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Studying the Effects of Information Exchange Channels in Different Communication Modes on Trust Building in Computer-mediated Remote Collaborative Design

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Abstract: The development of information and communication technology (ICT) offers new working styles, where participants in remote locations could communicate and collaborate on projects to achieve a common target. Former studies in different domains have focused on different aspects of trust to help trust building. Our focus is on exploring the effects of communication modes and information exchange channels on trust level in a computer-mediated collaborative remote design team. We describe trust building process in computer-mediated collaborative remote design and demonstrate how the influences were exerted by the combination of communication modes and information exchange channels. The results demonstrate which combination would be best for trust building in a certain condition of the remote settings. The propositions are formulized based on the analysis of the results, which would be critical to trust building in a remote collaborative design team using ICT.

Keywords: Trust, Communication modes, Information exchange channels, Collaboration, Design
Categories: H.5

1 Introduction

With the development of the information and communication technology (ICT), people located at geographically distributed environments have been able to collaborate through various computer-mediated communications (CMC) support systems. The types of the relationships enabled and maintained by CMC is significantly increasing, which includes a buyer-seller relationship, a student-teacher

relationship, a patient-doctor relationship, and even a highly collaboration required designer-designer relationship [Good, 2000]. Comparing to traditional collocated teams, virtual teams formed in the relationships can collaborate and communicate remotely for a same goal with technology, where the best expertise are combined without the limitation of geographical differences [Lipnack et al., 2000; Kirkman et al., 2001]. Optimizing the structure of the team can be one of strategies to support positive activities in the virtual team [Deng et al., 2005].

One of the core issues to the computer-mediated remote team effectiveness is trust [Cheikhrouhou et al., 2011]. Trust can be defined as a "willingness to be vulnerable, based on positive expectations about the actions of others" [Rocco, 1998]. The development of trust in a remote team has been a challenging problem to be tackled until now. Research work [Abdui-Rahman et al., 1998; Bos et al., 2002; Deng et al., 2005; Giuli et al., 2006] in different realms have provided solutions with a focus on different aspects of trust building. Some solutions emphasize social aspects of remote trust building [Abdui-Rahman et al., 1998; Hoffman et al., 1999] and others put stress on technological factors [Tucker, 1983; Coetzee et al., 2007]. The angle of this paper is on both social and technical aspects of trust building, which correspondingly concerns both communication modes and information exchange channels in a computer-mediated remote design team. The discussion aims to find out what information exchange channels would offer the highest trust level in a certain condition of the team environment.

The result of this research could be critical to the effective functioning of a computer-mediated remote collaborative design team to improve trust building. The contribution would come from two aspects of our approach: communication mode and information channel. The communication mode is important for a team structure setup and the information exchange channel is one of significant components for a hardware setup in a team. The development of trust would positively influence on a team efficiency in different ways. For instances, trust serves a team with collaboration activation, by supporting information shares and increasing information openness [Zaheer et al., 1998]. Besides, the methodology of this research might be helpful for experiment designs in similar research that deals with trust.

This paper examines the development of trust using different information exchange channels in different communication modes. Based on the results, communication modes could be matched to different information exchange channels for best support of trust in a computer mediated remote design team. In this paper, we first give a brief introduction about trust as a basic knowledge. Then, the related information on communication modes and information exchange channels is proposed. In addition, we describe our methodology and experiments. Finally, the results of the experiments are analyzed to find out if our propositions are proved.

2 Relevant Work

There are several definitions for trust from different realms. In psychology, trust is a prediction of reliance on an action, based on what a party knows about the other party. For example, trust is a statement about what is otherwise unknown and cannot be verified because it is far away or in the future [Zaheer et al., 1998]. In law, trust is an

arrangement whereby property (including real, tangible and intangible) is managed by one person (persons or organizations) for the benefit of another [Hayton et al., 2005].

Why is trust important in collaboration? For instance, in a remote design setting, trust is the key for co-organizations or partners to work together effectively. Without trust, the information openness would be impossible and the risk taken would be out of the question. Participants might even damage the effectiveness of the task performance, which directly relates to the interest of the collaboration, to avoid the close coordination [Coetzee et al., 2007]. Alternatively, even worse, the collaboration would terminate by the lack of trust among the team members, which can lead to serious damage. On the contrary, a high degree trust would lead a high productivity, which leads to a high interest.

To help a virtual team to overcome the geographical distance, trust is the best option to be developed [O'Hara-Devereaux et al., 1994]. According to Handy's argument on trust that "trust needs touch," a virtual team without face-to-face interaction would be hard to forereach a collocated team, or even hard to be as effective as a collocated team [Handy, 1995]. However, Jarvenpaa & Leidner [Jarvenpaa et al., 1998] successfully challenged the prior notion that "virtual communication eliminates the type of communication cues that people would use to convey trust, warmth, attentiveness, and other interpersonal dimensions"[Jarvenpaa et al., 1998]. They suggested that virtual interaction helps trust building, thus manipulating communication modes would be a strategy to serve trust building in a virtual team.

In the Leavitt's work, communication modes are categorized into five kinds of styles according to task characteristics and interaction: Y style, loop style, chain style, circle style, and star style [Leavitt, 1951]. This classification is the most basic one for the communication modes and the manipulating of them could be made based on the Leavitt's classification for the different scenarios. Deng and Wang [Deng et al., 2005] setup the communication modes as a sequence mode, a layer mode and a net mode. Communications in virtual supply chains are single lined, so they belong to a sequence mode. The layer modes exist in different kinds of virtual corporations when the statuses of the members are well arranged. The net mode often exists in a virtual product development team, in which the brainstorm is often used to produce more solutions [Deng et al., 2005].

The increasing of the remote collaboration has caused various information exchange channels, which are suitable for different tasks respectively. Then a question rose: on what basis should workers select communication channels? One of areas, which are affected by information exchange channels, is interpersonal trust although the related research is not quite enough [Coetzee et al., 2007]. Handy's argument that "trust needs trust" indicates that the right way to serve trust building is necessary in a virtual team [Handy, 1995]. A correct choice of information exchange channels for a task would help trust building among team members.

Trust is a key point to help with the team efficiency. There would be no good information sharing or easy transaction without trust. The information sharing would be highly limited, where the transactions could be evaluated under seriously contracting and monitoring [Das et al., 1998]. The team members may avoid a need for close coordination by changing the nature of collaborations [Herbsleb et al., 2000] or simply avoid collaboration with others, thus the productivity of the team would be

constrained. However, a higher trust level in a team would help the team to achieve a higher team efficiency and change the situation quickly [Nahapiet et al., 1998].

Early research work indicated that remote virtual team trust is harder to form than collocated team trust. Rocco found that social dilemma game teams formed collaboration quickly and keep it well while the players in the team were collocated, but were unable to achieve so when they were distributed [Wilson et al., 2006]. Wilson also found that the remote team trust was inhibited rather than collocated team trust, although the gap could be filled by time [Bordia, 1997]. One of the research showed that text-based interaction is less effective for tasks that have high social-emotive contents [Walther, 1992]. Previous research has shown that text-based CMC increases the sense of social distance between participants, reduces pressure to conform, and may encourage uninhibited behaviours [Maciel et al., 2009]. These characteristics might make trust agreements harder to form and maintain.

Most of the previous research has focused on asynchronous method like email and bulletin board systems. Although popular computer-mediated communication channels are text-based channel, audio-based channel, and video-channel for highly collaboration required tasks such as design activities [Bos et al., 2002], there are other applications that offer useful functions [Yong et al., 2009; Kuswara et al., 2011]. The examples are MSN, Google talk, QQ, and Skype that cover different communication aspects. The Skype combines the communication platforms - the computer and the mobile. The Google talk enables the application to be mixed into the website or explorer software. For our research, text-based s, audio-based channel, and video-channel are included and analyzed for the design team.

3 Communication Modes and Information Exchange Channels

Trust in a computer-mediated collaborative design team is a complicated issue. There are many factors, which are interrelated and influence on team trust. In the context of this research, trust is defined as a "willingness to collaborate with other members based on the agreement with other members' opinions in a computer mediated design team. Trying to simplify the wide range and complicated factors to help with trust building, two aspects of trust building support are adopted in this research: social aspect and technical aspect of trust. Most trust factors might fall into one of the two categories. One thing to note is that such categorization does not mean that the authors intended to coin these two new terms. There have been varied works on trust in both aspects, however, the focus of the works sticks either to the social aspect or to the technical aspect of trust. For instance, some researches deal with influences of social factors on trust and influences of trust on the psychology of users [Abdui-Rahman et al., 1998; Hoffman et al., 1999]. Other researches analyze influences of technique improvement on trust building and, reversely, influences of trust on the technical improvement [Tucker, 1983]. This paper has this categorization in order to better align the trust factors studied with the communication modes and information exchange channels. Specifically, the trust factors falling into the category of social aspect corresponds to the communication modes which is a more social construct. Likewise, the trust factors falling into the category of the technical trust corresponds to information exchange channels which is more technology-driven. The first one is social support that helps trust building with social strategies, which are mainly related

to human elements. For instance, team structures need to be altered according to the characteristics of a task to be assigned. From the social aspect, there have been such questions as how to put up with the difficulty caused by the human elements and how to make trust between team members to serve the team efficiency rather than to damage it. Meanwhile, the technical part of trust concerns technique elements used for the collaboration. For example, there have been investigations into the influences of the technique improvement on trust building in certain environments. Previous research work in studying trust building in virtual teams usually focused on either the effects of organization structure and communication modes (social aspect) on trust building, or the influences of technological capabilities (technical aspect) on trust building. Both social aspect and technical aspect of trust are investigated in this paper, which will help the generalization of the project to the real world for the both aspects are exited in the real world and influence trust building.

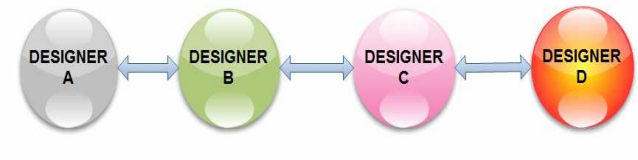
The importance of the trust in computer-mediated remote collaborative design could be generalized from the discussions in other realms.

1. Trust generates a willingness to overcome cultural differences and to work through other difficulties that arise in collaboration;
2. Trust between team members will encourage them to work together to cope with unforeseen circumstances. It permits them to adjust more rapidly, and with less conflict, to new circumstance which contracts and other formal agreements have not foreseen;
3. Trust can provide an alternative to incurring the costs and potentially de-motivating effects of close control and a heavy reliance on contracts;
4. Trust between collaborating team members or corporate units encourages the openness in exchanging ideas and information which is a necessary condition for innovation and other forms of new knowledge creation;

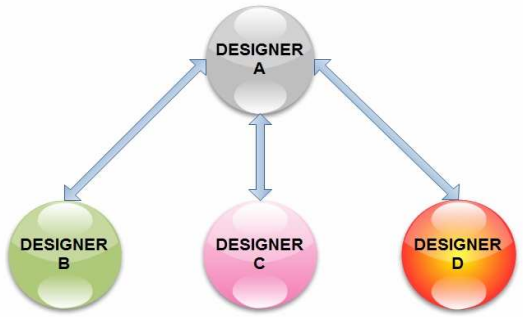
In this research, we consider the communication modes relate to the social part and the information exchange channels relate to the technical part for the frame of our investigation since the two factors represent the two typical aspect of trust building. The purpose of the research is to study how different compute-supported communication technologies (technical aspect of trust) support trust building in different team organizations, which directly determines the communication modes between the team members (social aspect of the trust). This combination study was also reflected into the way we formalize our methodology as shown in Figure 2 in the "methodology" section. The three communication modes and three types of information exchange channels were mixed to each other to produce 9 combinations. The details of the three communication modes are elaborated in the following sections.

Among the various definitions of communication modes, we use the definition proposed by Deng and Wang [Deng et al., 2005], which includes three modes such as a sequence mode, a layer mode and a net mode. An appropriate communication mode would be adopted depending on different situations. For example, a virtual team in a supply chain often communicates in line, so the sequence mode can be selected for that situation. For a virtual company where leaders direct the members and send out the information to others, the layer mode would be chosen. In the product development, the team members need a lot of alternative information from other

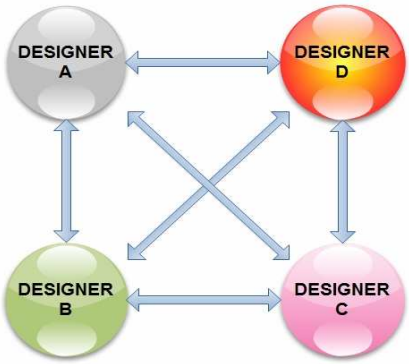
members. Thus, various strategies for information collection are used as a brainstorm and the net mode is adopted. All those communication modes exist in different structures of computer-mediated remote collaborative design team. The following is the frame of the three communication modes used in this research (Figure 1).



Sequence mode



Layer mode



Net mode

Figure 1: The Framework of communication modes adapted from [Deng et al., 2005]

As the high-speed Internet has developed, information exchange technologies are becoming more and more powerful and effective [Hurtado et al., 2011]. It is so hard to choose relevant information exchange channels for a communication mode because of the variety of technologies. However, most of them, which are popular in

computer-mediated remote collaborative design team, can be categorized into text-based, audio-based and video–based channels.

Some researches deliver social aspects of trust by focusing on the relationship between trust and communication mode [Deng et al., 2005]. Some researches deal with technical aspects of trust emphasizing the relationship between trust and information exchange channel [Bos et al., 2002]. We combine the two approaches for this research, thus delivering the relationships among trust, communication modes, and information exchange channels. The significance of our approach is to reflect that the social and technical aspects of trust affect each other and co-exist in the real collaboration simultaneously. Because there are significant relationships between modes and channels, the question what combination of a mode and a channel is best for supporting trust building might not be simply answered with "best channel plus best mode." Therefore, this research might be helpful for the practical applications of trust supporting strategy.

4 Methodology

4.1 Theoretical background

The past research almost has connected a higher trust degree with a higher team performance. According to Lipnack and Stamps, the success and failure of the task performance starts from trust since the function of trust sticks to a virtual team like glue [Lipnack et al., 2000]. The exploratory research done by Jarvenpaa and Leidner [Jarvenpaa et al., 1998] suggests that trust can exist in teams built purely on electronic networks. The study described a number of communication behaviors and member actions that distinguished global virtual teams with high trust from global virtual teams with low trust. The results suggest that global virtual teams may experience a form of swift trust but such trust appears to be very fragile and temporal. Although this study addressed the organizational structure and behaviors, it did not consider the different level of information exchange afforded by different technological channel. Therefore, the motivation grounded into the experimentation presented in this section aims to reveal the interrelationship between the organization behaviors (communication modes in this context) and the information exchange channels by considering the latter as an additional factor or dimension that will affect trust building in virtual teams.

Trust can lead to the high quality decision-making, the risk taking, and the satisfaction in the process of decision-making [Zand, 1972; Driscoll, 1978; McKnight et al., 2002]. The focuses of the previous research on trust are different, which include trust evaluation [Chen et al., 2008], trust elements [Sillence et al., 2006], trust model [Theodorakopoulos et al., 2006], trust influences [Kraetschmer et al., 2004], factors influencing trust [Coetzee et al., 2007], etc. There are a couple of different ways to evaluate or measure the level of trust built in a virtual team. Chen et al. [Chen et al., 2008] presented a trust evaluation method that assists members in determining whether resource holders have made appropriate decisions to share resources with other members. The evaluation method comprises a trust evaluation between two members and a reliability evaluation of member. Each resource can have a threshold that is a benchmark for resource sharing. The trust evaluation method was devised to

more focus on enabling secure resource sharing across team and enterprise boundaries, facilitates collaboration, and enhances information transparency among team members. McKnight et al. [McKnight et al., 2002] proposed and validated the measures for a multidisciplinary, multidimensional model of trust in e-commerce. The model includes four high-level constructs—disposition to trust, institution-based trust, trusting beliefs, and trusting intentions—which are further delineated into 16 measurable, literature-grounded subconstructs. Compared to the above existing trust evaluation method, another innovation aspect of the research work presented in this paper is the use of Prisoners' Dilemma to evaluate the level of trust built in virtual team with different communication modes and using different information exchange channels. The details of Prisoner's Dilemma are presented in Section 4.3. The aim of this research is to investigate the effects of different information exchange channels in different communication modes on trust building in computer-mediated remote collaborative design. The hypotheses are formulized in the section 4.2:

4.2 Hypotheses

The text-based channel, the audio-based channel, and the video-based channel have their own features. The communication frequency using different channels would be different correspondingly. The video and the audio would be much faster than the text channel. The quantity and type of communication would be different too. Like in the video channel, the information would include both picture and sound. With the same amount of time, the video channel could transport more information than the other two channels. In addition, for the information maintenance, the text channel may be better than the other two channels for the text is easier to keep on file than the other two channels. The same thing happens to the communication mode. The sequence mode, layer mode, and net mode got different features too. In the sequence mode, the information may cost more time and transfers. That feature might make the information maintenance more important in this mode. The layer mode often exists in the well status established group. In that mode, the frequency and the quantity of the information exchange might be more important. According to the above consideration of these features, the hypotheses for the experimentation are developed as follow with explanations:

1. The text-based channel of information exchange will build the highest trust in the sequence mode in computer mediated remote collaborative design.

As we mentioned the information-maintenance might be more important in the sequence mode. The text-based channel could maintain the information well and the video and audio channel could cause information missing or transportation incorrectly in the frequently information transportation. That might damage the team performance badly. According to that, the text-based channel may be the best partner for the sequence mode.

2. The video channel of information exchange will build the highest trust in the layer mode in the computer mediated remote collaborative design.

3. The video channel of information exchange will build the highest trust in the net mode in the computer mediated remote collaborative design.

For in the layer mode and net mode, the most important thing might be the information transportation speed, so the channel's information exchange frequency

and amount would be more important than information-maintenance. The video channel, which keeps the best performance at information exchange frequency and information amount, would be the best choice.

4.3 Methodology of Prisoner's Dilemma:

The core methodology for the experimentation is Prisoner's Dilemma. The reason for choosing this methodology is that it is dynamic, repeatable, and best suits to the experimentation scenario proposed in this study. The prisoner's dilemma constitutes a problem in game theory. The prisoner's dilemma is classic game theory. The prisoner's dilemma represents a problem in game theory that people might not cooperate even it is the best benefits for them. Merrill Flood and Melvin Dresher working at RAND in 1950 originally framed it. Albert W. Tucker formalized the game of it and gave it the name "Prisoner's dilemma." The classic form of the Prisoner's dilemma is as following:

There are two suspects arrested by police, the evidences holding by the police department is not enough for conviction. Then, the police separated the two prisoners and interrogated them individually. In that situation, if one of the prisoners betrayed and testified against the other, and at the same time the other prisoner stayed silent , then this prisoner could go free and the other would get a ten-year sentence. If both of them stayed silence, then both of them would just get 6-month sentence for charge. If both of them testified against each other, then both of them would be sent to prison for 5 years. In this situation, what would the prisoner do and why would they carry out that kind of activity would be worth to research [Tucker, 1983].

In the classic prisoner's dilemma form, the trust is one important factor that would cause the differences on the decisions of the prisoners. If the trust between the prisoners has been well established then the commitment of the silence might be accomplished. In that case, the group interest would be maximally maintained. If the trust between the prisoners had not been well placed, then one-party betray action or two-party betray action would happen. In this case, the group interest would be damaged.

In the repeat form of Prisoner's dilemma, the betrayed action and the loyal action would influence the trust and would have consequences in the following rounds, which means the trust could be maintained or lapse repeatedly.

The PD indicates the similar situation compared with this paper, the relationship between the "prisoners" also exists between the designers' interaction in the context of this paper. The group benefit of the prisoners is similar to the group interest of the design group. If the trust was built well, the interest of the both groups (the prisoners group and the designers group) would be well kept. That means the trust is one of the influence features to the group interest for the both situation. In addition to that, those things make the PD principle would be proper for the experiment. In this paper, the original form of PD is not exactly appropriate for the experiment. The intentions of the design team member are intend to believe others, which are not necessarily the case involved in the original PD, so, we change it from the original one. To simulate the real design work, we focus on the part where trust building happens. For example, the team members may have different opinions about one problem. They may prefer to working on that alone rather than working together. Besides that, if any member is not convinced by his/her partners, he/she may want to work alone too. Therefore, we

adapt the method of PD in the experiment to let the participants decide to work alone or work together at what extent. Because collaboration leads to more effectiveness than working alone in the normal situations, which corresponds to higher trust in this situation, we offer better payback for that the intention and willingness for collaboration.

4.4 Experimental Tasks

The entire experimentation consists of two phases: pre-experiment screening and experiment game. The proposed design task in the experiment is to design a simple website that can be procedurally divided into 15 sub-tasks for 10 design rounds. Each group consists of four human subjects who were expected to take four different roles that are necessary to accomplish the website design task respectively: content manager, structure manager, graphic designer, and programmer Content manager designs the text contents of the website. Structure manager designs the structure of the website and the layout of every webpage, Graphic designer is in charge of the images in the website. Programmer is responsible for scripting. In pre-experiment screening phase, all the recruited participants (participants are from the faculty with design background. They could benefit from the experiment by gaining experience and improving their skills of group design work through computer-mediated technologies. Moreover, a basic price of thirty dollars and additional prizes based on the design quality was given to the participants) were briefed with a cover instruction page that introduced the aim, motivation and expected skills of the experiment. A pre-test was given to each to test the level of their design skills. In order to avoid participants with extreme skills levels, the screening criteria tried to diversify their skills. All the participants who passed the screening test in the first phase were randomly grouped into four-person teams in the second phase. Besides that, the skill level of the participants was recorded as references for the grouping. The participants were sent into different groups based on the skill levels. It was assured that all groups were at the same group skill level. That would be help to minimize the noise, which was caused by the participants' skill level. Next, in the experiment game, another instruction page was given to each about the job and duty description of the four roles and the entire procedure of ten rounds of design. Then they were allowed to have 10 minutes to discuss and decide their role distribution through whatever combination of communication modes and information channels assigned (totally 9 combinations). The participants were advised that once the role was decided and agreed, it should not be changed throughout the entire experiment.

Then, the first round of the experimental game started. There were three further stages in each round. In the first stage, the instruction about what was expected to be accomplished in the first round was briefed to each participant and then he or she was allowed up to 5 minutes to discuss their preliminary idea using whatever combination of communication mode and information channel assigned or allocated. This stage was expected to initialize trust building among groups. Based on the 5-min discussion in the first stage, the second stage was to decide how much time (up to 10 minutes) they were willing to spend on the group work and the individual work. The decision has to be made within 2 minutes. Then the third stage of the first round started with the entire group starting the design using whatever combination of communication mode and information channel assigned. Each one in the group could only spend the

exact time they have decided on the group work previously in the last round. For example, if one decides to contribute 5 minutes to group work in the last round, he or she is only allowed 5 minutes for group design. Then the second round started, a similar instruction about what were expected to be completed in this round was briefed to each one and each group would have 5 minutes to discuss their design. Then each participant had to decide how much time they were willing to contribute to group work based on their experience (evaluation, suggestion, etc.) in the first round. Then, the actual design started which was up to 10 minutes. Totally 10 rounds were made. Each round took about 18 minutes (5 minutes for group discussion, 3 minutes for time decision (reflecting group interest), and 0-10 minutes for the actual design). The time distribution was recorded as reference to the trust level. Exactly the participants under supervision followed the time distribution.

4.5 Experimental Procedure and Set-ups

The experimental procedure is as follows (Figure 2): Firstly, the experiment was to measure the trust level in the sequence mode using the three information exchange channels. Then the results of using the three information exchange channels were collected. The second step was to measure the trust level in the layer mode using the three information exchange channels. The results were recorded. The third step was to measure the trust level in the net mode using the three information exchange channels. Then the results were collected. The last step was the result analysis to get the conclusion.

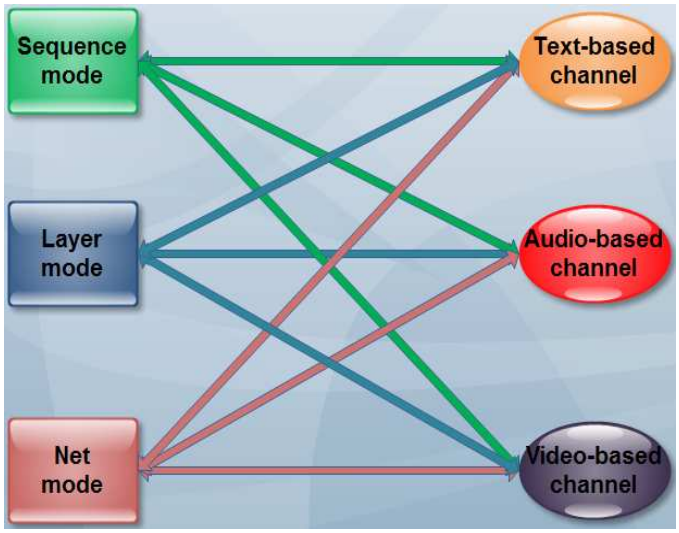


Figure 2: Experimental procedure

In the process of the experiment, the mode and the channel setup were fixed, which means the communication among the group were carried out in a particular combination of communication mode and information exchange channel. For example, in the sequence mode-video channel step of the experiment, the mode of the

communication could only be sequential. The other mode would be forbidden by the location and the software setup. Besides that, the information exchange channel would be video-based channel than text-based channel or audio-based channel. The limitation would be carried out by software setup.

For the experimental set-ups, the chatting software Tecent TM was used in the experiment which combined the text chatting, audio chatting and video chatting. This fact makes the achievement of the information exchange channels. Besides that, the communication directions could be well controlled by Tecent TM. Every participant was identified by a unique number and in different locations. According to the experimental process, the connection among the participant was cut or built as necessary. For example, in the sequence step of the experiment, the participants could only contact the participant directly who was next to him/her in line. The designer B could only contact with Designer A and Designer C directly. The direct connection as Designer A to Designer C was then shut down (Figure 3). In this way, the modes were formed and strictly controlled.

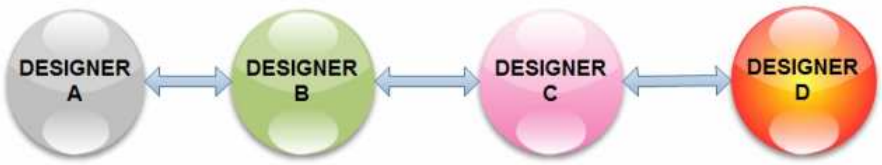


Figure 3: The sequence mode

4.6 Participants, Measurements and Data Collection

As mentioned above, each four participants were grouped a team who experienced the entire 10 design rounds. There were 10 replicates of teams, which means totally 40 participants were recruited for the experimentation. All those human subjects were recruited from the students with design background in the university level. The measurements for the level of trust were done mainly by three methods; professional web designers' evaluation on the quality of the final outcomes, post-experiment questionnaire, and communication recording. The data from these three methods were used together to possibly inter-reflect with each other to confirm the results.

1. Design quality assessment: After all 15 rounds were completed, several professional web designers were invited as judges to evaluate the quality of the groups' outputs. The validity of using the design outcome as a reflection of trust building is supported and proved by the study by Lipnack and Stamps where they found that the success and failure of the task performance started from trust and also reflected the level of trust involved [Lipnack et al., 2000]. Throughout the entire game, individual works and group works could not benefit each other. That is, participants should not use their individual achievements for the group works and vice versa.

2. Questionnaires: post-experiment questionnaires was given to each participant to measure the subjective trust level established in each group. Questionnaire was one of the most common used measures to evaluate the level of trust established in a dynamic virtual team. Questions for the questionnaires used were derived or adapted

from the commonly used ones in the community. The questionnaires results were considered as circumstantial evidences for the trust level derived from the group score.

3. Communication recording: Through the recorded data during the experiments, the following information were collected: The communication information like what they communicated in the group discussion and the communication direction like who was talking to whom; the quantity of the communication like the number of words in the text-based step which participants used in the communication and the times they communicated. According to different requirements of the data collection, different measurement tools were used. For example, an audio recorder was used to record the communication in the audio-based experiments. Furthermore, for the data analysis, different methods were used according to the characteristics of the data. First, the final group work scores were compared to decide which group developed the better trust in the experiment. For instance, in the net mode period of the experiment, the text-based group work score, the audio-based group work score, and the video-based group work score were compared in order to decide which communication channel would be the best partner for the net mode in the situation. The questionnaires results were considered as circumstantial evidences for the trust level derived from the group score. The contents of the communication were categorized based on the extent of relevant trust building and provide the detail information of unusual or non-sense results when there were conflicts between the group score results and the questionnaire results.

5 Results and Discussion

Firstly, the level of trust among each team was measured by the time distribution. For clarity, the first round of the game was disregarded, which was decided before the trust started. The no working round data was got rid of as well. The reason for that is in the no working round the distribution of time is not related to the trust in the team (the no working round means the participants have finished the entire job in the last round, therefore, they have no group work to do in this round). The group time distribution was affected by the trust among the participants. It was further assumed that if the team achieved a higher level of trust, then they would spend more group time on the group work. Besides, these results were proved by the post-experiment questionnaire.

In this step of result, the influence extent of the communication modes and the information exchange channel to the trust in the group was summarized. The ANOVA analysis showed that the combination of the communication mode and the information exchange channel has a significant effect on the group time distribution ($F=6.2$, $P<0.05$). Post-hoc comparison's using Tukey's test showed that the highest trust level was achieved in the video-net combination. The difference between the video-net combination and others is significant.

In the comparison based on communication modes, the result is interesting. In the sequence mode, the direct results from the group time distribution was that the text-based channel achieved the highest trust level; the audio-based channel came second; and the video-based channel trust level was the lowest. According to the Post-hoc, the difference between the text–based channel and the other channels was large, but there was no significant differences between the video-based channel and audio-based

channel in the sequence mode. The reason of that might be the lack of information maintenance that exited in audio-based channel and video-based channel. The information was easily reviewed and saved in the text-based channel, which was more difficult in the audio-based channel and video-based channel. Based on the special feature of the sequence mode, the participants had to pass the information indirectly, which means there might be information lost during the process. The lack of information maintenance caused distrust among the group. In the layer mode and the net mode, the results were quite similar, the video-based channel was the best trust builder in both mode. The second best was the audio-based channel. The text-based channel came last. The differences among the result were significant. In the post-experiment questionnaire, the results confirmed the conclusions from the group time distribution. The combination of the communication mode and information exchange channel affected the trust level in the group. The highest trust level was achieved by the video-net combination. The differences for the survey result were also significant. The only confusion happened between the video-based channel and the audio-based channel under the sequence mode. In the direct results in this step, the trust level was higher in the video-based channel than in the audio-based channel. Except that, the results from the survey proved the results from the group time distribution as well.

Even though the video-based channel results and audio-based channel results were not statistically different under sequence mode, the hypothesis of this research was proved. To find the reason behind the appearance, a closer round-to-round analysis was carried out. There were two factors that discussion were based upon: trust speed and trust trend.

Previous literature has suggested that different information exchange channels may cause the differences on the trust formation time by the information gather speed. Through the round-to-round analysis, the difference was quite noticeable according to the different information exchange channels. The video channel was the quickest trust builder in both layer mode and net mode. The audio-based channel came second in those two modes. The text-based channel came last. This result confirmed the hypothesis in the layer mode and the net mode. The other meaningful discover was under sequence mode. In the sequence mode, the trust was built faster by video-based channel than the other two channels. The text-based channel achieved that second. The audio-based channel came last. Why the video-based channel trust level is lowest among three channels? According to the round-to-round analysis, the reason is clear. The video-based channel achieved the top trust level much quicker than the other two channels, however, through the video-based channel, the damage to the trust was much quicker than the other two channels. In other words, the distrust formation was much quicker in the video-based channel than the other two channels. The evidence was provided by the group time distribution (see Figure.4). In the Figure, we can see that in the video-based channel, the top trust level, which represented by the group time achieved max much faster than the other two channels in the sequence mode. At the meantime, the trust damage speed was much quicker. In the video-based channel, the first time the group time achieved the top was the fifth round. Comparing to that, the achieve time of text-based channel was the ninth round. The audio-based channel achieve time was eleventh round. Besides the achieving time, the trust level trend was quite different among the three channels. The video-based channel trust trend was steeper than the other two channels. The difference between the video-based channel

and the other two channels was quite noticeable. The difference between the text-based channel and video-based channel was not significant. The reason that the video-channel did not perform the best appeared between the 6th round and the10th round. The trend of the trust level during this period was steep, which caused a significant lost in trust level. These proved that the more information exchange caused more trust change in both positive and negative way.

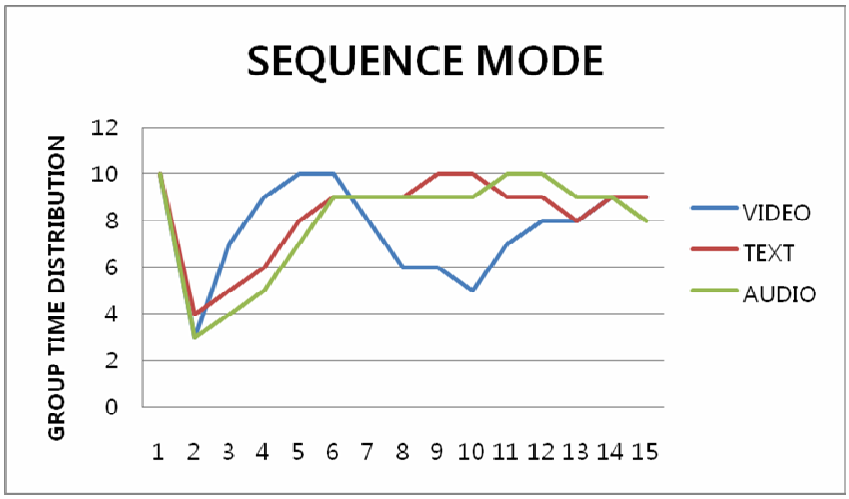


Figure 4: The sequence mode group time distribution

After the analysis based on the information exchange channels, the similar analysis based on the communication modes provided some interesting results as well. The net mode was certainly the quickest in building trust. The highest trust was achieved quicker under net mode than the other two modes no matter what information exchange channel was used. The difference between the net mode and the other two modes was statistically significant. The second quick trust building was layer mode. The reason for these results was the information gather speed. The connection among the different modes was quite different, and the net mode got much more connections among the team than the other two mode. As it was demonstrated in the typical four people group, the sequence mode only got three connections among the entire group. There were also three connections under the layer mode. However, six connections existed in the net mode. The evidences could be found in Table 1. From the table, we can tell that the average time of the max trust achievement in net mode was faster than the other two modes.

Mode / Channel	Sequence	Layer	Net
Text	9th Round	7th Round	6th Round
Audio	11th Round	8th Round	7th Round
Video	5th Round	4th Round	3th Round

Table 1: The achieve time of the max trust level

Besides that, there was another phenomenon happened in all experiments. The trust formation trend was similar: the trust level was built from the lower level, and then the trust was achieved to the max. After that, the trust level fell down. At last, the trust level flatted out. Linked with different features of communication modes and information exchange channels, the timeliness was helpful for the trust building system setup. For example, at the beginning of the team trust building, using the net mode and the video-based channel to achieve the high level trust within short time might be a good strategy. In the middle period, according to different natures of the job, the mode or channel could be adopted for the high-level trust maintenance. Besides, there was a common phenomenon through the entire experiment. The phenomenon is that the individual trust damage action would cause chain reaction through the entire group. This contribution could be used to avoid the vicious circle of trust damage.

6 Conclusion

This paper discussed the inter-influence between communication modes and information exchange channels on trust building in computer-mediated collaborative design. Experimentation and approaches of validating the relationships were presented as well. Through the results of the experiments, we found that the combination of a video-based channel and a net mode would lead to a higher level of trust in computer-mediated remote collaboration design. The video channel was the quickest trust builder in both layer mode and net mode. The audio-based channel comes second in those two modes. The text-based channel comes last. In the sequence mode, the trust was built faster by video-based channel than the other two channels.

Furthermore, we noted that the performances of information exchange channels were changed according to communication modes. Thus, we conjecture that the two factors, a communication mode and an information exchange channel, would influence trust building. It is also important to note that different features of communication mode and information exchange channel are critical to the trust building. That is the reason why different combinations of communication modes and information exchange channels produce the development of trust building differently. Moreover, how the different features of mode and channel interact were also explained through the experiment and analysis. In the sequence mode, the direct results from the group time distribution was that the text-based channel achieved the highest trust level; the audio-based channel came second; and the video-based channel trust level was the lowest. According to the Post-hoc, the difference between the text–

based channel and the other channels was large, however, there were no significant differences between the video-based channel and audio-based channel in the sequence mode. The reason of that might be the lack of information maintenance that exited in audio-based channel and video-based channel. In the layer mode and the net mode, the results were quite similar: the video-based channel was the best trust builder in both modes. The second best is the audio-based channel. The text-based channel comes last.

The video-based channel achieved the top trust level much quicker than the other two channels, however, through the video-based channel, the damage to the trust was much quicker than the other two channels. These proved that the more information exchange caused more trust change in both positive and negative way. After the analysis based on the information exchange channels, the similar analysis based on the communication modes provided some interesting results as well. The net mode was the quickest in building trust. The highest trust was achieved quicker under net mode than the other two modes no matter what information exchange channel was used. Therefore, the timeliness was helpful for the trust building system setup. For example, at the beginning of the team trust building, using the net mode and the video-based channel to achieve the high level trust within short time might be a good strategy. Another phenomenon found is that the individual trust damage action would cause chain reaction through the entire group. This contribution could be used to avoid the vicious circle of trust damage.

The results of the experiment could be generalized and support testified effects of different matches of communication modes and information exchange channels on the level of trust in computer-mediated collaborative remote design environments. These findings have provided empirical evidences for our suggestion that matches for the trust support and building strategies in a computer-mediated remote design team.

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