COMMUNICATING FOR CREATIVE SUCCESS IN REMOTE COLLABORATIVE WORK

A Thesis

by

STEPHANIE LEE KESKE

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Tim McLaughlin
Committee Members,	Lou Tassinary
	Susan Pedersen
Department Head,	Tim McLaughlin

May 2014

Major Subject: Visualization

ABSTRACT

This thesis investigated how technological communication tools contribute to creative success within the specific domain of animation production. Research indicates that communication is one of the most important factors in producing successful collaborative work; specifically, constant and open communication channels are the most conducive to creative collaboration. Communication habits in remote creative collaborative work have been little studied, but drawing upon established knowledge in co-located collaboration I hypothesized that teams with the highest volume of communication would produce the most successful creative output. In a three-year study of distributed student production teams, I compare quantitative communication modality and volume data with qualitative end-product success scores. My findings indicate that more communication is not necessarily a positive factor. Further, an increased variety of communication modalities did not correlate with creative success. The results do indicate a preference among communication modalities for different types of communication: namely, asynchronous modalities are preferred for logistical communication and synchronous modalities are preferred for aesthetic communication. Collaboration using computer-mediated communication tools requires further study to determine best practices for creative work.

ACKNOWLEDGEMENTS

I am very grateful to my committee chair Tim McLaughlin for his patience, wisdom, and advice through the long process that finally resulted in this paper. I considered myself lucky enough to be hired as his research assistant during my first year in the graduate program; I never imagined it would result in another semester in Germany plus my first publication and subsequent side trip to Italy. World travel opportunities aside, I am also thankful for his mentorship and invaluable perspective on academia, the industry, and life in general. I am also grateful to my committee members Dr. Lou Tassinary and Dr. Susan Pedersen for their time and expertise in evaluating my work.

Thank you to our students at A&M and AIB as well as the students at UTD and DATA who were guinea pigs in this project and tolerated all our experimentation, and to the fellow educators who helped facilitate the project: Karin Damrin, Marcus Pasing, Judith Reitz, Ariane Hanrath, Todd Fechter, and Joey Vidal. Thank you also to the members of our industry advisory board who generously gave their time to this project. And, many thanks to the professors and support staff of the Department of Visualization, who helped with the project in numerous ways and make the Viz Lab the special place that it is.

Thank you to my Viz friends who spent all those late nights in Langford with me for 7 long years of undergrad and grad school, and to all the other wonderful people who gave me so many fond memories of College Station. Finally, thank you to my parents, who still don't really understand what I went to school for but supported me through it anyway (yes, I'm finally going to graduate).

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE Page

LIST OF TABLES

1. INTRODUCTION

Distributed teams are becoming increasingly commonplace in many industries because they offer a way to bring together skilled knowledge workers without geographic constraints. Industries such as software development, architectural design and construction, and film production employ globally distributed teams to utilize employees' specialized creative skillsets and facilitate round-the-clock production. Members of these teams may come from different cultures and work in different time zones, and they may never actually meet face-to-face. Rather, teams use Internet-based communication and file-sharing tools to collaborate on the creation of digital works.

Globally distributed teams have become feasible because of the proliferation of high-bandwidth Internet connectivity and the transition to all-digital workflows in creative industries. The universality of Internet-based technology allows distributed workers to create, share, and discuss digital assets nearly instantaneously- in many cases using identical computer systems and software setups. Through these technological tools, a worker can have the same collaborative potential with someone across the globe as they have with someone in the next room.

Distributed teams can be highly productive in organizations that utilize specialized knowledge workers. Indeed, distributed teams have produced some very notable projects, including the online encyclopedia Wikipedia and the open-source web browser Mozilla Firefox. These enormously popular digital works are used by millions of people every day, and were created entirely by remotely distributed workers. A key feature of these products of distributed teams is that, as open-source projects, they have evolved over time with no specific end goal in mind [7]. "Success" for these projects is not the achievement of specific goals but rather a critical mass of functionality that becomes useful to the general public [3].

In contrast, creative works for entertainment are almost always developed as narrative stories, which by nature have a specific progression. Works of this kind are begun with the end in mind, and require some form of creative oversight. "Success" in this context is difficult to define, and as such it has been little-studied how distributed teams are successful in creative production. Further, collaboration towards these more subjective goals involves different thought patterns and communication techniques. Our goal is to expand research in this area and promote the consideration of systems that enable online creative collaboration. Following other studies in this area, we define online creative collaboration as (1) utilizing computer-mediated communication as a primary form of interaction, and (2) intended to produce some form of end product [6].

In this thesis, I focus on creativity in visual storytelling, particularly as a component of the animation and visual effects industries. Creativity can be defined in many ways and has been researched from a variety of academic perspectives. Educational psychologists Moran and John-Steiner define creativity as "the transformation of a domain's raw materials into something qualitatively novel yet appropriate" [8]. These industries require creative workers to transform vague ideas into rich visual worlds populated by believable characters with appealing stories.

I specifically investigate the use of communication in remote creative collaboration and report on how it contributes to producing successful creative output. I draw from preliminary remote collaboration studies and established literature in co-located collaborations, and situate my work with relevance to animation and visual effects studios and the educational institutions preparing students to enter these industries.

Research in creativity and co-located collaboration indicates that communication is essential to creative success. In remote collaboration, where communication is by necessity restricted by technological tools, it is possible to record and analyze every piece of communication that contributes to an end product. My research questions are:

- Does a higher volume of communication contribute to greater creative success in remote collaboration?
- How are different communication modalities utilized, and what effect does modality have on creative success?

I've structured this thesis to promote easy transfer of knowledge to industry. To this end, I present an evidence-based conclusion that greater communication volume does not necessarily contribute to creative success. I make observations and recommendations on communication habits and modality usage therein. I draw these findings from a case study successfully carried out in higher education institutions using easily accessible tools, in the hope that the study's methods and my findings will serve as a blueprint for other educators and industry professionals. Specifically, my findings have value for technologists designing information technology environments that promote creative productivity among distributed teams, and for managers who are ultimately responsible for the creative productivity of an organization.

This thesis is based on a study supported by the National Science Foundation Division of Information and Intelligent Systems, under Grant No. 0855908. The study was entitled "Pilot: Creative IT Project: Collaborative Undergraduate Computing Studios Facilitating Decentralized Participation". This work was carried out under the direction of Professor Tim McLaughlin, the study's principal investigator.

2. BACKGROUND AND RELATED WORK

2.1 Defining creative collaboration

Much of the domain of creativity's early study was that of the individual, or "lone genius". Research on group creativity has only recently come into its own, and in fact many studies have shown that the group setting is detrimental to creativity [13]. However, in situations where the scope of the desired creative product is much larger than can be accomplished by any one individual, collaborative teams are required. Sawyer states that "most of our culture's important creative products are too large and complex to be generated by a single individual; they require a team or an entire company, with a division of labor and a careful integration of many specialized workers" [15].

As collaboration is necessary for large-scale creative endeavors, it becomes important to understand how groups come together in creative pursuits. One early description of the creative process was proposed by Csikszentmihalyi in 1990. He describes a state of effortless, creative thought called 'flow', which occurs when people work under certain conditions within their skillsets at a challenging level [9]. Flow can also occur in creative groups when they perform at their peak. This 'group flow' is usually described colloquially with terms such as 'good chemistry' and 'team spirit' [15].

Understanding when group flow occurs and what makes teams successful at creative collaboration requires a wide perspective across several disciplines. Miell and Littleton have sketched a framework in which group creativity must be studied and understood in two contexts: first, human factors such as social, interpersonal, and cultural dynamics; and second, the tools and technologies that are used to support creative collaboration [8].

2.2 Human factors in creative collaboration

Group creativity hinges on the idea that groups themselves inherently have creative potential: by bringing together individuals with unique knowledge, skills, and abilities, the group has the potential to be more creative than its separate members- provided that the group membership is appropriately diverse [13]. However, the specific nature of diversity in a group is very important to the group's success in creative collaboration [10]. Distinct physical diversity- factors like gender, ethnicity, and age -was associated with negative effects, while diversity in more subtle attributes such as personality and personal values had a slightly positive effect on creative success [13]. Members of a group contribute their diverse perspectives towards a creative goal through the use of communication.

Communication within creative collaborative teams has been studied extensively in the realm of business and product design. In creative production, continuous and transparent communication between different levels and departments of an organization is central to creative success [11]. Open communication supports informal discussion, and these informal exchanges are vital to supporting creativity. This is because informal communication reduces social and organizational barriers between collaborators [17], which contributes to an environment that encourages the free interchange of ideas that is necessary in creative work.

Group flow requires constant communication, and the sort of communication that leads to group flow "is more likely to happen in freewheeling, spontaneous conversations in the hallway, or in social settings after work or at lunch" [16]. In a less corporate-centric approach, improvisational jazz ensembles are often studied as examples of collaborative creative teams. Indeed, Seddon's study of jazz ensembles emphasizes the importance of non-verbal interaction during creative collaboration and "the need for understanding beyond words- attunement -between collaborators" [8].

This type of intonation- and body language-based non-verbal communication is called indirect communication. Indirect communication is key to driving creativity because it facilitates passive connections and multiple interpretations. The fidelity and modality limitations of technology-enabled communication present a challenge for creative collaborative teams. When discrete technology structures, such as databases, were used to manage creative collaboration and idea generation, creativity was inhibited because the capacity for indirect exchange of ideas was lost [16]. In a study of architectural design using computer-mediated tools, awareness of the presence and actions of others was indicated as an important feature of the collaborative process. [1]

Research in co-located collaboration shows that open, informal communication is the most important factor in promoting creativity in teams. Additionally, non-verbal communication has been shown as a contributing factor, which presents a unique challenge. By necessity, communication in remote collaboration is constrained by the virtual environment, which limits interaction bandwidth and reduces opportunities for non-verbal exchange. In light of this challenge, I predict that the most successful remote collaborative teams will utilize as much communication bandwidth as possible to mimic collaboration in a co-located setting.

2.3 Remote collaboration

As remote collaboration has become more widespread with improvements in technology, a growing body of research is forming investigating best practices. One of the more well-studied areas of remote collaboration is that of the open-source software

(OSS) movement. Successful open-source projects such as Mozilla Firefox, an Internet browser, Ubuntu, an operating system, and WordPress, a blogging platform, are used by millions of people and organizations around the world. These projects were produced by volunteer programmers, designers, and testers who collaborated from thousands of individual locations using only technological tools to share their contributions.

Open-source software projects, like software projects in general, are creative in that they synthesize existing knowledge and techniques to produce a novel end product. However, computer software is typically focused on providing specific functionality rather than presenting visual narratives or other forms of entertainment. Indeed, research in remote collaboration with respect to visually creative projects is comparatively sparse; however, a few preliminary studies have been completed. I review these studies in addition to broader OSS-centric research in order to form a picture of what is understood about remote creative collaboration.

2.4 The animation production process

In this research, I specifically investigate the domain of group 3D animation production. To better clarify my interests in the existing literature, I first offer an explanation of the peculiarities of this process: Animation production is unique in that it has the form of a linear set of steps, with artists taking in-progress work, contributing their specific task, and sending the combined work on to the next artist in line. Though the digital process affords slightly more flexibility, computer animation projects are still typically completed in a specifically ordered way. In 3D animation, tasks generally include story development, layout, modeling, rigging, surfacing, animation, effects animation, lighting, and compositing.

Artists usually specialize in only one or two of these domains, and as such the overall production is fragmented into divisions of labor based on each artist's area of expertise. In general, it is impossible to completely single out any one participants' contribution to a final animated piece- every element depends on many others and is inextricably linked to the whole.

This structure is in contrast with other group collaborative fields. For example, OSS projects and Wikipedia follow a modularized division of labor where each participant claims responsibility for, and has nearly total control over, a stand-alone contribution. The individual's work typically does not depend on any other participant's work except in the well-defined way in which it 'plugs in' to the rest of the project. In these modular projects, the group's leadership is responsible for the curation and final integration of each part into the whole [7].

Another key element of 3D animation production is that it includes both technical and visual considerations. The technical considerations are often driven by the aesthetic goals and the aesthetic goals are informed by technical capacity. Though each artist works in a relatively narrow aspect of the project, there is the expectation that in doing so the artist assumes not only responsibility for their individual contribution, but also for the successful integration of their work into the the overall project both in technical and aesthetic terms. Again, this contrasts with OSS and other technical projects that do not include a visual component.

2.5 Group leadership and project structure

Group leadership is central to the completion of any collaborative effort and plays a role in creative success. Research in OSS projects suggests that successful teams follow a hierarchical structure, possibly because it eases coordination and reduces inefficient communication [4]. The modular structure of software projects provides each remote participant with a clear idea of how their contribution relates to the whole. Individual contributors do not require a great deal of interaction with peer participants, and thus a hierarchy of leadership is appropriate.

Relative to OSS projects, group 3D animation project roles are much more overlapping. The project structure must accommodate interaction between participants for the duration of the project. The creative leadership of animation projects generally serves to guide the story and overall imagery rather than coordinate the collaborative efforts or participants. A strict hierarchical leadership, while potentially more efficient, could inhibit the creative potential of the project.

In the same vein, the degree of project planning varies greatly for different types of collaborations. For OSS collaborations, even the most successful projects have often evolved organically, without clear expectations for the end product [7]. These projects have a continuous release schedule. In contrast, animation projects have a single release and are considered finished upon completion. Among the first findings from research in artistic collaborations is that successful projects are often front-loaded, with detailed plans for participants about both the technical expectations and artistic goals, including solutions to expected problems before they arise. The most successful collaborations were well-organized by leaders with strong artistic vision [6].

2.6 Remote creative collaboration

A study by Luther and Bruckman offers what may be the first investigation into remote collaboration with a specific focus on narrative storytelling. They investigate an online forum community which organizes itself into groups to produce short animated films, called "collabs", using the software program Adobe Flash [6]. The forum is used for 2D animation production, which has a considerably simplified process compared to 3D animation. Within the community, a single participant presents a story idea and then recruits other community members to collaborate on the animation production. The researchers investigated how communication and leadership contributed to the success of the collaborative animation through both quantitative assessment of communication data and qualitative interviews with participants.

The researchers found a strong correlation between communication volume and creative success in each collaboration, noting that "members of successful collabs post, on average, about three times more than members of failed collabs". This was similarly reflected in participants' perception of factors that contribute to successful collaboration. Participants also indicated that clear expectations in terms of technical constraints prevented compatibility problems and was crucial to a collab's completion [7]. These findings are consistent with previously-discussed conclusions on communication volume in studies of co-located collaboration.

The animation process described above has some distinct differences from the process we investigate in this study. Significantly, the animations were produced in a modular fashion with each participant responsible for all aspects of a single time-delimited segment of the story. The relative simplicity of the 2D animation production process makes it feasible for a single person to be proficient in every technical and aesthetic aspect. The "collab" community embraces a sort of 'collage' aesthetic wherein a single animation does not have to have to be visually unified. These factors imply that the study's findings are more akin to an OSS project because each participant's contribution is a highly modularized part of the whole. With the lack of literature regarding collaboration in 3D animation, however, we pay close attention to these findings.

2.7 Defining success in remote creative collaboration

I have been using the term 'success' without clarification thus far. However, definitions of creative collaborative success vary dramatically based on the nature of the project and the expectations of its' participants. In OSS projects, the end products are not sold commercially but freely distributed and meant to be useful to a certain audience. Thus, success in open-source software is generally regarded as maintaining an active user base [3]. In Luther and Bruckman's study of 2D animation collaboration, success was based on an even looser definition: because the community of participants was so unstructured, a "collab" was considered successful if it was simply seen through to completion. No assessment of visual or technical quality was made [7].

3. METHODOLOGY

3.1 Study context

When remote collaboration is conducted with computer-mediated communication modalities it is possible to quantify the communication that takes place and evaluate how it contributes to a project's creative success. This thesis is based on a case study of remote creative collaborative teams conducted from Spring 2010 - Spring 2012 in which teams of animation students, comprised of remotely-located members, produced short 3D computer graphics animated films. I present an analysis of data from this study to examine the hypothesis that remote teams with higher volumes of communication are more successful in producing creative output, and that communication modalities affect creative success. The study assessed the product of students' collaboration for both technological and aesthetic creative accomplishment.

The project's methods reflect principles of design-based research: the study is grounded in theory but designed to investigate real-world problems, it is flexible and iterative, it integrates approaches from both qualitative and quantitative research paradigms as necessary, and results are contextualized within the larger real-world setting. [18]

This study was designed with relevance to the animation and visual effects industries. In these industries, success is defined by both commercial measures, such as box office returns, advertising, and sales, and by critical measures, such as reviews by professional critics and peer assessment. Peer review happens both in casual internal settings, such as daily review sessions within a studio, as well as external methods such as the Visual Effects Society Awards and the Academy of Motion Picture Arts and Sciences Awards (commonly known as "The Oscars") [16]. In each of these settings, reviewers evaluate both artistry and technical skill. To this end, creative success in this study is defined as having a high degree of technical and artistic achievement as evaluated by a mentor group of animation and visual effects industry professionals.

The study was conducted with groups of junior- and senior-level undergraduate students at three locations, and groups of high school students from one location. The undergraduate institutions included Texas A&M University (TAMU) located in College Station, Texas, the University of Texas at Dallas (UTD) located in Dallas, Texas, and the Akademie für Internationale Bildung (AIB) located in Bonn, Germany. The students at AIB were junior-level undergraduates from TAMU on a study abroad program; thus their location in Europe represented only logistical challenges rather than cultural or language barriers. The high school was the Design and Technology Academy (DATA), located in San Antonio, Texas. We ran the study on three separate occasions (Trials 1, 2, and 3, respectively), with each trial composed of two teams (Team A and B, respectively). Their results were labeled T1A, T1B, T2A, T2B, T3A, and T3B. Each team was comprised of students from each location, and each team was tasked with producing a 3D computer-animated short film, 30 seconds in length, featuring specific components that required technical and artistic problem solving.

3.2 Project structure

The project's structure directly reflects the "waterfall" nature of animation production. The semester-long production schedule was broken up by task, with some tasks overlapping and others requiring discrete start and end points. The ordered tasks were as follows: (1)Story and art development, in which the subject, scope, and style of the animation is determined; (2)Editorial and layout, in which the story is translated into camera language; (3)Modeling, in which the story's set, props, and characters are created as 3D digital assets; (4)Rigging, in which the 3D digital characters are made animatable according to the performance needs dictated by the story; (5)Animation, in which the characters are made to perform the story; (6)Effects animation, in which special physical effects such as fog and fire are created to support the story; (7)Surfacing, in which the digital assets are given a color and textural look and feel that supports the story; (8)Lighting, in which the sets and characters are illuminated by digital lights to support characterization and storytelling; Finally, (9)Rendering and compositing, in which all of the 3D digital assets are transformed into 2D imagery and assembled into a final video product [5]

In this study, team members completed production tasks according to an assignment method that varied by trial, as seen in Table 3.1. In Trials 1 and 2, tasks were divided by location, with all members on both teams at each location responsible for the same tasks. In Trial 3, at least one team member at each location was assigned to each task and teams did not necessarily have co-located members working on the same tasks. The exception to this was that DATA, the high school location, was given the Effects Animation task in all trials. In all trials, students self-selected which tasks became their responsibility. In only a few cases, instructors adjusted individual task assignments to ensure that all tasks were covered for each trial of the project.

3.3 Communication tools

Team members utilized off-the-shelf digital communication tools to complete their projects. For scheduled multi-location reviews, the teams used Skype videoconferencing software installed on designated review computers at each location. The study provided CineSync video viewing software on the designated review computers for

Table 3.1: Production tasks by location, per trial

Task	Trials 1 & 2	Trial 3
Story Development	AIB, TAMU, UTD	AIB, TAMU, UTD
Art Development	AIB	AIB, TAMU, UTD
Editorial and Layout	AIB	AIB, TAMU, UTD
Modeling	AIB	AIB, TAMU, UTD
Rigging	TAMU	AIB, TAMU, UTD
Animation	TAMU	AIB, TAMU, UTD
Effects Animation	DATA	DATA
Surfacing	UTD	AIB, TAMU, UTD,
Lighting	UTD	AIB, TAMU, UTD
Rendering and Compositing	UTD, TAMU	AIB, TAMU, UTD

synchronous review of materials at each location. For the team members' usage in completing the project, listservs were implemented to facilitate team-based email communication. The commercial web-based chat software Campfire and project management tool Basecamp, which featured asynchronous threaded discussions and editable wiki-like documents, from 37Signals were also provided.

The study design varied the available communication modalities for each trial in order to study each modality's effect on the resulting creative output. Team members were given unlimited access to email in all trials. The Campfire web-based chat tool was introduced in Trials 2 and 3. The Basecamp project management system was implemented in Trial 3. In all trials, Skype video conferencing software was used on a limited basis for scheduled review sessions, but in Trial 3 it was additionally made available for team members to schedule their own sessions. Each team's communication in all channels was open and viewable by all members of that team and the instructors for the duration of each trial. Table 3.2 displays the communication modality used during each trial.

Table 3.2: Communication modalities' availability by trial

	Email	**Skype**	**Chat**	**Project Mgmt.**
	asynchronous	synchronous	semi-synchronous	asynchronous
Trial 1	constant	controlled instances	–	–
Trial 2	constant	controlled instances	constant	–
Trial 3	constant	freely available	constant	constant

3.4 Data collection methods

3.4.1 Subject communication data

All communication tools were monitored by the investigators throughout the duration of the project, and data was collected after the conclusion of each trial. Email messages were downloaded as a plain-text archive of files by date. Web-based chat transcripts were downloaded as a plain-text archive of files by date. Basecamp project-management messages and wiki documents were downloaded as an HTML archive and hand-coded into a spreadsheet with participant, team, and location data. Video conferences were hand-transcribed into spreadsheet documents and coded with participant, team, and location data.

3.4.2 Project quality data

Project quality for this study was measured via an opinion survey of animation and visual effects industry professionals. The survey group was comprised of five professionals with an average of 20.4 years of experience at a variety of studios with established high-quality reputations. The survey was administered after the conclusion of all three study trials. Project output data from each year was compiled into an anonymized online survey, with questions measuring aspects of success for each project. Data collected from the survey was compiled into a spreadsheet. Kendall's

W coefficient of concordance, which compares each individual reviewer's rankings, was calculated to determine the level of agreement among the survey group.

3.5 Data analysis methods

3.5.1 Quantitative subject communication data

Team member communication data from all trials was aggregated and numerically analyzed for several variables. Software scripts written for Python and Excel were utilized to digitally parse and track data to quantify the volume of communication by individual messages sent. These quantities were tabulated by communication modality, date, team, location, and gender, with frequency and percent distributions. Communication volumes were compared for each trial by team, modality, and location. A comparison of the above variables for all three trials over the duration of the project was also conducted.

3.5.2 Qualitative subject communication data

Team member communication data was analyzed qualitatively for content and coded with a priori codes devised by two graduate assistant researchers who had observed the trials as they occurred. A test set of messages was analyzed by both researchers to ensure coding calibration. Any uncertainties during coding were resolved with a consensus from both researchers. Communication was coded as either *logistical*, *aesthetic*, or *social* in nature. Communication was considered aesthetic if it concerned subjective issues such as visual quality or storytelling aspects of the production. Communication was labeled logistical if it concerned numerical or organizational topics such as file versioning, naming, location, and editorial timing. Social communication was that which did not concern specific aspects of the project but was rather of a generalized rapport-building nature.

3.5.3 Project quality data

Project quality score data was aggregated and averaged by project for eight individual scoring categories: Visual Creativity of Models, Technical Creativity of Models, Visual Creativity of Animation, Technical Creativity of Animation, Visual Creativity of Surfacing and Lighting, Technical Creativity of Surfacing and Lighting, Visual Creativity of Effects Animation, and Technical Creativity of Effects Animation. These category scores were averaged to obtain a mean project quality score per team per trial. This data serves as a measure of overall collaborative success for each team.

4. RESULTS

In all study trials, both student teams successfully collaborated using the given communication modalities to produce a final animated short film. Still images from each team's final product can be seen in Figures 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6. Communication data and project quality assessments were also successfully collected and analyzed for all trials.

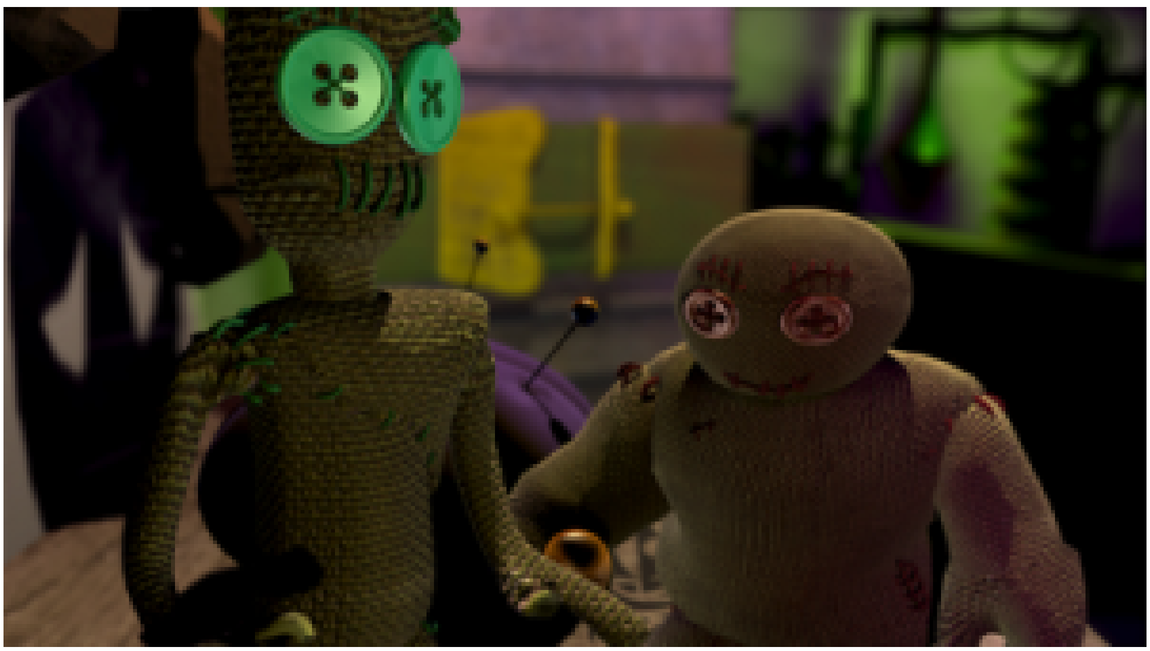

Figure 4.1: Example image from the short animation produced by Trial 1, Team A (T1A)

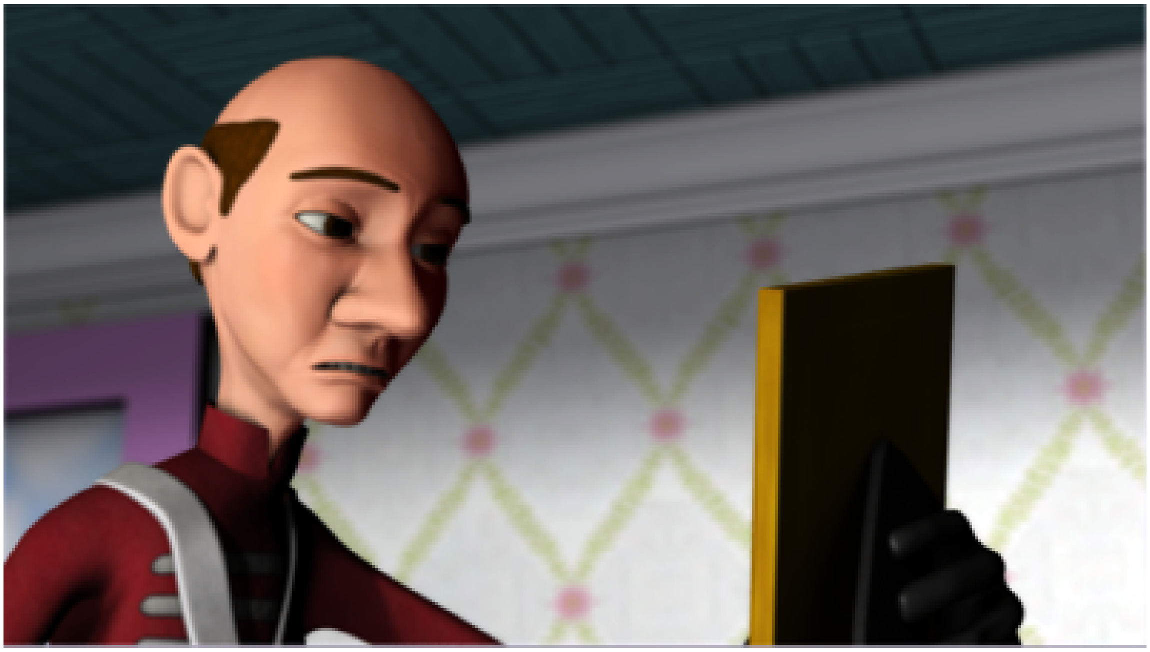

Figure 4.2: Example image from the short animation produced by Trial 1, Team B (T1B)

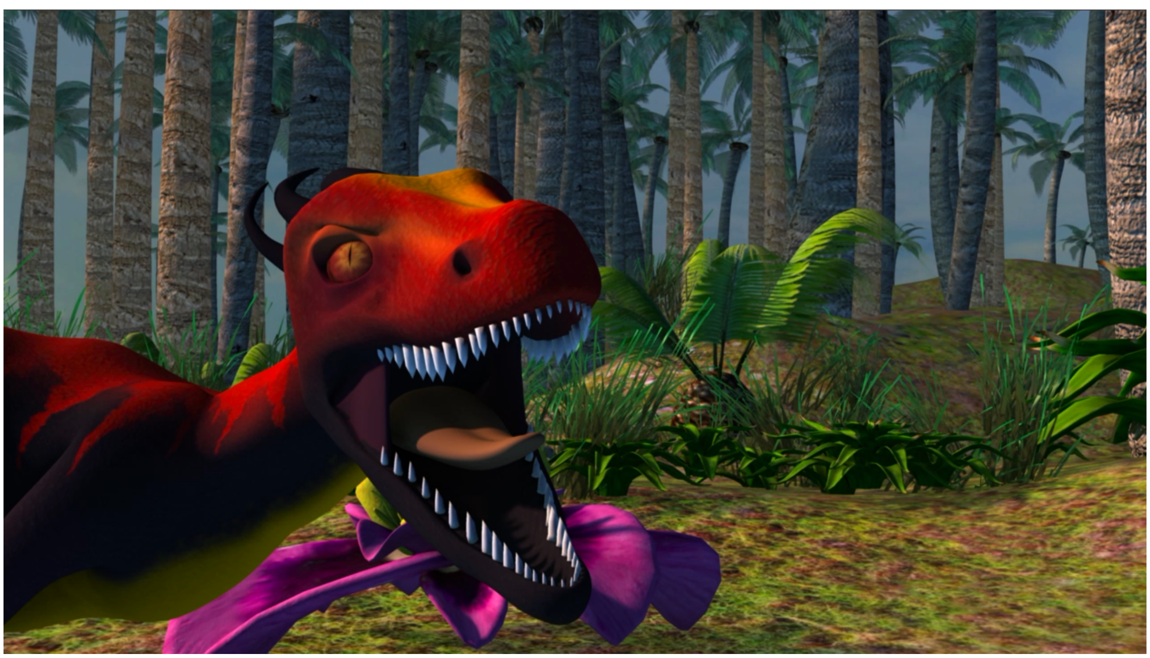

Figure 4.3: Example image from the short animation produced by Trial 2, Team A (T2A)

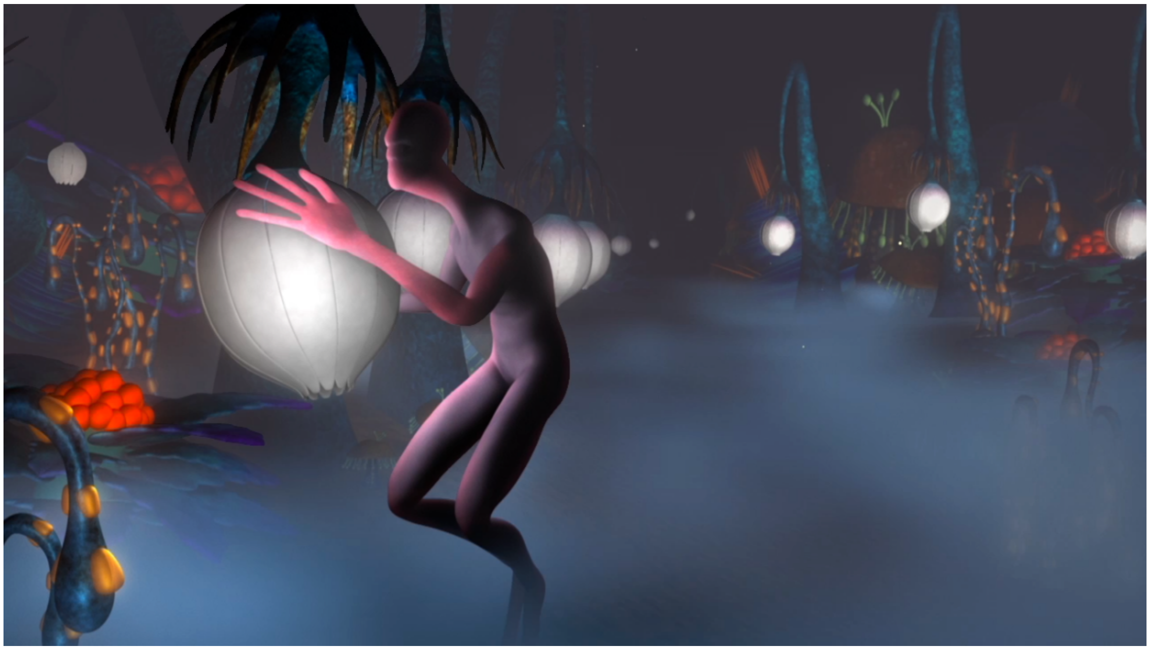

Figure 4.4: Example image from the short animation produced by Trial 2, Team B (T2B)

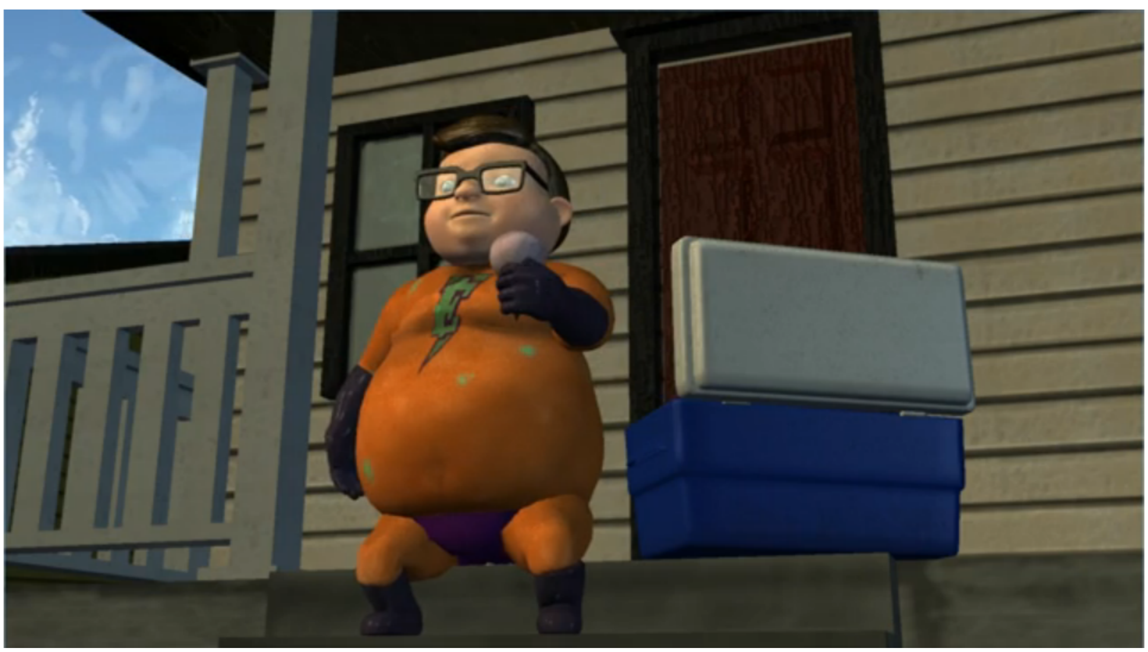

Figure 4.5: Example image from the short animation produced by Trial 3, Team A (T3A)

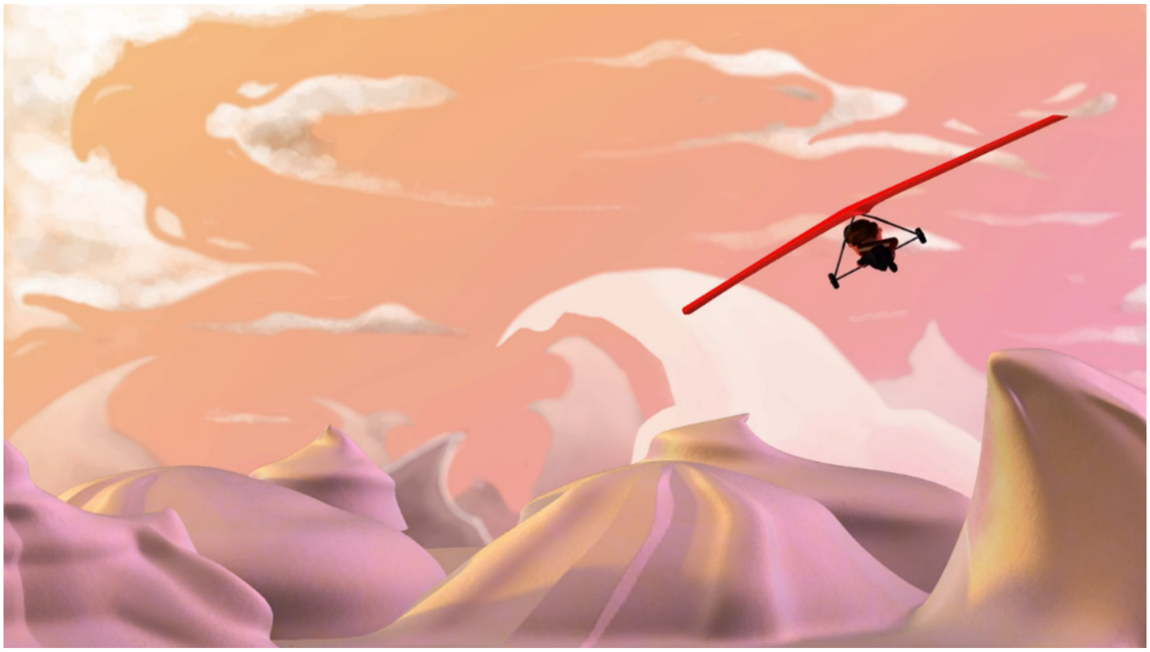

Figure 4.6: Example image from the short animation produced by Trial 3, Team B (T3B)

4.1 Communication volume and creative success

Across the six projects, industry reviewers rated Trial 2, Team B's (designated T2B) project the most successful with an average score of 2.53 points on a 4-point scale. The scale value designations were as follows: 1 indicated little or no evidence of originality in problem solving, and 4 indicated extraordinary creativity in problem solving. The rest of the projects were rated, in descending order of average score: Trial 1, Team A (T1A) with a score of 2.43; Trial 1, Team B (T1B) with a score of 2.03; Trial 3, Team A (T3A) with a score of 1.91; Trial 2, Team B (T2B) with a score of 1.71; and Trial 3, Team B (T3B) with a score of 1.56. These results are further described with individual category scores in Table 4.1. The individual scoring categories assess creative and technical problem solving for different steps of the animation production process; these steps include modeling, animation, surfacing and lighting, and effects animation. Kendall's W coefficient was computed as 0.6642

Table 4.1: Project quality scores of the visual and technical creativity exhibited in projects on a scale of 1 to 4; where 1 = no evidence of originality and 4 = extraordinary evidence of originality.

Question	**T1A**	**T1B**	**T2A**	**T2B**	**T3A**	**T3B**
Visual Creativity of Models	3.25	2.25	1.75	3.00	2.25	2.00
Technical Creativity of Models	3.00	2.00	1.50	2.50	2.00	1.75
Vis. Creativity of Animation	2.50	3.00	1.25	2.00	3.00	1.25
Tech. Creativity of Animation	2.00	2.25	1.25	2.25	2.25	1.25
Vis. Creativity of Surfacing & Lighting	2.75	1.75	2.00	3.00	1.75	1.50
Tech. Creativity of Surfacing & Lighting	2.75	1.75	1.75	2.75	1.75	1.75
Vis. Creativity of Effects Animation	1.50	1.75	2.0	2.50	1.75	1.50
Tech. Creativity of Effects Animation	1.75	1.50	2.25	2.25	1.50	1.50
Project Quality Score (Mean of above categories)	2.43	2.03	1.71	2.53	1.91	1.56

Table 4.2: Comparison of project quality (using the scale defined in Table 4.1) and communication volume (in total number of messages across modalities) for each trial of the project

	Trial 1	**Trial 2**	**Trial 3**
Number of Modalities Available	2	3	4
Total Communication Volume	830	2896	29185
Mean Project Quality Score	2.23	2.12	1.74

(P <0.01), which indicates overall agreement among reviewers.

In examining how communication volume and project quality were related, I first tabulated the communication and quality data per trial, without respect to each trial's individual teams. The data in Table 4.2 shows that the total volume of communication increases with each trial as the number of available modalities increases. It also demonstrates that the mean project quality score for each trial is inversely correlated with the volume of communication, which directly contradicts my hypothesis that higher volumes of communication contribute to greater creative collaborative success.

Table 4.3: Comparison of project quality (using the scale defined in Table 4.1) and communication volume by modality for all teams per trial of the project.

	T1A	T1B	T2A	T2B	T3A	T3B
Email Messages	141	248	152	105	26	10
Videoconferencing Exchanges	221	220	283	288	320	318
Chat Messages	–	–	324	914	19120	6970
Project Management Messages	–	–	–	–	1566	853
Total Communication Volume	362	468	759	1307	21,032	8,153
Project Quality Score	2.43	2.03	1.71	2.53	1.56	1.91

I further analyzed the data to investigate how the teams within each trial compared to one another. This view, as seen in Table 4.3, quantifies the volume of logged communication by each modality per team per trial, including a summation of the total communication used by each team for the duration of the trial. This data is compared to the project quality scores from Table 4.1. The comparison at this level reveals that there was again an unexpected inverse relationship between the volume of communication and the resulting project quality for the teams within Trial 1, which contradicts my hypothesis; yet, the hypothesis holds true for the teams within Trials 2 and 3.

This data also shows that the chat modality had the highest volume of usage overall, followed by the project management tool, the videoconferencing tool, and finally email. As more modalities were introduced, the use of email declined significantly. The volume of videoconferencing usage remained comparatively steady, as the scheduled video review sessions were of a similarly limited duration and across all trials.

4.2 Communication modality usage by communication types

The results for the analysis of logged communication by type, per modality, are shown in Table 4.4. A comparison across all teams and trials reveals a few correlations. Email, an asynchronous modality, was used significantly more for logistical communication than aesthetic communication across all trials. Conversely videoconferencing, a synchronous modality, was used significantly more for aesthetic communication than logistical communication across all trials. Chat, a semi-synchronous modality, did not show any clear correlations towards communication type. The project management tool, an asynchronous modality, had a slight correlation towards logistical rather than aesthetic communication. Both chat and the project management tool were the only modalities that were significantly used for social communication.

Table 4.4: Breakdown of communication type conducted by modality, for all trials

	T1A	**T1B**	**T2A**	**T2B**	**T3A**	**T3B**
Email: Aesthetic	26.63%	23.11%	11.18%	14.29%	0.00%	0.00%
Email: Logistical	73.37%	76.90%	88.81%	84.76%	88.46%	90.00%
Email: Social	0.00%	0.00%	0.00%	0.95%	11.53%	10.00%
Email: Total messages	141	248	152	105	26	10
Videoconf.: Aesthetic	61.99%	65.91%	70.67%	78.13%	71.88%	70.44%
Videoconf. Logistical	38.01%	34.09%	29.68%	21.52%	27.19%	29.25%
Videoconf.: Social	0.00%	0.00%	0.00%	0.35%	0.10%	0.31%
Videoconf.: Total exchanges	221	220	283	288	320	318
Chat: Aesthetic	–	–	51.23%	32.28%	39.20%*	32.33%*
Chat: Logistical	–	–	33.02%	53.06%	39.73%*	46.67%*
Chat: Social	–	–	15.74%	14.55%	21.01%*	21.00%*
Chat: Total messages	–	–	324	914	19120	8153
Project Mgmt.: Aesthetic	–	–	–	–	17.33%*	26.00%*
Project Mgmt.: Logistical	–	–	–	–	60.00%*	54.67%*
Project Mgmt.: Social	–	–	–	–	22.67%*	19.28%*
Project Mgmt.: Total messages	–	–	–	–	1566	853
Total Communication Volume	362	468	759	1307	21,032	8,153

*For T3A and T3B, Chat and Project Mgmt. data percentages are calculated from analysis on a subset of messages

5. DISCUSSION

5.1 Communication volume and creative success

The results indicate that a higher volume of communication by a group of collaborators is not necessarily a predictor of creative success. This is contrary to the expectation that 'always-on' communication saturation is a positive force in collaborative work. This finding would appear to counter the position that high-bandwidth communication is vital to creative collaboration held by Kanter, Ulrich and Eppinger, Luther and Bruckman, and others as discussed previously. At this time, further study is required to understand why higher volumes of communication did not always lead to greater creative collaborative success.

One possible explanation includes the premise that more time spent communicating means less time producing creative output. As more communication modalities were introduced, project quality scores trended downward. This could indicate that the variety of modalities led to fractured and inefficient communication patterns that consumed more productive time. There was also no imposed nor implied hierarchical structure to the modalities, unlike what is typical in industry settings. This could have lead to confusion in decision-making processes.

Another possible explanation is that that communication was largely of a negative, problem-identification nature rather than a positive, problem-solving nature. Although not a focus of this paper, this result could also indicate that novices at collaborative efforts, such as students, may not be adept at efficiently utilizing unsupervised communication modalities in a work setting. Further, the disparity in outcome between Trial 1 and Trials 2 and Trial 3 warrants a deeper investigation. Some factors in the study design, including methodology modifications described in section 5.3 certainly contributed to the data differences between trials but it is difficult to determine to what extent.

5.2 Communication modality usage

The data is not sufficient to make recommendations for modality usage with respect to creative success, but the results reveal some trends in communication modality usage for different types of communication. There is a clear preference for certain modalities when collaborators are communicating to different ends. Email was strongly preferred for logistical communication across all teams and trials. This may be because the relative permanence of email as an asynchronous modality allows it to be saved and referred to, which would be useful for logistical information. Indeed, though email usage declined drastically in Trial 3, it was functionally replaced as a logistical channel by the project management tool- the only other asynchronous modality available.

Similarly, videoconferencing was strongly preferred for aesthetic communication across all trials. This may be because its functionality as a synchronous modality affords the faster, less structured exchanges that have been shown to support creative work. Additionally, it is the only modality that makes non-verbal exchange possible, which has also been linked to successful group creative collaboration. Chat, while technically a semi-synchronous modality, was more of a mixed bag in terms of communication type preference. This may be because even though exchanges are immediate, an easily-viewable log exists that can be referred back to, giving it some of the functionality of an asynchronous modality.

5.2.1 Communication modality preference as a function of generation

Another lens with which to investigate the modality preferences of team members is the idea that there are ‘digital natives’- that is, students born roughly between

1980 and 1994 who have grown up surrounded by computers and the Internet -who comprise a unique generation with fundamentally different communication habits and educational needs. Prensky, who coined the term in 2001, described digital natives as considering "computer games, email, the Internet, cell phones, and instant messaging integral parts of their lives" [14].

The perceived cognitive differences in younger generations may be far overstated and supported by studies of questionable empirical basis. Studies indicate that "young people's relationships with technology are more complex than the digital native characterization suggests" [2]. While students have almost universally adopted technologies such as instant messaging, discussion forums, and Skype, they are mainly used in a social context. More research is needed to determine how young people utilize these technologies in a controlled industry or academic setting [12].

The 'digital natives' debate and its resulting effect on educational practices is far from settled, but for this discussion I emphasize that evidence for the proliferation of digital devices and high connectivity among students is well-established in the literature, and this study's results shed light on student technology usage in a creative collaboration context. As such, one possible explanation for the universal use of the chat modality for all types of communication is that it was the most similar to text messaging and other semi-synchronous communication modalities that team members were familiar with using throughout their daily lives.

5.3 Methodology modifications between trials

An important factor in interpreting results from this study is the consideration of methodology modifications made between trials. In concordance with the principles of design-based research, the study was designed to be flexible in allowing instructors to address participant feedback and best respond to the educational needs of the students involved. As such, the project trial conditions were modified between trials, resulting in additional variables affecting the project output.

Trial 1 was designed for teams to have a very loose structure, in the hopes that leadership would emerge organically. Feedback from participants indicated that more direct leadership was desired, so in Trial 2 the study was modified to include two graduate students serving as project directors for each team. It was unclear whether the addition of directors improved the overall participant experience, so the practice was not continued for Trial 3.

In Trials 1 and 2, production tasks were split by location with the purpose of utilizing instructors' experience in certain disciplines. In Trial 3, an attempt was made to move as close to a maximally distributed team as possible to achieve a very high level of connectivity and test the communication modalities in a large-volume capacity. In order to achieve this, production disciplines were split among the locations so that team members working on the same tasks would be remotely located. This had the additional benefit of allowing team members more freedom in their selection of disciplines.

The reasons for implementing these modifications are arguably valid and necessary as the study functioned as a required course for undergraduate students. There are risks of polluting the study data with multiple uncontrolled variables. However, the study's data collection methods remained the same and there is reason to be confident that the majority of the data reflect the communication changes between trials only.

5.4 Other limitations of the study

Although this research has reached its aims, there are several limitations to the usefulness of the findings. These limitations are especially relevant when applying the research to a non-academic, industry setting.

5.4.1 Students as a trial group

The study was designed as an educational endeavor integrated into a traditional undergraduate course. Because of this condition, the project could not be a strictly-controlled laboratory exercise; enrollment was open and participants were self-selected. The instructors did not necessarily have an indication of each student's prior skill level, and the students were sorted into groups without it as a factor. Thus, the makeup of the project participant teams could not have been strictly equal in terms of participant skill level which skews the project quality result data.

The use of students as a trial group had other limitations as well. Students do not necessarily all have the same motivations to succeed in their coursework, and it is possible that a high-quality project output was not a sufficient motivating factor for some students during the course of the project. Additionally, due to the semester-long length of each study trial, students had many other demands on their time which affected each individual's contribution to their team's project output.

5.4.2 One trial for each group of students

Due to the semester length of the study and the nature of year-specific curriculum at each institution, each study trial was run only once with each specific group of students. Through a variety of circumstances some students participated in two sequential trials of the project, although their roles changed in each trial. These conditions do not allow the study to measure the longitudinal effects of participants adapting to specific communication methodologies. This limits the applicability of this study, as industry collaborators would presumably be able to utilize communication tools on a long-term basis and adapt their behaviors towards efficient usage.

6. CONCLUSIONS AND FUTURE WORK

This study has obtained findings that will give insight into communication usage practices that contribute to successful remote collaboration. A comparison of communication modality usage data to project quality scores was made to reveal how team members' communication usage contributed to creative success. The study found that higher volumes of communication did not necessarily lead to more successful collaboration. This contrasts with findings from studies in other areas of remote collaboration and co-located collaboration that indicate communication volume as a strong factor in collaborative success. The disparity revealed in this thesis could stem from peculiarities in 3D animation production as a remote collaborative process.

This study also revealed preferences for communication type by modality; namely, that asynchronous modalities are preferred for logistical communication and synchronous modalities are preferred for aesthetic communication. Collaboration in 3D animation is unique in that both aesthetic and logistical communication is required for creative success. These findings could guide collaborative team facilitators when selecting communication tools to achieve certain tasks.

This study is significant in that it relies on a definition of success based on peer review in both aesthetic and technical achievement. This definition is drawn from the animation and visual effects industries, with the intention that the findings are relevant to creative collaborators and facilitators of creative collaboration in those fields. Indeed this data may be extrapolated to draw broader conclusions about how to use digital communication tools to achieve collaborative success.

This work reveals several directions for further study. Conclusions on communication and creative success were based only upon communication volume. The study did not generate the fidelity of data to determine why high volumes of communication did not lead to success. Further investigation into the nature and subject matter of collaborative communication could be useful to determine how communication and creative success are linked. Because the animation production process is based on such distinct steps, it could be useful to delve deeper into the individual steps and investigate communication patterns. 3D animation's "waterfall" production process means that problems at any one step could lead to failure overall, but this would be difficult to determine without further study.

Remote creative collaboration in 3D animation is a very new but ever-growing field. This study was designed based on research in other creative collaboration disciplines, and it reveals that established knowledge in other areas may not be directly applicable to the field. More studies, designed with the characteristics of 3D computer animation in mind, are needed to determine best practices for creative collaborative work.

REFERENCES

[1] J. Al-Qawasmi. *A Study of Computer-mediated, Collaborative Architectural Design.* Texas A&M University, College Station, 1999.

[2] Sue Bennett, Karl Maton, and Lisa Kervin. The 'digital natives' debate: A critical review of the evidence. *British Journal of Educational Technology*, 39(5):775–786, September 2008.

[3] Carl Gutwin, Reagan Penner, and Kevin Schneider. Group awareness in distributed software development. *Proceedings of the ACM 2004 Conference on Computer Supported Cooperative Work - CSCW '04*, page 72, 2004.

[4] Pamela Hinds and C McGrath. Structures that work: social structure, work structure and coordination ease in geographically distributed teams. *Proceedings of the ACM 2006 20th Anniversary Conference on Computer Supported Cooperative Work - CSCW '06*, 2006.

[5] Isaac Victor Kerlow and Victor Kerlow. *The art of 3-D computer animation and effects.* John Wiley & Sons, Hoboken, New Jersey, 2004.

[6] Kurt Luther and Amy Bruckman. Leadership in online creative collaboration. *Proceedings of the ACM 2008 conference on Computer Supported Cooperative Work - CSCW '08*, page 343, 2008.

[7] Kurt Luther, Kelly Caine, Kevin Ziegler, and Amy Bruckman. Why It Works (When It Works): Success Factors in Online Creative Collaboration. *Proceedings of the 16th ACM International Conference on Supporting Group Work*, pages 1–10, 2010.

[8] Dorothy Miell and Karen Littleton. *Collaborative creativity: Contemporary perspectives*. Free Association Books, London, July 2004.

[9] Csikszentmihalyi Mihaly. *Flow: the psychology of optimal experience*. Harper Collins, New York, 1990.

[10] Frances J Milliken and Luis L Martins. Searching for common threads: Understanding the multiple effects of diversity in organizational groups. *Academy of Management Review*, 21(2):402–433, 1996.

[11] Paul S Myers. *Knowledge management and organisational design*. Routledge, Newton, MA, 1996.

[12] Walther Nagler and Martin Ebner. Is your university ready for the ne(x)t-generation? *World Conference on Educational Multimedia*, 2009(1):4344–4351, 2009.

[13] Paul B. Paulus and Bernard Arjan Nijstad. *Group creativity : Innovation through collaboration*. Oxford University Press, New York, 2003.

[14] Marc Prensky. Digital natives, digital immigrants: Part 1. *On the Horizon*, 9(5):1–6, 2001.

[15] R Keith Sawyer. Group creativity: Musical performance and collaboration. *Psychology of Music*, 34(2):148–165, 2006.

[16] R Keith Sawyer. *Group genius: The creative power of collaboration*. Basic Books, New York, 2008.

[17] Karl Ulrich and Steven D Eppinger. *Product design and development*. McGraw-Hill/Irwin, New York, 1995.

[18] Feng Wang and Michael J Hannafin. Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, 53(4):5–23, 2005.