ASSESSING THE IMPACT OF TEXT-BASED COMMUNICATIONS ON TEAM PERFORMANCE IN A FLIGHT OPERATIONS CENTER SIMULATION

By

Chip A. Shriver

A Thesis Submitted In Partial Fulfillment
of the Requirements for the Degree of
Master of Science in Aviation Administration

Middle Tennessee State University
December 2015

Thesis Committee:

Dr. Paul A. Craig, Chair

Dr. Wendy S. Beckman

I dedicate this work to my endearing family and closest friends. With the love and encouragement of friends and family, the challenges faced during the completion of this work quickly became milestones. Special thanks to my mother, Brenda D. Holloway, for her unyielding affection and tireless support throughout all of my endeavors.

"When everything seems to be going against you, remember that the airplane takes off against the wind, not with it." — Henry Ford

ACKNOWLEDGEMENTS

I would like to offer my sincerest thanks and appreciation to those who provided essential support and direction during the completion of this study. Special thanks to my committee members, Dr. Wendy Beckman and Dr. Paul Craig, for sharing their wealth of aviation research knowledge and tirelessly answering all of my questions. I would also like to extend my thanks to all of the faculty, staff, and assistants in the NASA FOCUS Lab for their participation in this semester-long endeavor. Without the motivation, professionalism, and knowledge of the FOCUS Lab staff members, conducting this research would have been impossible.

Appreciation is also extended to the faculty and staff of the Department of Aerospace at Middle Tennessee State University for cultivating a rich, motivational learning environment for aviation enthusiasts. Special thanks to Professor Gerald L. Hill for continuously providing me with academic guidance and personal growth opportunities during my entire academic career at MTSU.

ABSTRACT

The rapid rate of advanced technological integration in the aviation industry is quickly producing unique changes in the way industry professionals accomplish daily operational goals. Communication structures among industry employees have already begun to change, as evidenced by the advent of the digital datalink system known as Aircraft Communications Addressing and Reporting System (ACARS). Though this system is utilized to reduce workload and increase data integrity through the relay of text-based messages from ground based stations to aircraft, it is crucial to assess how such improvements can be made in other areas of heavy workload within the industry. In an industry responsible for the safe and expeditious delivery of tremendous amounts of global commodities and invaluable lives, it is critical to develop a keen understanding of the effectiveness of industry communication. Therefore, this study was designed to assess the impact of text-based communications on team performance in a flight operations center setting via simulation. Both qualitative and quantitative methodologies were utilized in this research to generate an information rich study capable of capturing student performance as well as perception. Analysis of results revealed that no significant relationship existed between the quantity of relayed text-based messages and a team's performance. However, qualitative data indicated that the majority of participants viewed text-based communication as an aid in communication effectiveness. Qualitative analysis also indicated that participants perceived text-based communications to be more useful than verbal communications in numerous airline operations center situations.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I — INTRODUCTION

Today's organizations function quite differently than those of several years ago. Several organizational trends are responsible for this differentiation. The first of these is the increased utilization of team work among organizations, as evidenced by changes in their company structures to allow for greater flexibility and autonomy. The second trend, and perhaps the most pertinent to this study, is the rapid rate of technological improvement and its integration into the workplace. Computer capabilities, internet access, and email have contributed to a change in the way employees communicate. However, there is some debate as to whether or not these workplace changes and technological improvements aid in team performance. Most teams are provided access to such forms of communication, but it is generally at their discretion to determine the best methods for integrating such methods with verbal communication (Colquitt, Hollenbeck, Ilgen, LePine, & Sheppard, 2002). Such is the case in the NASA FOCUS (National Aeronautics and Space Administration Flight Operations Center Unified Simulation) Lab at MTSU (Middle Tennessee State University), where students are separated into teams and are provided multiple channels of communication to incorporate into team operations as they see fit. Functioning as a team, students in the NASA FOCUS Lab are tasked with managing the responsibilities of running an airline from an operations standpoint while immersed in a high-fidelity replication of a Part 121 regional airline operations center. Students from all of MTSU's aviation disciplines are placed in teams to practice working with others. Teams work to meet organizational goals such as customer satisfaction, disruption management, on-time performance, and safety. In the aviation industry, work-place communications tend to follow a multi-channel method; verbal and computer-

assisted modes. In an industry responsible for the safe and expeditious delivery of tremendous amounts of global commodities and invaluable lives, it is critical to develop a keen understanding of the effectiveness of industry communication. The NASA FOCUS Lab offers a unique platform from which invaluable data can be gathered regarding this topic. This proposal seeks to assess the impact of text-based communications on team-performance in a high-fidelity replication of an airline operations center at the NASA FOCUS Lab at MTSU.

Review of Literature

A joint study between Yale and Michigan State (1998) was designed to study the effects of face-to-face communication (FtF) and computer-mediated communication (CM) on the accuracy of team decisions (Hedlund, Hollenbeck, & Ilgen). It is important to note that FtF communication is defined as the use of primarily verbal communication to relay information, whereas CM communication is defined as communicating solely via computer. Participants included 256 undergraduate students in both management and psychology courses who received course credit and monetary compensation for participation in the study. Students were grouped into four-person teams and assigned one of two communication modes; CM communication and FtF communication. Ultimately, 32 computer-mediated and 32 face-to-face teams were formed to engage in the study. Students were tasked with obtaining information about aircraft entering simulated airspace to assess the aircraft's threat level. Each team member viewed the airspace from different locations, and had a limited amount of information that could be gathered that had to be later relayed to a team leader for a final decision. The CM teams were separated into two rooms, each with four computers, but with no more than two

members in the same room. The FtF teams were placed in the same room with four computers situated in a rectangular setup to allow for ease of verbal communication (Hedlund, Hollenbeck, & Ilgen, 1998). The team dynamics present in this research closely mirror the team dynamics present in the NASA FOCUS Lab as each team member is responsible for gathering, interpreting, and relaying position-specific information to a team leader. Additionally, similar to Yale and Michigan's FtF team layout, NASA FOCUS Lab team members are also positioned in a rectangular layout to aid in verbal communications.

The observers developed several hypotheses: H(1) knowledge sharing will be greater in FtF teams than in CM teams, H(2) staff validity will be greater in FtF teams than in CM teams, H(3) Hierarchical sensitivity will be higher in CM teams than in FtF teams, and H(4) performance advantages of FtF communication will be greater than CM communication when the effect of the communication mode on hierarchical sensitivity is controlled. Data analysis included multilevel theory regression analysis to support the prediction that core variables related directly to decision accuracy. Results indicated that FtF teams had increased levels of staff validity and knowledge sharing. Additionally, CM teams noticed higher overall hierarchical sensitivity. These findings support the aforementioned hypotheses. The study concluded with the confirmation that FtF teams consistently purported higher decision accuracy than CM teams (Hedlund, Hollenbeck, & Ilgen, 1998).

Researchers from the University of Illinois at Urbana-Champain (1993) explored the concept of group task performance and communication technology in a longitudinal study of CM versus FtF communication groups (Hollingshead, McGrath, & O'Connor).

The research, designed to assess the effectiveness of CM communication and task type on group performance, offered mixed conclusions on the benefits of CM and FtF communications. Two theoretical models were utilized in the prediction of the effects of CM communication and task type on group performance. Model 1, task as moderator, postulated that the kind of task that the group was working on would significantly influence the effects of the communication medium on task performance over time. Model 2, change as moderator, postulated that total technological experience and certain other changes imposed upon the group would serve to moderate the effects of the communication medium (Hollingshead, McGrath, & O'Connor, 1993).

Utilizing McGrath's task circumplex as a means of grouping tasks into functional categories, 22 groups performed a series of circumplex-defined tasks over the course of 13 weeks. Comparisons were then drawn between FtF and CM groups for each completed task. Researchers developed several hypotheses for each theoretical model. The following hypotheses were developed for Model 1: (H1a) for generate tasks, computer groups will outperform and will experience less process difficulty than FtF groups, and CM groups will report higher satisfaction with process, communication medium, and task performance, (H1b) for negotiation tasks, FtF groups will outperform CM groups, experience less process difficulty than CM groups, and will have more favorable reactions to group task performance, interaction process, and communication medium, (H1c) for intellective and decision-making tasks, FtF groups will perform equal to or greater than CM groups and will express less process difficulty and more positive reactions to group task performance, interaction process, and communication medium, and (H1d) the differences between media in group task performance, for a given task,

will decrease over time as groups adjust to the information richness of the communication medium available to them. The following hypotheses were developed for Model 2: (H2a) CM groups will show worse performance initially while learning software programs, (H2b) the difference in task performance between FtF and CM groups will greatly decrease over time as use of technology, group norms, and communication activity stabilize, (H2c) imposed change in media and membership will cause disruptions in group performance as members are moved between FtF and CM communication groups, (H2d) all groups will progress from relatively unstable to stable as weeks progress, and (H2e) initially, CM groups will be less satisfied with their groups' task performance, interaction process, and communication medium than will FtF groups. After group stabilization, there will be no difference in measures of satisfaction with task performance between FtF and CM groups (Hollingshead, McGrath, & O'Connor, 1993).

Analysis of task performance data indicated a mixture of upheld and rejected hypotheses. The relationship between technology and task performance, per results of the study, appeared to be more dependent on technological experience and group membership than on the type of task at hand. Such results offered support for all predictions included in Model 2, but offered only partial support for Model 1 predictions. Further analysis revealed that, as Model 1 predicted, FtF groups performed at a higher level on intellective and negotiation tasks than did CM groups. However, contrary to Model 1 predictions, no differences in task performance between FtF and CM groups on generate and decision-making tasks were noted. Researchers concluded the study with the admission that a great deal of evidence pertaining to the benefits of FtF and CM on task performance could not be deduced; as a result, additional research must be

completed to further study the complexities of the two models (Hollingshead, McGrath, & O'Connor, 1993).

Findings from the Hollingshead, McGrath, & O'Connor study (1993) were corroborated in a meta-analysis conducted by the University of Maryland's Psychology Department. The review focused on group and team research, with emphasis on research investigating factors that influence the effectiveness of organizational groups. The university's meta-analytical research on performance and effectiveness among teams in organizations (1996) purported that, of 150 analyzed research reports pertaining to performance in CM groups, CM groups were often characterized by a greater reduction in interaction and information exchange than FtF groups (Guzzo & Dickson). Additionally, the research suggested that CM groups utilized more time than FtF groups to accomplish the same task. Furthermore, the research suggests that a team's performance, CM or FtF, on a given task depends heavily on the task at hand. Specifically, CM groups exuded superiority at idea generation; on the other hand, FtF groups were superior at problem-solving and conflict resolution tasks. The research also suggests that the effect of computer technology on team performance may be a result of the structuring of a particular task instead of other aspects related to the electronic communication medium itself. In general, previous research indicates that increasing the structure of a task, through technological or non-technological means, often enhances group dynamics and processes. Research from Rogelberg (1992) found that teams who utilized more structured processes produced greater quality solutions than did teams that adhered to conventional discussion methods. Additionally, Hartell (1991) demonstrated that groups

proficiently trained on particular systems were more likely to handle trouble-shooting tasks effectively than non-trained groups (Guzzo & Dickson, 1996).

A study from the University of Hawaii at Manoa (1993) examined the impacts of communication mediums and computer support on group perceptions and performance through a comparison of FtF groups and dispersed meetings (CM) groups. The researchers compared team performance between two primary groups: EMS (Electronic Meeting Systems) groups and non-EMS groups. During the assessment of group performance, the study incorporated three commonly utilized measures of group performance: quality of the final decision made by the group, quality of the decision making process used to arrive at the chosen decision, and the number of alternate solutions examined during the decision making process. According to the report, group decision making is intimately connected with uncertainty reduction and equivocality resolution. For example, computer mediation for group communication and decision making allows for a reduction in uncertainty more than it resolves equivocality. Contrastingly, a FtF medium resolves equivocality more than it reduces uncertainty. For purposes of providing scientific rigor to the research, University of Hawaii researchers utilized cases that included all necessary information for decision making analysis. The research design incorporated a 2x2 factorial design with repeated measures to test the developed hypotheses. The two factors that were manipulated included computer support and communication medium. The computer support factor maintained two levels, with half of the participants receiving computer support and the other have not receiving computer support. Similarly, the communication medium factor had two levels, FtF meetings and audio conferencing (Chidambaram & Jones, 1993).

All groups were tasked with reading a case study, identifying problems, discussing issues, generating ideas, evaluating options, and making final decisions. The researchers generated the following hypotheses pertaining to group performance: H(4a) the quality of the final decisions will be better for EMS groups than non-EMS groups, and H(4b) the quality of the final decisions will be better for FtF groups than dispersed groups. Data analysis revealed that, in general, group performance was higher among EMS groups than non-EMS groups. Furthermore, computer support aided groups in exploring different alternative solutions and improved the quality of the decision making process. However, EMS had minimal impact on the quality of the final decisions made. Additionally, there was no statistically significant difference between the decisions of FtF groups than those of dispersed groups. Therefore, both hypotheses were rejected following data analysis. Neither computer support nor communication medium provided a significant impact on the quality of final decisions (Chidambaram & Jones, 1993). The results of this study serve to further highlight the contradictory evidence of the impacts of computer assisted and computer mediated communication on group performance.

A collaborative study between the University of Florida and Michigan State University (2002) examined the effects of computer-assisted (CA) communication on team decision-making performance. However, the results of this study differed from the 1998 study. The study incorporated 237 undergraduate students from a large midwestern university that were enrolled in an introductory management course. These participants were grouped into 79 three-person teams tasked with classifying aircraft as friendly or threatening based on several pieces of information (speed, range, angle, altitude, and radar type). Participants were assigned Alpha, Bravo, and Charlie roles and received

training on how to assess the differing threat levels. The teams were then assigned to one of two experimental conditions: verbal communications or computer-assisted communications. Each team member only had access to three pieces of information about an aircraft and was required to communicate with other team members to obtain the remaining pieces of information. Bravo and Charlie's recommendations took the form of a specific course of action to take on a 7-point scale of aggressiveness (1 = ignore, 2 = review, 3 = monitor, 4 = warn, 5 = ready, 6 = lock-on, 7 = defend). Once the information was obtained, the groups relayed the information to Alpha who then made a final decision (Colquitt, Hollenbeck, Ilgen, LePine, & Sheppard, 2002).

The observers hypothesized that CA communication conditions would be more beneficial to decision-making than would verbal communication conditions. Measures to assess team-decision making performance included the operationalization as mean square error, or the difference between the team's decision and the correct decision amassed across the multitude of trials. The decisions, as previously mentioned, ranged from 1 (ignore) to 7 (defend). For example, if the teams' decision differed from the correct decision by an average of three levels per trial, their mean square error would be nine. Once the data was analyzed, the observers concluded that their hypothesis was upheld. Access to CA communication improved team decision-making performance. Computer-assisted communication proved more beneficial to team decision-making than verbal communication in teams that were high in openness to experience (Colquitt, Hollenbeck, Ilgen, LePine, & Sheppard, 2002).

A more recent, empirical study by Dr. Nadeem Ehsan presented in the 2008 *International Symposium on Information Technology* supports the finding that CM

communications aid in team performance. The empirical study was designed to assess the cohesiveness among virtual teams using CM communication versus FtF communication (Ahmad, Ehsan, & Mirza, 2008). Although the study incorporates a comparison between strictly CM teams and strictly FtF teams (instead of a mix of verbal and CA communications), much insight can be gained from an assessment of the study.

The virtual teams study incorporated both qualitative and quantitative techniques for data acquisition and analysis. Interviews, questionnaires, and graphical data representation were incorporated in collecting and analyzing the data. The study's research sample included 100 employees of Medical Transcription and Billing Company (MTBC), an organization geographically separated between the United States and Asia. Research methodologies included in-depth interviews with all employees and the use of questionnaires to assess the varied opinions of employees, which were recorded in the statistical package for the social sciences (SPSS) software program for hypothesis testing via statistical analysis (Ahmad, Ehsan, & Mirza, 2008).

Several hypotheses were included in the empirical study. Two of these are most pertinent to the study at hand: H(0) in virtual project team environments, CM communication decreases team performance, H(A) in virtual project team environments, CM communication increases team performance. These hypotheses were tested using various charts with the questionnaires being analyzed in SPSS to measure cohesiveness among the virtual team members. Statistical analysis revealed that H(0), which predicted that CM would decrease virtual teams' performance, was not supported. As such, the alternate H(A) hypothesis was accepted, stating that CM communication increases team cohesiveness and performance. The different communication modes, when plotted on a

bar graph against team cohesiveness, revealed that team cohesiveness and productivity was highest among employees who utilized video conferencing. Contrastingly, the graph indicated that lowest cohesiveness and productivity existed among employees utilizing audio conferencing and instant messaging. The study ultimately concluded that teams should attempt to utilize CA communication technologies to improve performance and achieve goals (Ahmad, Ehsan, & Mirza, 2008).

A study conducted by Wayne State University in 2002 offers a different perspective on the team benefits of CM communication. The Wayne State University group conducted a meta-analysis entitled Computer-Mediated Communication and Group Decision Making: A Meta-Analysis. The research compared decision making in FtF versus CM groups (Baltes, Bauer, Dickson, LaGanke, & Sherman, 2002).

The meta-analysis was conducted via computer-based literature searches on Psychological Abstracts from 1887 to 2000, ABI/INFORM from 1977 to 2000, Business Periodicals Index from 1977 to 2000, and Dissertation Abstracts from 1891 to 2000. Inclusion criterion for the studies in the meta-analysis included: studies with groups of three or more participants, studies where a consensus or majority decision was reached, and studies that had the necessary statistics included for data analysis. This criterion ultimately resulted in the inclusion of 22 published and 5 unpublished sources. For analysis, the results of the various included studies were converted into common d statistics using Johnson's DSTAT computer program corrected for sample size. The subsequent meta-analysis was guided by the Hedges and Olkin's approach to meta-analysis (Baltes, Bauer, Dickson, LaGanke, & Sherman, 2002).

The study hypothesized that CM groups would be less effective than FtF groups when performing intellective and decision-making tasks, and CM groups would be less effective when task time becomes limited. The study also hypothesized that CM groups would be less satisfied with the group process than would FtF groups. The results of the meta-analysis suggested that CM groups are rarely more effective than FtF groups, supporting the initial hypothesis. Findings further suggested that CM groups were much less likely to be satisfied with group processes than FtF groups. Wayne State University concluded the analysis with a precautionary warning to managers, researchers, and theorists who are eager to utilize technology to improve team performance (Baltes, Bauer, Dickson, LaGanke, & Sherman, 2002). This study provides a staunchly contrasting outlook on the benefits to team performance of CAcommunications.

A contrasting empirical study published in the *Journal of Business Research* in 2005 indicates strong, positive correlations between CM communication and superior performance. The study also provides substantial supporting evidence that decentralized strategic decision making is closely related to higher overall organizational performance (Andersen, 2005).

The study targeted various manufacturing firms among various industries in an attempt to secure validity across functional areas. Participating firms were selected using the Compustat database classified by SIC codes. Firms included: meat packing, flour and cereal, sugar products, miscellaneous food, men and women's clothing, household furniture, electronic computer and storage devices, computer terminals and calculators, industrial machinery, and measuring and analytic equipment. All firms were stationed in the United States. The research methodology targeted members of these companies'

executive boards who were in charge of market-related activities. This was done primarily because market managers are generally involved in strategic planning. These board members were tasked with responding to questionnaires developed to assess firm-specific measures of decentralized strategic decision making, firm profitability, environmental dynamism, and computer-mediated communication. Questionnaire items were evaluated on a five-point Likert scale and aggregated into appropriate measures (Andersen, 2005).

The empirical observers made three hypotheses: H(1) higher levels of CM communication among middle managers is associated with increased levels of profitability, H(2) organizations with decentralized strategic decision making processes are associated with increased levels of profitability in dynamic environments, and H(3) greater levels of CM communication among middle managers increases the positive relationship between firm profitability and decentralized decision making. These hypotheses were tested using multiple regression analyses. Regressions were performed with firm profitability as the dependent variable and environmental dynamism, decentralized strategic decision making, and CM communication as the independent variables (Andersen, 2005).

Results of the empirical study indicate that utilization of improved communication technologies leads to higher organizational performance. Computer-mediated communications between middle managers at different functional locations within the firm increases profitability. The study further demonstrates that CM communication increases information processing capacities which results in improved effectiveness of decentralized strategic decision making. The study ultimately concluded

that CM communication and decentralized strategic decision making processes supported by CM communication improve organizational performance, substantiating hypotheses H(1) to H(3) (Andersen, 2005).

According to a meta-analysis from the University of Southern California (2010), the antiquated prediction that information and enhanced, CA communication technologies would substantially alter the work environment and certain aspects of group performance has not come to fruition (Rhoads). Research posits that one of the primary reasons for this development lies in the inability of such technologies to effectively replace certain characteristics of FtF communication. Such a connection, or lack thereof, can be better understood through the lens of human evolution. The success of human evolution throughout time has relied heavily on the species' simultaneous social, competitive, and teamwork development. Human survival has always been intimately connected with the ability of the species to communicate thoughts and ideas successfully. Psychologists coin this skill as the ability to "mind read". In other words, the ability to interpret the thoughts of others based on actions and words. According to Baron-Cohen's Theory of Mind, children develop the ability to analyze human behavior at an early age through the understanding of their own desires and beliefs. This type of early development, according to Baron-Cohen, is a result of genetic programming. Furthermore, eye contact is known to significantly modify human cognitive processes during FtF contact, moderating social control and information relay (Rhoads, 2010). This natural, cognitive, genetically instilled ability is unable to assist communication efforts among certain communication mediums in use today. Further, when humans analyze spoken words, an attempt to interpret the communicator's intention is made through the

interpretation of nonverbal and paraverbal (tone, pitch, and inflection) components of a conversation. Research has proven that participations pay more attention to nonverbal communication components during conversation. Additionally, paraverbal and nonverbal cues tend to control the flow of conversations, and a lack of such cue controls can result in unregulated, disordered conversation which can lead to communication breakdown (Rhoads, 2010).

Mohja Rhoad's meta-analysis also points to Daft and Lengel's (1984) Media Richness Theory (MRT) as potential reasoning why enhanced communication technologies have not prompted the changes to the workplace as predicted. According to Daft and Lengel, MRT places various media along a spectrum in which one side represents "rich" media and the other side represents "lean" media. The richness of the media is dependent upon the degree of emotional, normative, or attitudinal cues contained. Media Richness Theory delineates FtF contact as the richest of communication mediums due to the incorporation of all three cues projected. Video communication is purported as the next richest medium, followed by telephone, then electronic communications such as word documents or e-mail. Theorists argue that MRT fails to adequately explain why FfF communication is superior to other forms of communication for particular tasks. Critics maintain that performing a task successfully, such as decision making, does not always depend on the richness of the communication medium. Additional factors such as preferences, skills, and attitudes play key roles in technological adaptation. Such factors tend to change over time and change the way humans efficiently use technology (Rhoads, 2010).

According to Rhoads, FtF communication remains a superior communication medium for many organizations. Distance between team members matters and will most likely always matter. Current research on the matter falls short of being able to assess whether FtF communication will be upheld as the most efficient communication means or abandoned by the convenience of CM communication. Even still, CM communication is expected to contribute more and more in business, learning, and teamwork environments. Furthermore, given the rate of technological improvement and integration into workplace environments and younger workers' affinities for CM communication through texting and other means, digital technologies that modify communication means may become more prevalent than ever. In any case, findings pertaining to the comparative production and performance outcomes of CM versus FtF teams are mixed, which suggests that it remains unclear whether FtF communication is in fact superior to CM communication for a host of collaborative practices (Rhoads, 2010).

Statement of the Problem/Research Questions

The aforementioned, contrasting literature highlights inconsistencies in the certainty of the effects of verbal and/or computer-assisted communications on team performance. Such an opaque understanding of the influences of these types of communication on team performance, coupled with the current organizational and industry trends of rapid technological improvement and integration, underscores a significant gap in the fundamental understanding of team performance dynamics as a whole and in the aviation industry. In an industry responsible for the safe and expeditious delivery of tremendous amounts of global commodities and invaluable lives, it is critical to develop a keen understanding of the effectiveness of industry

communication. As such, it is apparent that additional research need be conducted for greater understanding and educational purposes. The purpose of this study is to determine the impact of text-based communications (as a means of CA communication) on team performance in a unified flight operations center simulation. To accomplish this, students enrolled in the Aerospace Seminar Capstone course in the Aerospace curriculum at MTSU, and are subsequently participating in the NASA FOCUS lab as part of the completion requirements for that course, took part in a multi-methodology, experimental study to answer the following questions:

(R1): Is there a significant difference in on-time performance between teams who utilize text-based communications and verbal communications and teams who utilize only verbal communications?

(R2): How effective do airline operations center participants perceive the different communication methods to be?

(R3): (For groups that communicate both textually and verbally) In what ways, or in which circumstances in an airline operations center do participants feel that text-based communication is more beneficial than verbal communication?

(R4): (For all groups) How can verbal communications in an airline operations center be improved?

(R5): Does an increase in text-based communications correlate to an increase in a team's on-time performance?

The following hypotheses were developed for the aforementioned research questions:

(H1): Teams who utilize text-based communications and verbal communications will observe better on-time performance than teams who utilize only verbal communications.

(H2): Participants will perceive that a 50/50 mix of verbal and textual communications proves to be the most effective means of communication in an airline operations center setting

(H3-H4): No hypothesis developed. Data was obtained via open-ended survey instrument and results are expected to vary widely.

(H5): An increase in text-based communications will directly correlate to an increase in a team's on-time performance.

CHAPTER II — METHODOLOGY

In order to assess the impact of text-based communications on team performance in a flight operations center simulation, a mixed procedure utilizing qualitative and quantitative methodologies was utilized. This mixed-method approach to data collection was pursued in an effort to generate an information rich study capable of capturing student performance as well as perception. Data was collected through the review of archived Skype instant (text-based) messages that were logged during student simulations. Financial data related to team performance was also retrieved from a flight status board and recorded for each team during each simulation to corroborate the data collected through Skype. Additionally, quantitative and qualitative data was produced and recorded via the administration of Likert scale and open-ended survey instruments. The data obtained was then analyzed to determine what impact, if any, text-based communications had on team performance in an airline operations center setting. Further, the qualitative data was analyzed to assess participants' perceptions of the effectiveness of textual and verbal communications in an airline operations center. This study, including methodologies and instruments used, was approved by MTSU's Institutional Review Board (IRB), protocol number: 15-150 (see Appendix A).

Participants

The participants in this study included students who were enrolled in the Aerospace Seminar (AERO 4040) Capstone course in the Aerospace curriculum at MTSU and subsequently participated in the NASA FOCUS lab as part of the completion requirements for that course. All of the students enrolled in the spring 2015 AERO 4040 course agreed to participate in the study following an explanation of the design.

Informed consent forms (see Appendix B) were signed by all students and were securely stored in a locked cabinet located within the NASA FOCUS lab that is only accessible via key card admittance. In total, 65 students from multilateral aerospace concentrations were observed while engaged in regional airline operations center simulations during the spring 2015 semester.

FOCUS Lab Background and Concept

The NASA FOCUS lab was established in 2010 under the guidance of Dr. Paul A. Craig as a result of industry concerns regarding the lengthy amount of time needed for aviation professionals to develop a complete understanding of how an airline operates and how their individual performance and decision making impacts the overall airline operation. According to industry experts, it may take up to 10 years for newly hired aviation professionals to fully understand the dynamics of an airline operations center. With the construction of the NASA FOCUS lab, MTSU's Aerospace department is actively working to reduce the amount of time required for newly hired aviation professionals to comprehend the big picture of an operations center by allowing senior undergraduate students an opportunity to work in teams with students from other aerospace concentrations to enhance teamwork skills.

Flight Operations Center Unified Simulation lab teams are composed of 10 to 12 students that are placed in a position most relevant to his or her aerospace concentration. It is important to note that although the majority of students are housed in one location, three positions are removed in order to cultivate a more realistic workplace environment. The FOCUS lab houses Universal E-Lines' operation center containing the following positions: flight operations coordinator, flight operations data, flight tracking and

scheduling, weather and forecasting, crew scheduling, maintenance control, and maintenance planning and scheduling. In a room adjacent to the FOCUS lab, the pseudo pilot position takes on the role of pilot for all but one of Universal E-Lines' simulated aircraft. The single aircraft not controlled by the pseudo pilot is controlled by two students operating a Canadair Regional Jet (CRJ) 200 simulator located at the Murfreesboro Municipal Airport (KMBT). Desktop computers with dual monitors are located at each position in the lab that allow each team member to organize and display multiple sources of information and software programs necessary to perform the tasks associated with their position. Additionally, headsets are connected to each position's computer to facilitate verbal communication among team members. Three large, liquid crystal display (LCD) television screens are also positioned on each sidewall in the lab that display information commonly used by all positions. These LCD screens display real-time weather maps, flight tracking radar, and the flight status board. In a room also adjacent to the FOCUS lab, the ramp tower houses three additional large LCD screens, 12 computers, and multiple control stations designed to control the movement of Universal E-Lines' aircraft along 16 designated routes across the Southeastern United States. The LCD displays located in the ramp tower display a 150-degree view of Nashville International Airport's (KBNA) C concourse, one of 16 airports utilized by Universal E-Lines. This view allows students in the ramp tower position to monitor and manage the movement of aircraft at KBNA. Additionally, all positions in the FOCUS lab utilize an interactive Microsoft Excel document that is tailored to each position which aids students in retrieving data needed to perform various tasks. The Excel documents can be manipulated by students to obtain information pertinent to other positions in the lab as

well. Furthermore, each Excel document contains a flight status board which displays flight numbers, departure and arrival airport identifiers, and departure and arrival times for all flights. The flight status board also calculates and displays cumulative delays, average departure performance time, daily revenue, and financial delay loss. Calculations from the flight status board, particularly financial loss due to delay, was utilized in R1 and R5 to assess the influence of text-based communications on group performance.

Communication in the FOCUS lab follows a multi-channel method; verbal and CA modes. While verbal communications are allowed to follow either FtF or CA channels, all text-based communications are required to follow the CA mode for storage and retrieval. Skype is the primary software utilized by participants to accomplish this communicative goal; as a result, all text-based communications and call history are logged in Skype archives for retrieval.

Throughout the course of one semester, participants in the FOCUS lab partake in three, 2.5 hour simulations with their assigned team members to accomplish Universal E-line's organizational and safety goals. Over the course of 2.5 hours, the FOCUS lab research team implements real-world scenarios, or triggers, into the simulation that vary in difficulty based on simulation number. These scenarios must be resolved by the team with Universal E-Line's organizational and safety goals in mind. The FOCUS lab research team also monitors and evaluates individual and team performance during all simulations. This information is then utilized by MTSU Industrial and Organizational Psychology staff to facilitate an After Action Review (AAR) designed to give team members feedback related to their performance. During AARs, participants are allowed

an opportunity to discuss various aspects of the team's performance, both successful and unsuccessful, in order to improve performance in future simulations. After Action Reviews serve to reinforce positive team behavior and the construction of new strategies and goals to streamline teamwork. By participating in NASA FOCUS lab simulations and subsequent AARs, students improve teamwork, problem-solving and coordination skills, develop strategies to counter weaknesses, and enhance strengths to become exceptional aviation professionals.

Design

A mixed methodology approach was utilized in this study to incorporate both quantitative and qualitative methods. Of the six teams participating in the NASA FOCUS lab in spring of 2015, three teams were allowed to communicate only verbally while the remaining three teams were allowed to communicate both textually and verbally. These communication restrictions were applied in an attempt to isolate and investigate the effects of textual communications on team performance. The experimental methodology was utilized for (R1) to draw comparisons between group communication types and on-time performance data that is recorded by the flight status board during every simulation. A quantitative survey methodology was utilized to answer (R2) via the administration of an end of course Likert scale questionnaire designed to assess the different groups' perception of the effectiveness of the various methods of communication. For (R3) and (R4), the qualitative survey methodology was utilized via administration of an open-ended questionnaire designed to obtain participants' feedback on communication preferences and suggestions for improvement. The correlational methodology was applied to answer (R5) to determine whether, and to

what degree a relationship existed between a team's number of relayed textual communications (the independent variable) and their on-time performance (the dependent variable).

Instruments

In order to obtain the data necessary to answer research questions R1 and R5, a combination of instruments was utilized including Skype and the NASA FOCUS lab's flight status board operated in Microsoft Excel. Skype was selected as the software of choice in the lab for CA communications due to the program's popularity and information storage capacity. All positions within the FOCUS lab were provided with Skype software as a possible communication channel. As a result, all CA communications, including calls and instant messages, were logged in Skype archives and later transposed into Microsoft Word for analysis. The flight status board operated from Microsoft Excel was utilized to capture performance and delay data during all simulations. The Excel driven program utilizes a proprietary formula based on recent airline industry delay information to compute the total financial loss Universal E-Line's accrues as a result of late departures and arrivals. This information from the flight status board was also transposed into Microsoft Word for organization and analysis.

In order to obtain the data necessary to answer research questions R2-R4, multiple survey instruments were utilized. In total, four survey instruments were developed and administered to the six FOCUS lab groups at the end of their last simulation. These survey instruments were pilot-tested by aerospace graduate students and faculty for conciseness. Please refer to Appendix C to view these survey instruments in their entirety. Groups received surveys based on their group assignments and communication

capabilities. Groups 1-3 that were capable of only verbal communication received two surveys: Likert Scale Survey (R2) Constructed for Groups Capable of Verbal Communication Only and Open-ended Survey (R4) Constructed for All Groups. The five point Likert scale survey constructed for groups 1-3 consisted of four questions designed to assess participants' perceptions of the effectiveness of verbal communications in an airline operations center setting. The associated open-ended survey that groups 1-3 received consisted of two short answer questions constructed to assess what changes participants felt could be made in the lab to improve communications. Groups 4-6, that were capable of verbal and text-based communications, received three surveys: Likert Scale Survey (R2) Constructed for Groups Capable of Textual and Verbal Communications, Open-ended Survey (R3) Constructed for Groups Capable of Textual and Verbal Communications, and Open-ended Survey (R4) Constructed for All Groups. The five point Likert scale survey constructed for groups 4-6 consisted of five questions designed to assess which communication method or combination of communication methods participants felt to be the most effective. The associated open-ended survey constructed for groups 4-6 consisted of four short answer questions designed to evaluate participants' opinions of when using one form of communication is more beneficial than the other in an airline operations center setting. The last and final survey administered to groups 4-6 was the open-ended survey constructed for all groups which groups 1-3 also received.

Procedure

Following MTSU IRB approval, students participated in training or "on-boarding" where they received information on the FOCUS Lab's inception, design,

operation, and industry significance. Additionally, the parameters of this research along with a description of purpose, benefits, and risks to participants was explained before informed consent forms were obtained. Following on-boarding, all students were assigned to 1 of 6 teams and were allocated to FOCUS lab positions based on their associated aerospace concentrations. Participants were then instructed to review appropriate online training modules and complete the associated knowledge assessments uploaded on MTSU's Desire2Learn website. After reviewing all online training materials, participants then received hands-on, position-specific training with subject matter experts (SMEs) from the lab. It is important to note that during training teams 1-3 were encouraged to communicate verbally and/or textually as they deemed most appropriate while teams 4-6 were encouraged to communicate only verbally through FtF or CA (Skype) modes. After completing all training requirements, participants were assigned dates and times to partake in NASA FOCUS lab simulations with their teams. Over the course of one semester, all teams completed three high-fidelity airline operations center simulations with increasing levels of difficulty. The difficulty of the simulations was controlled through trigger implementation. For example, triggers with lower overall impact on the airline or that had simpler solutions were implemented during first level simulations. Likewise, more impactful triggers requiring complex solutions were implemented in subsequent simulations. In an effort to produce reliable data, a set of predefined triggers was established to be administered to all teams participating in simulations of a given difficulty. At the end of every simulation, text-based communications sent from each position on the team were retrieved from Skype archives and recorded in Microsoft Word. These text-based communications were then totaled

and recorded along with the team's on-time performance data drawn from the flight status board. This data was recorded for all 6 teams for a total of 18 simulations. Furthermore, following the completion of the third and last simulation of the semester, participants were asked to complete the appropriate Likert-scale and open-ended surveys found in the instruments section and Appendix B. These research questions were selected in order to generate an information rich study capable of capturing student perception. Of the 65 students participating in the study, 50 completed the assigned surveys resulting in a total of 133 completed surveys. Participant scheduling conflicts and/or absenteeism is attributable to the 77% survey completion rate. All data obtained was stored in the NASA FOCUS Lab on secure devices. Statistics appropriate for a mixed methodology study were then applied to the data, producing interesting results discussed in the next Chapter.

CHAPTER III — DATA ANALYSIS

On-time Performance Comparison between Communication Groups

The experimental methodology was utilized to obtain on-time performance data between verbal only groups and groups with both textual and verbal communication capabilities. The experiment generated parametric data which adhered to the following assumptions: the scores in the data represented a random sample from the population under study, the distribution of the sample mean was normal, and the variances of the different study groups were similar. A Levene's Test for Equality of Variances was performed in SPSS to verify homogeneity of variance (see Table 1). The Levene's Test for Equality of Variances determined that the data collected for this research question were equally variant. Adherence to these aforementioned assumptions indicated that a t-test was an appropriate tool for statistical analysis of this data. Table 2 depicts a summary of the data through descriptive statistics for both verbal only groups and textual and verbal groups.

Table 1

Levene's Test for Equality of Variances

		Levene's Test for Equality of Variances	
		F	Sig.
OTP	Equal variances assumed	4.327	.054

Note. OTP= On-time Performance

Table 2

Descriptive Statistics for Verbal and Textual/Verbal Groups

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
OTP	Verbal	9	$25225.75	8149.85	2716.61
	Textual/Verbal	9	$31576.73	26736.45	8912.15

Note. OTP=On-time Performance

Assuming equal variance, a 2-tailed independent samples t-test was conducted in SPSS to test for a statistically significant difference in on-time performance between the two distinct communication groups (see Table 3). A calculated t(16) = -.682 and p = .505 indicated no significant difference in the on-time performance of the two different communication groups. There was no significant difference in the scores for verbal communication only on-time performance (M = 25225, SD = 8149) and text and verbal communication on-time performance (M = 31576, SD = 26736) conditions; t(16) = -.682 p = .505.

Table 3

T-test for Equality of Means

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
OTP	Equal variances assumed	-.682	16	.505	-6350.97444	9316.99952	-26102.13111	13400.18222
	Equal variances not assumed	-.682	9.474	.512	-6350.97444	9316.99952	-27267.85950	14565.91061

Note. OTP=On-time Performance

Student Perception of Communication Effectiveness

The quantitative survey methodology was deployed to assess airline operations center participants' perceptions of the effectiveness of both textual and verbal communication methods. Likert scale surveys, which were individually tailored to the two distinct group communication types (see Appendix C), generated non-parametric data for statistical analysis using a frequency analysis in SPSS software. Groups 1-3 received Likert scale surveys constructed for groups capable of verbal communication only, while groups 4-6 received Likert scale surveys constructed for groups capable of textual and verbal communications. Students in groups 1-3 received a four question survey which required each question to be ranked numerically on a five point scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree. Table 4 depicts the response frequencies of each question for groups 1-3, those capable of verbal communication only.

Table 4

Response Frequencies of Likert Scale Survey Questions for Groups 1-3

	Q1 **Having only verbal comms increases effectiveness**		**Q2** **Having only verbal comms decreases effectiveness**		**Q3** **Having the option to text would increase comms effectiveness**		**Q4** **Using only verbal is most effective means of communication**	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
SD	0	0	3	13.0	0	0	0	0
D	11	47.8	5	21.7	0	0	12	52.2
N	6	26.1	4	17.4	4	17.4	6	26.1
A	4	17.4	9	39.1	15	65.2	5	21.7
SA	2	8.7	2	8.7	4	17.4	0	0
Total	23	100.0	23	100.0	23	100.0	23	100.0

Note. SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree

With the response frequency data analyzed and formatted in Table 4, it is evident that participants in groups capable of verbal communication only perceive the communicative restriction as a hindrance to effective communication. Furthermore, participants perceive text-based communications as an aid in communication effectiveness, as evidenced by the response frequencies of question 3; 65.2% of participants agreed and 17.4% of participants strongly agreed that having the ability to communicate textually would be beneficial to effective communication. Students in

groups 4-6 received a five question survey which required each question to be ranked numerically on the same five point scale. Table 5 depicts the response frequencies of each question for groups 4-6, those capable of textual and verbal communication. Pie graph representations of each question contained in Table 4 and Table 5 are available for reference in Appendices D and E respectively. With the response frequency data analyzed and formatted in Table 5, it is evident that participants in groups capable of both textual and verbal communications view verbal communication as the superior communication method, as indicated by the response frequency of question 2 (Q2). Contrastingly, participants also viewed a 50/50 mix of verbal and textual communications to be the most effective means of communication, as evidenced by the response frequency of question 3 (Q3). This discrepancy is indicative of unreliable data; as a result, no conclusive answer can be drawn for this research question. This disparity is perhaps a result of restrictive language found within the survey and is further addressed in Chapter 4, along with an in-depth discussion of results.

Table 5

Response Frequencies of Likert Scale Survey Questions for Groups 4-6

	Q1 **Textual comms are most effective**		**Q2** **Verbal comms are most effective**		**Q3** **50/50 mix of comms are most effective**		**Q4** **Using only textual comms is most effective**		**Q5** **Using only verbal comms is most effective**	
	f	%	f	%	f	%	f	%	f	%
SD	3	11.1	0	0	0	0	11	40.7	2	7.4
D	7	25.9	0	0	3	11.1	7	25.9	8	29.6
N	10	37.0	3	11.1	6	22.2	6	22.2	4	14.8
A	5	18.5	12	44.4	14	51.9	3	11.1	9	33.3
SA	2	7.4	12	44.4	4	14.8	0	0	4	14.8
Total	27	100.0	27	100.0	27	100.0	27	100.0	27	100.0

Note. f = Frequency SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree

Student Perception of Text-based Communication Superiority

The qualitative survey methodology was utilized to assess participants' opinions of text-based communication superiority. An open-ended questionnaire specifically tailored for groups 4-6, those capable of both textual and verbal communications, was administered to obtain the data necessary to delineate circumstances in which students felt that text-based communication was more beneficial than verbal communication (see Appendix C). Questions 1 and 3 of the open-ended survey generated the data for this research question. The collected data was then coded and themed in Microsoft Excel for frequency analysis in SPSS. This information is available for reference in Appendix F.

Table 6 displays the frequency analysis for question 1, while Table 7 displays the frequency analysis for question 3.

Table 6

Question 1 Response Frequency Analysis; Open-ended Survey for Groups 4-6

In what way(s) do you feel that textual communication is more beneficial than verbal communication?

Response	Frequency	Percent	Valid Percent	Cumulative Percent
texts are more concise/provides additional clarity	12	32.4	32.4	32.4
generates a referenceable communication trail	6	16.2	16.2	48.6
not more beneficial	4	10.8	10.8	59.5
other	4	10.8	10.8	70.3
relaying complex/information rich messages	3	8.1	8.1	78.4
during high workload periods	2	5.4	5.4	83.8
faster information relay	2	5.4	5.4	89.2
fewer interruptions	2	5.4	5.4	94.6
provides for more time for effective decision making	1	2.7	2.7	97.3
aids in workplace noise reduction	1	2.7	2.7	100.0
Total	37	100.0	100.0	

With the response frequency data analyzed and formatted in Table 6, it is evident that the majority of participants in groups 4-6, those capable of both verbal and textual communications, perceive textual communication to be more beneficial than verbal communication due to the communication method's clear, concise nature. A graphical representation of the data contained within Table 6 is available for reference via pie graph in Appendix G.

Table 7

Question 3 Response Frequency Analysis; Open-ended Survey for Groups 4-6

Provide an example of when text-based communication proved to be more effective than verbal communication.

Response	Frequency	Percent	Valid Percent	Cumulative Percent
other	8	26.7	26.7	26.7
generates a referenceable communication trail	6	20.0	20.0	46.7
communicating with someone in a different location	5	16.7	16.7	63.3
referencing a flight # or list of flight #s	4	13.3	13.3	76.7
provides for more time for effective decision making	2	6.7	6.7	83.3
relaying complex/information rich messages	2	6.7	6.7	90.0
aids in workplace noise reduction	2	6.7	6.7	96.7
not more beneficial	1	3.3	3.3	100.0
Total	30	100.0	100.0	

With the response frequency data analyzed and formatted in Table 7, it is evident that the majority of participants, 26.7%, provided a response categorized as “other.” No emerging theme could be identified among the responses that were categorized as

“other.” However, the second highest response frequency of 20.0% was recorded as “generates a referenceable communication trail." This indicates that a considerable portion of participants capable of both textual and verbal communication perceived text-based communication as more effective than verbal communication when recalling previous communications was required to adequately perform a task. A graphical representation of the data contained within Table 7 is available for reference via pie graph in Appendix G.

Student Perception of Improvements to Verbal Communication

The qualitative survey methodology was utilized to assess participants’ views of how verbal communication could be improved in an airline operations center setting. Question 1 of the open-ended survey created for all groups generated the data necessary for this analysis (see Appendix C). The collected data was coded and themed in Microsoft Excel for frequency analysis in SPSS. This information is available for reference in Appendix H. Table 8 displays the frequency analysis for question 1 of the open-ended survey created for all groups.

Table 8

Question 1 Response Frequency Analysis; Open-ended Survey for Groups 1-6

What can be done to improve verbal communications in an airline operations center such as the FOCUS lab?

Response	Frequency	Percent	Valid Percent	Cumulative Percent
streamlined headset use and functionality	12	20.0	20.0	20.0
Properly Functioning Equipment	11	18.3	18.3	38.3
Concise tone/common language/etiquette	8	13.3	13.3	51.7
Other	6	10.0	10.0	61.7
location/positioning/ close proximity	5	8.3	8.3	70.0
following SOPs	4	6.7	6.7	76.7
nothing	4	6.7	6.7	83.3
minimize excessive chat	3	5.0	5.0	88.3
Additional training	3	5.0	5.0	93.3
familiarity with personnel	2	3.3	3.3	96.7
additional employees	1	1.7	1.7	98.3
Screen share	1	1.7	1.7	100.0
Total	60	100.0	100.0	

With the response frequency data analyzed and formatted in Table 8, it is evident that the majority of participants, 20.0%, feel as though verbal communications in an airline operations center could be improved through streamlining headset usage and functionality. Additionally, a significant portion of participants, 18.3%, believe that properly functioning equipment could also significantly improve verbal communications in a setting such as the FOCUS lab. A graphical representation of the data contained within Table 8 is available for reference via pie graph in Appendix I.

Text-based Communications and Team Performance

The experimental methodology was utilized to obtain on-time performance data for groups 4-6, those capable of both verbal and textual communications. The experiment generated parametric data for statistical analysis to determine if a relationship existed between a team's number of textual communications and their on-time performance. Upon initial examination, a scatter plot of OTP (on-time performance) versus number of texts depicted non-linearity between the data (see Figure 1). This non-linear relationship was confirmed via linear regression analysis in SPSS (see Table 9).

Figure 1

OTP V. Texts Scatterplot

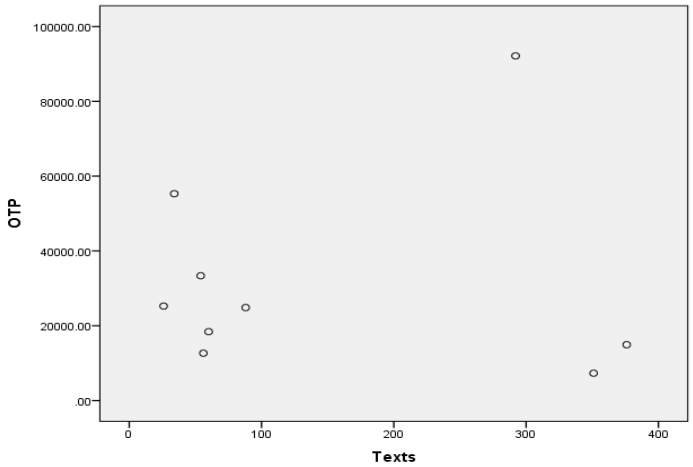


Table 9

Linear Regression Analysis

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	30532.60	14009.21		2.18	.07
Texts	7.03	69.18	.04	.10	.92

a. Dependent Variable: OTP

The non-linear relationship shown to exist between a team's number of relayed text messages and their on-time performance indicates no correlation between the variables. The linear regression analysis corroborates these findings, $p = 0.922 > .05$. As

a result, it can be confidently concluded that an increase in text-based communications does not correlate to an increase in team performance.

CHAPTER IV — DISCUSSION AND RECOMMENDATIONS

In order to assess the impact of text-based communications on team performance in a flight operations center simulation, a mixed procedure utilizing qualitative and quantitative methodologies was used. The research questions were designed to generate an information rich study capable of capturing both student performance and perception. As a result, the influence of text-based communications on student performance was captured through experimental means, while students' perceptions of communication effectiveness was captured through qualitative survey evaluation.

Research Question 1 Discussion

The first research question was designed to assess what impact, if any, text-based communications had on on-time performance between teams who had the ability to communicate textually and verbally and teams who could only communicate verbally. During active laboratory simulations, teams who had the ability to communicate textually were seemingly able to coordinate the release of flights in a timelier manner. As such, it was hypothesized that teams who utilized text-based communications and verbal communications would observe better on-time performance than teams who utilized only verbal communications. However, data analysis failed to reveal a statistically significant difference between the two different communication-type groups. A 2-tailed independent samples t-test indicated that there was no significant difference in the scores for textual and verbal communication on-time performance and verbal communication only on-time performance. In regards to research question one, there exists no significant difference in on-time performance between teams who utilize text-based communications and verbal communications and teams who utilize only verbal communications.

Research Question 2 Discussion

The second research question asked "How effective do airline operations center participants perceive the different communication methods to be?" The quantitative, Likert scale survey methodology was deployed to delineate airline operations center participants' responses to this question. Groups 1-3 received Likert scale surveys constructed for groups capable of verbal communication only, while groups 4-6 received Likert scale surveys constructed for groups capable of textual and verbal communications. Participants in groups capable of verbal communication only perceived the verbal only communicative restriction as a hindrance to effective communication. Furthermore, verbal only participants perceived text-based communications as an aid in communication effectiveness; 65.2% of participants agreed and 17.4% of participants strongly agreed that having the ability to communicate textually would be beneficial to effective communication. Contrastingly, participants in groups capable of both textual and verbal communications viewed verbal communication as the most effective communication method. However, the same participants also viewed a 50/50 mix of verbal and textual communications to be the most effective means of communication. This disparity is perhaps a result of restrictive language found within the survey with words such as "most" and "only" occurring frequently. Such restrictive language occurring frequently within the Likert scale surveys could have potentially created confusion for students, yielding unreliable rankings. This discrepancy is indicative of unreliable data; as a result, no conclusive answer can be drawn for this research question.

Research Question 3 Discussion

The third research question strictly pertained to teams who communicated both textually and verbally and asked “In what ways, or in which circumstances in an airline operations center do participants feel that text-based communication is more beneficial than verbal communication?” The qualitative methodology using an open-ended questionnaire was administered to obtain the data necessary to delineate circumstances in which students felt that text-based communication was more beneficial than verbal communication. Question one of the survey asked “In what way(s) do you feel that textual communication is more beneficial than verbal communication?” Response frequency analysis indicated that the majority of participants, 32.4%, believed that text-based communication was more beneficial than verbal communication due to the communication method’s clear, concise nature. Question three of the survey stated “Provide an example of when text-based communication proved to be more effective than verbal communication.” Response frequency analysis indicated that the majority of participants, 26.7%, provided a response that could only be categorized as “other.” No emerging theme could be identified among the responses that were categorized as “other.” However, the second highest response frequency of 20.0% was recorded as “generates a referenceable communication trail." This indicates that a considerable portion of participants capable of both textual and verbal communication perceived text-based communication as more effective than verbal communication when recalling previous communications was required to adequately perform a task.

Research Question 4 Discussion

The fourth research question asked "How can verbal communications in an airline operations center be improved?" The qualitative survey methodology using an open-ended questionnaire was utilized to assess participants' opinions of this question. The majority of participants, 20.0%, believed that verbal communications in an airline operations center could be improved through streamlining headset usage and functionality. Additionally, a significant portion of participants, 18.3%, believed that properly functioning equipment would also significantly improve verbal communications in a setting such as the FOCUS lab. These findings are as expected as they reflect the primary technological issue of the FOCUS lab during the collection of this research data - maintaining headset connections between all participating stations.

Research Question 5 Discussion

The fifth research question asked "Does an increase in text-based communications correlate to an increase in a team's on-time performance?" The experimental methodology was utilized to obtain on-time performance data and relayed text-based communications for groups 4-6, those capable of both verbal and textual communications, to determine if a relationship existed between a team's number of relayed textual communications and their on-time performance. A scatter plot of OTP (on-time performance) versus number of texts depicted non-linearity between the data. This non-linear relationship was confirmed via linear regression analysis in SPSS and indicates no correlation between the variables. As a result, it can be concluded that an increase in text-based communications does not correlate to an increase in team performance.

Limitations of Research

The greatest limiting factor within this research is perhaps the uniquely small sample size from which all of the data was collected. The FOCUS lab at Middle Tennessee State University serves as an incredibly rich research environment, but the number of students cycling through the Aerospace Seminar course in a given semester varies between approximately 30 and 70 - a small sample size for almost any research project. It is from this small sample size that yet another limiting factor can be highlighted – general student aptitude. Though MTSU's Aerospace Department is known for producing high quality aviation professionals, not all students share the same enthusiasm for group work or exhibit the high level of social skills necessary to function effectively in a teamwork-laden environment such as a flight operations center unified simulation. The FOCUS lab is designed to improve student deficiencies in these areas, but such deficiencies may be reflected in data collection prior to improvement.

An additional limitation within this study was the inability to completely isolate the text-based and verbal communication variables. For this research, three groups were able to communicate textually and verbally while three other groups were allowed to communicate only verbally. Ideally, a setup in which several groups could communicate only textually while several other groups communicated only verbally could perhaps produce more scientifically rigorous results. Unfortunately, this type of experimental setup was not possible in the FOCUS lab as it was not in line with the teamwork enhancement goals of the simulation.

A further limiting factor can be pinpointed in the data collection phase of this research. The Likert scale surveys constructed for research question 2, though pilot

tested, exhibited restrictive language and thus produced uncertainty and confusion among participants. As a result, confident conclusions could not be drawn regarding student perception of communication effectiveness. Further pilot testing could have ensured the creation of a more concise survey instrument.

Recommendations for Future Research

Though this research suggests that the impact of text-based communications on team performance in a flight operations center simulation is minimal at best, a great deal of additional, future research must be undertaken regarding the influence of textual communications on team performance in aviation related environments. Contrasting conclusions found in existing research on the topic of team performance and technology, coupled with the ever apparent pervasiveness of technological improvement in the industry, highlights the importance of conducting such future research. This study focused primarily on evaluating the variable of on-time performance against the number of relayed textual communications to arrive at conclusions. An experiment constructed to assess what impact the quality, not quantity, of text-based communications may have on team performance would be equally as valuable. Additionally, the limitations of this research could be considered, addressed, and reapplied to a similar research endeavor in the same or similar environment. Additionally, addressing the limiting factor of a small sample size would serve positively in enhancing the effectiveness of such research.

REFERENCES

Ahmad, M., Ehsan, N., & Mirza, E. (2008). Impact of computer-mediated communication on virtual teams' performance: An empirical study. *International Symposium on Information Technology, 3*, 26-28. doi: 10.1109/ ITSIM.2008.4632068

Andersen, T, J. (2005). The performance effect of computer-mediated communication and decentralized strategic decision making. *Journal of Business Research*, *58*, 1059-1067. doi: 10.1016/j.jbusres.2004.02.004

Baltes, B., Bauer, C., Dickson, M., LaGanke, J., & Sherman, M. (2002). Computer-mediated communication and group decision making: A meta-analysis. *Organizational Behavior and Human Decision Processes*, *87*(1), 156-179. doi: 10.1006/obhd.2001.2961

Chidambaram, L., & Jones, B. (1993). Impact of communication medium and computer support on group perceptions and performance: A comparison of face-to-face and dispersed meetings. *MIS Quarterly*, *17*(4), 465-491. doi: 10.2307/249588

Colquitt, J. A., Hollenbeck, J. R., Ilgen, D. R., LePine, J. A., & Sheppard, L. (2002). Computer-assisted communication and team decision-making performance: The moderating effect of openness to experience. *Journal of Applied Psychology*, *87*(2), 402+. doi: 10.1037//0021-9010.87.2.402

Guzzo, R. A., & Dickson, M. W. (1996). Teams in organizations: Recent research on performance effectiveness. *Annual Review of Psychology, 47*, 307-338. doi: 10.1146/annurev.psych.47.1.307

Hedlund, J., Hollenbeck, J. R., & Ilgen, D. R. (1998). Decision accuracy in computer-mediated versus face-to-face decision-making teams. *Organizational Behavior and Human Decision Processes, 76*(1), 30-47. doi: 10.1006/obhd.1998.2796

Hollingshead, A., McGrath, J., & O'Connor, K. (1993). Group task performance and communication technology: A longitudinal study of computer-mediated versus face-to-face work groups. *Small Group Research*, *24*(3), 307-333. doi: 10.1177/1046496493243003

Rhoads, M. (2010). Face-to-face and computer-mediated communication: What does theory tell us and what have we learned so far? *Journal of Planning Literature*, *25*(2), 111-122. doi: 10.1177/0885412210382984

APPENDICES

APPENDIX A

IRB Approval

MIDDLE TENNESSEE STATE UNIVERSITY

1/10/2015

Investigator(s): Chip A. Shriver, Dr. Paul Craig
Department: Aerospace
Investigator(s) Email Address: Cas7i@mtmail.mtsu.edu; Paul.Craig@mtsu.edu

Protocol Title: Assessing the Impact of Text-Based Communications on Team Performance in a Flight Operations Center Simulation

Protocol Number: #15-150

Dear Investigator(s),

Your study has been designated to be exempt. The exemption is pursuant to 45 CFR 46.101(b)(1) Evaluation/Comparison of Instructional Strategies/ Curricula.

We will contact you annually on the status of your project. If it is completed, we will close it out of our system. You do not need to complete a progress report and you will not need to complete a final report. It is important to note that your study is approved for the life of the project and does not have an expiration date.

The following changes must be reported to the Office of Compliance before they are initiated:

- Adding new subject population
- Adding a new investigator
- Adding new procedures (e.g., new survey; new questions to your survey)
- A change in funding source
- Any change that makes the study no longer eligible for exemption.

The following changes do not need to be reported to the Office of Compliance:

- Editorial or administrative revisions to the consent or other study documents
- Increasing or decreasing the number of subjects from your proposed population

If you encounter any serious unanticipated problems to participants, or if you have any questions as you conduct your research, please do not hesitate to contact us.

Sincerely,

Lauren K. Qualls, Graduate Assistant
Office of Compliance
615-494-8918

APPENDIX B

Informed Consent Form

Informed Consent

Middle Tennessee State University

Project Title: Assessing the Impact of Text-Based Communications on Team Performance in a Flight Operations Center Simulation

Purpose of Project: This proposal seeks to assess the impact of text-based communications on team-performance in a high-fidelity replication of an airline operations center at the NASA FOCUS LAB at Middle Tennessee State University

Procedures: Administration of Likert scale surveys and Open-ended, qualitative questionnaires

Risks/Benefits: Minimal/Minimal. Volunteering to participate in this research will not affect class performance.

Confidentiality: Anonymous survey/Secure information storage

Principal Investigator/ Contact Information: Chip A. Shriver / Cas7i@mtmail.mtsu.edu

Participating in this project is voluntary, and refusal to participate or withdrawing from participation at any time during the project will involve no penalty or loss of benefits to which you might otherwise be entitled. All efforts, within reason, will be made to keep the personal information in your research record private but total privacy cannot be promised, for example, your information may be shared with the Middle Tennessee State University Institutional Review Board. In the event of questions or difficulties of any kind during or following participation, you may contact the Principal Investigator as indicated above. For additional information about giving consent or your rights as a participant in this study, please feel free to contact the MTSU Office of Compliance at (615) 494-8918.

Consent

I have read the above information and my questions have been answered satisfactorily by project staff. I believe I understand the purpose, benefits, and risks of the study and give my informed and free consent to be a participant.

_____ _____

SIGNATURE DATE

APPENDIX C

Survey Instruments

Team #: _____ Position: _____

Likert Scale Survey (R2): Constructed for Groups Capable of Textual and Verbal Communications

For the following questions, please rate each question utilizing the following scale:

1.) Strongly Disagree 2.) Disagree 3.) Neutral 4.) Agree 5.) Strongly Agree

Considering the group dynamics in the FOCUS lab:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Textual communications prove to be the most effective means of communication.					
2. Verbal communications prove to be the most effective means of communication.					
3. A 50/50 mix of verbal and textual communications proves to be the most effective means of communication.					
4. Using only textual communications is the most effective means of communication.					
5. Using only verbal communications is the most effective means of communication					

Team #: _____ Position: _____

Likert Scale Survey (R2): Constructed for Groups Capable of Verbal Communication Only

For the following questions, please rate each question utilizing the following scale:

1.) Strongly Disagree 2.) Disagree 3.) Neutral 4.) Agree 5.) Strongly Agree

Considering the group dynamics in the FOCUS lab:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Having only verbal communications available increases communication effectiveness.					
2. Having only verbal communications available decreases communication effectiveness.					
3. Having the option to communicate textually would aid in communication effectiveness.					
4. Using only verbal communications is the most effective means of communication.					

APPENDIX C (CONT.)

Team #: _____ Position: _____

Open-ended Survey (R4): Constructed for All Groups

Taking into consideration your experiences in the FOCUS lab and your team's communication dynamics, please answer the following question(s):

1.) What can be done to improve verbal communications in an airline operations center such as the FOCUS lab?

2.) What specific procedures and/or techniques would improve communications in the FOCUS Lab?

APPENDIX C (CONT.)

Team #: _____ Position:_____

Open-ended Survey (R3): Constructed for Groups Capable of Textual and Verbal Communications

Taking into consideration your experiences in the FOCUS lab and your team's communication dynamics, please answer the following question(s):

1.) In what way(s) do you feel that textual communication is more beneficial than verbal communication?

2.) In what way (s) do you feel that verbal communication is more beneficial than textual communication?

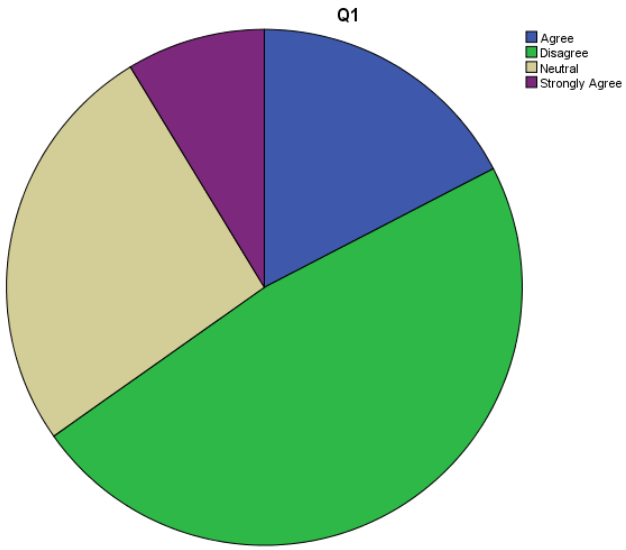
3.) Provide an example of when text-based communication proved to be more effective than verbal communication.

4.) Provide an example of when verbal communication proved to be more effective than textual communication.

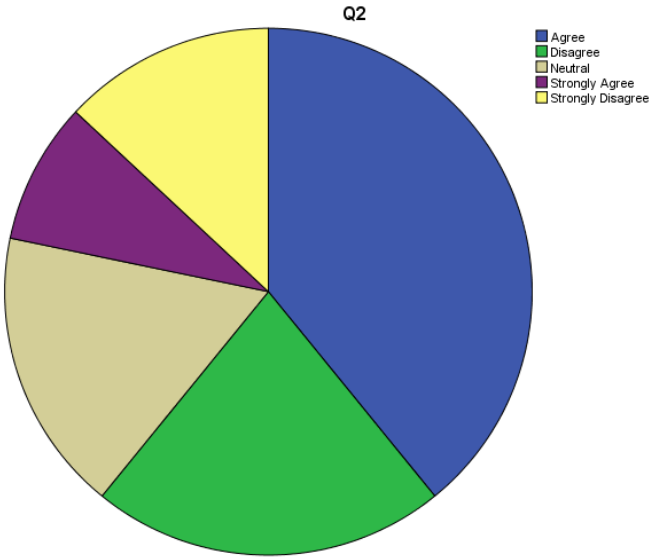
APPENDIX D

(R2) Likert Scale Response Analysis Delineated Via Pie Graph Illustration

Groups 1-3; Verbal Communication Capability Only

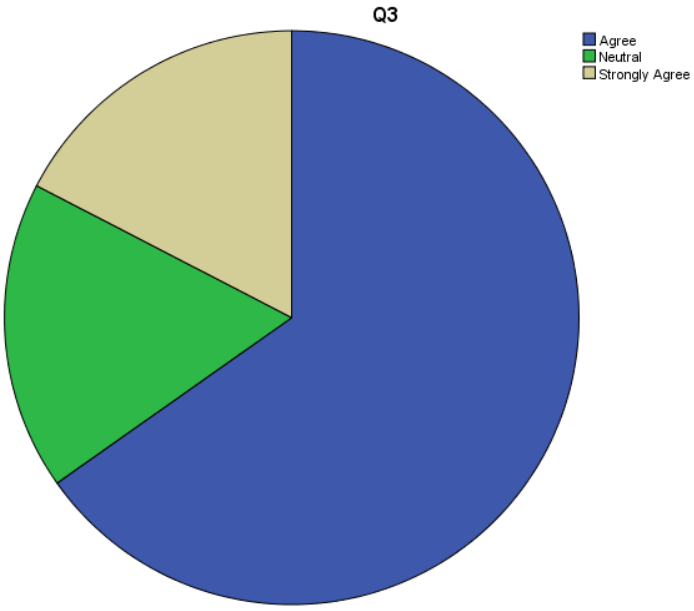


Q1: Having only verbal communications available increases communication effectiveness.

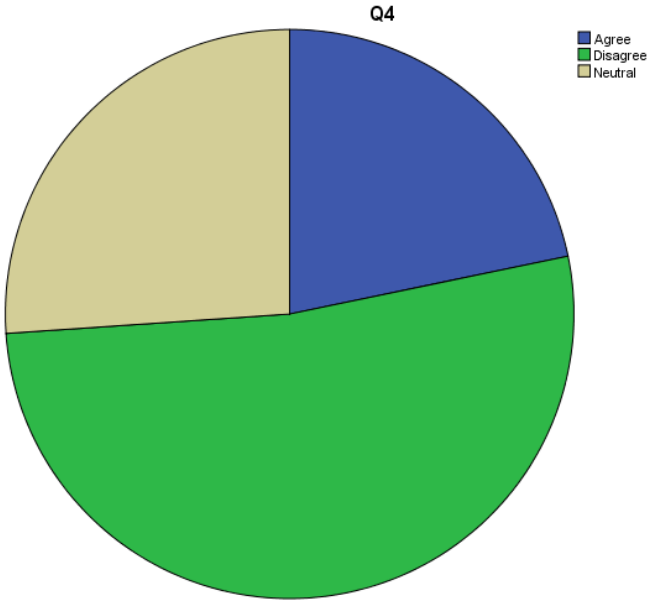


Q2: Having only verbal communications available decreases communication effectiveness.

APPENDIX D (CONT.)



Q3: Having the option to communicate textually would aid in communication effectiveness.

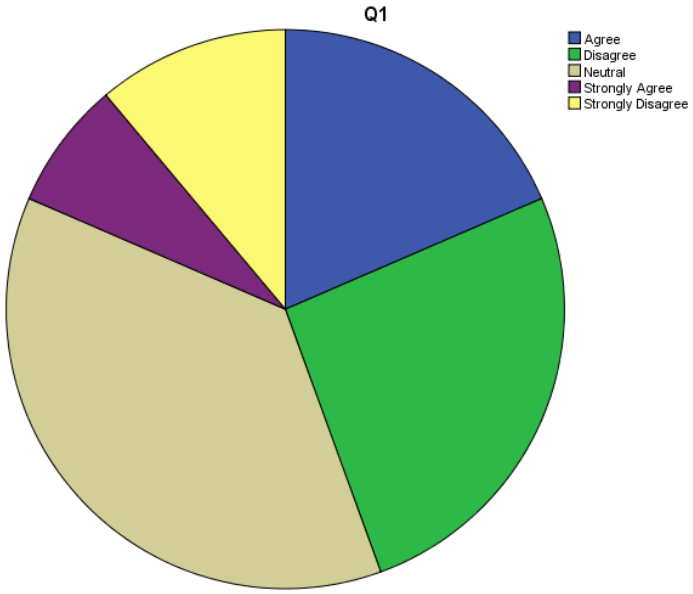


Q4: Using only verbal communications is the most effective means of communication.

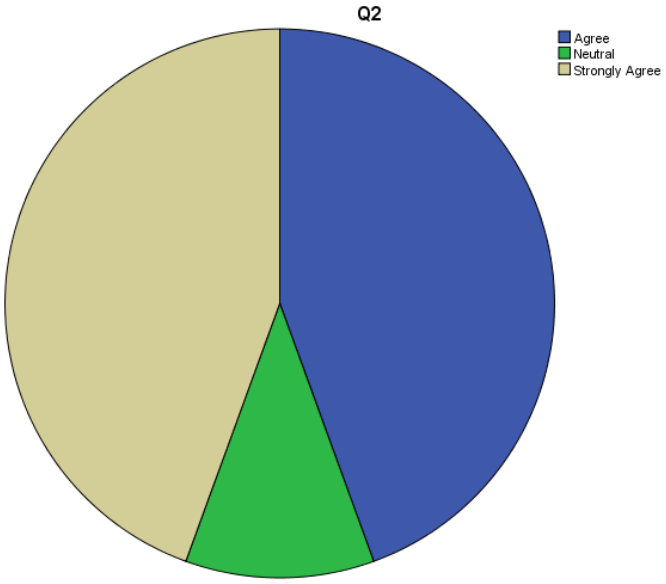
APPENDIX E

(R2) Likert Scale Response Analysis Delineated Via Pie Graph Illustration

Groups 4-6; Verbal and Textual Communication Capabilities

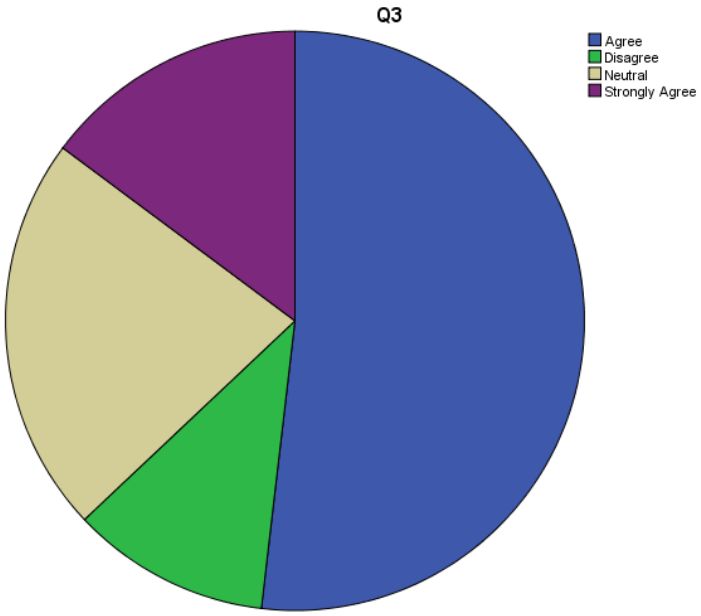


Q1: Textual communications prove to be the most effective means of communication.

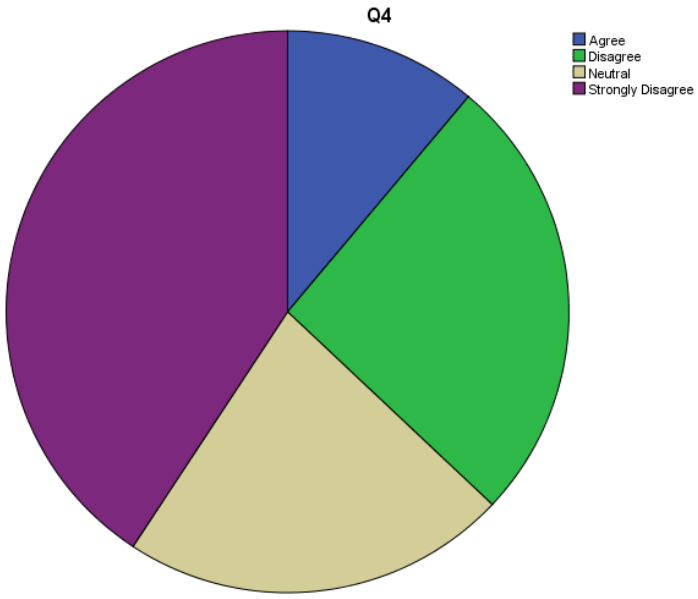


Q2: Verbal communications prove to be the most effective means of communication.

APPENDIX E (CONT.)

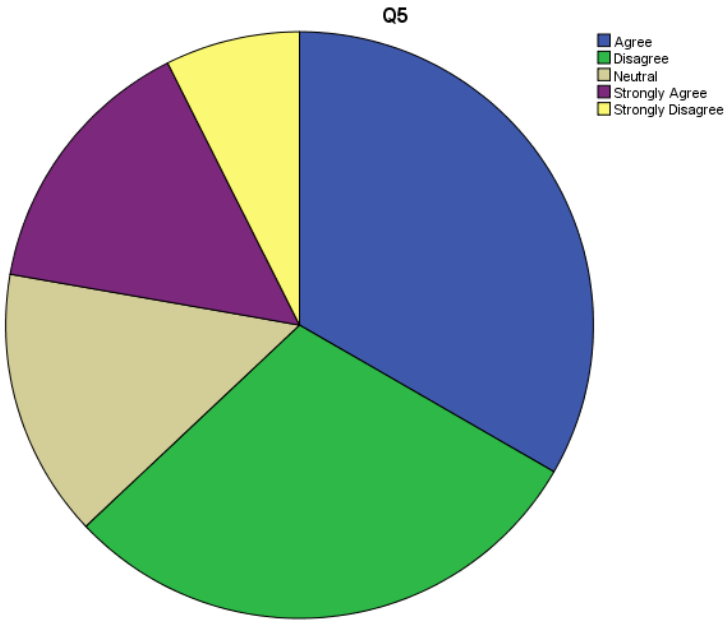


Q3: A 50/50 mix of verbal and textual communications proves to be the most effective means of communication.



Q4: Using only textual communications is the most effective means of communication.

APPENDIX E (CONT.)



Q5: Using only verbal communications is the most effective means of communication.

APPENDIX F

(R3): Open-ended Survey Data Coding and Theming for Groups 4-6

Question 1: In what way(s) do you feel that textual communication is more beneficial than verbal communication?

Team No.	Theme	Response
4	e	More concise
4	a	I feel that textual communication is not more beneficial than verbal communication
4	b,e	if a position is very busy and didn't get or misunderstand of what that person was saying then they can read off the text message
4	e,j,i	to decongest the verbal communications so that the person you are trying to speak with doesn't mishear you or be interupted
4	e	clear, precise communications, especially similar sounding flight numbers
4	c	Texting communication was not used during focus lab
4	c	I've never used the stuff, so don't ask me!
4	a	I don't feel that written is better
4	i	Textual communication is not an immediate interruption
4	e	It provides a clear understanding
4	a	I don't really think that textual communication is more benefical than verbal
5	c	When I was not busy.
5	d	Reference for later
5	b	In some situations, textual is the only way to get a message across
5	h,e	It helps with some people like me communicate with FOD2
5	d	You can go back and look at what was said
5	e,h,d	It is clear that remind other person what I need or what was information
5	e,d	Clarity, can always go back and recheck what was said to verify information was relayed properly
5	d	By matching lists that can be quick referenced multiple times
6	f,e	Quick and effective
6	g	It helps with multi-tasking and lets you think of issues more clearly
6	e,d	info is handed so you can look at it multiple times. It could be easier to understand or the writer could explain it better on paper
6	c	When talking/giving update to universal pilot
6	e	With specifics like flight numbers, then textual ensures accuracy
6	e	Easier to read. Easier to understand
6	a	I feel like the verbal communication is more benefical
6	f,h	When relaying info to the coordinator. It's easier than having to call him up and wait for him/her to pick up

Key	
Theme	Code
not more beneficial	a
during high workload periods	b
other	c
generates a referencable communication trail	d
texts are more concise/provides additional clarity	e
faster information relay	f
provides for more time for effective decisionmaking	g
relaying complex/information rich messages	h
fewer interruptions	i
aids in workplace noise reduction	j
addressing multiple people or groups	k
tone/inflection provides clarity/highlights importance	l
gaining an employee's attention	m
referencing a flight # or list of flight #s	n
communicating with someone in a different location	o
in an emergency	p
communicating with someone in the same location	q

APPENDIX F (CONT.)

Question 3: Provide an example of when text-based communication proved to be more effective than verbal communication.

Team No.	Theme	Response
4	c	ACARS
4	d,o	When communicating with the crew coordinator I was able to go back and check what was said during the conversation
4	d	everybody in their position can refer to their textual communication if they aren't able to hear verbaly
4	d	when it's not pertinent at the moment but will be on a later flight you will have it written down so you don't forget
4	c	getting details on kjax being ground stopped during sim
4	c	it was not used at all during lab
4	c	N/A
4	o	On mx action forms
4	c	I have no examples to provide
4	d,h	I could text the adjustments to the FOD2 coordinator
4	d	If something is in writing or text it is there permenantly to refer back to
5	g	was able to go through the line by line, check what isn't done
5	n	order of flight
5	j	In a busy loud room where you can't speak to someone while others are
5	d	Ira seems to think he can keep better track
5	c	when there was a maintenance delay
5	n	FOC is always busy so it is good to remind that which flight is requesting for release or it arrived
5	n	dealing with a long string of data i.e. multiple flight #'s
5	n	switching tail numbers for replacement a/c
6	o	when in separate locations
6	j	helps with noise and talking over everybody
6	g,h	for flight planning, it is better to write down all the details you could miss some details
6	o	when giving updates to universal pilot
6	c	I honestly can't think of one time. But I am biased towards verbal communication
6	a	None
6	c	I never used text in the lab
6	o	when trying to communicate with FOD2 coord

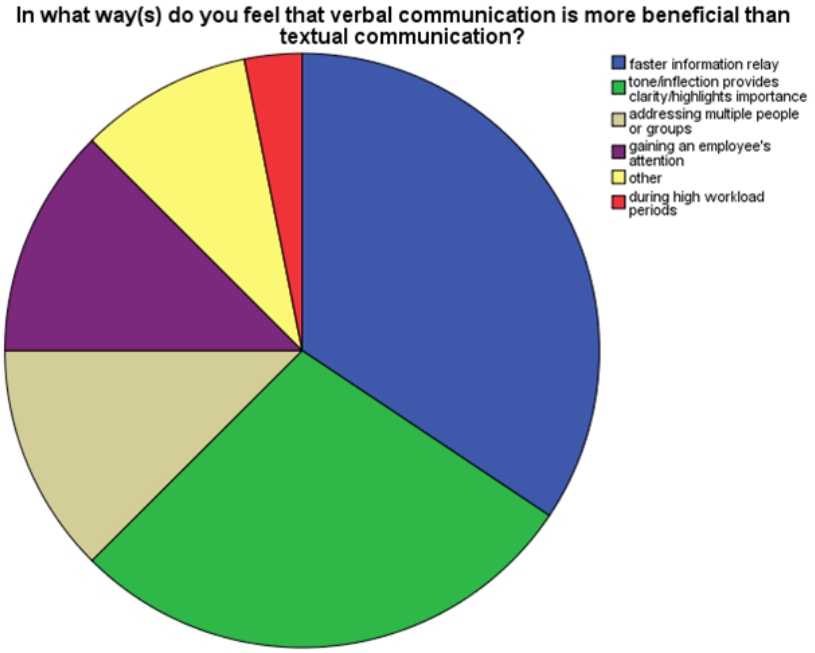
Key

Theme	Code
not more beneficial	a
during high workload periods	b
other	c
generates a referencable communication trail	d
texts are more concise/provides additional clarity	e
faster information relay	f
provides for more time for effective decisionmaking	g
relaying complex/information rich messages	h
fewer interruptions	i
aids in workplace noise reduction	j
addressing multiple people or groups	k
tone/inflection provides clarity/highlights importance	l
gaining an employee's attention	m
referencing a flight # or list of flight #s	n
communicating with someone in a different location	o
in an emergency	p
communicating with someone in the same location	q

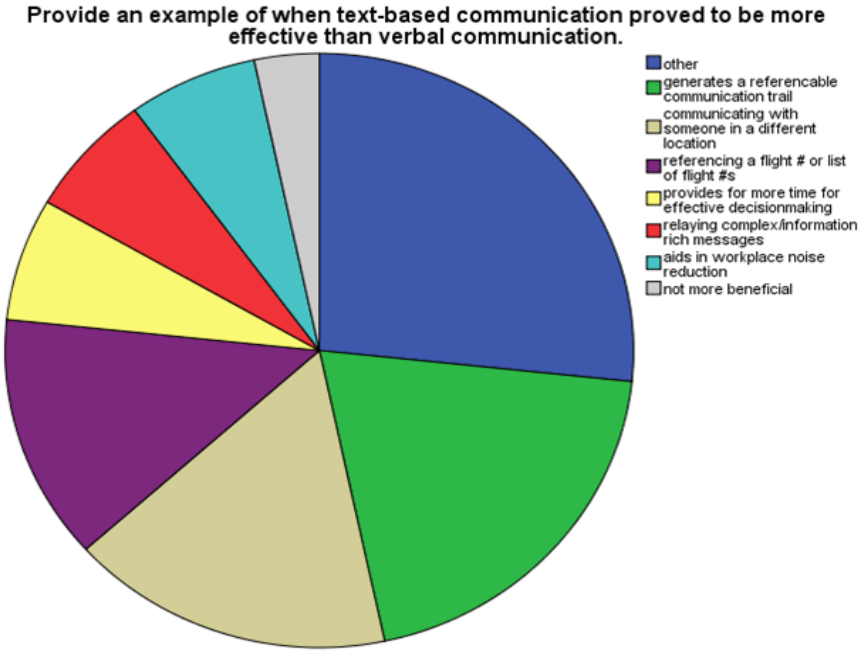
APPENDIX G

(R3) Frequency Analysis; Graphical Representation

Q1



Q3



APPENDIX H

(R4): Open-ended Survey Data Coding and Theming for Groups 1-6

Question 1: What can be done to improve verbal communications in an airline operations center such as the FOCUS lab?

Team No.	Theme	Response
6	a	make sure everything is working
6	c,j	everybody takes their turn on speaking, then nobody is talking over any one else
6	c	be alert and listen to each other
6	h	I don't really know of any, our team was most successful using verbal comms
6	h	allowing each position to be able to hear all communications, that way everyone is on the same page
6	l	none, communications were pretty good
6	d	CRM (Crew Resource Management)
6	l	Not much, We are all in the same room so verbal comms are pretty good
5	b	table positioning
5	a	better reliability
5	b	better visuals and forms of direct communication
5	a,f	mics should operate better
5	h	people would rather utilize technology, so if there was less technological ways to communicate, verbal communicationwould increase
5	c	speaking manner and sometimes peron to person is better than talk with Skype
5	a	more reliable technology
5	d	SOPs in regards to releasing an a/c based on position
4	e	more workers
4	l,b	since everyone is so close in the lab, verbal communication is almost perfect
4	f	headsets are better to avoid people from shouting or talking across the room
4	g	knowing persons name and position
4	c	trying to use precise, clear language. Respect if need be.
4	l	I feel that the communications are good
4	a	I think skype should be operational at all times
4	c	Please make sure each person recognizes in a timely manner the people talking to them. It's just polite
4	f	Better understanding of headset system
4	f	it would be more beneficial if all of our headsets were connected
4	h	landlines with speed dials or shortcut buttons to connect more quickly with little effort so we can stay focused on our duties
3	a,f	need to get the microphone system working better initially
3	i	being able to see what they are currnetly working on intead of asking
3	a,f	better comms between focus lab and CRJ sim (headset)
3	j	keep the chit chat down to a minimum
3	f,k	relay to teams the importance of open comms (headset)
3	a,f	Fix the mics
2	c,j	Allow one person to talk at one time. Make sure communicators acknowledge each other. Repeat messages back.
2	h	Don’t know
2	d	to avoid confusion, a set nomenclature would assist in communication information. This would allow everyone to understand the context
2	a	The technology could have been more reliable throughout the sim
2	a,f	It seems if the comm equipment worked better, things would go smoothly
2	c	I feel like the people "playing" as pilots with problems in flight and Admin are condescending when they talk to me not collaborative
2	k	Practice along team lines
1	g	Learn names to better communicate, be bold and concice
1	d	Learn exactly what needs to be communicated to save words and time
1	f	better bluetooth hands free communication
1	h	Use more texting since it is so loud
1	b	Have some way to look at the person you are talking to, like skype video feed
1	k	Hands-on training
1	a,f	The Skype system could be updated, and the positions woulde be a lot easier to contact. And/or use cellphones to speak with the other CRJ pilots
1	f	From a ramp tower position adding a headset connection to FOC would help tremendously.
1	c	When someone speaks, have confidence, make eye contact, and don't wait. A lot of what happens in here needs to be communicated quickly
1	b	Video calls instead of just audio

APPENDIX H (CONT.)

Key	
Themes	Theme Code
Properly Functioning Equipment	a
location/positioning/ close proximity	b
Concise tone/common language/etiquette	c
following SOPs	d
additional employees	e
streamlined headset use and functionality	f
familiarity with personnel	g
Other	h
Screen share	i
mimize excessive chat	j
Additional training	k
nothing	l
Texting	m
Pre-sim briefing	o
Following a set flow of information (by FOC)	p

APPENDIX I

(R4) Frequency Analysis; Graphical Representation

Q1