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Computer-Mediated Communication and Success in Educational Collaboration

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ABSTRACT

The continuous development of technology has made computer-mediated communication the normal means of communication in many organizations. Many educators are beginning to use resources designed to prepare their students for the global world of computer-mediated communication. Even though computer-mediated communication is different from face-to-face, it does not necessarily inhibit collaboration. This study examined the success of a non-collocated team playing *MoonWorld*, an educational and collaborative computer game, using only computer-mediated communication versus the success of a team that was collocated and able to use face-to-face communication. The data showed that there were differences in the collaboration between the two teams, but that both teams were successful despite one having the ability to communicate face-to-face. The findings suggest that if a virtual environment is designed correctly, computer-mediated communication can be used to successfully collaborate.

KEYWORDS:

Computer-mediated communication, Face-to-face communication, Media Richness Theory, Collaboration, Virtual worlds, Distance learning

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Computers have changed the way humans collaborate and work in teams both in the professional and educational worlds. Computer-mediated communication (CMC) has many benefits, saving businesses money and time by allowing teams separated by distance to work together. Oftentimes, this allows consultants and experts from all over the world to collaborate with teams. Similarly, educators and students can interact with experts in a given field thanks to distance learning opportunities that would have never been possible without CMC. In this global society educators must prepare their students to collaborate using CMC. We must understand how to maximize the benefits of CMC while reducing the deficiencies so that these students are prepared to be both technologically savvy and good communicators.

Many communication theories (Daft & Lengel, 1986; Short, Williams, & Christie, 1976; Rutter, 1987; Rice & Shook, 1990; and Rice, 1993) still focus on the negative aspects of CMC. Instead of recognizing the benefits of each and differences between the two, these studies can often be misinterpreted to mean that CMC should be avoided because it can never be a substitute for face-to-face (FtF). Other studies (Fulk, Schmitz, & Steinfield, 1990; Kock, 2005; Kinney & Watson, 1992; and Dennis, Kinney, & Hung, 1999) have challenged media richness theory and have found benefits to using CMC. The idea that CMC is a less-robust medium can discourage people from using it for things like distance learning opportunities. However, many more educators are realizing the necessity of CMC, to prepare their students to succeed in a thriving global and technical world. The challenge is to balance the need for CMC with clear unambiguous communication in collaboration.

Teaching students how to work as a team is essential to their education, especially in the areas of science, technology, engineering, and math. It's so important that the National Academy of Science (NAS) highlights collaboration and teamwork in its report, "A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas." The virtual environment and game *MoonWorld* was designed in response to the suggestions made by the NAS. The designers intended for teams playing *MoonWorld* to use inquiry based science to ask questions, plan and carry out investigations, interpret data, construct explanations, engage in argument from evidence, and successfully communicate their findings with their teammate, all within a virtual environment.

MoonWorld aims to help students learn to collaborate. The game is designed so that players are in a world together, but on different computers. Players can sit right next to each other or on opposite sides of the globe; either way they will need to work as a team to be successful. This is reflective of the way organizations that have employees and contractors located across the country or world must collaborate as well. Knowing how to collaborate using CMC is relevant and important in both education and business. This research asks if FtF collaboration produces the best results in the game environment. Specifically, if learners playing an educational game non-collocated using computer-mediated communication experience the same success as collocated players using face-to-face communication. Success is determined by the number of tasks completed and questions answered correctly.

Review of Literature

CMC is often perceived as a second-rate form of communication that makes encoding, decoding, and interpreting difficult for those communicating, while FtF collaboration is perceived as the best and easiest form of communication, reducing equivocality and speeding up communication, according to communication theories such as media richness theory (Daft & Lengel, 1986) and social presence theory (Short et al., 1976). Other studies such as Fulk, Schmitz, and Steinfield (1990), Kock (2005), Kinney and Watson (1992), and Dennis, Kinney, and Hung (1999) have disputed these theories and reconciled the deficiencies of CMC.

Many organizations, educators, and students can be dissuaded from using CMC collaboration because of the negative stigma CMC has. This negative stigma can hinder them from growing and exploring new technologies, products, and ideas that could be useful in certain types of collaboration. However, the fundamental assumption in this research is that all communication can be flawed, even FtF, but that all forms of communication also have benefits. By highlighting CMC benefits and avoiding situations where it may be insufficient, we can learn to use it correctly in collaborative work.

Theoretical Basis

A lot of CMC research has focused on the ways CMC is not like FtF (Daft & Lengel, 1986; Short et al., 1976; Rutter, 1987). Their research is based on the idea that CMC is permanently flawed because it lacks qualities that only FtF can possess. Other theorists, while still focusing on the differences between CMC and FtF, have focused on human ability to adapt to CMC and also the ability for us to adapt CMC to be more like FtF (Kock, 2005; Walther, 1992).

Deficit approaches. Before computers were mainstream, communication theorists were busy researching the effects communicating via telephone had on the quality and effectiveness of communication. Social presence theory (Short et al., 1976), media richness theory (Daft & Lengel, 1984; Daft & Lengel, 1986), and the cuelessness model (Rutter, 1987) emerged from telephonic communication research.

Daft and Lengel developed media richness theory in the 1980s based on the idea that all communication media have a different capacity to process information efficiently and effectively (Daft & Lengel, 1984). They assume that two forces influence communication in an organizational setting: uncertainty and equivocality. The "richness" of the medium determines whether uncertainty and equivocality are reduced or increased. They demonstrate the "richness" of communication media on a spectrum, defining richness as the ability of information to change understanding within a time interval (Daft & Lengel, 1986). On this spectrum, face-to-face communication is the richest, and letter writing is the least rich. This means that face-to-face communication is the most efficient without wavering in clarity, making it the richest. Letter writing is the least efficient and most equivocal, but useful in conveying "standard data" or complex messages (Daft & Lengel, 1986).

Daft, Lengel, and Trevino (1987) found more support for their initial work. They observed that managers who used FtF for personal interaction and collaboration, and other media for task-oriented work were more successful than the managers who did not. Rice and Shook (1990), and Rice (1993) also found that FtF was preferred for personal communication, but non-FtF media were suitable for task-oriented situations, supporting media richness theory. Further studies (e.g., Sproull & Kiesler, 1987) showed the negative consequences CMC had on group work. Specifically, groups felt less cohesive when using CMC versus FtF. This could because of the increase in uncertainty and equivocality in CMC or because of a lack of personal interactions and nonverbal cues.

Where media richness theory is concerned with the increase of uncertainty and equivocality in non-FtF communication, social presence theory is concerned with the decrease in interpersonal communication, suggesting that media other than FtF are impersonal, individualistic, and task-oriented (Short, Williams, & Christie, 1976). Like media richness theory, social presence theory implies that simple tasks and standard data can be communicated through CMC. Moreover, nonverbal cues such as gestures, facial, expressions, tone, and appearance are absent making it difficult to communicate emotion and establish roles. If true, this would hinder collaborative work and make it difficult to accomplish tasks if communicators have only CMC media available to use. Specifically, media richness theory would argue that the presence of gestures could make the message clearer and feedback easier and more efficient. Anderson et al. (2007) found that players gestured more in FtF conditions than in CMC.

Sproull and Kiesler (1992) developed the reduced social cues model showing the negative aspects of the lack of social context cues. Although they discovered that geographical location, position within an organization's hierarchy, and situational variables are absent in electronic mail, they concluded that CMC media that diminish social cues may work better for task-related efforts.

Disputing media richness theory. Many studies have disputed media richness theory. Markus (1990) found that managers often use email for complex messages and tasks. Fulk, Schmitz, and Steinfield (1990) and Kock (2005) discuss in detail studies that have shown little support for media richness theory, including Kinney and Dennis (1994), Kinney and Watson (1992), and Dennis, Kinney, and Hung (1999).

In some cases research has shown that the "richness" of a medium does not matter or can be worked around. Particularly, studies have shown that in task-related communication the richness of the medium does not matter (Kock, 2005; Daft et al., 1987; Rice & Shook, 1990; Rice, 1993). In other situations, such as social information processing theory developed by Joseph Walther, the research showed that lack of FtF in CMC can be worked around. Walther's research focuses on the absence of nonverbal cues. This argues that even if nonverbal cues are absent, people will implement other cue systems available to them, adapting to the circumstances (Walther, 1992).

Kock (2005) is also concerned with humans adapting to CMC when he looks at media richness theory through the lens of evolution. His theory is called media naturalness theory because he believes FtF is the most natural form of communication from an evolutionary

standpoint, but that we can mimic this naturalness through CMC. He lists five requirements of natural communication through CMC, or what he calls, e-communication (Kock, 2002):

1. A high degree of collocation, which would allow the individuals engaged in a communication interaction to see and hear each other.
2. A high degree of synchronicity, which would allow the individuals engaged in communication interaction to quickly exchange communicative stimuli.
3. The ability to convey and observe facial expressions.
4. The ability to convey and observe body language.
5. The ability to convey and listen to speech.

Where Daft and Lengel call these qualities "rich," Kock (2002) calls them "natural". Media richness theory says that a manager will choose a medium based on the appropriate richness for the task. If they cannot use their preferred method, the task outcome will be low. Kock (2002) considers cognitive effort, communication ambiguity, and physiological arousal as variables instead of task outcome allowing for positive outcomes when using a medium that may not be as natural as FtF. Earlier research by Kock (1998) considered that those using CMC might even over compensate when using CMC, thus achieving better results.

CMC game communication. Kock (2002) concludes that we need CMC media to solve communication problems, but we should try to make CMC as much like FtF as possible, while preserving the qualities of CMC that make them useful (e.g. convenience). Keating and Sunakawa (2010) explored how gamers are able to adapt to the virtual collaborative environment. What they call "participation cues" account for the player's ability to adapt to collaboration in a virtual world while being collocated. Participation cues is the name given to cues used by players who are in a virtual world together, but also sitting next to each other in the "real" world. Keating and Sunakawa use participation cues to account for the ways players communicate in both worlds at the same time. Their study included observing groups of gamers collocated, but interacting in a virtual world.

After filming the gamers for seven hours, the group observed gestures, body language, gaze, and conversation. Keating and Sunakawa (2010) found that the groups developed their own way to communicate. They were able to manipulate chat features to show emotion (bold, italic, capital letters), the speed and tone of their voices during conversation conveyed meaning, etc.

Educational games are innovative ways to engage and educate students. Many of them, such as *MoonWorld*, teach the students to collaborate in inquiry science tasks. Reese (2012) found that *MoonWorld* does not just teach concepts, but also causes collaboration in scientific practices and cross-cutting concepts. In the case of many educational games, CMC is appropriate and easy to use in the virtual environment.

Purpose of Research

The gamers observed by Keating and Sunakawa (2010) were able to use participation cues to successfully collaborate and complete tasks in a virtual gaming world. However, they did

not observe task outcome if nonverbal cues are absent. Other theories and models, such as media naturalness theory, have suggested that CMC has its place especially in task-oriented situations.

Virtual world, educational computer games are currently trending in a generation of learners with a high competency level in CMC. This study looks specifically at the success of task completion and the quality of work in collocated and non-collocated players. According to media richness theory, collocated players who are able to use FtF communication including nonverbal cues will communicate with ease compared to the non-collocated team. The interest in this study is exploring the validity of media richness theory and the theories and models based upon it.

Media richness theory, which rates the richness of a medium based on the reduction or increase in uncertainty and equivocality, features FtF as the richest way to communicate. The theory implies that communicators using CMC media will struggle to communicate more than those using FtF. However, Daft and Lengel (1986) found that CMC media is better to communicate "standard data" and complex messages. Like media richness theory, social presence theory (Short & Williams, 1976), Rice and Shook (1990), and Rice (1993) found that non-FtF media were suitable for task-oriented situations supporting media richness theory. These theories initially seem to imply that the effects of CMC on collaboration are negative.

This study investigated first if FtF collaboration produces the best results in the game environment. It also asked if learners playing an educational game non-collocated using computer-mediated communication experience the same success as collocated players using face-to-face communication.

Scope and Methodology of Study

Educational games have continuously changed and improved as technology and the internet improves. These games now take advantage of rich virtual worlds and distance learning opportunities. The educational computer game, *MoonWorld*, was selected as the tool to conduct this study because of its educational attributes and its multi-player collaborative virtual environment. The game gestures a talk system that players can use to communicate, a text chat window, and avatar features to facilitate communication in the environment. Players must collaborate with their teammate to navigate, and solve problems together in this environment. Success was determined by measuring the amount of tasks each player or team completed and reviewing the correct and incorrect answers to questions.

The researcher filmed players' interaction with one another and their gestures, and verbal interaction was transcribed and coded. Important verbal and nonverbal cues included gaze at one another and gaze at one another's computer screen, pointing, and shaking head yes or no based on previous research using the game that determined the types of teamwork *MoonWorld* players use (Reese, 2012). In this study, Reese videotaped players and transcribed verbal communication and gestures to determine the best way to collaborate. By coding the players' interaction and then determining their success in the game as a team, assumptions are made about the use of CMC versus FtF in a virtual learning environment and distance collaborative work in general.

Participants were recruited based upon computer experience. The sample size of this study was four players who would make up two teams.

Research Design

The teams collected rock samples at every station and then answered questions about the rock sample and the terrain at the station. The number of tasks completed was important because if the teams did not work together properly using their compass, they would not go to the correct stations, and if they did not go to the stations in the correct order, they would not be able to collect samples and complete questions. Success was ultimately defined by the number of tasks completed and the percentage of questions answered correctly.

The collocated players played in a computer lab seated next to one another. A camera filmed their faces from the front, and an additional camera filmed the players from behind to show their computer screens and hands. The non-collocated players played in separate rooms with a camera on each player, and each team had a total of two hours in world. Since one team went further than the other, only stations both teams visited were considered for data. The CL team did not have time within their two hours to make it to the end of the game; however, the NCL team did. So the data analyzed was based on the stations the CL was able to reach.

For the NCL team, videos from each work station were synced and placed side by side. Once synced and clipped to include only stations that the CL team visited, the video was transcribed. Each time a new topic was discussed by the teammates, a new number was assigned to that interaction. For example, if a team was discussing the setting in order to answer a question, and then they began discussing what type of rock they picked up, the two topics were considered two separate interactions.

For the CL team, specific nonverbal cues were coded, including players looking at one another at the same time or one player looking at the other, looking at their teammate's computer screen, shaking their head yes or no, and pointing. Verbal interactions were totaled for each team, and each player's verbal participation was measured in seconds for each interaction.

After observing the video, the researcher coded the interactions and counted how many times a nonverbal cue, specifically gestures and gaze, occurred. This was adapted from Reese's (2012) report, but instead of observing emotional gestures, it observed operational and instructional gestures. The chart below shows the operational/instructional gestures that were coded in this study versus emotional gestures that were previously studied and coded in *MoonWorld* research:

Operational/Instructional Gestures	Emotional Gestures
Eye contact with partner	Gesturing with hands to show excitement
Shaking head yes or no	Covering face with hands
Gesturing with hands	Clapping
Looking in teammate's direction	Smiling at teammate
Pointing at teammate's computer screen	Frowning at teammate
Pointing at their own screen	

During transcription, the length of each interaction was noted. Whenever a player began and ended speaking, the time code was recorded. If players spoke at the same time, or over one another they were measured separately. Also, each time the team began to talk about a new topic, the researcher numbered the interaction so that when the transcription was finished, each team had a counted number of interactions, and each player's contribution to the collaboration was measurable in seconds. For the collocated team, the researcher noted the gestures and gaze within the transcript as well.

Once the video was coded, noting nonverbal cues and verbal interaction, the amount of team interaction was compared with the success of the team. The number of rock samples collected and the number of elevations/distances requested were used to measure the teams' ability to complete tasks. The number of questions answered correctly or incorrectly measured the success of the teams' collaboration and ability to work together to learn and make decisions in the *MoonWorld*.

Results of Study

Each team had strengths and weaknesses in their collaboration. Neither team necessarily did better or worse than the other based on both measurements (tasks completion and questions answered correct or incorrect), but the teams excelled in a different measurement. The CL team only made it to station 12 while the NCL team completed all 16 stations and went on to the research facility. This could be because the CL team took longer to make decisions when answering the questions. Figure 1 shows the amount of interactions and time of each interaction measured in seconds.

Figure 1

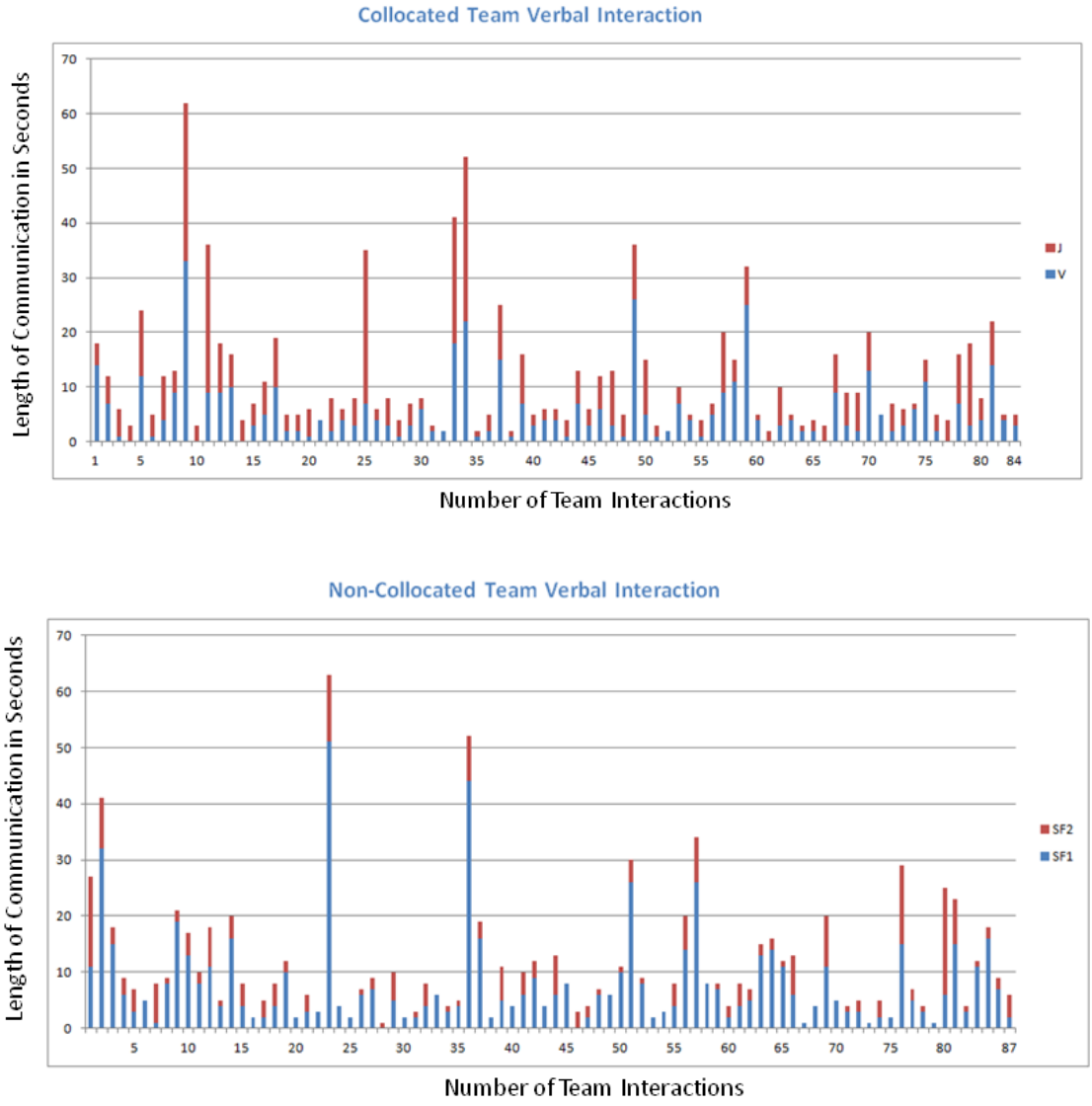
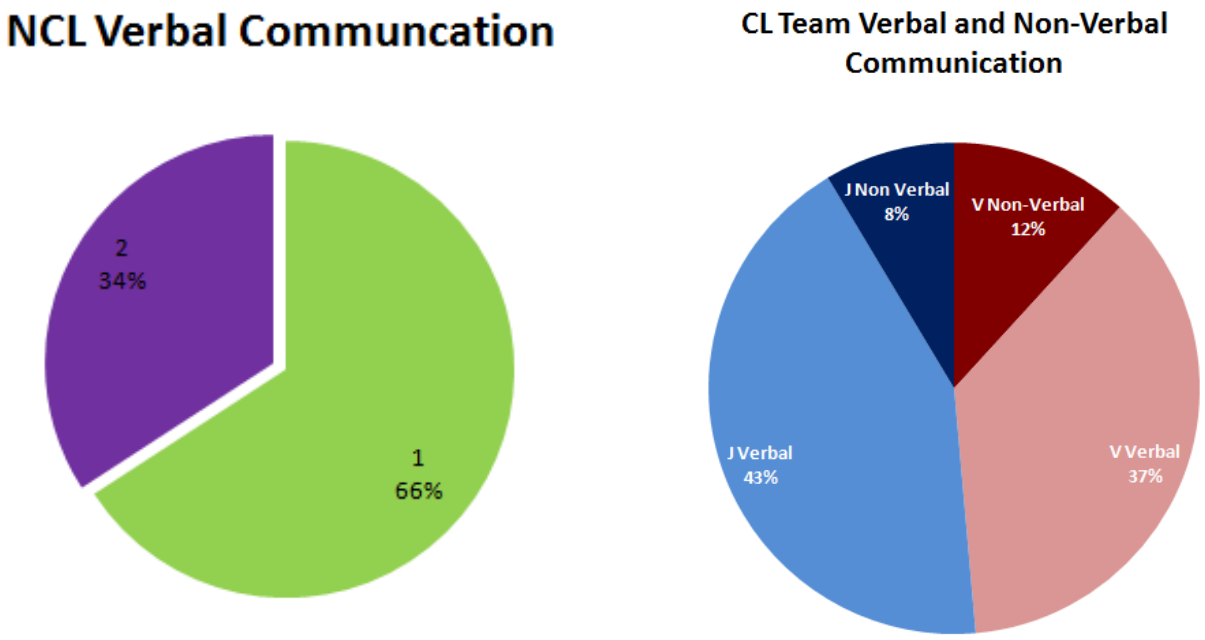


Figure 1 shows that the number of interactions were similar, as the NCL team totaled 87 and the CL team 84. Looking at figure 1, it is also visible that the CL team had more lengthy interactions. Although the CL team spent more time in certain interactions, the average interaction between the CL players was 11.50 seconds, similar to the NCL team who averaged 10.84 seconds per interaction. This shows once again that despite their different ways of playing the game both teams had a similar amount of interaction.

One glaring difference between the teams was player contribution. The CL team was concerned with working together and sharing the burdens, while the NCL team was more leader/follower collaboration, and made decisions quickly when answering questions. Figure 2 shows each player's contribution to the collaboration.

Figure 2



The percentages are based on the length (in seconds) of each person's verbal contribution, while the percentage for nonverbal interactions is based on the number of cues coded for each player. In the NCL team, SF1 (green) took on a leadership role reading and answering questions when SF2 (purple) could not find the Q&A box on their screen. SF2's contributions were very valuable, including picking up rock samples, making suggestions during Q&A, and helping to navigate. In contrast, the CL team's verbal and nonverbal interaction was almost equal. Players V (red) and J (blue) did the same things (both opened Q&A, picked up rocks, used to compass to get to next station).

In addition to the amount of player contribution, the teams experienced a difference in success as defined by tasks completed and questions answered correctly. The NCL team completed more tasks than the CL team. They collected more rock samples (Figure 3a) and requested more distances and elevations at each station (Figure 3b).

Figure 3a

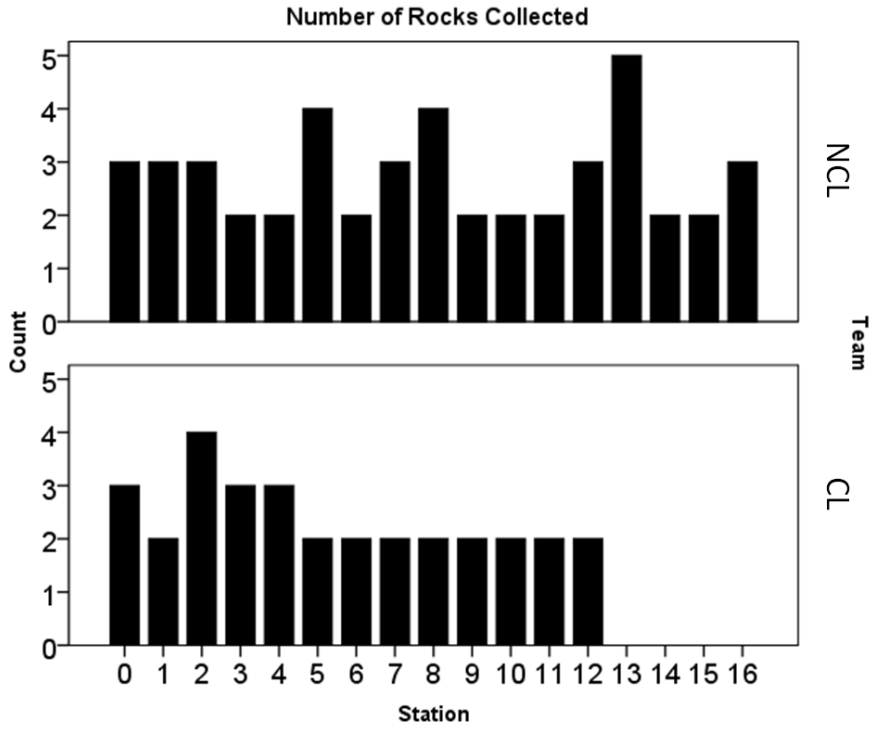
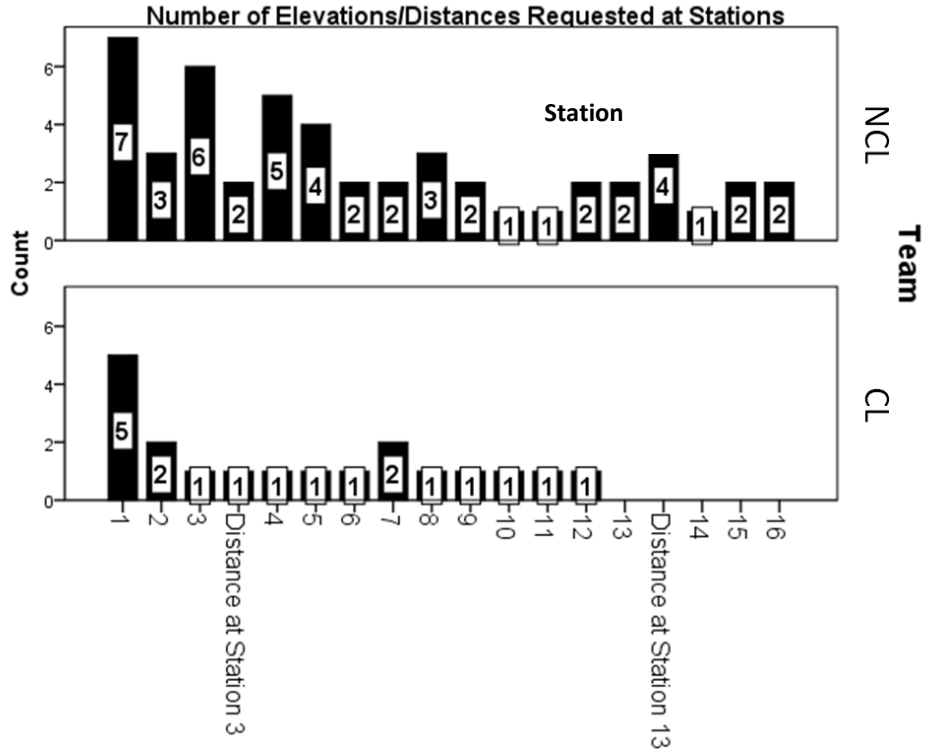
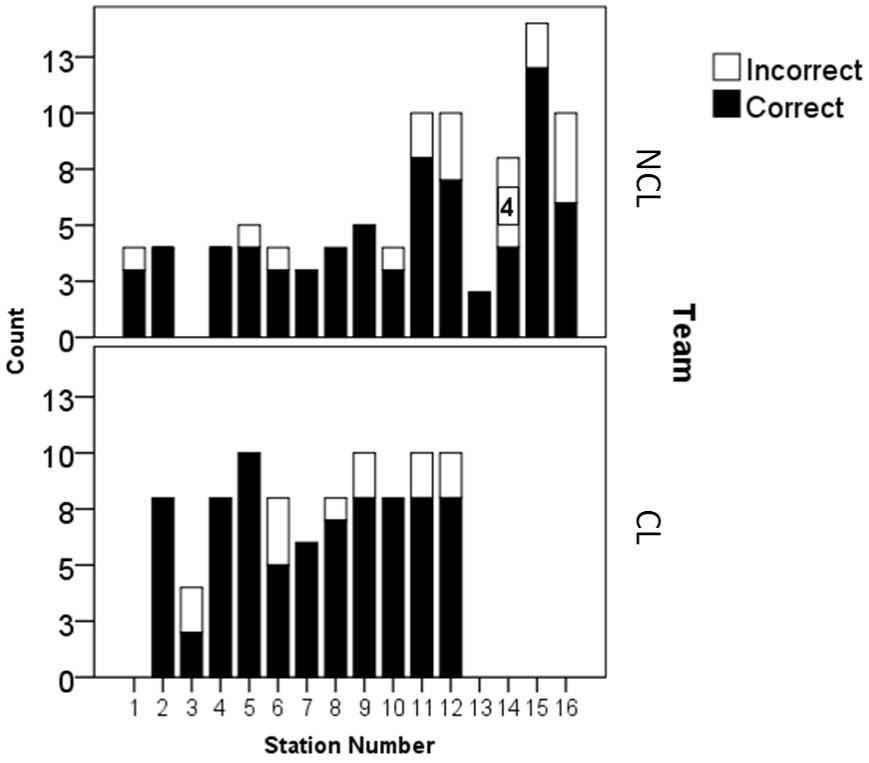


Figure 3b



However, the CL team spent more time on the questions, carefully collaborating to choose each answer. They answered more questions correctly than the NCL team, because both players were sharing the work and answering questions (Figure 4).The teams were almost equal in incorrect answers, but the CL team seemed more precise, taking more time on each question considering and deducing each possible answer.

Figure 4



The CL team needed 32:32 to complete 12 stations. When one of the teammates disagreed, they would look at the other player's screen. Or when one teammate was hesitant to reply back to a question or comment made by their teammate, they would look at their teammate to confirm if they heard them. Table 1 shows an example of the difference in collaboration between the NCL and CL teams at the same station.

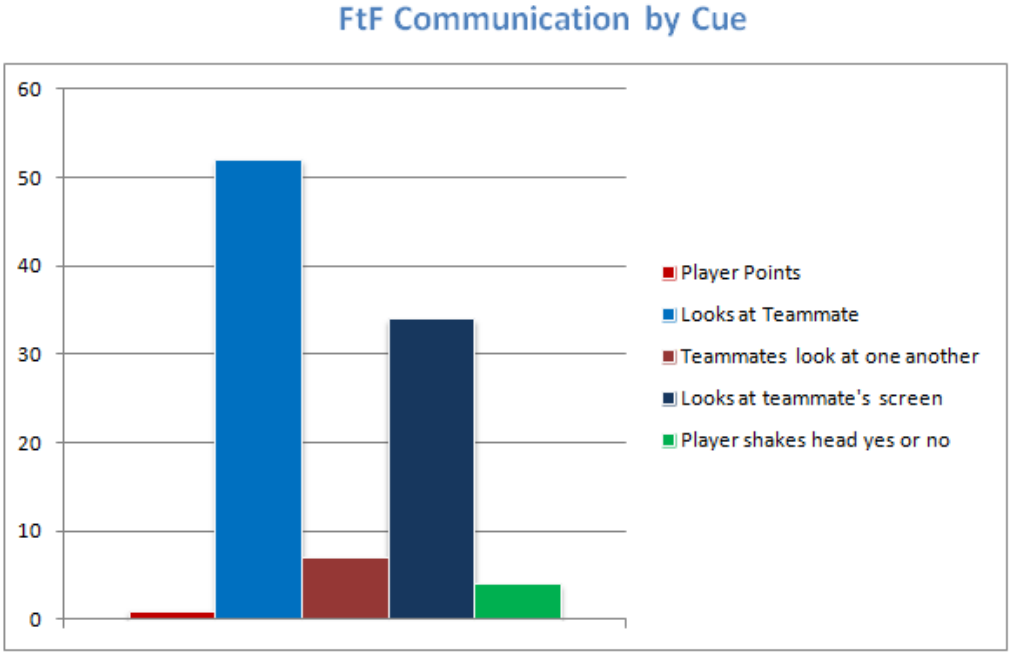
Table 1

NCL Team		CL Team	
1-(reading) Describe the setting here.	9:53-9:55	V-Have you looked at the Q and A yet?**(V looks a J's screen)**	11:57-11:59
1-Bright ray, crater central mountain, line of craters, basic crater outer wall, crater floor, crater rim, wall, floor, mound, crater terrace, lava flow, lava plain, and volcanic dome.	9:57-10-17	J-I'm looking now	11:59-12:01

2-Does it look like a lava flow?	10:19-10:20	J-I think it looks like one of the lava ones	12:06-12:10
2-Or would you say base of crater?	10:21-10:22	J- Either **(J looks at V's screen)**lava flow or lava plain	12:11-12:14
1-Oh! Wait no! Because see look up on the hill. It does look like it comes down.	10:22-10:27	J-Maybe plain because its flat	12:16-12:18
2- Mmm hmm	10:27	V-Umm I think maybe plain	12:17-12:20
1-I think that's a good idea…to go with	10:28-10:30	J-Oh I was thinking flow because it looks like it's coming down from the crater	12:20-12:24
1-Lava flow. Because it looks like it's a stream.	10:31-10:32	V-Oh what angle did you use **(V looks at J's screen)**	12:25-12:27
2- Mmm hmm. It looks like uhh…	10:33-10:34	V-Ohhh! I see what you mean	12:28-12:30
1-Are you comfortable with me putting that or?	10:34-10:37	**(J looks at V's screen)**	
2-Sure	10:37	V-Okay Yeah that's a good point. It does look like its flowing	12:30-12:34
1-(to self) Let's see…(reading as she answers question) lava flow…	10:39-10:43		

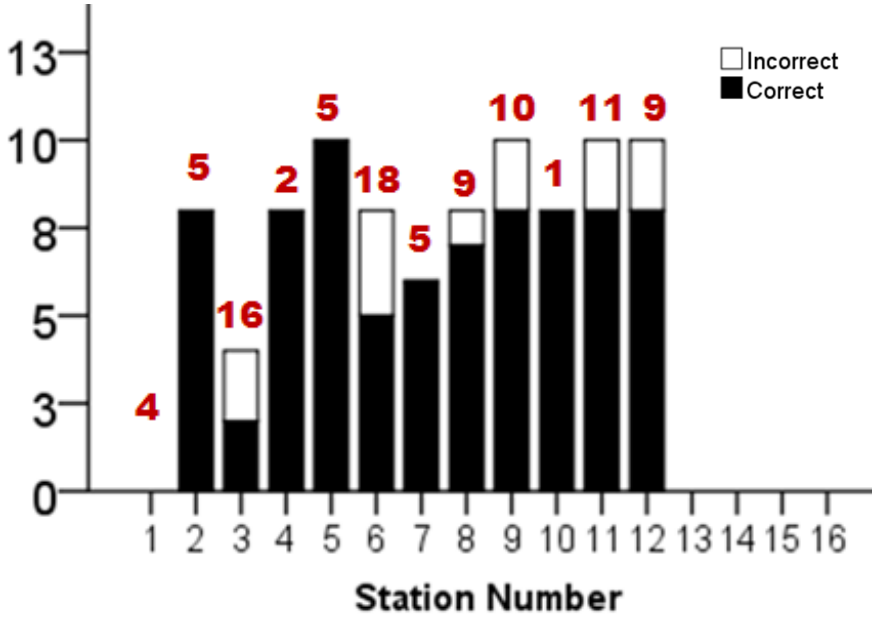
The two most used FtF cues that the CL team used were looking at their teammate and looking at their teammate's screen (Figure 5). The CL team implemented the nonverbal cues 98 times. It is possible that the cues helped them in answering the questions because they could see their teammate's computer screen. However, it may have been a distraction and not allowed them to become fully immersed in the virtual world, accounting for the NCL team's completing more tasks.

Figure 5



The CL team often implemented nonverbal cues when they were unsure about what they were doing or when they did not know the answer to a question. It seems that the nonverbal cues did not help them, but simply made them feel more comfortable. Figure 6 shows the correlation between the use of nonverbal cues and the number of questions correct and incorrect. The CL team used more nonverbal cues, as shown in red, when they answered questions incorrectly.

Figure 6



Discussion of Results

Keating and Sunakawa (2010) provide insight to the results. The CL team may not have been as immersed in the virtual world because they were participating in two worlds, virtual and real, simultaneously. Keating and Sunakawa studied players who already had experience in the game they were playing. The players in this study learned a new game and concepts. It may not have been possible for them to develop and use participation cues as Keating and Sunakawa defined them.

This goes back to the idea that selecting the correct medium for collaboration is essential. Research since the development of media richness theory (Daft & Lengel, 1986) has continuously shown that CMC can be very effective in task-related collaboration (Kock, 2005; Daft et al., 1987, Rice & Shook, 1990; Rice, 1993). In the case of educational virtual worlds, it seems that players immerse themselves in the game's virtual world if they are not distracted by being collocated with their teammate. The NCL team completed more tasks and were very task-oriented as predicted by the studies mentioned above.

Looking at the results through the lens of media richness theory, the CL team was able to process information more effectively because the opportunity to look at one another, and more importantly, one another's computer screen, reduced uncertainty. The findings seem to support

Daft and Lengel's (1986) research that found CMC to be appropriate for task-related collaboration. When looking at educational virtual worlds, the players may be collocated or non-collocated depending on the type of collaboration desired. This pilot study indicates if the desire is for careful consideration and collaboration, FtF communication is appropriate. If the collaboration is strictly task-oriented, being collocated is not necessary.

Therefore, the answer to the first research question asked in this study, "Does FtF collaboration produce the best results in the game environment," is no. The research showed that using FtF communication did not give the CL a significant advantage over the NCL team. However, it did change the type of collaboration. The NCL team succeeded in task-related collaboration and designated roles for each player, while the CL team carefully answered each question and shared duties equally.

The second research question in this study was, "Do learners playing an educational game non-collocated using CMC experience the same success as collocated players with FtF available to them?" This research showed that both teams experienced the same amount of success (number of tasks completed or correct answers), but not the same success. The NCL team completed more tasks, but the CL worked better together and collaborated more carefully in answering the questions.

Recommendations for Further Study

In order to collect more conclusive data, this study should be repeated with a larger sample. Also, with a larger sample, more conditions can be assigned to each group. For example, do females or males benefit more from FtF communication in collaboration? This study noted that the CL team was made up of two females and the NCL team was one female and one male. Would the results have differed if gender had been considered when assigning teams? In addition to gender, a further study could consider the relationship between players who are non-collocated. Does knowing one's teammate in advance help a team playing non-collocated, and inversely, if players do not know who their teammate is, will it be more difficult to communicate using CMC?

Limitations

Since it was a pilot, only one team was assigned to each condition; therefore, it is difficult to make a generalizable conclusion with such little data. Players have different learning styles, personalities, and communication preferences, all of which must be considered when assessing. In addition to the limitations caused by sample size, the game also offers technical limitations. For example, in the CL team it was visible that the graphics on one screen were better than the graphics on the other. If their screens were the same, they may not have looked at one another's screen as many times.

Conclusion

This research was intended to look at the differences between CMC and FtF communication in collaboration—particularly, collaboration in virtual educational games. In

MoonWorld, although their success was different, both the NCL and CL teams experienced success. It seems that being collocated was not an advantage to the CL team in terms of achievement in the game. Even in the CL team who were able to use FtF, the nonverbal cues did not necessarily help the team achieve more in the game, but it served as reassurance or comfort when they were unsure about themselves. There was no evidence to show that the NCL team severely suffered for lack of FtF qualities.

As indicated by previous studies (Daft et al., 1987; Kock, 2005; Rice & Shook, 1990; Short et al., 1976), groups using CMC do well if the work is task-orientated. However, using FtF helped foster teamwork in the CL team, while the NCL team was more leader/follower. This is supported by Sproull and Kiesler's (1987) research that indicated groups using CMC felt less cohesive than groups using FtF.

Media richness theory highlights the deficits in CMC. However, the findings from the present study show that the richness of a medium does not matter for teams collaborating to accomplish tasks in a virtual world. Daft and Lengel (1986) based the richness of a medium on the reduction or increase in uncertainty and equivocality. This study showed that FtF, the use of gaze and gestures in particular, did not reduce uncertainty or equivocality. The CL team used nonverbal cues when they felt uncertainty, but the majority of the time it did not assist in answering the question correctly. Media richness theory does not consider that all communication media are flawed in some way, even FtF. It is in knowing that these flaws exist in CMC and working to compensate for them that groups can successfully communicate and collaborate over distances. Organizations and educators should not fear CMC media for collaboration because the benefits of the tools are often far greater than the deficits.

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Appendix

Definition of Terms Used

Face-to-face communication (FtF): Communication that occurs between communicators who are in one another's presence.

Computer-mediated communication (CMC): In the review of literature, the studies will refer to CMC as any communication used through computers. However, in the methodology and analysis sections CMC refers to only the CMC features in *MoonWorld*, mainly voice chat using a headset and microphone.

MoonWorld: "The best way to learn is to do, but that is difficult when you want to understand the geologic evolution of the Moon. The NASA-sponsored Classroom of the Future at the Center for Educational Technologies at Wheeling Jesuit University in Wheeling, WV, has created a virtual lunar landscape in Second Life to provide you a chance to don a spacesuit and drive a rover across the surface of the Moon. In *MoonWorld* your avatar explores the lunar surface, closely observing the terrain, collecting samples, and making measurements to piece together the history of one part of the Moon–the Timocharis region. Your team returns to the lunar base to synthesize your data and to make sure the life support system is still pumping out air, water, and food. *MoonWorld,* which is funded by NASA, includes both simple and complex impact craters as well as a lava flow and a volcanic dome. Your job, based on your avatar's collection and analysis of observations, measurements, rock samples, and a drill core, is to determine the stratigraphic relations between these landforms–in what sequence did they form, and what evidence supports your conclusion" (http://moonworld.cet.edu).

***Collocated*:** In this study the term collocated will be used to describe the condition assigned to the team who plays *MoonWorld* in the same place. This team will have the opportunity to see one another's computer screen and use nonverbal cues. Collocation will mean "to set or arrange in a place or position; *especially*: to set side by side" ("Collocated," 2012).

Non-collocated: This term will refer to the team whose players will be playing *MoonWorld* in different rooms. They will not be afforded the opportunity to use FtF communication such as gestures.