':'trimf',[-1.25 -1.388e-17 1.25]
MF2='mf2':'trimf',[0 1.25 2.5]
MF3='mf3':'trimf',[1.25 2.5 3.75]
MF4='mf4':'trimf',[2.5 3.75 5]
MF5='mf5':'trimf',[3.75 5 6.25]

[Input3]
Name='AT3'
Range=[0 5]
NumMFs=5
MF1='mf1':'trimf',[-1.25 -1.388e-17 1.25]
MF2='mf2':'trimf',[0 1.25 2.5]
MF3='mf3':'trimf',[1.25 2.5 3.75]
MF4='mf4':'trimf',[2.5 3.75 5]
MF5='mf5':'trimf',[3.75 5 6.25]

[Input4]
Name='AT4'
Range=[0 5]
NumMFs=5
MF1='mf1':'trimf',[-1.25 -1.388e-17 1.25]
MF2='mf2':'trimf',[0 1.25 2.5]
MF3='mf3':'trimf',[1.25 2.5 3.75]
MF4='mf4':'trimf',[2.5 3.75 5]
```

```
MF5='mf5':'trimf',[3.75 5 6.25]

[Input5]
Name='AT5'
Range=[0 5]
NumMFs=5
MF1='mf1':'trimf',[-1.25 -1.388e-17 1.25]
MF2='mf2':'trimf',[0 1.25 2.5]
MF3='mf3':'trimf',[1.25 2.5 3.75]
MF4='mf4':'trimf',[2.5 3.75 5]
MF5='mf5':'trimf',[3.75 5 6.25]

[Output1]
Name='Team_alignment'
Range=[0 100]
NumMFs=9
MF1='mf1':'trimf',[-12.5 -1.11e-16 12.5]
MF2='mf2':'trimf',[0 12.5 25]
MF3='mf3':'trimf',[12.5 25 37.5]
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MF5='mf5':'trimf',[37.5 50 62.5]
MF6='mf6':'trimf',[50 62.5 75]
MF7='mf7':'trimf',[62.5 75 87.5]
MF8='mf8':'trimf',[75 87.5 100]
MF9='mf9':'trimf',[87.5 100 112.5]

[Rules]
4 4 4 4 4, 7 (1) : 1
4 4 4 4 4, 8 (1) : 1
5 4 4 4 4, 7 (1) : 1
5 4 4 4 4, 8 (1) : 1
5 5 4 4 4, 8 (1) : 1
5 5 4 4 4, 7 (1) : 1
5 5 5 4 4, 7 (1) : 1
5 5 5 4 4, 8 (1) : 1
5 5 4 4 4, 8 (1) : 1
5 5 4 4 4, 7 (1) : 1
5 4 4 4 4, 7 (1) : 1
5 4 5 4 4, 7 (1) : 1
4 4 5 3 3, 7 (1) : 1
4 4 5 4 4, 7 (1) : 1
4 4 5 4 4, 8 (1) : 1
4 4 5 5 5, 7 (1) : 1
4 4 5 5 5, 8 (1) : 1
```

Table A-5: FIS results for survey result analysis