

**Study of team building based on 3D game**

by

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## Table of Contents

LIST OF FIGURES .....	iii
LIST OF TABLES .....	iv
ABSTRACT.....	v
INTRODUCTION .....	1
BACKGROUND .....	2
Trust in Newly-Formed Teams .....	2
Team Building Exercises .....	4
Measurements in Team Performance.....	5
3D Virtual Game.....	6
METHODOLOGY .....	7
Research Objectives.....	7
Hypotheses.....	7
Team Building Exercise Based on Minecraft .....	7
Performance Task .....	10
Independent and Dependent Variables.....	10
RESULTS .....	11
Participants.....	11
3D-Game vs Free conversation.....	12
TLQ scores.....	12
Completion time.....	12
3D-Game vs Dialog Technique.....	13
TLQ scores.....	13
Completion time.....	14
DISCUSSION .....	14
Limitations and Assumptions.....	14
Hypothesis One.....	15
Hypothesis Two .....	16
Hypothesis Three .....	16
CONCLUSION.....	17
FUTURE WORK.....	18
REFERENCE.....	20

## LIST OF FIGURES

Figure 1. The first-person view of pattern builder .....	8
Figure 2. The first-person view of pattern instructor .....	9

## LIST OF TABLES

Table 1. Experiment procedure.....	11
Table 2.The Mann-Whitney U test results for comparing effects of 3D-game team building and free conversation on TLQ scores .....	12
Table 3.The Mann-Whitney U test results for comparing effects of 3D-game team building and dialog tech on TLQ scores .....	14

## ABSTRACT

- Objective: To determine the effect of 3D-game team building on team performance and team interaction.
- Subjects and Methods: Between April and May 2015, 13 teams including 39 adult participants were randomly assigned to take designed TBE based on Minecraft, dialogue technique or free conversation no more than 15 minutes. Then they are required to work out a 3D puzzle. The puzzle completion time was recorded. Participants rated the team learning and team interaction via TLQ after each exercise or task.
- Results: Teams who experienced 3D-game TBE didn't show significant higher performance in terms of TLQ scores and puzzle completion time than those who did not. There were small significant differences in terms of dialog promotion and open communication, and collaborative learning between 3D-game and dialog tech teams.
- Conclusion: The effect of 3D-game TBE on TLQ scores and puzzle completion time was not significant, but it influenced team's stability of puzzle completion time. The designed 3D-game team building focused on enhancing teammates' willing of communication while dialogue technique focused on creating the atmosphere of collaborative learning.

## INTRODUCTION

Rapid team formation has been a common and challenging situation for modern teamwork. However, most studies, which focused on studying the long-term, months or even years, team building interventions (Voight, Mike, and John Callaghan, 2001; Amos, Mary Anne, Jie Hu, and Charlotte A, 2005; Hope, Joanie Mayer, et al., 2005; Stevens, Diane, and Gordon Bloom, 2003), can't be applied to those newly-formed teams who are expected to work well together as soon as possible. The most common mistakes that newly-formed make are the fear to be blamed for failure and poor communication, which can cause bad decisions and frustrating practices, but these mistakes can be countered by a high level of mutual trust. (Rally Help, 2015). For example, the college students in a project group who have poor interpersonal relations at the outset may be afraid of being the one messing up the project, blamed by others and show a poor communication among teammates, while the ones with close relation are likely to avoid these mistakes. However, in the most cases of rapid team formation team members are not familiar with each other and this causes a low level of mutual trust in the team. Therefore, how to foster environment of mutual trust in the team within a short term is the first problem for newly-formed teams.

3D online games like Minecraft provides a second life world with relatively unlimited area where the players over the world can collaborate together to complete in-game tasks at any time. Interestingly, player not only talks about in-game events but also shares their recent events and even emotion in real world like the latest movies, the favorite music and the project they are working on (Maznevski and Chudoba, 2001). In addition, 3D online game can provide opportunities of simulated face-to-face conference for distant team members who can work with other teammates to complete predesigned in-game tasks (Jason B. Ellis et al., 2008). The advantages of 3D online game are not only to free team members from the constrain of space and time (Boden and Molotch, 1994), but also provide a virtual environment to design appropriate team building exercise (TBE) for different team building purposes

(Ellis, Jason B., et al., 2008). For this reason, it is promising to design an appropriate TBE in 3D game for enhancing mutual trust in team and promoting team communication.

This research is inspired by following two questions: For enhancing mutual trust among team members and promoting team communication, 1. Is the TBE that happen naturally in 3D game effective for the newly-formed teams? 2. Is there any different effect between TBE based on 3D-game and traditional ones on the newly-formed teams' performance and interaction?

## **BACKGROUND**

Team forming is the first stage for any team to be effective and successful (Bruce Tuckman, 1965). At this stage, individual team member lack of commitment to the organization, which is resulted from low initial trust (Rally Help, 2015). In this section we review literatures in four areas related to newly-formed team. We begin by discussing the concept of trust for newly-formed teams. In addition, we review the team building literatures and existing TBE for trust and communication. We then turn to talk about the team performance and team interaction, and finally discuss the popular 3D virtual world game, Minecraft, as a platform to create engaging but goal-oriented TBE.

### **Trust in Newly-Formed Teams**

Trust plays an important role in the successful formation and growth of any newly-formed team (Senge et al., 1994). Dirks and Ferrin (2001) suggested trust can indirectly cause positive attitudes of trustor in the early phrase of team interaction, such as high satisfaction and good perceived performance, but trust don't have strong relationship with actual performance. The study of Jarvenpaa et al. (2004) suggested that there is a critical link between team communication and trust in the newly-formed team, that is, in a low trust situation, frequent communication among teammates can increase the mutual trust and team cohesion, and increased trust may have a positive influence on team communication level.

The conclusion from conventional wisdom is that trust is very difficult to build and requires frequent social interaction, face-to-face meetings, and direct observations of fellow team member commitment. These traditional ways to build trust are supported by several trust studies which assumed trust starts at a small level and gradually increases over time (Blau, 1964; Rempel, Holmes & Zanna, 1985; Zand, 1972). Members of a newly-formed team often have little prior experience of working together and may rarely or never meet face-to-face. Thus, a low initial trust among newly formed team members could be predicted by traditional trust model. However, Meyerson et al. (1995) explored swift trust by finding that the members of temporary teams showed a high initial trust to one another. Besides, this phenomenon of high initial trust was shown in the virtual teams (Jarvenpaa and Leidner, 1999). This phenomenon of high initial trust was explained by McKnight et al.'s model on initial trust formation in new organizational relationships.

According to the model of organizational trust developed by Mayer et al. (1995), the trust coming from sharing experience and close interpersonal relations are categorized as interpersonal trust; by contrast, the trust that grows through team member reliability, consistency, and responsiveness when dealing with teammates is called as task-based trust. Unlike interpersonal trust which develops based on social bonds formed by long history of face-to-face meeting or informal chat, task-based trust in newly-formed team can develop swiftly because the expectation of reliable performance and consistent follow-through tend to be easy to confirm and stable (Meyerson et al., 1995). In words, the team member's trust should swiftly increase if his or her expectation of other's reliable performance is consistent with perceived performance. The special way that the task-based trust develops may provide a new strategy to design an appropriate TBE to foster mutual trust based on reliability, consistency and responsiveness of newly-formed team members.

## Team Building Exercises

Salas, Eduardo, et al. (1999) reported a meta-analytic integration of past team building literatures indicating that team building exercises (TBE) tend to rely on least one of four possible strategies: goal setting, interpersonal relations, problem solving, and role clarification. Surprisingly, the authors found no significant effect of TBE on objective measures of performance, but there is small tendency for team building to increase performance on subjective measures. In addition, the effect of TBE is affected by team size. In words, the larger the team size is, the smaller effect of TBE is.

There are quite few effective TBE that aim to promote trust or communication for newly-formed team like general indoor or outdoor activities (Diversity and Dialog, 1996; Hattie et al., 1997), sharing team information with pre-questionnaires or open-end dialog (Holton 2001; Bernard et al. 2000). These kinds of TBE range in effectiveness, but have their specific limitations. For example, minefield as an effective outdoor programs may not be appropriate for distance team members since it requires that one team member help the blindfold partner walk through a large areas with obstacles. Holton (2001) believed that virtual team members could build trust by sharing their background information with questionnaires, including Bendaly Team Fitness Test (Bendaly, 1997), Online Keirseley Temperament Sorter (Keirseley, 1984) and Modified Belbin Group Role Questionnaire (MacIver et al, 1995), before they work together. But participants reported that longer interactive communication may be he more helpful. Bernard et al. (2000) examined the effect of a dialogue technique, which force the student to share the basic background information and past experience about effective communication to construct the team mental model as team norms, on enhancing team relational development and decision outcome.

Most recently Ellis et al. (2008) based on the theories of social identity and team building invention and proposed 3D online game as a promising approach for team building. Even though the authors designed four kinds of 3D-game TBE corresponding to goal-setting, interpersonal relations, problem solving and role clarification. But the authors didn't testify their final game designs with

performance task. In this study, we only design a 3D-game TBE aiming to improve team members' communication and trust, and test its effect during TBE and performance task.

## **Measurements in Team Performance**

Salas et al. (1999) categorized team performance affected by team building into two types: subjective and objective measurement of performance. This schema based on De Meuse et al.'s study outcome classification (1981) including behavioral changes, organizational changes and attitudinal/perceptual changes. Specifically, behavioral changes refer to group-member behaviors that might be modified by intervention, including work-group performance, turnover, critical incidents, interaction and absenteeism; organizational changes include turnover within organization and productivity. Attitudinal/perceptual changes is subjective output of team building intervention, including satisfaction, group climate, communication, perceived trust, openness and supportiveness, perceived group effectiveness, and superior-subordinate relations. For subjective measurement of team performance, there is quite few of questionnaires used for measuring perceived team performance like Group Behavior Inventory (Friedlander, 1966) and Group Environment Questionnaire (Carron, Albert V. et al., 1985). Usually productivity, error frequency and task completion time that are easily recorded or evaluated as objective measurement of team performance.

Irene Bresó and his colleges (2008) developed and validated a team learning scale, Team Learning Questionnaire (TLQ), including four dimensions of team leaning: Continued Improvement Seeking, Dialogue Promotion, Collaborative Learning and Open Communication and Strategic and Proactive Leadership that Promote Learning. This tool could help researchers to understand the dynamic team interaction in above four aspects of organizational scenario. Stone et al. (2011) used TLQ to as basis to evaluate the different effects between virtual welding training and real welding training on team interaction and learning.

In this study, TLQ was chosen to evaluate the team learning and team interaction during TBE and performance task. The TLQ evaluation was modified so that the questions and content were specific to the tasks in the experiment. The modified TLQ tracked three key dimensions of team learning and interaction that were relevant to this study: 1) Continuous Improvement Seeking (the degree to which a team have interest in taking actions that allow them to continuously improve); 2) Dialogue Promotion and Open Communication (the degree to which open and honest communication is encouraged and takes place within a team); and 3) Collaborative Learning (the degree to which team members are seen and used as sources of knowledge by the rest of the team). Each dimension consists of a series of questions, which the participant answers on a five-point scale (the higher the rating for a given question the more positive the participant feels about the team learning for that question). In addition, the time that team complete the performance task is recorded as the objective measurement of team performance

### **3D Virtual Game**

Given the trust challenge faced by newly-formed teams and limitation of previous TBE, we see a potential match between these needs and the affordances of 3D online game. Specifically, game tasks in 3D virtual world which involving social and task-based communication can meet the need of fostering team trust rapidly.

Minecraft was chosen as the environment in which to build our TBE. Minecraft is a sandbox video game which allow multiplayer build constructions out of textured cubes in a 3D procedurally generated world (Wikipedia, 2015). In Minecraft, each user's presence in the world is expressed as a combination of cubes like human body. Minecraft is well known for great freedom, where player can choose how to play by build almost everything appeared in real world. Educators have use Minecraft as platform to teach students in a way they will find fun and engaging. For example, history teacher can made a massive world to let students explore ancient cultures. Mojong reported over 2500 schools worldwide have bought Minecraft education edition by 2014 (John Keilman, 2014). In addition, a

large amount of game mods, a redesigned multiplayer game map, are developed by players themselves and shared with others every day. Because of the popularity of Minecraft, the ability to build objects freely, and interact with others, Minecraft could be a perfect platform for team-building games.

## **METHODOLOGY**

### **Research Objectives**

Two primary research objectives are investigated in this work. First, to validate effectiveness of designed 3D-game team building exercise (TBE) on team performance. Second, to compare the different effects between designed 3D-game TBE and dialog technique TBE on team performance and team interaction.

### **Hypotheses**

In this study, we examined the three following hypotheses:

1. The teams who experience the 3D-game TBE should report higher TLQ scores than the ones without TBE, but there should be no difference in 3D puzzle completion time between them.
2. There should be no difference in puzzle completion time between the teams who experience a 3D-game TBE and the one who experience a dialog technique TBE; but there should be a small difference in self-reported TLQ scores.
3. The 3D-game team building teams should be more willing to communicate with teammates than dialog technique teams.

### **Team Building Exercise Based on Minecraft**

Three participants as a team worked on a virtual mini stadium built in Minecraft world, which is designed as a simulated out-door open space. In Minecraft world, participants could use the keyboard and

mouse to control their movement and build a pattern by putting virtual carpets of three different colors (white, black and brown) on the ground (Figure 1). The two of them were seated together in front of their computers while another one was seated away from the teammates. In the exercise, the alone participant was given a drawn pattern and worked as an instructor to describe the pattern verbally to the other two teammates with a head up display in the game (Figure 2). The other two worked as builders to realize the pattern according to the instructions heard from teammates. The instructor in the game can't show the original pattern to the builders or directly tell them what the pattern is, but only guide them by verbal communication. Participants worked on the pattern for up to 15 minutes no matter whether the pattern is completed.



**Figure 1. The first-person view of pattern builder**



**Figure 2. The first-person view of pattern instructor**

This 3D-game TBE is a variant of minefield exercise which has been used to enhance communication and trust among team members for nearly 30 years (Robinson and Peter B, 1996). During the activity of minefield, participants operate in pairs and one person need lead the other, who is blind-folded, to walk through an open space with fixed obstacles (Mine Filed, 2013). But in our TBE, instructor has to lead the other two builders to complete the pre-scheduled pattern in an virtual open space.

## **Dialog technique**

The dialog technique we chose as the traditional TBE was proposed by Tan, Bernard CY et al. at 2000, which aimed to enhance electronic communication in virtual teams. This exercise was consisted of three stages: small talk, infinite container, and laser generation. In the small talk stage, team members are required to talk about their background information (e.g., name, major and hobbies) and share jokes. In the infinite container stage, team members individually list what they think to be good communication practices. They then share the past experiences that support these listed practices. During this stage, teammates are encouraged to be friendly ask questions or communicate, but criticisms and defensive behavior are strongly discouraged. In the “laser generation” stage, team members collate their critical past

experiences to build a team mental model that encompasses all positive communication practices to be adopted during teamwork. This model serves as team norms to guide future interaction and activities of the team.

## **Performance Task**

After team building activities or free convention phrase, the team will work out a 37-pieces 3D puzzle of Eiffel Tower. Since the performance of team can be affected by many other factor like individual ability and personality, the performance task should be not complicated. Because 3D puzzle is a common game for teenager and adults, we choose it as performance task to test the output of TBE.

## **Independent and Dependent Variables**

TBE is the only one between-subject independent variable with three levels that primarily manipulated in this research: participants are assigned into three groups to finish different tasks including 3D-game TBE, dialog technique TBE, free convention (no TBE).

The metrics of interest in this experiment included TLQ and the time that team complete the performance task. The reported TLQ scores are primary subjective measurements of team learning which used to evaluate team performance and team interaction, and the time of completing the performance task is the objective measurement to evaluate team performance.

## **Overview of the Experiment Design and Procedure**

This study was conducted within a controlled lab environment where three participants as a team would complete team building task and performance task. Participants first sign a consent form outlining the tasks at hand and the risks involved. Pre-survey is then completed to attain demographic information for self-report. The first task, three participant as a team are assigned to take one of three optional tasks such as 3D-game TBE, a dialog technique TBE and free communication. The first task ends after a maximum of 15 minutes or after the participant finish TBE early. Follow-up TLQ 1 is completed and the

second task, performance task begins. After team finish the performance task (3D puzzle) the final TLQ 2 is asked and the participants are debriefed, thanked, and leaves the lab area. Also see Table 1.

**Table 1. Experiment procedure**

Pre-surveys	Team Building	Mid-survey	Performance Task	Post-survey
Consent form Demographics	3D-game	TLQ 1	3D Puzzle	TLQ 2, Debriefing
	Dialog technique			
	None(free conversation)			

## Testing Environment

This study would make use of three personal computer with AMD A8-3850 with Radeon™ HD Graphics and each one is loaded with the game Minecraft for 3D-game task. The display will be a 17" flat panel color monitor with a maximum resolution up to 1280x1024 pixels. This study also uses a generic USB keyboard and mouse to provide movement control for participants. For the performance task, participants would deal with a 37-pieces 3D puzzle of Eiffel Tower.

## RESULTS

The three hypotheses are categorized into two contrast pairs: 3D-game TBE vs dialog technique TBE and 3D-game TBE vs free conversation. The difference of each pair was tested by running separate analyses. Additionally, each analysis used a subset of the participants. For hypotheses one only participants of the 3D-game and free conversation were used. Similarly, the data set for hypothesis two included only participant who experience 3D-game TBE and free conversation task.

## Participants

A total of 39 participants, aged 19-24 (mean 20.3 years) participate in the experiment. Of the 39 participants, 13 were females and 26 were males. Anyone with serious pre-existing medical conditions, such as a history of motion sickness, or being prone to seizures, are not allowed to take the team building

exercise based on 3D-game Minecraft, but could be assigned to dialog technique team or free conversation team to for this study. In general, the participant pool represent healthy adults. In this study, there is five teams of 3D-game TBE, four teams of dialogue technique and four teams of free conversation.

### 3D-Game vs Free conversation

#### TLQ scores

A Mann-Whitney U test was run to determine if there are differences in reported TLQ scores between participants who take 3D-game TBE and those who take free conversation task. Distributions of TLQ 1 and TLQ 2 scores for S1) Continued Improvement Seeking, S2) Dialogue Promotion and Open Communication, S3) Collaborative Learning were not clear, as the sample size is too small. The results of the analysis are shown in the table below. The table indicated that 3D game team was not found to report significantly higher scores in terms of continued improvement seeking, dialogue promotion and collaborative learning and open communication.

**Table 2. The Mann-Whitney U test results for comparing effects of 3D-game team building and free conversation on TLQ scores**

Measure	TLQ 1 S1	TLQ 1 S2	TLQ 1 S3	TLQ 2 S1	TLQ 2 S2	TLQ 2 S3
Median, 3D-game	12.8	11.5	12.25	12	12.5	13.5
Median, Free conversation	11.1	13	12.625	12.6	12.5	14.5
U	7.5	5	9.5	6.5	9	4.5
z	-0.4225	-0.8452	-0.0845	-0.5916	-0.1690	-.9297
Significance (p)	0.336302	0.199012	0.466323	0.277057	0.432886	0.176271

#### Completion time

A Welch t-test was run to determine if there is difference in puzzle completion time between participants who take 3D-game TBE and those who take free conversation task. Distribution of puzzle completion time should be normal based on common experience. The variance of completion time in free

conversation teams is bigger than the one of 3D game teams ( $F= 0.0855$ ,  $p=0.0190$ ), but the 3D game team ( $M = 16.4$  min) was not found to be significantly distinct from free conversation team ( $M = 19.125$  min) in puzzle completion time ( $T_{0.1,1,3,4} = -1.6377$ ,  $p= 0.3148$ ). The experiment note released that the worst teams of free conversation who took the longest time to complete puzzle are likely to figure out the issues one by one together, while there are nature leaders in the best teams of free conversation who schedule and push team to move on during puzzle task. On the other hand, 80% 3D-game teams automatically adopt the strategy of assigning different part of puzzle to individual teammates at the beginning of the puzzle task.

### **3D-Game vs Dialog Technique**

#### **TLQ scores**

A Mann-Whitney U test was run to determine if there are differences in reported TLQ scores between participants who take 3D-game TBE and those who take dialog technique TBE. Distributions of TLQ 1 and TLQ 2 scores for the three team learning dimensions were not clear, as the sample size is too small. The results of the analysis are shown in the table below. The difference in terms of continued improvement seeking between 3D game team and dialog technique team is not significant. Both teams present a strong desire to learn know other teammates' experience to promote team performance. Interestingly, in team building task and puzzle task there were significant differences between 3D-game team and median dialog technique team in terms of collaborative learning. In addition, dialog technique team was found to report a significant distinct scores in the terms of dialogue promotion and open communication in the team building task while no difference in puzzle task.

**Table 3. The Mann-Whitney U test results for comparing effects of 3D-game team building and dialog tech on TLQ scores**

Measure	TLQ 1 S1	TLQ 1 S2	TLQ 1 S3	TLQ 2 S1	TLQ 2 S2	TLQ 2 S3
Median, 3D-game	12.8	11.5	12.25	12	12.5	13.5
Median, Dialog technique	10.5	13.25	14.5	13.6	11.875	14.5
U	6	2	2	4.5	5	2
z	-0.6761	-1.3523	-1.3523	-0.9297	-0.8452	-1.3523
Significance (p)	0.249481	0.088148	0.088148	0.176271	0.199012	0.088148

## Completion time

An unpaired t-test was run to determine if there is difference in puzzle completion time between participants who take 3D-game TBE and those who take dialog technique TBE. Distribution of puzzle completion time should be normal based on common experience. The variances of completion time in 3D game team and dialogue technique team are equal ( $F = 0.0855$ ,  $p = 0.5109$ ), and the 3D game team ( $M = 16.4$  min) was not found to be significantly distinct from dialog technique team ( $M = 16.375$  min) in puzzle completion time ( $T_{0.1,2,7} = 1.8945$ ,  $p = 0.5051$ ). The experiment note showed that all of dialogue technique teams adopted the strategy of assigning different part of puzzle to individual teammates at the beginning of the puzzle task as well as 3D-game team.

## DISCUSSION

### Limitations and Assumptions

The first major limitation of this work is the small sample size, which could influence the significance of the team performance difference between different TBE or treatments. In addition, running participants of a variety of experience levels could be a contributor to varying team interaction and mutual attitude as the friendship among participants, video game experience or national culture can all independently contribute to the way that participants interact with other teammates. Lastly,

participants' personal fitness condition could affect the team performance since bad health condition could be a contributor to a low level of personal performance like slow response and passive attitude.

The assumption that all individuals are being forthright and honest with their self-report metrics and demographic information is crucial. Participants may give answers they think researchers would like to hear to "help" the research. Additionally, for data analysis, the sums of three team members' self-reported TLQ scores in different dimensions are used as the subjective team performance metrics and they are assumed to have same shape distribution, while the objective team performance metric, completion time of 3D puzzle, is assumed as normal distributed.

## **Hypothesis One**

The hypothesis one of this experiment aimed to determine the effect of the designed team building exercise (TBE) based on 3D-game Minecraft on TLQ scores and 3D puzzle completion time. Interestingly, even though there was no significant difference found in puzzle completion time, the teams who experienced 3D-game TBE show more stable performances than free conversation team. Specifically, two of free conversation teams took the shortest time and the other two teams took the longest time to complete the 3D puzzle among all of teams. This result supported the conclusion made by Salas et.al at 1999 that team building has no significant effect on subjective measurement of performance. Besides, this also indicates good teams may not only show a higher level of performance but also a stable team performance. Otherwise, no significant difference was found in TLQ 1 and TLQ 2 scores between teams who take 3D-game team building and those who did not. A possible explanation for this is that the effect of 3D-game TBE on the subjective measurement of performance is too small to inspect by such small sample size. The self-reported TLQ scores could be affected by individual personality and nature leadership. Specifically, some participants who are naturally active played the role of leader to guide the other teammates to effectively finish the 3D puzzle task by assigning different work and controlling the communication.

## **Hypothesis Two**

The second hypothesis stated that the designed 3D-game TBE should not make a significantly distinct effect on puzzle completion time comparing to traditional dialogue technique team building while do have difference in TLQ scores. The results of TLQ 2 analysis showed that for the continuous improvement seeking dimension there was no significant difference between two types of teams. Both 3D-game teams and dialogue technique teams expressed strong willingness to make actions to perform well and continuously improve during the 3D puzzle task. In addition, these two types of teams took no significant distinct length of time to complete the 3D puzzle. These results confirmed the second hypothesis. However, dialogue technique (DT) teams did report higher TLQ scores than 3D-game teams for the collaborative learning dimension for performance task. This result indicated that participants in dialog technique team were much more willing to consider other teammates as the source of knowledge than 3D-game team. Another interesting finding was that the 3D-game teams reported a significantly higher value (Median score = 13,  $p = 0.0542$ ) about frequent mutual communication than DT team (Median score = 8.5) when worked on the 3D puzzle task even though no significant difference for dialog promotion and open communication dimension was found. This results indicated that participants in 3D-game team were more willing to communicate with each other than those in DT team.

## **Hypothesis Three**

The hypothesis three indicated participants in 3D-game team should express a stronger willing to communicate with each other than ones in dialog technique team. This difference should be relevant to the different ways of team interaction resulted from these two types of TBE. Interestingly, the results of TLQ 1 analysis indicated when experiencing the team building exercise, participants in dialog technique teams are more likely to learn knowledge from other teammates than those in 3D-game teams, which is consistent with the results of TLQ 2 for performance task. This results may reveal the focus of dialog technique TBE is to create the environment of encouraging mutual learning among team by forcing

teammates sharing experience, thus improve likelihood of positive team interaction of considering teammates as knowledge resource. On the other side, the 3D-game teams reported significant lower scores than dialog technique teams for dialog promotion and open communication dimension during team building exercise. This indicated that participants in 3D-game team were less willing to communicate with each other when they were working on the assigned task in the virtual environment. This results may be explained by the fact that some participants, who played as pattern builder in 3D-game group, communicated less frequently than the other builder, who is more active to communicate with the instructor, passively follow the instruction and then reported lower TLQ scores about dialog promotion and open communication. Another interesting finding was that the results of TLQ 1 and TLQ 2 were not consistent for dialog promotion and open communication dimension. Specifically, participants in 3D-game team reported a weaker desire to communicate with teammates during TBE, but were more willing to communicate during performance task than those in dialog technique team. This inconsistency may indicate the designed 3D-game TBE and dialog technique TBE had different effect on team interaction to enhance team communication and trust. The possible explanation is that the focus of designed 3D-game TBE is enhancing team communication by increasing participants' task-based trust while dialog technique TBE is focusing on interpersonal trust. During 3D-game TBE, builder had to consistently follow through the orders and description from instructor and instructor consistently perceive the reliable performance and feedback from builder. Thus task-based trust among teammates increased swiftly which promoted their willing of communication in the later performance task.

## **CONCLUSION**

This work clearly demonstrate the advantages of taking team building exercise (TBE) to enhance team communication and trust on the 3D game platform, Minecraft, like convenience for distance communication, unlimited virtual areas and flexible environment for TBE design . Even though the results of this study doesn't validate the effectiveness of designed 3D-game team building exercise by

TLQ scores and puzzle completion time when compared to free conversation teams, the teams who experienced 3D-game TBE show a significant stable team performance in terms of puzzle completion time. In addition, the participants in 3D-game team are more willing to communicate with other teammates than those in dialog technique (DT) team during performance task while the participants in DT team are more likely to consider other teammates as knowledge resource. Moreover, there is no significant difference in puzzle completion time between 3D-game team and DT team. Lastly, DT team building focuses on creating an open communication atmosphere of collaborative learning while the designed 3D-game team TBE may focus on enhancing teammates' mutual trust or task-based trust to enhance communication level.

## **FUTURE WORK**

There are three major future work for this study. First, to test the effect of TBE based on 3D-game on large team. In this study, the designed 3D-game TBE based on Minecraft was only tested by teams of three participants. Although the past study indicated that the effect of TBE decreased as the team size increased (Salas, Eduardo, et al. 1999), the effect of TBE based on 3D-game on large group which includes more than three people was unknown. Therefore, designing an appropriate 3D-game TBE for large group and testing its effect on team performance and team interaction is necessary in the future. Additionally, the effect of TBE based on 3D-game on team performance may change corresponding to different tasks and teams. The 3D puzzle task, which is relatively easy to work out, was chosen as the performance task in this experiment, and teams consisted of college students were recruited to test their performance and team interaction after TBE. In fact, characteristics of team and task must to be considered to design TBE for newly-formed teams in the real world (Bonner, Desmond, et al., 2015). Thus designing an appropriate TBE based on 3D game world and testing its effect on temporary teams in practical scenarios, like a newly-formed NBA team in a new season, a temporary interdisciplinary team for industrial product development and a temporary commander with soldiers during a military action,

should be a very important future work. Lastly, the long term effect of TBE based on 3D-game was unknown. In this study, the newly-formed teams experienced TBE within only 15 minutes and then took the performance task almost immediately, but the team performance may change in a long time like one week or one month after experiencing TBE. Therefore, comparing the long term effects between TBE based on 3D-game and traditional dialogue technique is another interesting future work.

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