FACTORS LEADING TO ENGINEERING STUDENT TEAM PERFORMANCE DURING INTENSE INTERNATIONAL DESIGN COMPETITION

A Dissertation

by

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ABSTRACT

Student teamwork activities are a very common teaching method in both face to face and online courses in engineering, as being able to work productively in a team is critical for engineering students' academic success and career development. Well-developed teamwork abilities have significant potential to improve engineering students' academic and workplace performance. However, limited research has been dedicated to the team process and output model for engineering students who are tasked with solving complex problems in short time frames. Therefore, a research model for intense team settings is worth exploring.

The purpose of this study is to test an intense, and short-term team process and output model using engineering student project teams in an international design competition as the research environment. First, team process and output variables were examined using exploratory factor analysis. Second, team process and output measurements were verified using confirmatory factor analysis. Third, the relationship between the intense team process variables studied, and the relationship between each process variable and output variable was examined using structural equation modeling.

The results of the study showed that shared leadership, team growth mindset, and team learning behaviors are positively correlated, which indicates that social cognitive theory has the potential to be applied at the team level. It was also found that team growth mindset was predictive of team performance, while shared leadership and team learning behavior were not. This intense process and output model provides empirical

evidence of the potential benefit of applying social cognitive theory at the team level. This research has also examined an intense process and output model, which is necessary for the creation of guidelines. These guidelines can then be applied to the formation of successful teams of students, educators, Human Resource Development professionals, and organizations when time is at a premium.

DEDICATION

I dedicate this dissertation to my family who love and care about me deeply. Their continued support and understanding were essential to the success of my academic journey in the U.S., and for me to accomplish this career milestone.

I am very thankful to my parents who planned for me to study abroad and have supported my graduate studies in the U.S. since August 2013. I am equally thankful for the consistent support of my in-laws who selflessly cared for my daughter, Audrey, while I was busy learning to be a new mom and writing a dissertation from home. Thanks also goes to my husband, Karl, who has supported my dream and equally shared responsibility for our child throughout the writing process. And I must also thank my daughter, Audrey, who learned to sleep through the night when she was only one month old to support my dissertation writing each day. I am very grateful for everyone's encouragement, patience, and love.

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Contributors

This work was supervised by a dissertation committee consisting of Professors Michael Beyerlein, Khalil Dirani, and Judy Sandlin of the Department of Educational Administration & Human Resource Development and Professor Miranda Walichowski of the Department of Educational Psychology.

All other work conducted for the dissertation was completed by the student independently.

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CHAPTER I

INTRODUCTION

Teamwork has been, and continues to be, a vital issue in 21st century organizations for several reasons (Levi & Slem, 1995). With high job demand and oftentimes a limited pool of qualified candidates, companies need to employ strategies to empower their new hires to perform at a high level. Therefore, teamwork has become a significant part of people's working lives as companies work to leverage their talent pool through collaborating on critical tasks. When one considers the complexity of new product development, high quality teamwork is essential for companies to more rapidly make better decisions regarding their products. As Mattessich and Monsey (1992) stated "Collaboration results in easier, faster and more coherent access to services and benefits and in greater effects on systems" (p. 10). As is the case with teamwork in organizations, student teamwork plays a critical role in universities, especially in the engineering filed.

Engineering education recognized that effective teamwork skills play an essential role in maximizing a professional engineering student's success (Ostafichuk et al., 2010). There are two reasons why this is so. The first is that teamwork is the predominant mode of engineering professional practice, as teamwork can positively affect engineering students' academic success and future career development (Patil & Codner). The second is that engineering professors tend to use project teams as a common and effective way to improve student performance (Froyd et al., 2005).

Problem Statement

This section contains theoretical and practical problems for researchers based on the literature. It covers specific gaps in the knowledge base that I have discovered. The first gap is that few research studies have been conducted in the context of international engineering student teams. A limited amount of research has explored why some engineering student project teams perform better than others (Borrego et al., 2013). One of the reasons is that students rarely experience effective team environments in which people feel comfortable sharing ideas and growing together. Also, students rarely have access to the training needed to develop the competencies required for creating teams in which everyone feels comfortable sharing, learning, and growing. Consequently, students later find themselves in the workplace with significant knowledge gaps.

The second gap is that engineering students have a high attrition rate. Less than half of students persist until graduation. Due to this gap, programs and approaches have been designed and documented to boost engineering degree attainment rates. Some examples for this would include building team-based design courses at the curriculum's start (Courter et al., 1998), teaching teamwork by using student-centered learning approaches (Missingham & Matthews, 2014), using self-reflection and collaborative learning practices to raise awareness of students' individual and team performance (Marques et al., 2018), creating study abroad international experiences in the curriculum (Maldonado et al., 2014). Last but not the least, holding engineering student-design competitions driven by students' passions and self-motivation rather than curricular requirement (Khorbotly & Al-Olimat, 2010). These approaches can produce more far-reaching effects than traditional classroom teaching in engineering fields as they not

only provide knowledge about teamwork, but also allow students to experience engineering teamwork in an authentic learning context.

The third gap is that "many engineering students struggle to see the relevance of inter-personal skills to their professional performance and experience the collaborative process as intrusive and confronting" (Missingham & Matthews, 2014, p. 413). Inter-personal skills such as team growth mindset, shared leadership, and team learning behavior have not been studied together in student Intense Design Experience (IDE) teams. Furthermore, little research can be found about the concept of team growth mindset. Some of the studies focused on the relationship between either shared leadership to team creativity or team learning behavior with team performance. No studies have yet discussed the interrelationships among the three variables.

The fourth gap is that we lack a team process and output model in the Intense Design Experience (IDE) context. According to Henderson and Walkinshaw (2002), even though much team research has been done, no single, universal team effectiveness model yet exists. Each model has its strengths and weaknesses (Essens et al., 2005). For example, some models focus on internal aspects or variables of the team (Klimoski & Jones, 1995), while other models focus on external aspects or variables such as contextual and situational factors (Tannenbaum et al., 1992). However, no team effectiveness model has yet been discussed regarding an IDE global competition context, especially in a short time frame.

The fifth gap is that most research that focused on a short-term approach lasted for a few months. For example, building a design course into the curriculum for a few

semesters or adding a short-term study abroad experience for 2-8 weeks (Olson & Lalley, 2012). Very little research has focused on an even shorter term of approach to help with engineering education especially if the time frame lasts less than a week.

Purpose Statement

The purpose of this study is to develop and test an intense team process and output model using engineering student project teams in an international design competition as a research environment. More specifically, based on the three major aspects of social cognitive learning theory (behavioral, personal, and environmental), I studied the relationships among team learning behaviors (behavioral), team growth mindset (personal), and shared leadership (environmental). In addition, according to systems theory, I also explored whether each process variable can predict the output variable (team performance).

The ultimate goal of this study was threefold: (a) to explore if social cognitive theory has the potential to explain team dynamics in the context of an Intense Design Experience, (b) to discover the relationship among shared leadership, team growth mindset, shared leadership and team performance in an intense student design team competition context, (c) to test the viability of an intense team process and output model as a theoretical framework for HRD professionals to employ as a guide to building successful teams in a short timeframe.

To achieve the purpose of the study, my dissertation research focused on understanding the input, process, and output factors leading to success of intense engineering student design teams in the context of an annual Intense Design program

called Invent for the Planet (IFTP). More specifically, the input factors I investigated included information describing attributes of the participants such as member sex and team size. Process variables that I investigated included shared leadership, team growth mindset, and team learning behavior. Lastly, the output factor I measured was team performance. By investigating the input, process, and output variables that I am interested in, I generated new knowledge about how both input and process variables contribute to team performance.

Research Questions

Below are the research questions that guided my dissertation study.

1. Does social cognitive theory explain team dynamics in the Intense Design Experience (IDE) context?
2. What is the relationship between each process variable and team performance in an intense student design team competition context?

Theoretical Framework

According to Swanson et al. (2001), the HRD discipline has three core theories that have served as the stabilizing legs of the discipline and field of practice. The three legs are economic theory, psychological theory, and systems theory (Swanson et al., 2001). By considering the characteristics of how individuals learn and how teams function effectively, I have chosen systems theory and social cognitive theory under Swanson's psychological and systems theory categories to guide my understanding of effective team performance. The theoretical framework will be presented in detail in Chapter II.

Applying both systems theory and social cognitive theory, I developed the intense team process and output model shown in Figure 1 as my theoretical framework based on the study context. More specifically, Figure 1 presents the sequential nature of the variables addressed in my research under input, process, and output. Input provides raw material and energy for the team to process, which then generates process characteristics that define the team's dynamic structure that generates outputs. Take "Input" as an example, it includes information describing the participants such as member sex and team size.

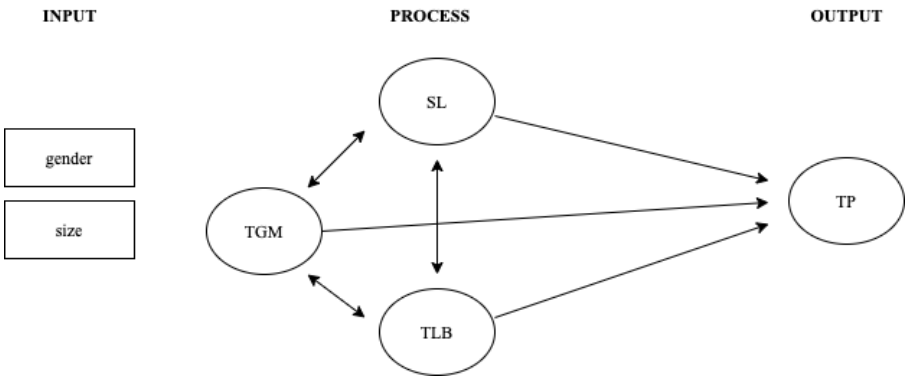

Figure 1 Intense team process and output theoretical model.

Introduction to Methods

To identify the relationships among input, process, and output in the context of team performance during Invent for the Planet (IFTP), university students from all over the world were asked to share their perceptions of each variable concept. Survey questions were administered to students who participated in the IFTP competition. For a more detailed explanation, see Chapter III, Methodology. First, team process and output

variables were examined using exploratory factor analysis. Second, team process and output measurements were verified using confirmatory factor analysis. Third, the relationship between the intense team process variables studied, and the relationships between each process variable and output variable were examined using structural equation modeling.

Participants

The participants of this study were university students from across the world who participated in the IFTP global competition in 2020. 39 universities and approximately 1142 students participated in the competition. The sample of my study has the following characteristics: participants come from different universities and cultural backgrounds, this diversity creates communication challenges, team conflicts were then likely results. However, we should also note that too much similarity reduces the diversity of perspective critical for the production of the most creative solutions. Third, the participants pursued different university courses of study. They were very likely to use different discipline related terminologies, which has the potential to introduce another impediment to effective communication between members.

Data Collection

The survey used for data collection in this study was developed as part of a larger study by an Aggies Invent research team consisting of faculty and graduate students from Texas A&M and several other universities. The existing survey has been used to assess engineering students' perceptions of teamwork from a 48-hour simulation of a workplace project team experience. As one of the members of that research team, I have

used half of the scales within the existing survey to examine details about the team collaboration process.

Instrumentation

The instrument I adopted from the larger study consisted of the following three sections: (a) team input from the demographic information of the survey, (b) three team process variables, and (c) team performance. The survey data was used to assess student perceptions of shared leadership (Grille & Kauffeld, 2015; Leight et al., 2018), team growth mindset (Han et al., 2019), team learning behavior **(**Van den Bossche et al., 2011), and team performance (Hinds & Mortensen, 2005).

Significance of the Study

This project has developed new knowledge regarding how students build team competencies and effectiveness to increase potential career success in future work environments. This study is unique in several ways that enable a closer look at student-level learning and performance by capturing teamwork processes through a survey. With the behavioral sequences characterized by data analysis forming a foundation for informed inference, I have identified the specific skills of team member interaction that may then be clustered into sets of competencies. Matching that conceptual hierarchy to theories of team effectiveness and performance can either increase the validity of those theories or suggest new alternatives.

Summary

In Chapter I, I have introduced my research about engineering student teamwork. I then discussed the problem statement, purpose statement, and my research questions. I

have also discussed my team process and output theoretical framework based upon systems theory and social cognitive theory. My methodology has been briefly introduced in Chapter III. Finally, the significance of the study was presented. In Chapter II, a literature review of the variables involved in the study will be presented based on my theoretical framework of the study.

CHAPTER II

LITERATURE REVIEW

The Literature Review Process

The following review of the literature provides background and support for my dissertation study and my hypotheses. This chapter is divided into four parts including an introduction, an explanation of the theories I used to create the intense team process and output theoretical model, a review of the key input, process, and output variables, and a summary of my hypotheses based on a review of the literature.

My literature review process started with a broad search on Google Scholar with terms such as "*factors enabling team effectiveness*." The goal for this broad search was to identify variables important to team success and test search words for my dissertation study. This broad search process generated around 20 articles, which gave me exposure to relationships among important variables, such as team emotional intelligence, trust, conflict, and team performance (Rezvani et al., 2019). In addition, I checked the reference lists of the 20 articles to see what productivity factors had been studied so far. After reviewing the team effectiveness variables, I generated a list of search terms: *shared leadership, team growth mindset, team learning behavior, and team performance*.

Theoretical Framework

In this section, social cognitive theory and systems theory are introduced as my theoretical framework for this study. In order to give a brief overview of both theories, I

first introduced their history and definition. Then, I discussed key factors undergirding each theory. Lastly, I introduced the application of both theories currently adopted in organizations.

Social Cognitive Theory

History and Definition

Since psychological theory in HRD "captures the core human aspects of developing human resources as well as the socio-technical interplay of humans and systems" (Swanson, 2001, p.304), I selected Albert Bandura's social learning theory (1977) and social cognitive theory (1986) to help understand the mechanisms of human functioning and learning in teams.

Albert Bandura's work (1986) fully developed social learning theory, which posits that people can learn by observing, interacting, and imitating other people in the social context. Ormond (2010) proposed four core assumptions of Social Learning Theory (SLT), which was revolutionary at the time since it contradicts the behaviorist theory of learning that had dominated psychology for the previous half century. The four core assumptions of SLT are, first, people can learn by observing the behaviors of others; Second, learning can occur without a change in behavior; Third, the consequences of behavior play a role in learning; And lastly, cognition plays a role in learning. Therefore, social learning occupies a central place in Human Resource Development (HRD). For example, when HRD practitioners are doing training sessions in groups, facilitators can apply role modeling as part of their instructional plan for each team member to learn from each other.

In 1986, Social Cognitive Theory (SCT) was developed from Social Learning Theory (SLT) by Albert Bandura. Social Cognitive Theory proposed that an individual's personality and learning occurred in a triangulate social setting with a dynamic and reciprocal interaction of the person, environment, and the person's behavior (Bandura, 1986). What is unique about SCT is that it takes an individual's previous experiences, current environment into consideration. All of which shape whether a person will engage in a specific behavior, and the reasons why a person engages in that behavior. In addition, SCT has a triadic reciprocal causation relationship which means that the three factors have mutual causation effect on each other. The individual context is a critical factor in the learning that occurs. Therefore, SCT will be used to frame this research project.

Key Variables

The three main variables in Social Cognitive Theory are environmental factors, personal factors, and behavioral factors. In other words, the variables represent the work environment itself, what the person is thinking, and what the person is doing. The examination of all three factors provides for a strong systemic view of performance via this three-way interaction.

Social Cognitive Theory explains in detail how important each factor is. For example, the work environment variable represents how safe the physical surroundings and social environment is around the person. The personal variable involves the characteristics such as beliefs, values, attitudes, cognitive skills, physical attributes, and previous knowledge, etc. The behavioral variable characterizes what the person's actions

are such as observation, interaction, and imitation in a certain context for the purpose of learning. As each of the variables influence the others, when a person wants to change an old behavior or learn a new behavior, she or he needs to change at least one of the variables.

Applications

Some researchers used social learning theory to understand different aspects of teamwork such as "best practices" (Staples & Webster, 2007). For example, Inks and Avila's (2008) study showed that social learning theory helped students to apply active learning strategies so they could learn from each other in multiple ways. Also, multiple generation studies, such as Srinivasan (2012), indicated that HRD practitioners could adopt social learning theory to bridge the gap between different generations, thus enabling the identification and valuing of each generations' characteristics and strengths so people could learn from each other without feeling one generation was better than the another.

Past studies have also shown the applicability of social cognitive theory in understanding prevalent issues in various aspects at the team level, such as management studies (Huan, 2015), organizational learning (Staples & Webster), knowledge sharing, perceived team efficacy, and cultural intelligence (Chen & Lin, 2013). For example, Huan (2015) reviewed how researchers have used the cognitive theory in firm innovation management studies and found that cognitive theory is a fundamental perspective to approach innovation in companies. Staples and Webster (2007) used SCT to develop a research model to explore how personal beliefs about proposed best

practices affected team effectiveness in both traditional and virtual teams. They also looked at how team members' beliefs are influenced by others and by environmental factors. The results supported the conclusion that observing team members' activities is an important way for employees to learn about teamwork activities and enhance their beliefs in their own abilities. Moreover, Chen and Lin (2013) provided an illustrative and practical perspective of how SCT can be further applied to understanding knowledge sharing in cross-cultural teaming contexts. Their findings demonstrated that "knowledge sharing is directly influenced by metacognitive, cognitive, and motivational cultural intelligence. At the same time, knowledge sharing is indirectly impacted by metacognitive and behavioral cultural intelligence through the mediation of perceived team efficacy" (Chen & Lin, 2013, p. 1).

Systems Theory

History and Definition

The second theory I employed was systems theory, as teams are complex, adaptive, dynamic systems. According to Swanson (2001), **"**Systems theory captures the complex and dynamic interactions of environments, organizations, work process and group/individual variables operating at any point in time and over time" (p. 305). Therefore, systems theory is one of the critical theories I employed to guide my dissertation research. There are a number of systems theory-based models of teams, all of which contain differences in specific details regarding the nature of teams. They all reflect the underlying notion that teams are complex, dynamic systems, existing in larger systemic contexts of people, tasks, technologies, and settings. In this dissertation, I have

considered the widely used I-P-O model (Ilgen et al., 2005) and its "upgraded" IMOI model to explain my research. Each is described in the following sections.

I-P-O Model

Steiner (1972), McGrath (1984) and Hackman (1987) developed a classic system model called the Input-Process-Output (I-P-O) model to explain team effectiveness. In Hackman's (1987) words: "This framework posits that various input factors, such as features of the group, its task and its work context, affect group-interaction processes (i.e. the interpersonal transactions that take place among members), which in turn affects the output of the group" (Hackman, 1987, p. 316). In the I-P-O model, inputs are fed into processes that in turn result in outputs. Thus, the model suggests a linear progression of main effect influences proceeding from one category (I, P, or O) to the next. For example, after producing output, there might be feedback from customers using the output.

I-P-O Key Variables

Based on a system world-view model of HRD as a process within an organization and its environment, we can see that systems theory has four components. They are environment, organization, work process, group and individual variables. Keeping these components in mind, Hackman's (1987) I-P-O model applied these four variables in systems theory. However, Hackman's (1987) I-P-O model distinguishes between individual level, team level, and organizational level inputs. More specifically, individual level inputs include team members' competencies and personalities, team level inputs include team size and structure, and organizational and contextual inputs

include such information as organizational design characteristics. Output variables are more specific about task performance, such as team members' satisfaction, or changes in attitude (Hackman, 1987).

IMOI Model

Although I-P-O model has been a classic and powerful influence on team studies and has been adopted by researchers for many years, multiple researchers have claimed that the I-P-O model is insufficient for fully characterizing teams (Ilgen et al., 2005; Moreland et al., 1996). These researchers indicated that the convergence of consensus regarding the utility of I-P-O models as a guide to empirical research fails to capture the emerging consensus about teams as complex, adaptive systems. That is to say, the I-P-O model does not capture the concept of teams being complex, adaptive systems, and does not have the power to fully characterize the complex nature of team interactions thereby constraining research into team dynamics. As a result, they modified the traditional I-P-O model into the IMOI (Input-Mediator-Output-Input) as a more fully realized team effectiveness model.

Ilgen et al. (2005) stated three reasons why the IMOI model is a better team effectiveness model. First, many of the mediatory factors are not processes but emergent cognitive or affective states or properties, because team research includes not only behavioral processes, but also emergent cognitive and affective states. Second, the I-P-O model limits research by implying a single-cycle linear path from inputs to outputs and fails to identify the feedback loop. Third, recent research has moved away from relying on a linear progression model to a non-linear model.

IMOI Key Variables

Input, mediator, output, and input are the four key variables in the IMOI model. Ilgen et al. (2005) separated teamwork into three stages or phases (forming, functioning, and finishing). In each phase, two variables in the IMOI are present in the process. For example, "I" and "M" occur in the forming stage. The authors talked about trusting, potency, and safety within the stage. "M" and "O" occur in the second functioning stage: bonding through managing diversity or membership, managing conflict among team members; adapting in terms of performance in routine versus novel conditions; helping and workload sharing; and learning, including learning from minority and dissenting team members, and learning from the team's best member have been discussed. "O" and "I" occur in the last stage called finishing. "O" represents the product from the team occurring the previous stage which becomes "I" (input) for collaborating on the next round with the team.

In summary, Ilgen et al. (2005) made three changes to the classic I-P-O model. First, they eliminated the hyphens between letters to signify that the causal linkages may not be linear or additive, but rather nonlinear or conditional. Second, substituting "M" for "P" reflects the broader range of variables that mediate the variability in team performance and viability. Third, adding the extra "I" at the end of the model explicitly invokes the notion of cyclical causal feedback since by adding up the feedback from output, the input for next round of collaboration can be improved.

In this study, I considered using the I-P-O model and be aware of the emergent states concept from IMOI model as both of them make sense for some part of my study

nature. For example, I used the I-P-O model to represent the linear timeline for the intense design competition study context since the three-day competition associated almost perfectly with I-P-O model. Participants got to know each other and form groups on day one. Each of the team members brought various background and knowledge to the team as their inputs. They then worked in a team setting to explore solutions to the problem they picked on day two, which considered to be the teamwork process. And team members then presented their final result and received evaluation by judges on day three, which considered as their output product. Additionally, as for keeping the awareness of emergent state in the IMOI model, since some of my variables such as team growth mindset and shared leadership are considered to be emergent cognitive and affective states during the competition process, I would like to be aware of the emergent state variables in the IMOI model to show that the I-P-O model is not entirely sufficient to address the study's complexity.

To summarize theories I adopted in my dissertation research, I weaved both social cognitive theory and systems theory as my framework for two reasons. First, I want to take a systematic approach to the investigation of student team processes in the Intense Design Experience (IDE) program. Systems theory and the two models within it have the potential to enable me to characterize the processes and variables that must be considered and to understand how an effective student design team works in a short period of time. The second reason is that the processes through which people learn, and the psychological aspects that influence people to learn new behaviors or change their previous behaviors fascinate me. I think both social learning theory and social cognitive

theory are well suited to guide my work in discovering the characteristics (psychological and interpersonal) that contribute to the success of short-term student teams.

Team Input

A detailed analysis of the relevant literature was conducted to form the foundation for my research questions, research design of the methodology, data analysis, and discussion. I have separated the review of the literature into three sections: input, process, and output. In each section, I first reviewed the background and definition of variables. I next focused on combinations of variables. For example, I reviewed what had been researched on the relationship between shared leadership and team growth mindset. Under each subtopic of the chapter, I have proposed my hypothesis based on my review of the literature.

Team input is the first part of the literature review that focused on the input factors of the study. The Invent for the Planet (IFTP) survey collected demographic, team information, and information about the participants' perspectives about teamwork. For example, as regards the participants' team information, I collected the team's name, university of the team, number of team members, gender spectrum, and previous relationships among the members. I did not include culture as my study scope since most of the teams were not comprised of teammates with different cultural background, except the U.S. The following paragraphs explain the input factors I used as my control variables in my dissertation study.

Gender Diversity

Previous research has shown that gender diversity is a potential determinant of team performance in various settings. According to Hoogendoorn et al. (2013), mixed gender teams in business are more likely to offer a diverse set of knowledge and skills and are more generous and egalitarian. Moreover, the study found that teams with a larger percentage of females perform better by building meaningful relationships and creating successful work processes. Similarly, Bear and Woolley (2011) strongly suggested that the presence of women in the group greatly improved team collaboration process and team performance in STEM (Science, Technology, Engineering and Math). Specifically, Apesteguia et al. (2012) found that three-women teams were less aggressive in their strategies. Also, three-women teams invested more in social sustainability initiatives than any other gender combination teams. Therefore, in this study, I am interested to see if gender diversity especially the number of women in teams can control the relationship between process variables and team performance.

Team Size

Team size (number of team members) has been shown to be one of the enhancers of team innovation (West, et al., 2003) and team performance (Sweeney et al., 2019). The impact of team size on team performance explained why several studies used team size as a potential control variable as it can influence both team effectiveness and performance. In addition, based on the literature from the fields of business and education, the optimal size of a learning team is five to seven members (Michaelsen & Sweet, 2008). Large teams are purported to be more likely to possess the collective intelligence required to solve complex classroom problems. Although larger teams can

have more collective intelligence, smaller teams develop group cohesiveness more quickly, thereby enhancing their initial team performance. Thus, I am interested to see if team size is a potential control variable between team process variables and team performance.

Team Process

The second section of the literature first focuses on reviewing each process variable in the study. Then I switch my focus to review the interrelationships of the three process factors: shared leadership, team growth mindset, and team learning behavior.

Shared Leadership

Numerous researchers have conducted studies in shared leadership. However, scholars have yet to agree on a general definition. This lack of consensus is one of the reasons why the concept of shared leadership has been criticized (Carson et al., 2007). As Scott and Caress (2005) declared, shared leadership is an ongoing and fluid process, which requires continuous reevaluation and scrutiny.

The most widely cited shared leadership definition is from Pearce and Conger (2002), who defined shared leadership as "a dynamic, interactive influence process among individuals in groups for which the objective is to lead one another to the achievement of group or organizational goals or both" (p. 1).

While Pearce and Conger's (2002) shared leadership definition is the most popular one according to some researchers, Hoch and Dulebohn's (2017) definition of shared leadership, "the spreading of leadership to multiple or all team members" (p. 4), resonates with me more. This shared leadership definition showed the transition process

from traditional leadership where one person is in charge and the others follow (Pearce et al., 2009) so that everyone can be a leader in the team. That is to say, the nature of shared leadership involves broadly sharing power and influence among team members (Pearce et al., 2009). Therefore, de Cruz (2019) concluded that shared leadership has team-based structure while traditional leadership has an individual based structure.

According to Grille and Kauffeld (2015), shared leadership has two dimensions: task-oriented shared leadership (TOSL) and relation-oriented shared leadership (ROSL). Grille and Kauffeld (2015) deemed that relation-oriented shared leadership (ROSL) processes enhance the emotional bonding of a team, resulting in both a positive team environment and higher commitment to team goals (Mannix & Neale, 2005). Task-oriented shared leadership (TOSL) refers to the shared concern among members for achievement of collective goals by initiating structures which aim at increasing efficiency and coordination among team members (Stogdill & Coons, 1957). Furthermore, Leight et al. (2018) developed five additional items to assess creativity-oriented shared leadership (COSL) based on analysis of video recordings of student teams.

Team Growth Mindset

Recently the term "growth mindset" became one of the buzzwords in personal development and psychological wellness. However, most people still do not grasp what the concept truly means. Stanford Professor Carol Dweck (2006) coined the terms "fixed mindset" and "growth mindset" to describe the two sets of behavior differences when children cope with failure experiences. In her studies, she discovered that some children

"cope" with the failure by thinking it is the end of the world (fixed mindset). However, others "relished" it by viewing the failure as an exciting learning opportunity (growth mindset) (Diener & Dweck, 1978; Dweck & Reppucci, 1973; Elliott & Dweck, 1988).

Compared to research about individual growth or fixed mindset, mindset at the team level remains under-studied. Scholars assume that individual mindsets can impact either the collective level or system level as small shifts in individual mindsets can cause big systemic changes (Meadows, 1999). However, some similar concepts such as collective efficacy has been explored. Research has shown that efficacy at a team level (collective efficacy) can influence team performance (Bandura, 1997; Cheng & Yang, 2011; Hsu et al., 2007). For example, Cheng and Yang's (2011) study proposed collective creative efficacy (shared belief in collaborating to develop creativity of process during information system development) to explore the link between efficacy and creativity at the team level. The study concluded that collective efficacy is an important element to explore behavior, performance, and creativity.

It seems to me that the concept of collective efficacy overlaps with a team level growth mindset since team members have shared belief in collaborating and learning as the ultimate goal during the teaming process. Han et al. (2019) suggested the possibility of expanding the study of individual mindsets to team mindsets based on focus group interview results. The authors defined team growth mindset as the belief shared by team members that they can develop each other's capacity through sharing knowledge, learning from failure, and managing challenges through joint effort. According to their analysis of both individual and team level mindsets, they found that team growth

mindset has the following components: peer feedback, challenging each other, learning from errors, and taking risks with sharing (Han et al., 2019). To conclude, team growth mindset focuses on collective beliefs about how a team can enhance its processes and outputs.

Team Learning Behavior

Team learning behavior is a concept derived from organizational behavior research (Myers et al., 2018). Before understanding team learning behavior, it is important to understand the concept of individual learning, because the process of transforming from individual learning to team learning is a bottom-up process (Kozlowski & Klein, 2000). Individual learning describes how each person learns to enhance his or her knowledge and performance (Liu & Fu, 2011). Team learning, on the other hand, is concerned with the learning patterns individual members generate via interactions and common experiences (Liu et al., 2014). The team learning patterns each member generate are considered to be a series of behaviors, which are called team learning behaviors.

Different researchers have distinctive definitions and understanding of team learning behavior. According to Edmondson (1999), team learning behavior is "an ongoing process of reflection and action, characterized by asking questions, seeking feedback, experimenting, reflecting on results, and discussing errors or unexpected outputs of actions" (p. 353). Other researchers defined team-learning behaviors as "activities through which individuals acquire, share, and combine knowledge through experience with one another" (Argote et al., 2001, p. 370), and can include challenging

assumptions, reflecting on past performance, and providing high-quality feedback (Edmondson et al., 2001). To conclude, team learning behaviors include the following components: asking for information (acquire), seeking feedback (acquire), discussing errors (share), reflecting on performance (combine).

Besides the actual behaviors in team learning, Van den Bossche et al. (2006) unraveled team learning behavior concept into three aspects: construction, co-construction, and constructive conflict. Based on the three aspects, the authors developed a questionnaire to measure team learning behavior and found that all question items tapped into one construct. *Construction* of meaning is a stage when one of the team members describes the problem and proposes solutions, then the rest of the team members actively listen to understand the problem. *Co-construction* happens when the construction of meaning process evolves into team collaboration. For example, when one of the team members explained the meaning of the problem, the other members refine, reflect, build on, or modify their collective understanding of the problem in order to arrive at a new interpretation of the challenge they face. *Constructive conflict* describes the process involving arguments and clarifications between team members when they are working to arrive at a collective interpretation of the challenge.

Table 1 summarized the abovementioned definitions of each process variable in this study.

Table 1 Process Variables and Definitions Adopted in My Study.

Variable	Definition
Shared Leadership	"An emergent team property that results from the distribution of leadership influence across multiple team members" (Hoch et al., 2010b: p. 105).

Team Learning Behavior	"An ongoing process of reflection and action, characterized by asking questions, seeking feedback, experimenting, reflecting on results, and discussing errors or unexpected outputs of actions" (Edmondson, 1999, p. 353).
Team Growth Mindset	The belief shared by team members that they can develop each other's capacity through sharing knowledge, learning from failure, and managing challenges through joint effort (Han et al., 2019).

After having a better understanding of each process variable, I start my review on the interrelationships between each process variable. Based on what has been discussed previously in applications of social cognitive theory, I proposed a team level SCT by using three variables to represent the three aspect of individual level SCT. In Figure 2, the left side of the figure illustrates a triangular relationship of Bandura's social cognitive theory derived in 1986, which focuses on individual learning theory. The right side of the figure is my proposed application of social cognitive theory focusing on team learning. Shared leadership creates a sharing environment which represents the environmental aspect of SCT. Team growth mindset represents the cognitive aspect of SCT. Team learning behaviors represents the behavioral aspect of SCT. The arrow in the bottom showed how I proposed to transfer SCT from an individual level to the team level with the three process variables chosen in my dissertation study. I described in the following sections how these three process variables interact with one another.

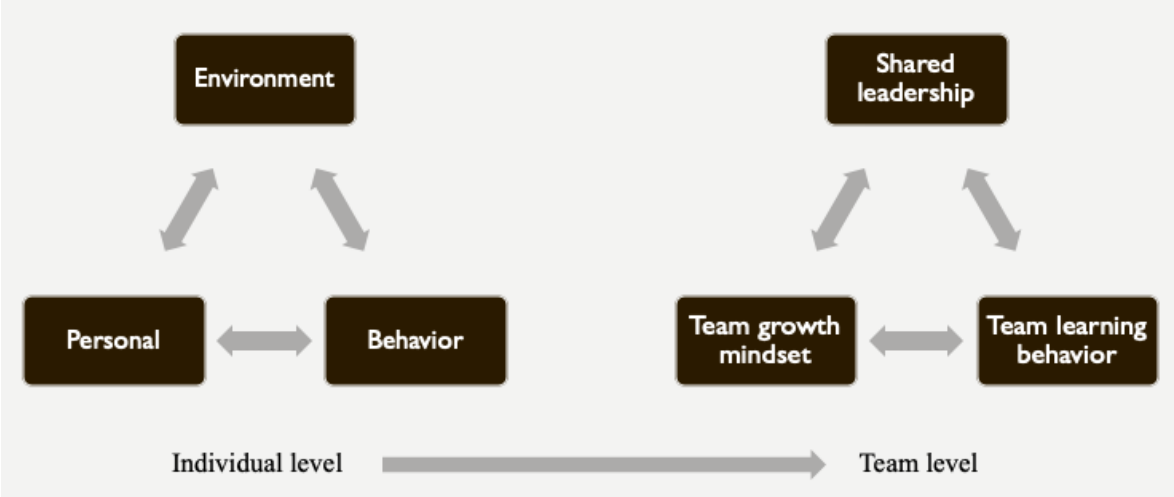

Figure 2 SCT from individual level to team level.

Shared Leadership and Team Learning Behavior

Numerous researchers have found a positive, reciprocal relationship between shared leadership and team learning behavior (Liu et al., 2014; Wang et al., 2017). That is to say, although studies were being conducted in different settings using various methodologies, some studies reported that shared leadership can stimulate team learning behavior (Liu et al., 2014;). Some reported that team learning behavior can stimulate shared leadership (Wang et al., 2017).

Existing empirical literature has shown evidence that shared leadership stimulates team learning behavior. I detail this research below. Liu et al. (2014) found evidence from 70 work teams in China that shared leadership had a positive impact on both individual and team learning. This study claimed to be the first effort to connect shared leadership with learning behaviors in both individual level and team level. The reason for this is because shared leadership facilitates some key team learning factors

(e.g., Edmondson, 1999), which include “trust, interdependence and coordination among members, reduction of team conflict, reduction of the communication barriers associated with unequal status, and low levels of psychological safety” (Bergman et al., 2012; Drescher et al., 2014). For example, Hoch (2013) found that team innovative behavior was positively associated with shared leadership.

There is also evidence from the literature showing that team learning behavior can stimulate shared leadership. Wang et al.’s (2017) also found that in the early stages of the teamwork, teams engaged in more learning behaviors were more likely to keep their shared leadership network structure stable. Team learning behaviors require members to share or create knowledge (Wilson et al., 2007), which requires interpersonal risks (Bunderson & Reagans, 2011) when members challenge assumptions, reflect on what task progress, evaluate alternatives, or criticize the work of others (Edmondson et al., 2001). During this process, different team members uncover their different levels of willingness and capacities to help the team to learn. Once their sharing and engagement in team learning are perceived by others as contributions to team outputs, those sharing their knowledge should be viewed by teammates as exercising leadership (Berger & Webster, 2006).

To conclude, shared leadership seems to have a reciprocal causation relationship with team learning behavior, which has been explored by several streams of research. They suggest that shard leadership and team learning behavior have a different relationship according to the stages of teamwork (Marks et al., 2001) in self-managed teams. That is, stages of the teamwork decide when shared leadership can stimulate team

learning behavior and when team learning behavior can stimulate shared leadership. For example, Wang et al. (2017) collected data from 66 MBA student teams on a business simulation project in Asia and found that shared leadership could stimulate team-learning behaviors at the early stages of the teamwork when members were preparing to work on a focal task (Marks et al., 2001). When teammates share leadership working on a new task, communication and negotiation are needed (London & Sessa, 2007), which require team members to exercise learning behaviors such as raising questions and offering feedback. Therefore, shared leadership is likely to stimulate higher levels of learning behaviors early in the team task.

Following these evidence, shared leadership and team learning behaviors may have a reciprocal and self-reinforcing relationship. Therefore, my third hypothesis is that shared leadership and team learning behavior are positively correlated.

Shared Leadership and Team Growth Mindset

Research focused on the direct relationship between the combination of shared leadership and team growth mindset variables is rare (Han et al., 2020). Most research have focused on different leadership styles with individual growth mindset in either employees or employers (Caniëls et al., 2018; Chan, 2016; Lee, 2018).

Even though research on the direct relationship between shared leadership and team growth mindset is very limited, many research have focused on the relationship between various kinds of leadership and individual growth mindset. Caniëls et al.'s (2018) found a positive and significant relationship between employees' proactive personality with transformational leadership in a study of 259 employees in a high-tech

company in the Netherlands. The authors found that transformational leadership moderates the relationship between proactive personality and work engagement only when employees have a growth mindset. Similar results were summarized in Lee's (2018) study. He found a significant and positive relationship among authentic leadership, hope, individual growth mindset, grit, and organizational effectiveness. In addition, Chan (2016) stated that when a servant leader has a growth mindset, he or she will make a conscious effort to develop self-effectiveness in areas of listening, empathy, healing, awareness, persuasion, conceptualization, foresight, stewardship, commitment to the growth of people, and community building.

As for now, only in Han et al.'s (2020) examined the direct relationship between team growth mindset and shared leadership. The study was within student design team context and found that individual growth mindset has a significant and positive direct effect on team growth mindset and shared leadership. Also, team growth mindset mediates the relationship between individual mindset and shared leadership. Therefore, my fourth hypothesis is that shared leadership and team growth mindset are positively correlated.

Team Learning Behavior and Team Growth Mindset

Although limited research examined the relationship between learning behavior and growth mindset at the team level (Han et al., 2019), research has been done regarding their positive relationship at the individual level (Hanson et al., 2016).

Growth mindset has been used as interventions to help individuals make choices and change behaviors. Hanson et al. (2016) stated that when teachers adopted a growth

mindset and believed that individuals can grow and learn, stereotype behaviors would reduce, the ability to be open to new information, solve conflict, tolerate others' behaviors would increase (Blackwell et al., 2007; Yeager et al., 2014). Similar findings showed in Dweck (2012) and Walton (2014) study that when schools used growth mindset, faculties were more likely to have the ability to help students grow and learn.

In the meanwhile, learning behaviors can also reinforce growth mindset since one of the components of growth mindset is learning behaviors: "An ongoing process of reflection and action" (Edmondson, 1999, p. 353). People learn from the interactions that take place among the team members (cognitive factor), the work that the team is doing (behavioral factor), and from social-environmental responses (environmental factor) to their work (Gabelica et al., 2014). All these factors in team learning will facilitate team members' growth mindset.

Based on the evidence from the above literature, growth mindset and learning behaviors have a positive and significant reciprocal relationship at the individual level, it is possible to argue that growth mindset and learning behavior can have a positive and significant reciprocal relationship at the team level, which currently only exists conceptually as there is limited evidence to show the correlation between the two team level variables. The components of a team growth mindset include peer feedback, challenging each other, openness to change, learning from errors, and taking risks with sharing (Han et al., 2019). All of the abovementioned components lead to changes in learning behaviors for all team members, which provide the foundation of effective team learning. Vice versa, when learning behaviors changed among team members, team

growth mindset will be reinforced. Thus, my fifth hypothesis is that team learning behavior and team growth mindset are positively correlated.

Team Output

This third section of the literature review focuses on the relationship between each process variable with the team performance output variable.

Team Performance

Team performance is one of the components of team effectiveness because "performing well" is one of the characteristics of effective teams. For example, Guzzo and Dickson (1996) in their review of teams within organizations wrote that "effectiveness in groups is indicated by (a) group-produced outputs (quantity or quality, speed, customer satisfaction, and so on), (b) the consequences a group has for its members, or (c) the enhancement of a team's capability to perform effectively in the future" (p. 309).

Since team performance has a connection with team efficiency, some scholars viewed team performance as a continuous effort in the process to help with team efficiency (Moura et al., 2019), while some others viewed team performance as final group-produced outputs (Salas et al., 2008). Moura et al. (2019) defined team performance as "the multilevel process that comes up as team members engage in managing both their individual and team levels of work and teamwork processes" (p. 71). However, Salas and his colleagues, who defined team performance as a product of team members working together towards goals and drawing on their pool of individual

and shared resources (Salas et al., 2008). In this study, team performance is being viewed as a product of team members created instead of the teamwork process.

According to Schmutz et al. (2019), team performance is often related to the inputs, processes and outputs (I-P-O) model. For example, teamwork processes such as communication and decision making will affect output factors such as quality of care, errors or performance. Furthermore, teamwork processes can be influenced by inputs such as team members' experience, task complexity, time pressure, etc. That is to say, improving both team inputs and process factors can improve team performance. Since input variables have been reviewed in the earlier sections, the following sections aim to review the relationship between each process variable and team performance.

Shared Leadership and Team Performance

Multiple researchers have found evidence of a positive relationship between shared leadership and team performance. According to Solansky (2008), shared leadership allows more team members to address a team's developmental and functioning needs, which consequently influences a team's performance. Pearce and Conger (2002) stated that shared leadership incorporates other leadership behaviors such as transformational, transactive, participative, empowering, and aversive behaviors. Therefore, shared leadership was found to be an important team output predictor especially in project teams that require significant decision making and self-management skills (Bergman et al., 2012).

Grille and Kauffeld (2015) showed that shared leadership can lead to improved team performance, therefore, researchers have recently shifted their attention from

vertical leadership to shared leadership (Badrani et al., 2015; Carson et al., 2007; Ensley et al., 2006). Similarly, Day et al. (2004) indicating that increased information processing and learning in shared leadership environments contributes to team members' knowledge, abilities, and skills, and promoted more team effectiveness than vertical leadership. In addition, Ensley et al. (2006) examined 66 management teams' performance to compare vertical leadership and shared leadership. The study found that shared leadership was able to predict teamwork effectiveness better than vertical leadership. Hoch et al. (2010) concluded that, "the influence of shared leadership in most settings has exceeded that of hierarchical leadership in predicting team and organizational outputs to positively impact team performance" (p. 2).

Despite some evidence of the positive effect of shared leadership on team performance, some scholars have not reported this reinforcing effect (Mathieu et al., 2015; Serban & Roberts, 2016). Mathieu et al.'s (2015) meta-analysis reported that shared leadership did not have a direct relationship with team performance based on data gathered from 57 student-teams. Serban and Roberts (2016) found that with a variety of antecedents and outputs not all relationships between shared leadership and team performance were significant. The study of shared leadership in student project teams is in its early stages, and more research are needed to investigate the relationship between shared leadership and team performance.

The reason why shared leadership sometimes can predict team performance and sometimes not might have something to do with the study context. Klein et al. (2006) examined extreme action medical teams in an emergency trauma center and found that

when teams face challenging conditions such as time pressure or a high degree of risk, shared leadership can be an essential driver of team performance. Additionally, Wang et al.'s (2014) study showed that shared leadership is context specific, since the study recognized that shared leadership could influence team effectiveness in specific team sharing contexts such as sports or in unconventional and multicultural environments (de Cruz, 2019).

In the IFTP setting, teammates need to work on creative tasks under challenging conditions in terms of time pressure. Therefore, my sixth hypothesis is that shared leadership has a positive relationship with team performance.

Team Growth Mindset and Team Performance

The literature has shown that growth mindset at individual level has a positive influence on an individual's performance. Dweck (2006) found that praising children when they conquer difficulties instead of praising their fixed traits helped them become less fearful of challenges and view feedback as a way to improve rather than as a personal attack. Moreover, when adults see their intelligence as something that can grow in time, this growth mindset has profound effects on their motivation, learning, and school achievement (Dweck, 2006).

Research has shown that individual growth mindset enhances individual performance, and that teams can and do take on a "collective mindset" (Kegan et al., 2009). These perspectives suggest that team performance may be improved more powerfully by growth mindset at the team level than growth mindset at the individual level. Thus, I believe growth mindset and performance also have a positive relationship

at the team level. Since the components of a team growth mindset include providing peer feedback, challenging each other, openness to change, learning from errors, and taking risks with sharing (Han et al., 2019), all the components can have a great potential to positively affect overall team performance. Hence, my seventh hypothesis is that team growth mindset has a positive relationship with team performance.

Team Learning Behavior and Team Performance

The following Peter M. Senge quote from the *Fifth Discipline* demonstrates why team learning behavior is vital to organizational team performance. Senge stated that "team learning is vital because teams, not individuals, are the fundamental learning unit in modern organizations. This is where 'the rubber meets the road'; unless teams can learn, the organization cannot learn" (Senge, 1991, p. 10). That is to say, due to the fundamental nature of team learning, learning behaviors at the team level have a direct impact on how much the organization can learn.

Numerous researchers have reported that team learning behavior is one of the most important influential variables that effect team performance (Argote et al., 2001; Edmondson, 1999). For example, Widmann et al. (2016) carried out a systematic review of 31 articles and concluded that team learning behaviors can facilitate innovative performance. The study concluded that team learning behaviors specifically focused on sharing, team reflection, and team activity. These team learning behaviors in turn had the strongest impact on teams' engagement in innovation development. As the authors stated: "learning and innovation development are mutually dependent aspects of teamwork" (p. 1). Widmann et al. (2016) suggested organizations and practitioners focus

more on fostering team development via enhancing learning behaviors and innovative work behaviors in teams. Similarly, other scholars reported that physician teams with stronger team learning behaviors tended to have significantly reduced burnout rates, which demonstrated a positive association between team learning behavior and team performance (Myers et al., 2018).

Although previous research reported that team learning behaviors enhance team performance, some contradictory findings have also been reported. After a decade of research on what happens when teams focused on learning, some studies have suggested that emphasizing team learning too much can have a detrimental effect on team performance in the short run. For example, Bunderson and Sutcliffe (2003) obtained empirical evidence from management teams that showed that learning focused teams (develop business-related skills, find best practices, and seek new ideas and challenges) could depress team performance. More specifically, the study showed that teams focusing on either a "constant learning and changing attitudes" approach or an "if it-ain't-broke-don't-fix-it" approach had similar effect on team performance. An overemphasis on team learning can cause members to become distracted from their real goals and spend too much time and effort attempting untried solutions instead of strategies which are already working. This finding is similar to what Myers et al. (2018) research which reported that team learning behaviors may be more beneficial for individuals who have low to average levels of learning goal orientation than people who have average to high levels of learning goal orientation. To conclude, team learning behavior can have both positive and negative effects on team performance depending on

team members' learning goal orientation levels, the performance level of the team, and time involved in the teamwork.

Since IFTP participants are elite teams represent each university globally, I view them as high-performance teams. Also, the competition only lasts for 3 days which considered to be a short run. Therefore, team learning behaviors might not be a key reason for their performance since team learning behaviors are reported to have positive relationship to team performance for average to low performance teams and in the long run. Consequently, my sixth hypothesis is that team learning behavior has a negative relationship with team performance.

Hypotheses Development

Based on the intense team process and output theoretical model in chapter I (Figure 1), my hypotheses were developed (Figure 3). My research questions were to examine if process variables are associated with team performance in the context of Intense Design Experience (IDE) for engineering university students. Each hypothesis was supported by a substantial scholarly literature described in the previous sections. Figure 3 is a visual representation of my hypotheses. Each link in Figure 3 represents a hypothesis. Below is a list of my hypotheses.

Hypothesis 1: Shared leadership and team learning behavior are positively correlated.

Hypothesis 2: Shared leadership and team growth mindset are positively correlated.

Hypothesis 3: Team learning behavior and team growth mindset are positively correlated.

Hypothesis 4: Shared leadership has a positive relationship with perceived team output.

Hypothesis 5: Team growth mindset has a positive relationship with team output.

Hypothesis 6: Team learning behavior has a negative relationship with team output.

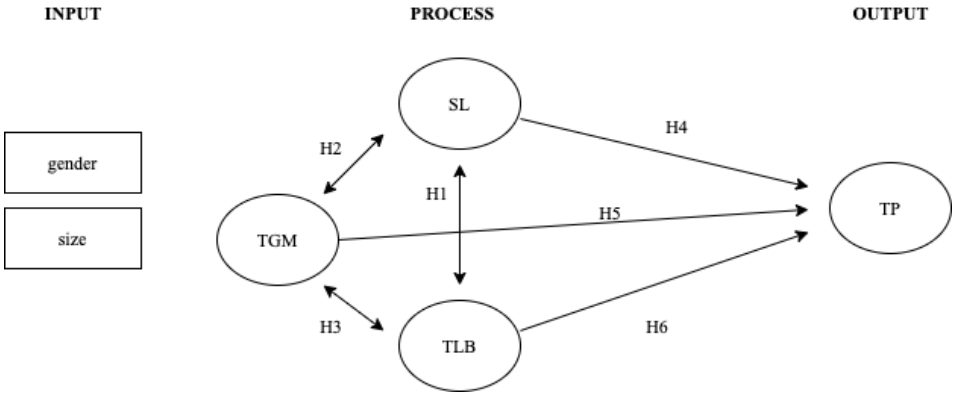

Figure 3 Hypothesized intense team process and output model.

Summary

In this chapter, I have briefly described my search processes and strategies. Then I reviewed the theories that built an intense team process and output theoretical model. I also reviewed the key variables in my dissertation study, which were separated input, process, and output sections. I then focused on the interrelationships among the three process factors and the relationships between each process variable and the output variable. I proposed a research hypothesis at the end of each section. As will be highlighted in chapter III, my review of the literature heightened my theoretical

sensitivity to the studied phenomenon – factors that influence team performance in the context of an Intense Design Experience (IDE) competition.

CHAPTER III

METHODOLOGY

This chapter describes my methodology. Included are my research setting, participants' characteristics, data collection procedures, instrumentation for each scale, and a data analysis plan, and limitations of the study design.

The purpose of this study is to test an intense team process and output model using engineering student project teams in an international design competition called Invent for the Planet (IFTP) as a research environment. The ultimate outputs of this study were twofold. First, I tested if the three process variables (shared leadership, team growth mindset, and team learning behavior) were mutually influenced by applying social cognitive theory. Second, I characterized the impact of three process variables (shared leadership, team growth mindset, and team learning behavior) on team performance.

To understand how team transition from formation to producing solutions, I sent the IFTP survey to student teams from universities that participated in this 48-hour intense design competition. The following research questions guided these inquiries:

1. Does social cognitive theory explain team dynamics in the Intense Design Experience (IDE) context?
2. What is the relationship between each process variable and team performance in an intense student design team competition context?

Research Setting

I used Invent for the Planet (IFTP), a global intense design competition, as my research setting. IFTP is a 48-hour intense design competition which aims to challenge university students to innovate, design, build, and present solutions to real-world problems. The event was created by the Director of Entrepreneurship in the College of Engineering at Texas A&M University (TAMU) as part of the Aggies Invent series of Intense Design Experiences (IDE), which began in 2014. The first IFTP was launched in February 2018 with 14 universities from five continents. IFTP 2019 was held in February with 27 universities participating. IFTP 2020 included 39 universities from all over the world. Figure 4 represents the regions where 2020 participants come from.

Figure 4 2020 IFTP participants' regional location.

Three Rounds

The 2020 IFTP competition had three rounds. In the first round, each university held a local competition during the same weekend. Each local team chose one challenge issue to work on from a set provided to all the universities. In the second round, each winning team at the local level submitted a video presenting their prototypes for a

central set of judges to review at the global level. In the third round, six teams were selected by these judges for the final global competition that occurred on the TAMU campus a few weeks later. The global champion was determined from the results of the final round. In each round, judges used a standard rubric to assess the innovativeness of the problem solution and the quality of the presentation of that solution to choose the winning team. Figure 5 illustrates the 2020 IFTP three-round selection procedures.

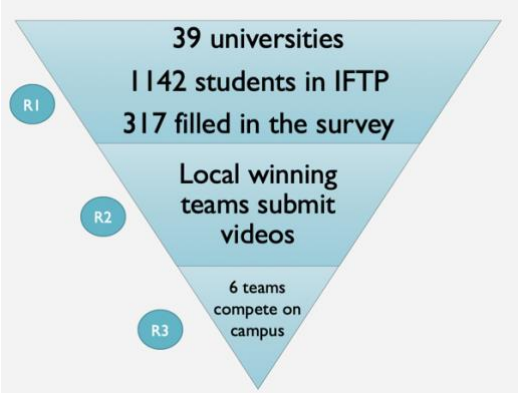

Figure 5 IFTP competition procedures.

Three Days

There are three days in each round of IFTP. Each round, participants are able to use all the facilities, professional staff, and experienced mentors available in their local engineering lab during the course of the competition. Each university uses the same event structure and procedure, and the same set of real-world problems. At the beginning of the competition, participants gather in a large room and are presented with 10 to 15 need statements on such issues as nuclear security and other current societal challenges. Event facilitators present students with open-ended needs statements (challenging problems) for them to solve within 48 hours. This set of problems is emailed to all

participating students two days before the event and then displayed on tables around the room for viewing. Participants negotiated to form teams of 4 to 6 people based on similar interests in addressing one of the problem statements. The teams then researched the topic they chose and develop a plan to build a physical prototype model. On the last day of the event, each team developed a solution and then presented their solution to the problem and explained the prototype they created.

Participants

The sample for this study is comprised of university students across the world who participated in the Invent for the Planet (IFTP) in 2020. Approximately 50 students participate in the event from each of 39 universities, for a total of 1142 participants. The study sample has the following characteristics: (a) participants in the IDE program come from different universities from diverse cultural backgrounds. This diversity of people and cultures creates challenges for teammates to communicate, especially for students from the U.S.; (b) participants pursued different university courses of study. Thus, they were very likely to use different discipline related terminology, which might introduce another impediment to communication between members.

Data Collection Procedures

In the following section, I present my IFTP survey dissemination strategy. First, the answers to the survey questions were compiled using Qualtrics. Second, a recruitment email was sent to universities participating in the IFTP event. After receiving their permission, Texas A&M IFTP facilitator sent the Qualtrics survey link via email to local facilitators, who then sent the link to student participants at those

participating universities on Sunday (the last day of the event). On Sunday, after the teams finish their presentations, before judges announce the results, students received an email with the survey link. The survey starts with an information sheet which provides the purpose and background of this study and a statement to which participants can signify their consent to participate. If they consent to participate, they would click "next" and began the survey. The survey consists of demographic and other items that measure several constructs. Before the judges announce the final ranking, a 30-minute block of time during which the contacts at different universities would distribute the online questionnaire to the students, and for the students to complete the survey instrument. Thus, the data generated by this research was being provided via participants answer questions on the first page of the survey. If students chose not to participate, they would simply exit the Qualtrics survey web page.

Instrumentation

I understand that, depending upon the research task at hand, it is better to apply quantitative methods to some tasks while in other cases it is preferable to apply qualitative methods. Both methods have advantages. For example, quantitative methods can be very efficient, but cannot answer "why" things happen, and are typically preferred in research seeking to examine relationships among variables, rather than emotions, feelings, or thoughts. As my research questions focuses on relationships among variables, I chose to apply quantitative methods of inquiry by employing an existing survey as my data collection instrumentation.

A research team that studies Aggies Invent created the original version of the Invent for the Planet (IFTP) survey. Several team members in this Aggies Invent research team found interesting variables in team research and searched the literature to find the most widely used instruments for each variable. The instrument they created measures 22 variables including demographic characteristics. Researchers on the Aggies Invent team have used the IFTP survey to collect data from student participants in the global competition since 2018. The instrument continues to evolve due to the evolution of team members' research interests. For example, recently the intelligence quotient (IQ) scale was being added to the survey items.

As one of the research team members, I have used half of the variables available within the existing 2020 IFTP survey to examine details about team collaboration process from a 48-hour simulation of workplace project team experience. My study focused on identifying critical underlying patterns of interaction behavior that drive team performance. The full set of survey items used in this study is listed in Appendix A, which contains three parts: demographic information, process variables, and output variable. The instrument characteristics of the scales from the IFTP survey used in my study are presented in Table 2.

Table 2 Characteristics of Instruments Used in the Study.

Section	Variable	Dimensionality	Item	Cronbach's α
Process	Shared leadership	• Task-oriented • Relationship-oriented • Creativity-oriented	15	0.79 - 0.82
	Team growth mindset	One dimension	5	0.81
	Team learning behavior	• Construction • Co-construction • Constructive conflict	9	0.70 - 0.92
Output	Team performance	One dimension	4	0.84

Control Variables

Team size and team gender diversity were chosen as control variables, since these demographic variables may influence team performance (e.g., Bear & Woolley, 2011; Michaelsen & Sweet, 2008). Team size was self-reported in numbers. Gender was dummy-coded, with male coded as "1" and female coded as "2".

Measuring Shared Leadership

According to Drescher et al. (2014), shared leadership is the notion that individuals within a group can share leadership functions. The scale I adopted for measuring shared leadership has 15 items, 10 of which is originated from Grille and Kauffeld's (2015) study, which focused on task-oriented shared leadership (TOSL) and relationship-oriented shared leadership (ROSL). The remaining five questions were developed to assess creativity-oriented shared leadership (COSL) based on analysis of video recordings of student teams (Leight et al., 2018). Cronbach's α for the three factors ranged from 0.79 to 0.82. Responses were made on a five-point scale ranging

from 1 = ‘Strongly Disagree’ to 5 = ‘Strongly Agree’ to capture the three shared leadership dimensions. All of the 15 survey items are listed in the Appendix A.

Measuring Team Growth Mindset

In this study, I adopted a six-item scale based on the Han et al. (2019) study. The items are listed in Appendix A. For example, one sample item from team growth mindset scale is “our team stepped up to the challenges we encountered with confidence.” I used a 5-point Likert scale whose answer choices ranged from (1) “strongly disagree” to (5) “strongly agree”. The Cronbach’s α for team growth mindset scale was 0.80.

Measuring Team Learning Behavior

I used a 9-item instrument created by Van den Bossche et al. (2006) to measure team learning behavior. An example question is “Team members elaborate on each other’s information and ideas.” Responses were made on a five-point scale ranging from 1 = ‘Strongly Disagree’ to 5 = ‘Strongly Agree’ to measure three aspects of the team learning behavior including construction, co-construction, and constructive conflict described in chapter II. The Cronbach’s α for team learning behavior ranged from 0.70 to 0.92. The full scale is presented in Appendix A.

Measuring Team Performance

Team performance is the only output variable in my study. I adopted and modified Hinds and Mortensen’s (2005) team performance scale. The modified version of team performance scale measures content, efficiency, excellence, and originality, which is the closest measurement compare to the judge’s rubric of the IFTP competition.

The originality aspect of the team performance asked how creative and original your product is. In the judge's rubric, the question asked, "Is the proposed solution unique or a unique adaptation?" The Cronbach's alpha of the adapted team performance scale was .84. The full scale is presented in Appendix A.

Descriptions of Data Analysis Process

The sample size should be based on both the diversity in the population and the number of variables in the model. The rule of thumb for minimum sample size for studies using factor analysis including Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Model (SEM) is 100 to 150 (Anderson & Gerbing, 1988; Tabachnick & Fidell, 2013; Tinsley & Tinsley, 1987). Some researchers consider an even larger sample size with 200 participants (Boomsma & Hoogland, 2001; Hoogland & Boomsma, 1998; Kline, 2005).

In total, 233 participants finished the survey fully and 84 people finished taking the survey partially. I followed the following criteria and steps to obtain the final number of my survey data. First. I did not include participants who finished less than five minutes since the average of accomplishing the survey is 10 minutes. Participants who declined to fill in the survey has also been excluded. After cleaning up the data sheet, 224 survey data responses remained. After cleaning the data, I used statistical software STATA 16 to perform item, scale, and regression analyses such as EFA, CFA, and SEM. The following sections explains various steps I took in order to analyze my data.

Factor analysis was conducted to develop and validate the instrument through EFA and CFA for a set of variables (Mertler & Vannatta, 2010). I conducted EFA and

CFA for all of the process variables and the output variable using STATA 6. The purpose of EFA is to delete survey items with a factor loading more than .3. The purpose for conducting CFA is to confirm the structure of the survey scales by applying the model fit criteria. This analysis calculated whether there is a mutual relationship among process variables in order to answer my first research question. Also, using STATA 6 software, I estimated a Structural Equation Model (SEM), which evaluated the relationships between process variables and team performance in order to answer my second research question. Control variables were also added in the model to see if team gender diversity and team size can affect the relationship between process variables and output variable.

Limitations of Research Design

There are several limitations of the research design. First, the instrument in the existing survey has not done a validation for non-English speakers. Second, team performance results came from participants' perceptions instead of a more objective measurement: judge's score based on the competition rubrics. Third, not all team members answer the survey since it is difficult to have everyone response to the survey.

Summary

In Chapter III, an introduction to the research setting, participants, data collection procedures and instrumentation was presented. The procedures used for data collection and the instruments used to collect the data were explained in detail. In addition, the different types of analyses were presented to test the research hypotheses. The results of the analyses will be discussed in Chapter IV.

CHAPTER IV

FINDINGS

Chapter three presented my methodology, which included participants' characteristics, data collection procedures, survey instruments, and data analysis. The purpose and intent of this chapter is to report findings of the analysis based on the Invent for the Planet (IFTP) survey data. This chapter first presents descriptive statistics, which include demographic characteristics and results of the correlation analysis. The second portion of this chapter reports the results of the reliability analysis. The final part of the chapter summarizes the results of factor analyses (EFA, CFA, and SEM), which test the intense team process and output theoretical model presented in chapter II. STATA 16 and Microsoft Excel were used to analyze the data. The sample size to run all of the factor analyses is 224.

Descriptive Statistics and Correlation Analysis

Descriptive statistics of 224 respondents' demographic characteristics and responses to all of the 29 items in the shared leadership (15 items), team growth mindset (5 items), and team learning behavior (9 items) were computed using STATA 16.

Demographic Characteristics (Input)

The first and middle part of the IFTP survey was designed to gather information about the respondents' teams. Team information requested at the very beginning of the survey included team name, current university, number of members in the team, gender distribution in the team, and previous years of experience with the IFTP competition.

In total, there were 39 universities registered for the IFTP competition. According to the survey results, 224 respondents from 18 universities filled out the IFTP survey completely. The participants' average age was 22. The team sizes ranged from 3 people to 6 people. The average team size was 5. As for gender, 11 participants reported having no woman on their team, but only one participant reported having no man on the team. The average percentage of females out of the entire teams was about 40%. The average percentage of males out of the whole teams was about 60%. Table 3 shows where the registered universities are located all around the world.

Table 3 Region Information of the Participated Universities.

Region	Country	# of University	University Registered IFTP
North America	USA	14	• Arizona State University • Boise State University • Cypress Lakes High School • Embry-Riddle Aeronautical University • James Madison University • Loyola University New Orleans • New Mexico State University • Northern Arizona University • Portland State University • Texas A & M University at Corpus Christi • Texas A&M University at College Station • University of New Orleans • Villanova University • Wichita State University
	Canada	1	University of Manitoba
Central America	Mexico	4	• Universidad de Celaya • Universidad Politécnica de Yucatán • Universidad Tecnolã“gica Metropolitana de Aguascalientes • Universidad Tecnologica Laja Baj-o
South America	Chile	1	Universidad de Chile
	Brazil	1	Universidade Federal do Rio de Janeiro/ Federal University of Rio de Janeiro

Region	Country	# of University	University Registered IFTP
	Peru	1	University of Lima
Europe	Greece	1	Aristotle University of Thessaloniki
	Belgium	1	Catholic University of Louvain (UCLovain)
	France	2	• ENISE - Ecole National D'ingenieurs de Saint-Etienne • ENSAM - Ecole Nationale Supérieure d'Arts et Métiers
	Finland	1	JAMK (Jyväskylä) University of Applied Sciences
	UK	1	Swansea University
	Romania	1	Technical University of Cluj-Napoca
Mid-east	Qatar	1	Texas A&M University at Qatar
	Lebanon	1	American University of Beirut
South or Southeast Asia	Pakistan	2	• Dhanani School of Science and Engineering • Habib University
	Vietnam	2	• Ho Chi Minh City University of Technology and Education – Vietnam • Hue Industrial College (HueIC)
	Malaysia	1	INTI International University Universiti Teknologi Petronas
	Thailand	1	Mahidol University
	Indian		Indian Institute of Technology Gandhinagar
Asia-Pacific	Australia	1	University of Sydney
North Africa	Egypt	1	Arab Academy for Science Technology and Maritime
	Total	**39**	

Descriptive Statistics (Process and Output)

The means and standard deviations are presented in Table 3. The normality assumption (i.e., skewness < 2, kurtosis < 7) (West et al., 1995) was well satisfied. Descriptive statistics for the 29 survey items are listed in Table 3: shared leadership (three scales and 15 items), team growth mindset (one scale and five items), and team learning behavior (three scales and nine items). Using STATA 16, the item scores

reported in Table 4 consist of sample size, the means, the standard deviations, and the minimum and maximum. The correlations were computed using STATA 16.

Table 4 Descriptive Statistics for Process and Output.

Factor	Item	N	Min	Max	Mean	SD
Shared Leadership	TOSL	224	1	5	4.35	0.80
	ROSL	224	1	5	4.41	0.77
	COSL	224	1	5	4.46	0.73
Team Growth Mindset	TGM	224	1	5	4.52	0.65
Team Learning Behavior	TLB1	224	1	5	4.45	0.72
	TLB2	224	1	5	4.47	0.64
	TLB3	224	1	5	4.52	0.80
Team Performance	TP	224	1	5	4.13	0.82

Note. TOSL = Task- oriented Shared Leadership; ROSL = Relation-oriented Shared Leadership; COSL = Creativity- oriented shared leadership; TLB1=construction; TLB2= co-construction; TLB3 = construction conflict; TP = Team Performance.

Results of Correlation Analysis

Table 5 shows that all of the process and output variable correlations are statistically and positively significant ($p < 0.1$).

Table 5 Correlation Matrix of Variables in Use.

	TOSL	ROSL	COSL	TGM	TLB1	TLB2	TLB3	TP
TOSL	1							
ROSL	.84**	1						
COSL	.80**	.85**	1					
TGM	.59**	.60**	.55**	1				
TLB1	.52**	.55**	.46**	.68**	1			
TLB2	.63**	.64**	.60**	.73**	.73**	1		
TLB3	.60**	.59**	.52**	.74**	.76**	.73**	1	
TP	.40**	.40**	.30**	.52**	.45**	.50**	.45**	1

Note. ** p < .001 (Two-tailed). TOSL = Task-oriented Shared Leadership; ROSL = Relation-oriented Shared Leadership; COSL = Creativity-oriented Shared leadership; TGM=team growth mindset TLB1=Construction; TLB2= co-construction; TLB3 = construction conflict; TP = Team Performance.

Results of Variance Inflation Factor (VIF)

Since shared leadership showed a high correlation based on the correlation analysis results above, I did VIF to see if the three constructs in shared leadership has multicollinearity. The results showed that the average VIF of shared leadership is 3.55, and no variable exceeded VIF values of 10, confirming that multicollinearity was not an issue (Aiken & West, 1991). This result excluded the possibility of multicollinearity as an issue for the shared leadership scale.

Results of Factor Analysis

"Factor analysis provides a diagnostic tool to evaluate whether the collected data are in line with the theoretically expected pattern, or structure, of the target construct and thereby to determine if the measures used have indeed measured what they are purported to measure" (Matsunaga, 2010, p. 98). Therefore, I conducted both exploratory factor analyses (EFA) and confirmatory factor analyses (CFA) for all of the scales I used in the study. Namely, shared leadership, team growth mindset, team learning behavior, and team performance. The purpose of doing factor analysis for each scale was to ensure the scales measured what they were supposed to measure. In addition, the reliability analysis for all scales were included in this section.

Results of Exploratory Factor Analysis (EFA)

I first used the Principal Component Analysis (PCA) to examine the structure of each scale. Overall, the PCA results reported that all of the scales used in my study had only one factor with eigenvalues that were larger than 1 (Cliff, 1988). That is to say, all scales were unidimensional based on my study sample. More specifically, shared leadership had only one factor with eigenvalue that was greater than 1, explaining 59.29% of all the variance. That is to say, TOSL, ROSL, and COSL collapsed into a single Shared Leadership (SL) factor rather than remaining independent scale. Team growth mindset had only one eigenvalue that was greater than 1, explaining 68.05% of all the variance. Team learning behavior had only one eigenvalue that was greater than 1, explaining 58.21% of all the variance. In other words, the three constructs of team learning behavior collapsed into a single Team Learning Behavior (TLB) factor, rather

than remaining independent scales. Team performance had only one eigenvalue that was greater than 1, explaining 71.95% of all the variance.

After understanding each scale was unidimensional, I conducted EFA for item selection. EFA results for each scale reported that no items needed to be deleted, since all factor loadings were greater than 0.4 (Meyers et al., 2016). More specifically, shared leadership's factor loading ranged from 0.62 to 0.83. Team growth mindset's factor loading ranged from 0.68 to 0.84. Team learning behavior's factor loading ranged from 0.58 to 0.84. Team performance's factor loading ranged from 0.73 to 0.85.

Results of Reliability Analysis

Based on the EFA results, reliabilities were estimated for the following four latent variables: Shared Leadership (SL), Team Growth Mindset (TGM), Team Learning Behavior (TLB) in the process domain, and Team Performance (TP) in the output domain. I used STATA 16 to obtain the reliabilities (Cronbach's alpha, coefficient of internal consistency) in Table 6. According to the general criteria to interpret the Cronbach's α (Meyers et al., 2016), all the reliabilities were very good (α >.85) for research purposes.

Table 6 Estimates of Reliability.

Scale	Factor	N of Items	Cronbach's alpha
Process	Shared Leadership (SL)	15	.95
	Team Growth Mindset (TGM)	5	.88
	Team Learning Behavior (TLB)	9	.91
Output	Team Performance (TP)	4	.87

Note. N=224.

Results of Confirmatory Factor Analysis (CFA)

After identifying the structures and selecting items in the Exploratory Factor Analysis (EFA), I used STATA 16 and ran Confirmatory Factor Analysis (CFA) to validate the structure of the scales by looking at model fit indices (Russell, 2002).

To assess the data model fit, the following goodness-of-fit indexes were used: the Comparative Fit Index (CFI; Bentler, 1990), the Root mean Square Error of Approximation (RMSEA; Steiger, 1980), and the Standardized Root Mean Square Residual (SRMR). A value of the CFI of .90 and higher indicates an adequate fit. A value of the RMSEA of .05 designates good fit, while values near .08 indicate fair fit and those of .10 and higher indicate poor fit (Browne & Cudeck, 1992). A threshold of .08 and lower on the SRMR designates an adequate fit (Hu & Bentler, 1999). In addition, if the p value is less than .001, the model is showing a significant misfit.

Fit indices for each scale were reported as follows: Chi-square, p value, CFI, RMSEA, and SRMR. According to Chin's (1998) criteria, most of the scales in my study showed a good model fit. Specifically, the fifteen-item single factor Shared Leadership (SL) showed a good model fit (χ^2 (90) = 216.16, p=0, CFI=0.94, RMSEA=0.08, SRMR=0.04). The fifth-item single factor Team Growth Mindset (TGM) yielded a good fit to the data (χ^2 (5) =12.23, p = 0.03, CFI = 0.99, RMSEA = 0.08, SRMR = 0.03). The nine-item single factor Team Learning Behavior (TLB) construct yielded a good fit to the data χ^2 (27) =78.94, p = 0, CFI = 0.95, RMSEA = 0.09, SRMR = 0.04). The four-

item single factor Team Performance (TP) construct yielded a good fit to the data (χ^2 (2) = 2.35, p = 0.308, CFI = 1.00, RMSEA = 0.03, SRMR = 0.01). Therefore, the CFA model fit results verified the scales used in the study were valid and no further model modification was needed.

Results of Structural Equation Modeling (SEM)

The CFA results indicated that SL, TGM, TLB, and TP were underlying latent factors in my study. Therefore, I used STATA 16 and further analyzed the data with the Structural Equation Model (SEM) procedure to investigate if the hypothesized research model in Chapter 2 (Figure 3) explains the collected data. The model involved four factors: shared leadership, team growth mindset, team learning behavior, and team performance. Figure 6, the results of SEM with the intense team process and output theoretical model accessed the relationship among three process variables and the relationships between each process variable to team performance. As shown in Figure 6, solid lines represent statistically significant parameters ($p < .05$). Non-significant path coefficients were presented as dotted arrows. All parameters were standardized.

RQ 1

To answer the first research question (Does social cognitive theory explain team dynamics in the Intense Design Experience?), I tested the first three hypotheses to see if process variables are mutually influenced. To identify if the model was adequate, Comparative Fit Index (CFI; Bentler, 1990), the Root mean Square Error of Approximation (RMSEA; Steiger, 1980), and the Standardized Root Mean Square Residual (SRMR) were examined. The standardized results showed that the χ^2 test was

statistically significant (χ^2 = 825.40, df = 374, p < .001). Other indices were within a range that would be associated with good fit: CFI = .90; SRMR = .05; and RMSEA = .07 (90% CI: .07 – .08). To conclude, the model fit indices for the first model was adequate. The results showed that relationships of all process variables were positive and significant with each other. In detail, the correlation coefficient between shared leadership and team learning behavior was .71 (p < .01). The correlation coefficient between shared leadership and team growth mindset was .68 (p < .01). The correlation coefficient between team growth mindset and team learning behavior was .88 (p < .01).

Further, to answer the second research question regarding the relationship between each process variable and team performance. I added team performance as an output variable to test the last three hypotheses. Again, CFI, RMSEA, and SRMR were examined. Results showed that the $\chi 2$ test was statistically significant ($\chi 2$ = 1115.66, df = 547, p < .001). Other indices were within a range that would be associated with fair fit: CFI = .89; RMSEA = .07 (90% CI: .06 – .07); and SRMR = .05; meaning the model did capture the relationships underlying the covariance in the observed data matrix fairly well. To sum up, the model fit indices was adequate. The results showed that only team growth mindset could positively and significantly predict team performance. In detail, team performance would increase .39 standard deviations when team growth mindset increased one standard deviation (p = .02). The regression coefficient from shared leadership to team performance was .02 (p = .87). The regression coefficient from team learning behavior to team performance was .21 (p = .22).

The first three hypotheses (H1, H2, and H3) were under research question one and were supported in solid lines in Figure 6. H1 was supported. Shared leadership correlated positively with team learning behavior ($r = .71$, $p < .001$), which showed a strong relationship between the two (Cohen, 1988). H2 was supported as shared leadership correlated positively with team growth mindset ($r = .68$, $p < .001$), which showed a strong relationship between the two (Cohen, 1988). H3 was supported as team growth mindset correlated positively with team learning behavior ($r = .88$, $p < .001$), which showed a strong relationship between the two (Cohen, 1988).

The remaining hypotheses (H4, H5, and H6) were under research question two. As shown in Figure, only H4 was not supported. The relationship between shared leadership and team performance (H4) was not significantly associated ($b = .02$, $p = .87$). The relationship between team learning behavior and team performance (H6) was not significantly associated ($b = .21$, $p = .22$). That is to say, both shared leadership and team learning behavior could not predict team performance in this case. Only team growth mindset had a significant and positive influence on team performance (H5) ($b = .39$, $p = .02$). The results remained the same after controlling team size and proportion of female members. In detail, the main effect from size to team performance was .02 ($p=.71$). The main effect from female membership to team performance was -.04 ($p = .56$). Therefore, there is no need to control for size and female rate.

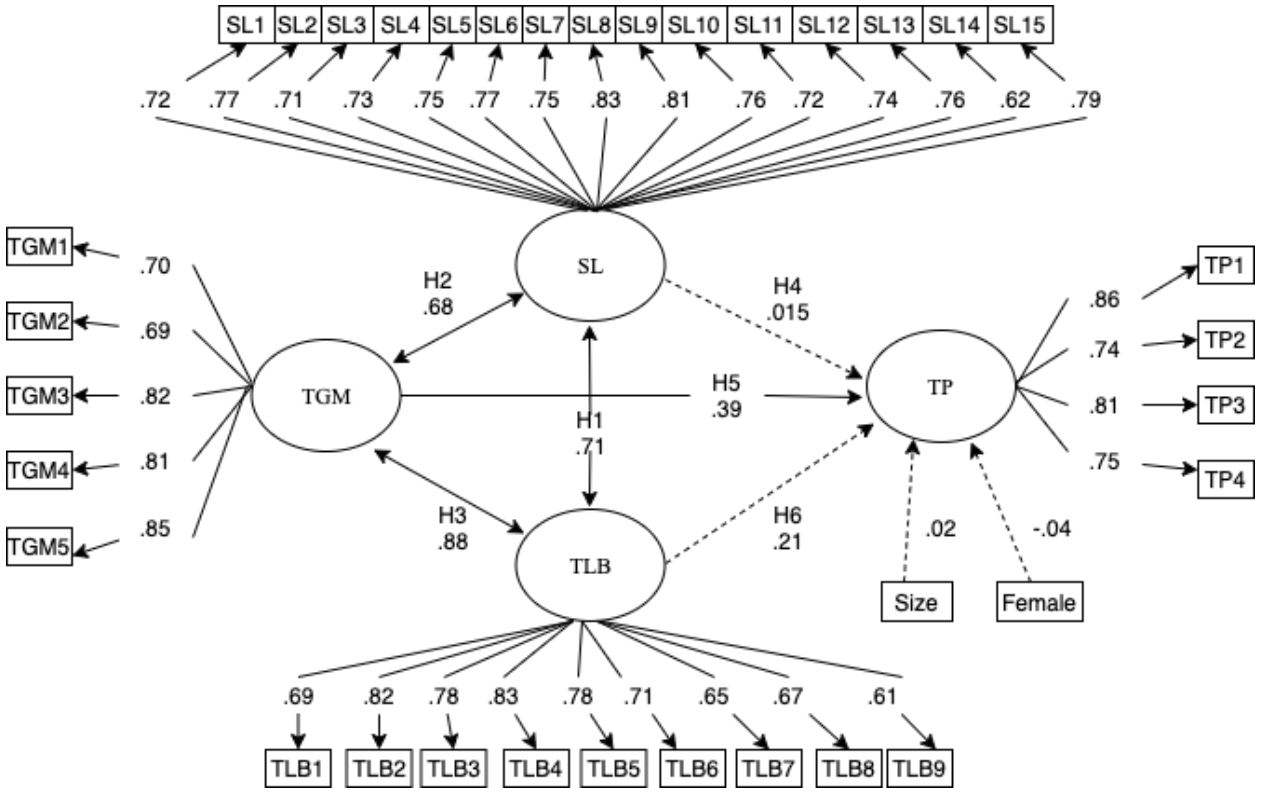

Figure 6 The intense team process and output theoretical model.

Note. SL = shared leadership; TLB= team learning behavior; TGM = team growth mindset; TP = Team Performance.

Summary

In chapter IV, I mainly focused on reporting the IFTP survey results, which include quantitative analyses such as descriptive statistics, correlations, reliability analysis, and EFA, CFA, and SEM. In addition, I also discussed participants' demographic characteristics such as region, gender distribution, and team size. The SEM analysis results indicated that the hypothesized empirical model had an acceptable fit for four fit indices. Process variables were mutually influenced and only TGM had a positive and significant relationship on team performance. The findings will lead to the discussion, with regard to research questions and hypotheses, in Chapter V.

CHAPTER V

CONCLUSIONS

The previous chapter reported findings based on the Invent for the Planet (IFTP) survey data. The purpose of this chapter is to discuss the survey findings, which include three major sections. In the first section, I discuss my research questions and hypotheses. The second section mainly focuses on theoretical and practical implications for HRD research. The last section provides limitations and recommendations for future study. My research questions are presented as follows:

1. Does social cognitive theory explain team dynamics in the Intense Design Experience (IDE) context?
2. What is the relationship between each process variable and team performance in an intense student design team competition context?

Discussions

In this section, I discuss my research questions and hypotheses by interpreting and comparing the results with previous research. As mentioned in Chapter II, the relationships between the three process variables can be anticipated applying Social Cognitive Theory (SCT). Shared leadership is one of several variables representing the environmental aspect of SCT in this study, Team growth mindset represents the cognitive aspect of SCT in the team level. Team learning behavior represents the behavioral aspect of SCT. If the three representative team level variables are correlated, that can possibly imply SCT's relevance for explaining team process and output in short term competition.

Additionally, each process variable demonstrated either a significant positive or non-significant relationship with team performance. Therefore, I divided SEM into two sections to answer both research questions. The first section exhibited the interrelationship encompassed the three process variables. The second section illustrated the relationship between each process variables and team performance. Both sections were being used to test the intense process and output theoretical framework.

Research Question 1: Correlational Relationship Among Process Variables

The first research question focused on whether there was a mutual influence among the three process variables: shared leadership, team growth mindset, and team learning behavior. In other words, the first research question was seeking answers whether social cognitive theory has the possibility to explain team dynamics rather than individual learning. This research question was answered by finding the three process variables were highly correlated in the first part of SEM analysis, which has been explained with the first three hypotheses. Hypothesis 1, 2, and 3 are explained in detail regarding each mutual influence relationship in the following paragraphs.

Hypothesis 1: Shared Leadership and Team Learning Behavior

Hypothesis 1 was supported by the empirical data of my study sample. Shared leadership had a significant and positive correlation with team learning behavior. The correlation coefficient between shared leadership and team learning behavior ($r = .876$) was significant ($p < .001$).

The results from hypothesis 1 aligned with earlier studies (Wang et al., 2017), which found that shared leadership and team learning behavior had reciprocal

relationships. That is to say, shared leadership stimulated team learning behaviors (Koeslag-Kreunen et al., 2018), and team learning increases member awareness of leadership functions (Li et al., 2009). Wang et al.'s (2014) study showed that shared leadership tends to have a strong relationship to behavioral processes and emergent team states compared with team performance, which also supported the finding that shared leadership is strongly related to team learning behavior.

This result also made sense based on items from each variable. For example, team learning behavior includes describing, refining, and reflecting on a certain problem, which also requires asking questions from one another in the team. These kinds of learning behaviors shared some similarities with shared leadership survey items, such as members enjoying brainstorming and generating ideas by focusing on the same problem. Moreover, teams with shared leadership would address each other's concern and provide information when a question was being raised.

Hypothesis 2: Shared Leadership and Team Growth Mindset

Hypothesis 2 was supported by the empirical data of my study sample. Shared leadership had a significant and positive correlation with team growth mindset. The correlation coefficient between shared leadership and the team growth mindset ($r = .679$) was significant ($p < .001$). That is to say, shared leadership and the team growth mindset were mutually influenced.

This result was also supported by previous literature. For example, Han et al., (2020) directly found that team growth mindset mediates the relationship between individual mindset and shared leadership. Furthermore, a recent study found that joint

team-level efforts such as trust, empowerment, dispositions, and beliefs are underlying mechanisms to drive shared leadership (de Cruz, 2019). In addition, the positive relationship between the concepts of shared leadership and team growth mindset makes sense logically. For example, when members have team growth mindset, they believe they can develop each other's capacity by sharing knowledge, which enables the aspect of shared leadership related to integrating team members' diverse knowledge in order to find new ideas and generate new solutions.

Hypothesis 3: Team Growth Mindset and Team Learning Behavior

Hypothesis 3 was supported by the empirical data of my study sample. Team growth mindset had a significant and positive correlation with team learning behavior. The correlation coefficient between team growth mindset and team learning behavior ($r = .706$) was significant ($p < .001$).

Although no direct literature studied the relationship between team growth mindset and team learning behavior, we still can find a clue according to some literature indicating the possibility of them having a mutual relationship. For example, team learning can possibly occur when team members share their viewpoints openly (Sun et al., 2017). Being open for growth supports the concept of team growth mindset since open-mindedness opened opportunities for learning and growing (Bowell & Kingsbury, 2016). Furthermore, the relationship between these two variables makes logical sense. First, according to what incorporates the two variables, team learning shared some components within team growth mindset. For example, one of the team learning behaviors was to discuss errors in unexpected results. This behavior relates to team

growth mindset, with the fact that members believe that they can actively learn from obstacles through joint effort. Second, the team growth mindset requires team members to conduct team learning behaviors. For example, when everyone holds the belief that they can benefit from learning each other's opinion, team learning behaviors such as asking questions, seeking information, and requesting feedback from one another are more likely to happen.

Research Question 2: Process Variables and Team Performance

The second research question investigated the relationship between each process variable to team performance. To answer this question, I ran the second section of SEM, which examined the structural relationship of my theoretical model. Although the model showed a good fit, the statistical results did not find the relationship between shared leadership and team performance to be significant. Neither found the relationship between team learning behavior and team performance. However, I found that team growth mindset can predict team performance. With this being said, hypothesis 5 and 6 were supported and hypothesis 4 was not supported since shared leadership was not a direct predictor of team performance. Hypothesis 4, 5, and 6 explained in detail regarding the relationship between each process variable to team performance in the following paragraphs.

Control variables were tested to see if gender diversity and team size can affect the relationship between each process variable and team performance. The results showed that both control variables did not have an impact to the relationships. Specifically, the descriptive statistics showed that the average percentage of females out

of the entire teams was about 40% and the team sized ranged from 3 to 6 people. That is to say, the female numbers ranged from 2 to 3 people. Based on Apesteguia et al. (2012) study, three-women teams were less aggressive and had better performance than other gender combination teams. It is not surprising to find that gender diversity of my study could not control team performance. In addition, since the optimal size of a learning team is five to seven members ((Michaelsen & Sweet, 2008), it is also not surprising to see that controlling team size can't affect the relationship between process variables and team performance.

Hypothesis 4: Shared Leadership and Team Performance

Hypothesis 4 was not supported by the empirical data of my study sample. SEM results did not match the hypothesized theoretical model. Shared leadership could not predict team performance ($b = .015$, $p = .871$).

Since previous research had inconsistent results on whether shared leadership could impact team performance, this result is not surprising since it found support with one side of the findings from previous research. The reason why shared leadership has no impact in this study may due to the following reasons. First, shared leadership has been conceptualized and measured differently in the literature (Wang et al., 2014; Zhu et al., 2018). For example, D'Innocenzo et al. (2016) measured shared leadership with the aggregation of a team-level, social network approach, and using density of a network or network centralization as an index of shared leadership in teams. However, in this study, I measured shared leadership based on the perception of individual team members. Therefore, the inconsistent usage of measurements to capture shared leadership among

team members might be one of the reasons why shared leadership cannot predict team performance.

Second, sample populations that showed shared leadership could predict team performance were solely from the U.S. teams (Ensley et al., 2006; Han et al., 2018). However, IFTP teams were from all over the world, which was more diverse than U.S. teams. This might be another reason why shared leadership could not predict team performance since diverse teams might face some language barriers and cultural differences. Third, Wang et al.'s (2014) meta-analysis study reported that shared leadership tends to have a stronger relationship with team process variables compared with team performance. This might be another reason why shared leadership is showing no relationship with team performance but showing a strong positive correlation with the other two process variables (team learning behavior and team growth mindset).

Hypothesis 5: Team Growth Mindset and Team Performance

Hypothesis 5 was supported by the empirical data of the study sample ($b = .388$, $p = .022$). The statistical results revealed the hypothesis that team growth mindset could predict team performance.

Due to the fact that team growth mindset is a fairly new notion, very few studies has focused specifically on whether team growth mindset has an influence on team performance. However, based on literature in regard to individual growth mindset's positive influences on individual performance, it is logically possible to propose that a collective individual growth mindset can also have a positive impact on team performance. This possibility has been supported by some recent conference

proceedings. For example, Han et al. (2019) found that managers and employees tended to have quick judgements about their colleagues, which is against the concept of having a team growth mindset. The quick judgements and implicit biases shaped manager and employees' decisions about evaluating others' capabilities when teaming together. Han et al. (2019) found similar results that team growth mindset had a positive influence on team performance by analyzing focus group interview transcripts using 2019's IFTP data.

Hypothesis 6: Team Learning Behavior and Team Performance

Hypothesis 6 was supported by the empirical data of the study sample ($b = .214$, $p = .223$). The statistical results revealed the hypothesis that team learning behavior could not predict team performance.

Based on the literature, team learning behavior could either promote or hinder team performance (Argote et al., 2001; Bunderson & Sutcliffe, 2003; Edmondson, 1999). There are several possible explanations why team learning behavior could not predict team performance in my study. First, according to Bunderson and Sutcliffe's (2003) study, team learning could have a detrimental influence on team performance in a short run. That is to say, whether team learning behavior has a positive or negative relationship on team performance depends on the development phase of the team. The IFTP context was very similar with Bunderson and Sutcliffe's (2003) study context since the competition only lasts three days, which considered to be a short period of time. Also, I only measured team learning and performance on the last phase of the team when the competition ends. Therefore, if I have measured team learning behaviors in different

phases, the results might be different. Moreover, Bunderson and Sutcliffe's (2003) study found that if learning has been over emphasized for high performance teams, team performance would be compromised. The definition of learning causes the result difference. However, it is difficult to find out whether learning had been emphasized appropriately during my study context only based on the survey data. It is possible that learning has been over emphasized since mentors were assigned to IFTP groups to facilitate their team learning. Lastly, type of learning behaviors involved in the survey might also impact whether team learning behaviors have a positive or negative effect on team performance.

Implications

The current study extends the theoretical literature and provides ideas for applications with intense student team learning dynamics. Implications of this study for theory, research, and practice in the field of HRD are discussed based on the findings and discussions.

Theoretical Implications

From a theoretical perspective, this study's theoretical contributions suggest that Bandura's (1986) Social Cognitive Theory (SCT) has a possibility to be applied at team level to understand team dynamics under intensive context. According to the literature, SCT has been used in both individual and team level to understand various concepts such as cultural intelligence (Chen & Lin, 2013); perceived team efficacy and knowledge sharing (Bandura, 1986; Chiu et al., 2006).

This study has demonstrated the possibility that SCT can be used to understand team processes by finding that SL, TGM, and TLB are correlated. However, due to the limitations of my study design, data has only been collected by the end of the event. Therefore, I was not able to further test if the three process variables were mutually reinforcing, which showed and required in SCT. Given the encouraging correlation results and limitations in the study, I propose to further experiment if SCT can guide some other team process variables. Also, collecting data in different time points are needed to test if process variables have mutual causation relationship to fully support SCT structure.

Moreover, although previous studies focused on long term team effectiveness model, this study offers a short-term team process and output model within a short time frame by finding that only team growth mindset can predict team performance in an intensive time period. More specifically, the results of my study built the model in an engineering competition context that only lasts for three days. This expands the literature about team effectiveness models that can be used in a short time frame.

Research Implications

The current study reveals research implications in relation to three process variables and team performance in higher education. It is the first attempt to explore whether shared leadership, team growth mindset, and team learning behavior can predict team performance in a short-term intense design experience for engineering student teams.

Besides the attempt in this unique study context, shared leadership and team learning behavior had only one dimension based on the PCA and EFA results, which aligned with some of the study findings (Grille & Kauffeld, 2015) and against some others (Leight et al., 2018). Thus, future study can explore what are some possible reasons why the dimensions of shared leadership and team learning behavior are showing different dimensions in different study settings.

Furthermore, this study found that shared leadership and team learning behavior cannot predict team performance. These results might imply that these two variables could not predict team performance in a short period of time with early stage of team development, since scholars have found similar results when shared leadership has been studied in early stages of student project teams in longer time periods (Serban & Roberts, 2016). Also, team learning behavior has been found not able to predict team performance when involvement of time, performance level of the team, and team members' learning goal orientation levels are considered (Bunderson & Sutcliffe, 2003; Myers et al., 2018). Therefore, future study is needed to explore if shared leadership and team learning behavior can predict team performance with a comparison of short time frame study nature and longer time frame, team members' learning goal orientation levels, and team performance level.

Last, the most exciting finding from the study is that team growth mindset can predict team performance, especially with the comparison that the other two process variables cannot predict team performance. This result implies future researcher to pay more attention to the newly raised concept: team growth mindset, which considers a

combination of team mindset and growth mindset and furthered both concepts. Also, further investigation of similar concepts such as open-mindedness, positive psychology, collective efficacy needs to be explored along with team growth mindset.

Practical Implications

This study provides practical career implications for university students seeking employment and organizations seeking to recruit, train, and develop their employees to work in a team setting. Also, it provides insight for HRD practitioners, leaders, and managers about training and development opportunities to provide for their employees and cultivate their expertise especially forming and working in a group within a short period of time.

In this study, the intense team process and output model was tested with the result that shared leadership, team growth mindset, and team learning behavior are mutually correlated. Also, team growth mindset can predict team performance. With this being found, students, teachers, HRD practitioners, and organizations can use this model to guide their team building and learning practice when a group of people work together for only a couple of days. For example, HRD practitioners could prioritize to foster team members' team growth mindset and understand that once team growth mindset has been built, it is very likely to affect employees to adopt shared leadership and learning behaviors in teams, which overall will enhance employees' social learning and performance in the team setting. Also, a related video might be developed for managers to broaden their perspective of recruiting and training process. Practitioners should consider team contexts when developing online or face to face training interventions.

Educators can develop online training for elementary or college students for growth mindset.

Previous literature showed some evidence that most of the skills represented by the variables in the theoretical model can be learned or improved (Dweck, 2006). That is to say, organizations need to understand that those skills can be developed over different time period. For example, shared leadership and team learning can happen in different stages (Wang et al., 2017). Therefore, organizations need to prioritize which team skills to train and when to train. With the goal that team growth mindset can be developed or nurtured in a short time frame compared with shared leadership and learning behaviors, organizations can find specialists to teach employees how to build individual growth mindset, since it has direct impact to team growth mindset. Practitioners can also coach employees or students effective team growth mindset behaviors, shared leadership and learning behaviors to increase team performance.

Limitations

Despite the contributions of this study, several limitations to this study are important for discussion: (a) self-reported measures, (b) further development of team growth mindset and shared leadership scale, (c) participation rate, and (d) survey design.

The first potential study limitation is self-reported measures. Self-reports are often criticized in terms of response bias and inaccuracy that makes findings less robust (Watcharadamrongkun, 2012). This study used the IFTP survey instrument that relied on self-reported measures. The findings depended on the diverse perceptions of key informants, regarding their understandings, attitudes, and experiences, rather than on

observable organizational practices. For example, the IFTP event actually had judges' scores for each team based on the official rubric for the competition. My original study plan was to compare participants' perceived team performance with judges' scores for the particular team. However, the judges' scores from each university around the globe were difficult to collect. Therefore, I only used the students' self-reported measure for team output as the variable in the data analysis.

A second potential limitation is that some scales are still in the development phase. For example, team growth mindset scale was fairly new and still under development by some researchers (Han et al., 2020). Although team growth mindset scale used in my study had one dimension and showed good reliability and validity, it is very possible that team growth mindset has more constructs when more question items are developed. A similar situation applies to shared leadership scale, since recent researchers (Leight et al., 2018) develop Creativity Oriented Shared Leadership (COSL) construct and not so many scholars have tested the accuracy of the dimension.

In addition to the limitation of newly added COSL dimension of shared leadership scale, my PCA, EFA, and correlation results showed that the three constructs in shared leadership are very similar. In other words, the participants in this study sample could not identify the differences among the three construct questions. The high correlation results happened in multiple studies, which showed a possibility that shared leadership scales need further improvement or a methods bias appeared due to similar response scales.

The third limitation is that not all members of the team participated in the survey. Instead of hearing every member's voice, a bias could occur from collecting only part of the perspectives of the team. When team members with extremely positive or extremely negative attitudes about the IFTP experience chose to do the survey, their answers would not represent the entire teams' attitude.

The last limitation is the design of the IFTP survey, which takes at least 15 minutes to finish. The length of the survey was very likely to make the participants exhausted since they only have 30 minutes break to take the survey before their final project presentation at the end of three intense days of design work. Even though they can take it after the competition finished, 84 people failed to finish the survey completely. Also, about 80% of the participants stopped participating halfway through the survey. Furthermore, the survey was not being translated into the native languages of the IFTP participants, which might cause a language barrier and confusion for some participants whose first language were not English.

Recommendations for Future Research

The abovementioned limitations point to avenues for future research, which can extend the findings of this study in the following areas.

First, conclusions in the study came from self-reported measures based on individual's perception about his or her team experience in the IFTP competition. As such, the study may suffer from personal bias. Future research can use case studies or focus groups to provide richer understanding of the relationship among the three process variables and the relationships between each process variable and team performance.

Also, future studies need better communication and coordination to obtain the judges' score for each team, so we have an objective reference to the team performance.

Second, the study only examined one construct of team growth mindset scale based on the literature. Future research should explore if there are additional constructs in team growth mindset and test whether the further developed team growth mindset scale can also predict team performance in short time frame. Additionally, more team level variables should be tested to validate if social cognitive theory can be applied in a team setting. Since this study only found correlation of the process variables, future studies can examine whether there is a reciprocal causation relationship by collecting the data in different time points to further test if SCT can be adopted in team setting.

Third, since not all members in a team participated in the survey, future research should think of ways to include more participants within the same team and compute an average score for the team to represent a relatively less biased number for each scale.

Last, due to the length of IFTP survey, future research should definitely consider making the survey less than 15 minutes to finish. Also, researchers should modify some of the questions which might cause confusion for the participants. For example, with the question "How many females are in your team, excluding you", I noticed that many participants were confused by the "exclude you" part and still counted themselves in the answer. In addition, since participants filled in the survey before they need to present their work to the judges, future researchers may need to be more creative to pick a more relaxed time during the IFTP event for participants to finish the survey to increase the participant rate.

Conclusion

Due to the fact that team research lacks the exploration of a process and output model specifically tested in a short time frame, the results of this study revealed that social cognitive theory can not only be used in the individual learning environment but also has the potential to be used to understand team learning dynamics in a short time frame. More specifically, shared leadership, team growth mindset, and team learning behavior are mutually correlated. The results also imply that the length of the teamwork could possibility affect the relationship between shared leadership and team performance, and team learning behaviors and team performance. In the meantime, the result highlighted the importance of team growth mindset on team performance, which adds value to the team literature since very few scholars have looked into this relationship. This intense team process and output model will provide researchers a guide for further exploration of possible intervening variables that may increase team performance in a short run. Also, it extended social cognitive theory at the team level with an intensive context, which can possibility guide other researchers to continue testing other process variables in different time frames to see if those variables are mutually influenced to validate the application of SCT at the team level. Additionally, this intense team process and output model shed light on team growth mindset which is a critical predictor for team performance when working in a short-term setting.

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APPENDIX A

IFTP SURVEY QUESTIONS USED IN MY STUDY

Demographics	1. What is your team name? 2. Which university are you attending? 3. Including yourself, how many members are on your team? 4. How many members of your team are male? 5. How many members of your team are female? 6. How many of your team members have you worked with before IFTP?
Shared Leadership (Grille & Kauffeld, 2015; Leight et al., 2018)	**Task-Oriented Shared Leadership** 1. As a team we clearly assign tasks. 2. As a team we clearly communicate our expectations. 3. As a team we provide each other with work-relevant information. 4. As a team we ensure that everyone knows their tasks. 5. As a team we monitor goal achievement. **Relationship-Oriented Shared Leadership** 1. As a team we take sufficient time to address each other's concerns. 2. As a team we recognize good performance. Just to recognize or take the time to share with the group what you recognized? 3. As a team we promote team cohesion. 4. As a team we support each other in handling conflicts within the team. 5. As a team we never let each other down. **Creativity-Oriented Shared Leadership** 1. As a team we are open to hearing new ideas and learning from others. 2. As a team we tolerate ambiguity and use it as a chance to be creative. 3. As a team we enjoy brainstorming and generating ideas and thoughts. 4. As a team we do not mind when ideas expressed do not appeal to others or are not ultimately used by the team. 5. As a team we integrate diverse knowledge to come up with new solutions/ideas for projects.

Team Growth Mindset (Han et al., 2019)	1. Our team actively learned from obstacles. 2. Our team stepped up to the challenges we encountered with confidence. 3. Our team managed challenges through joint effort. 4. Our team benefited from learning each other's opinions. 5. Our team believed in each member's ability to learn.
Team Learning Behavior (Van den Bossche et al., 2006)	1. Team members draw conclusions from the ideas that are discussed in the team. 2. Team members elaborate on each other's information and ideas. 3. Comments on ideas are acted upon. 4. Team members listen actively to each other. 5. If something is not clear, we ask each other questions. 6. Information from team members is complemented with information from other team members. 7. This team tends to handle differences of opinions by addressing them directly. 8. In this team I share all the relevant information and ideas I have. 9. Opinions and ideas of team members are verified by asking each other critical questions.
Team Performance (Hinds & Mortensen, 2005)	1. Content (Quality of facts, research, ideas, and solutions for the final product) 2. Efficiency (How well the team used available resources including time, knowledge, and experts) 3. Excellence (How well the product achieves the goals of the project) 4. Originality (How creative and original the product is)

APPENDIX B

CONSENT FORM

You are invited to take part in a research study being conducted by the principal investigator Dr. Michael Beyerlein, from the Educational Human Resource Development Department at Texas A&M University (TAMU), USA. The purpose of this research is to identify patterns of communication excellence in engineering student teams. You will be invited to participate in this research by filling out this survey. It will take you about 20 to 30 minutes to finish. The information in this form is provided to help you decide whether or not to take part in the study. If you decide to take part, you will be asked to check 'next' at the end of this form by clicking on the consent at the bottom of this page. You have the option of skipping any questions you do not want to answer. The data will be kept confidential to the extent allowed by law. If you decide you do not want to participate, there will be no penalty against you, and you will not lose any benefits you normally would have.

Only the following people and organizations may access your data from this study:

- the members of the research team
- the IRB ethics committee that approved this study; and
- domestic and foreign regulatory agencies and government officials who have a duty to monitor or oversee studies like this one.

We will conduct the study in accordance with the rules in the United States which may differ from some rules or laws in other countries. All reasonable steps will be taken to protect your privacy in accordance with the applicable data protection laws.

For universities in Europe and the U.S., you take part in the EU-U.S. Privacy Shield Framework.
According to European Commission Implementing Decision (EU) 2016/1250, the EU-U.S. Privacy Shield provides an adequate level of protection for Your Study Data. (See, https://www.privacyshield.gov/list)

The General Data Protection Regulation gives you certain rights with regard to Your Study Data. You have the right to request access to, or make a correction to, or request erasure of Your Study Data. You also have the right to object to or restrict our Data Processing of Your Study Data. Finally, you have a right to request that we move, copy or transfer Your Study Data to another organization. In order to make any such requests, please contact Dr. Michael Beyerlein at beyerlein@tamu.edu.

We will store your data for five years or longer if the project requires it, unless you notify us you wish to withdraw your consent. You may withdraw your consent at any time. If you withdraw your consent, this will not affect the lawfulness of our collecting

and analyzing your data in our research up to the point in time that you withdraw your consent.

Are There Any Risks To Me?
No risks are expected to you from participation in this research.

Will There Be Any Costs To Me?
Aside from about 20 to 30 minutes of your time, there are no costs for taking part in the study.

IFTP student teams with more than half the members completing this survey will be entered into a drawing for a $100 gift certificate on Amazon (US dollars). There will be five teams winning certificates in the random drawing.

Will Information From This Study Be Kept Private?
The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely, and only the researchers listed above will have access to the records. Information about you will be stored in computer files protected with a password. This consent form will be filed securely in a separate official area.

Who may I Contact for More Information?

You may contact the Principal Investigator, Dr. Michael Beyerlein at 979-862-4347, Beyerlein@tamu.edu, to talk about a concern or complaint about this research. For questions about your rights as a research participant, to provide input regarding research, or if you have questions, complaints, or concerns about the research, you may call the Texas A&M University Human Research Protection Program office by phone at 1-979-458-4067, toll free at 1-855-7958636, or by email at irb@tamu.edu .

CONSENT STATEMENT
I voluntarily agree to participate in this research survey study. The procedures, risks, and benefits have been explained to me, and my questions have been answered. I understand that any identifiable information in regard to my name will remain confidential, that is, this information will not be listed in the dissertation of any future publication (s).

APPENDIX C

IRB APPROVAL LETTER

EXEMPTION DETERMINATION
(Common Rule –Effective January, 2018)

June 10, 2020

Any study that requires in person or face-to-face study visits may not begin or resume until your site has an approved plan that adheres to the re-opening guidelines posted on the Division of Research's VPR website: https://vpr.tamu.edu/covid-19. This plan is to be sent to your Department Chair and Dean, then forwarded to the Clinical Research, Education and Service Advisory Committee for approval.

Type of Review:	IRB Amendment
Title:	Team learning processes of Invent for the Planet student teams: an international perspective
Investigator:	Michael Beyerlein
IRB ID:	IRB2018-1436M
Reference Number:	111686
Funding:	Internal Funds
Documents Reviewed:	Dissertation proposal of Jiacheng Lu 1.0
Review Category	Category 2: Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: i. The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects; ii. Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or iii. The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by .111(a)(7).

Dear Michael Beyerlein:

The HRPP determined on June 10, 2020 that this research meets the criteria for Exemption in accordance with 45 CFR 46.104.

This determination applies only to the activities described in this IRB submission and does not apply should any changes be made. Please use the reviewed, stamped study documents (available in iRIS) for applicable study procedures (e.g. recruitment, consent, data collection, etc…). If changes are needed to stamped study documents or study procedures, you must immediately contact the IRB. You may be required to submit a new request to the IRB.

Your exemption is good for three (3) years from the Approval Start Date (02/14/2019). Thirty days prior to that time, you will be sent an Administrative Check-In Notice to provide an update on the status of your study.

If you have any questions, please contact the IRB Administrative Office at 1-979-458-4067, toll free at 1855-795-8636.

Sincerely,
IRB Administration