Author: **Fultz, Aaron S.**

Title: ***Use of Technical Communication Prepared by Science and Engineering Consultants***

The accompanying research report is submitted to the **University of Wisconsin-Stout**, **Graduate School** in partial completion of the requirements for the

Graduate Degree/ Major: MS Degree / Technical and Professional Communication

Research Advisor: Dr. Gregory Schneider-Bateman, Assistant Professor

Submission Term/Year: Spring 2018

Number of Pages: 53

Style Manual Used: American Psychological Association, 6th edition

☒ **I have adhered to the Graduate School Research Guide and have proofread my work.**

☒ **I understand that this research report must be officially approved by the Graduate School. Additionally, by signing and submitting this form, I (the author(s) or copyright owner) grant the University of Wisconsin-Stout the non-exclusive right to reproduce, translate, and/or distribute this submission (including abstract) worldwide in print and electronic format and in any medium, including but not limited to audio or video. If my research includes proprietary information, an agreement has been made between myself, the company, and the University to submit a thesis that meets course-specific learning outcomes and CAN be published. There will be no exceptions to this permission.**

☒ **I attest that the research report is my original work (that any copyrightable materials have been used with the permission of the original authors), and as such, it is automatically protected by the laws, rules, and regulations of the U.S. Copyright Office.**

☒ **My research advisor has approved the content and quality of this paper.**

STUDENT:

NAME: Aaron S. Fultz **DATE: 05/09/2018**

ADVISOR: (Committee Chair if MS Plan A or EdS Thesis or Field Project/Problem):

NAME: Dr. Gregory Schneider-Bateman **DATE: 05/10/2018**

This section for MS Plan A Thesis or EdS Thesis/Field Project papers only

Committee members (other than your advisor who is listed in the section above)

1. **CMTE MEMBER'S NAME:** **DATE:**
2. **CMTE MEMBER'S NAME:** **DATE:**
3. **CMTE MEMBER'S NAME:** **DATE:**

This section to be completed by the Graduate School

This final research report has been approved by the Graduate School.

Director, Office of Graduate Studies: **DATE:**

Fultz, Aaron S. ***Use of Technical Communication Prepared by Science and Engineering Consultants***

Abstract

The key objectives of this study are to identify how clients of a global science and engineering firm use the technical communication they receive from the consultancy and to determine how closely that use matches the expectations of the consultants who develop and deliver the communication. More specifically, the research attempts to ascertain the types and frequency of technical communication received by the clients, what they generally consider most important within the communication, how they transfer (parse, repurpose, and/or share) the communication, and how often they look at and transfer such communication. In turn, the science and engineering consultants were asked their understanding of how clients might respond to the preceding inquiry. The answers from clients and consultants are then compared to identify gaps or deficiencies in the consultants' understanding of what modes of communication delivery work best for clients, or are at least which are preferred, and how technical communication developed by the science and engineering consultants can be altered to better meet client needs.

Acknowledgments

My immediate thanks go to Dr. Gregory Schneider-Bateman and Dr. Julie Watts for their advice during the planning and documenting of this study and to Daryl Hockley for championing the study at SRK Consulting. As this work is a capstone to my MSTPC studies, thanks also to professors Cody Reimer, Daisy Pignetti, Genesea Carter, Gregory Schneider-Bateman, John Spartz, Julie Watts, and Kate Edenborg for preparing challenging coursework and for exceptional teaching during my time at UW-Stout. Finally, loving thanks to my partner-in-life, Javi, for supporting me along the way and to my chihuahua, Chiquita, for always running to greet me no matter how late I came home from studying.

Table of Contents

Chapter I: Introduction

SRK Consulting provides independent consulting services to the earth and water resource industries. The company was established in 1974 and employs over 1,400 professionals in 45 offices across six continents. Consultants within the organization are mostly scientists and engineers who provide a range of advice and solutions in disciplines such as geo-environmental, geology, and water management, as well as civil and mining engineering. They carry out their work by conducting field or desktop studies and then documenting their findings and recommendations in a variety technical communication, such as reports, memos, and presentations. This material is supplemented by statistical and three-dimensional modelling, geographical mapping, and drafting.

The audiences for the above communications, i.e., SRK's clients, include professionals and staff in management, field operations, regulatory governance, accounting, finance, and, of course, science and engineering. Clients rely on the technical communication SRK's produces to make critical business and operational decisions and to manage earth and water resources.

Statement of the Problem

In general, the work that goes into the technical communication that SRK produces follows a standard scientific investigation pattern and writing format: introduction, methodology, results, and discussion (IMRD). However, as a technical communication specialist at SRK, I am seeing evidence clients do not assimilate the information within reports, memos, and presentations according to this pattern. They appear to cherry-pick or parse information, suggesting the long form deliverable in IMRD (or similar) format—although a viable investigative pattern and means of documentation—may not be as user centered as it could (or should) be.

My sense is this is happening for two reasons. First, technologies are more readily available that make it easier to develop and deliver information in more accessible ways (e.g., video, infographics, and data visualization software), which is an idea supported by Groarke's (2015) discussion of growing trends toward multimodal argumentation. Second, there appears to be an increasing intolerance for long form communication especially among generations who have grown up with these technologies, which can be inferred from Buehl and Benson (2016).

Purpose of the Study

The purpose of this study is to (a) compare client versus consultant understanding of how clients use technical communication prepared by science and engineering consultants at SRK and (b) identify client needs relative to communication structures and modes. To this end, I will analyze the results of the study to formulate recommendations for SRK to consider relative to enhancing the technical communication they produce for their clients.

Assumptions of the Study

The following assumptions were made relative to carrying out this study:

1. Survey participants are clients of or consultants at SRK Consulting.
2. Participants will answer questions honestly and to the best of their ability.
3. Participants have a sincere interest in the subject of the study.
4. The number of participants will be enough from which to draw reliable conclusions.

Definition of Terms

The terms below will be used in this report and are defined as follows for the purposes of this study:

Multimodal communication. Communication that relies on more than one mode of communication (e.g., textual, linguistic, or visual forms) to convey an argument.

Structural pattern. A method of segmenting and organizing content such as the standard scientific pattern of introduction–methodology–results–discussion or IMRD.

Limitations of the Study

Because the surveys that formed the basis of this study were anonymized, there is no way to confirm the accuracy of the answers provided. However, the study assumes the client and consultant participants are qualified to respond to the surveys based on their usage and authorship of technical communication, respectively, which is the primary subject of this study.

Methodology

The balance of this report begins with a literature review that highlights other research relevant to this study and the main themes that guided the analysis. The literature review is followed by the methodology used to carry out the study including the instrumentation and data collection procedures used and data analysis approach. Next are the results, which were documented using the survey data found in the appendices. The results are followed by the discussion, conclusions, and recommendations chapter.

Chapter II: Literature Review

Keeping in mind the general subject of science and engineering communication, this study pulls from two main themes found in the reviewed literature: structural patterns and multimodal argumentation. There appears to be a disconnect between the pattern SRK Consulting generally uses to structure its technical communication in (i.e., in introduction–methodology–results–discussion or IMRD) and how clients assimilate, use, and transfer that information. This disconnection suggests a deliverable in the IMRD format may not be user centered (i.e., rhetorically focused). Further, a deliverable that is not only rhetorically focused but also multimodally focused (i.e., one that includes visual, numeric, and textual content, for example) would more closely match the client use case.

It is true that science and engineering communication generally uses multiple communication modes; however, the literature suggests the modes used are not always well integrated, i.e., they are not connected thus weakening the argument they are intended to support. Further, this idea of disconnectedness reveals itself as a subtheme throughout the structural pattern and multimodal argumentation themes. Not unlike the disconnectedness between science and engineering communication and client use of that communication, we discover a disconnection among structural patterns, between technical communication and its practical application, and between communication modes.

Structural Patterns

Structural patterns (e.g., IMRD) can inhibit rhetorical thinking when authoring content, but they can also assist rhetoric by helping authors segment and organize content.

How structural patterns can inhibit rhetoric. On the surface, structural patterns (e.g., IMRD) in science and engineering communication appear to be rhetorical. They are, after

all, intended to provide a framework in which technical communicators can place content in a way that is self-supporting and meaningful to the intended audience. However, such prescriptions can, unintentionally, squelch rhetoric as suggested by Lin and Evans (2012). These authors analyzed major structural patterns within empirical research articles. They found that the IMRD pattern, while conventional, is by no means the default pattern; other macro-structures are more readily used in science and engineering. In fact, ILM[RD]C and IM[RD]C—where L is literature review, [RD] is combined results and discussion, and C is conclusions—are more common in science and engineering writing. Yet, Lin and Evans suggested these types of structural patterns may be desirable by science and engineering authors because the patterns limit the scope of discussion to keep the content or length of material in check. In addition, the structural patterns can subsume information causing incomplete, under-represented, or even inaccurate messaging.

Even worse, these patterns can strain the reader according to Wolfe (2009), who analyzed how technical communication instruction within engineering textbooks matches up or doesn't match up with the types of content engineers are expected to produce in the field. For example, she uncovered the need to emphasize (effectively) visual and numerical data within engineering writing instruction to bring it in line with the types of material being produced in field. In other words, where science and engineering clients are wanting clear connection with and explanation of visual material but don't receive it; therefore, the material becomes straining. Part of the problem, as Wolfe puts it, is science and engineering writing instruction and the authors themselves are not keeping up with communication trends such as advanced data visualization approaches; the instruction and authors seem focused on (if not stuck on) the structural patterns. Some of these patterns, like IMRD, as Lin and Evans (2012) point out emphasizes discrete

sections, but separating discussion from results can inhibit context for the reader and can be significantly straining as a result.

Each of these cases indicates a disconnect in some way between the science and engineering writers and their audiences. It may be that rhetorical approaches are limited in science and engineering writing; hence, the need for SRK's clients to cherry pick and parse the technical communication they receive consultants.

How structural patterns can assist rhetoric. On the other hand, structural patterns can assist rhetoric if taught and employed as starting rather than end points. Lin and Evans' (2012) showed that structural patterns are evolving albeit slowly. Permission must be granted and a willingness must exist to "customize" structural patterns to fit a given rhetorical situation.

Warnock and Kahn (2007) explored how this might be done. They proposed that engineers view writing as an audience-driven pursuit and most often miss the opportunity to engage writing to express and explore (i.e. to think and plan). This disconnect is understandable given technical communication instruction focuses the writer on audience, but engaging in non-structured writing opens the door to communication that is more rhetorically grounded. Warnock and Kahn's brand of writing is "expressive/exploratory technical writing" or XTW. In this approach, structural patterns are not the focus, rather using writing as a means of invention to learn and understand what the science and engineering writer needs to deliver to the audience. Writers, according to the authors, are motivated because within XTW there is something in it for the writer (learning, understanding, and planning). Perhaps, Warnock and Kahn fall short in their article because they do not connect XTW with audience needs in the end, although one assumes the intention is there for science and engineering consultants to do so.

Wolfe, Britt, and Alexander (2011) are more explicit in their approach. They studied how sentence combining and pattern practices, which are pedagogical strategies, may help engineering students learn to write more effectively. They showed that by employing such strategies in writing education and combining them with structural patterns raised students' rhetorical awareness, i.e., they value what their audiences value in terms of content.

Whether it's developing an ongoing awareness of trends in technical communication (Lin and Evan, 2012), "tossing out" structural patterns at first at least (Warnock and Kahn, 2007), or providing more fundamental rhetorical strategies, science and engineering writers' rhetorical awareness can be enhanced. Doing so would mitigate the disconnectedness that seems apparent between science and engineering communication and client needs. Part of that awareness, however, needs to be grounded not only in how clients assimilate and use technical communication—which may or may not be according to a structural pattern—but also the formats and delivery options that best accommodate client needs and uses of the technical communication they receive. Those options are part and parcel with multimodal argumentation.

Multimodal Argumentation

Buehl and Benson (2016) wrote about the pros and cons of constructing arguments using multimodal rhetoric within scientific discourse. Ultimately, they concluded multimodal arguments with their combination of objects and explanation increase audience adherence to claims made within arguments. The authors define multimodal argumentation as "rhetoric that accounts for the complete range of representation resources activated as means of persuasion" (p. 15). According to Groarke (2015), these resources or modes (e.g., linguistic, visual, or numerical representations) are parts of argument and their "ingredients" are things like lists, graphs, and data, respectively. Groarke (2015) provided a method for identifying the structure of

multimodal arguments and how these modes can be used to establish the meaning and interpretation of a problem. He also cautioned the visual modes of argument may be more susceptible to implication and thus manipulation (more on that later).

The primary purpose of communication modes is to support claims (i.e., modes are evidence) according to Whithaus (2012). He explored how claim-evidence argumentation within science writing is shaped not only by linguistic, but also numerical and visual communication forms. He concluded the models of argumentation should be updated to account for these multimodal communication forms within claim-evidence patterns (e.g., IMRD) and should filter through to technical communication pedagogy and research. Whithaus also recognized that modes can influence structure although not at a macro-level. For example, data commentary must be placed near the visual material it is discussing.

To that end, Nordrum and Eriksson (2014) presented their findings on the disconnection between visual material within technical communication and related data commentary. While providing a rhetorical model to address the problem, they recognized that often pedagogical discourse ignores such instruction. Similarly, Buehl and Benson (2016) noted visual material has the potential to produce misinformation, a false sense of security in information, or worse both. As an example, the authors suggested that to prove an animal is not going extinct one need only introduce a living example of that animal. On the surface, it may appear all is well, but what if that is the only living member of that species? Hence, multimodal communication relies on the interplay among modes to provide claim and evidence to sufficient degree.

As well, it is the precise potential for intentional or unintentional manipulation of visual argument, Buehl and Benson (2016) said, that causes anxiety among instructors of science writing, visual argumentation, and the like. Yet, according to Nordrum and Eriksson (2014), very

few studies or textbooks focus on resolving these issues. They suggest part of the responsibility, however, lies with students of technical communication / multimodal rhetoric. Students must seek out peer review and continually assess the quality of their data and, most importantly, its representative forms. Nothing is more serious, they suggest, than the quality between the linguistic claim and its visual evidence.

While cautions in multimodal rhetoric exist, it has the potential for delivering salient information in a variety of connected forms (e.g. video which has visual and auditory elements). Buehl and Benson (2016) and Groarke (2015) call for research and practical norms for multimodal rhetoric on par with its linguistic counterpart. Further, the outcomes of that research and those norms should be transferred to science and engineering as well as technical communication pedagogy, which includes continual assessment of the delivery technologies of multimodal rhetoric.

Final Remarks on the Literature

The literature reviewed was developed within the last decade and focused not only on the themes of structural pattern and multimodal rhetorical within science and engineering communication (or one or the other). They also focused on science and engineering pedagogy, argumentation, and the interplay between claim and evidence. These themes and ideas within the literature along with the subtheme of disconnectedness guided this study.

Chapter III: Methodology

This chapter covers how subjects were selected and provides a general description of each participant group (i.e., client- and consultant-participants). It will then cover the data collection instrument that was used in the study, followed by related procedures and the analysis approach as well as limitations of the study.

Subject Selection and Description

To study how SRK's clients use technical communication received from science/engineering consultants compared to how those consultants think it gets used, I prepared an online survey for delivery to several clients and another survey to as many of SRK's consultants who were willing to participate. These participant groups were ideal for the study because they either (a) receive technical communication from science and engineering consultants regularly or (b) develop technical communication within science and engineering regularly for clients. Otherwise, no other selection criteria were intentionally applied and no populations are known to have been excluded from the study.

As no self-identifying information was collected, it is impossible to detail the general demographics of each participant group. However, as I am generally familiar with those who may have participated, especially the consultant group, it can be assumed participants included males and females of varying races and ethnicities, who were likely between 22 and 70 years old. (The latter of which can be inferred from responses to Question 2 regarding number of years of work experience.) In addition, it can be stated that client-participants work at mining and exploration companies, environmental service organizations, and governmental departments and agencies.

Instrumentation

Data collection was carried out through two surveys: one for client-participants and the other for consultant-participants. The surveys were virtually identical; however, questions were worded to suit each participant group as needed. For example, the first three questions on education, work experience, and expertise generally applied to both participant groups, while the remaining questions required revisions. To illustrate these revisions, Question 4 posed to clients read "How often do you *receive* technical communication of any type *from science/engineering consultants*?". That same question posed to consultants read "How often do you *send* technical communication of any type *to clients*?". The italics show the wording specific to each group.

I prepared the survey questions with input from senior consultants and research advisors from UW-Stout to capture quantitative and qualitative data. Five were open-ended questions, six were closed-ended, and four were mixed open- and closed-ended. After the first three generally applicable questions mentioned earlier, three questions focused on general use of technical communication. The remaining nine questions focused on a specific genre of technical communication chosen by each participant based on which type of communication they engaged with most often (namely, "complete report," "high-level summary," "presentation," or "technical memo").

The surveys were delivered using SurveyMonkey.com and the questions developed for each survey can be reviewed in the appendices.

Data Collection Procedures

Consultant-participants were invited to respond to their survey via SRK email or internal social media (i.e. Microsoft Yammer®). Client-participants were identified and invited either via email or in-person directly by SRK consultants who expressed interest in the study.

Neither survey asked for any self-identifying information, which assured participants their names would not be available in survey data or results. Client- and consultant-participants were asked to take the survey via web browser. It is assumed each participant was alone when taking the survey, meaning no communication about the survey encouraged group participation. No specific conditions were required other than a computer and an Internet connection. According to SurveyMonkey.com, the client survey took on average 13 minutes to complete and the consultant survey took on average 7 minutes to complete.

All data from client and consultant surveys were captured in the SurveyMonkey.com platform. SurveyMonkey.com employs several privacy shields including data and URL security and encryption. All surveys are also password protected. The data and results are accessed from my work computer, which requires authentication from me. When data is exported and removed from SurveyMonkey.com, it will be maintained on a password-protected Microsoft SharePoint Online® site owned by SRK, but the data will remain anonymized.

Data Analysis

Data was collected, compiled, and compared to assess information in line with the study's goals, which are (a) to compare client versus consultant understanding of how clients use technical communication prepared by science and engineering consultants and (b) to identify client needs relative to communication structures and modes.

To this end, I noted key patterns and connections among the results, which I later used to formulate ideas and recommendations for SRK to consider in order to improve the technical communication they produce for their clients. As well, qualitative responses were analyzed and codified. The latter exercise allowed me to categorize the results so they could be evaluated qualitatively. For example, in Question 3, participants were asked to input their primary field of

expertise. I assessed their answers collectively, identifying similarities and codifying each answer as either “Business,” “Engineering,” or “Science.” This allowed me to count the number of professionals in a given field and evaluate subsequent answers based on field type, as needed. This was my primary approach to analyzing the data from both surveys and allowed for effective comparison between two.

Limitations

While I believe the results of this study to be helpful to SRK and ultimately to its clients, some limitations are worth noting.

Given the participants were restricted to SRK consultants and clients, the results may have limited applicability outside of those groups. However, the findings might be generally applicable to other groups with similar interactions around technical communication.

The number of participants in the client and consulting groups varied widely: 20 versus 100, respectively. As a result, comparatively, the consultant survey seemed to produce more granular data. For example, no clients indicated receipt of presentations from consultants leaving related gaps in their data compared to consultant responses, which does have presentation data.

Finally, because the surveys were completely anonymized, no follow up on responses for clarification or further study is possible. However, the results could lead consideration of additional avenues of research that may be used for follow-up studies in the future.

Chapter IV: Results

The results documented in this chapter come from two virtually identical surveys that I conducted between March and April 2018. Both surveys contained the same 15 questions, with slightly different wording to accommodate their respective participant groups. Twenty clients and one-hundred consultants responded. The client survey had a 100% completion rate, and the consultant survey had an 87% completion rate.

Appendices A through O list quantitative results for each question. For ease of comparison, each appendix contains client and consultant responses. Questions 1 to 3 (Appendices A, B, and C) focused on participant demographics. Questions 4, 5, and 15 (Appendices D, E, and O) asked each participant group for general information about the technical communication they receive or send. Question 6 (Appendix F) required participants to identify the most common technical communication they receive or produce from four genres: complete report, high-level summary, presentation, or technical memo. Questions 7 to 14 (Appendices G to N) then proceeded to ask participants questions relative to the genre they identified.

In similar fashion, I have grouped the results under three subsections within this chapter: demographics, general feedback, and genre-specific feedback. In each subsection, I compare client and consultant responses highlighting results that may help inform the purpose of this study, which is to (a) compare client versus consultant understanding of how clients use technical communication prepared by science and engineering consultants and (b) identify client needs relative to communication structures and modes. Chapter V provides a discussion of these results including conclusions and recommendations.

Demographics

Questions 1, 2, and 3 asked participants to identify three demographics about themselves: level of education, years of work experience, and primary field of expertise. Results for client- and consultant-participant groups for each demographic can be found in Appendices A, B, and C, respectively.

Client- and consultant-participants were similarly educated, with most holding bachelor's or master's degrees (33–50%). Both groups had about the same number of participants with associate's degrees or postsecondary diplomas (4–5%). However, consultant-participants held more than double the number of doctoral degrees (13% compared to 5% for clients).

Years of work experience were also about the same for both groups. Clients had about 10% more participants with 10 to 20 years of experience compared to consultants. However, consultants had 13% more participants with more than 20 years of experience.

The results also showed little difference between each group's areas of expertise. Clients had over double the number of engineers over scientists responding to the surveys (60% versus 24%), while consultants were more balanced between engineers and scientists (52% versus 38%). Business professionals were the least likely to respond to the surveys whether clients or consultants (10–15%).

General Feedback

Questions 4 and 5 (Appendices D and E) asked clients and consultants how often they received or sent technical communication and whether they preferred to view that communication printed out or on-screen. Question 15 (Appendix N) invited clients to provide their general comments, criticisms, or complaints relative to the technical communication they receive from science and engineering consultants. Consultants were asked to answer the same

question, but relative to the technical communication they see from other scientists and engineers.

Responses from both participant groups (Question 4) indicated most technical communication is sent and received weekly. Clients indicated 60% of the communication from science and engineering consultants is received weekly. Consultants indicated 44% of the time they send out technical communication weekly. Otherwise, for both groups, technical communication was received or sent out daily or monthly with similar frequency.

Clients mostly like to view the communication on-screen (63%) verses printed out (37%), according to their responses to Question 5. Consultants believed their clients preferred on-screen viewing to printing-and-viewing (67% to 33%, respectively).

In Question 15 (Appendix O), clients and consultants had a lot to say about the technical communication they receive and/or view. However, I was able to codify their feedback (i.e., "comments, criticisms, and complaints") into three categories: content, function, and writing. Feedback on content focused on issues like structure and length. Feedback on function focused on interaction with technical material such as searching. Feedback on writing focused on communication quality such as conciseness. Clients and consultants commented on content (57% and 38%) and writing (71% and 50%) more frequently than on the function of technical communication (21% and 10%). The following three paragraphs contain representative comments from clients and consultants on all three categories.

Content. "Cutting and pasting material from other documents without enough scrutiny affects the logic of a statement" (client). "The era of writing the whole scientific method of introduction, methods, results, and discussion is over" (consultant).

Function. “Figures that can't be read” (client). “Limited opportunity to use 3-D interactive information in documents” (consultant).

Writing. “Some information contained within recommendations and conclusions is not supported, other than by the author's opinion” (client). “Information should be prioritized in terms of relevance to the client to fulfill their needs” (consultant).

Genre-Specific Feedback

Question 6 (Appendix F) showed clients receive complete reports and technical memos from consultants most often (45% and 50%) and consultants agreed (33% and 48%). However, consultants said they send high-level summaries twice as many times as clients said they received them (10% versus 5%). Further, consultants stated they sent clients presentations 9% of the time, but clients indicated they did not received presentations at all.

Clients indicated in Question 7 (Appendix G) they were more likely to receive complete reports monthly or quarterly (both 33%) and weekly (22%). Clients received technical memos with slightly higher frequency but still weekly (50%) and monthly (40%). Consultants mostly seem to agree, indicating they send complete reports, high-level summaries, and technical memos weekly and monthly (40–45%). The exceptions were complete reports, which were sent on weekly basis less frequently (13%). Moreover, while clients indicated they did not receive presentations, consultants indicated they deliver presentations weekly (63%) and monthly (25%).

Question 8 (Appendix H) focused on how clients used each of the four technical communication genres they could choose from in the survey (i.e. complete report, high-level summary, presentation, and technical memo). Across all genres clients favored viewing and transferring content in summaries, conclusions, results, and figures. This is not to say clients did not use the introduction, methodology, results, discussion, tables, and supporting material. They

did; however, they mostly viewed them once but did not transfer them for use by someone else. Consultants generally agreed with these findings, which also held true for presentations (although there is no client data regarding presentations).

As the previous question indicated clients most often viewed and transferred technical received from science and engineering consultants, it is no surprise in Question 9 (Appendix I) clients stated they frequently transferred content from all genres of information. Consultants perception tended to agree although roughly half believed clients viewed and transferred information “frequently” and the other half only “sometimes.”

Clients also indicated in Question 10 (Appendix J) that they most often transferred technical communication to others “as is with a written summary or excerpt.” Consultants tended to agree except regarding complete reports, which they believed clients transferred “as is.”

In Question 11 (Appendix K), clients indicated they mostly transferred technical complete reports, high-level summaries, and technical memos to other staff members and other science and engineering consultants (67–100%). Complete reports were also transferred heavily to regulators (56%). Clients also transferred to site personnel complete reports (44%) and technical memos (50%) regularly. There was less emphasis on transferring technical communication to external stakeholders. Consultants tended to agree, adding they believed presentations were mostly transferred by clients to other team members (53%), other consultants (50%), and site personnel (75%). The one notable exception was consultants believed all genres of technical communication were regularly delivered to regulators (40–64%); however, this held true on for complete reports not the other genres.

Question 12 (Appendix L) asked clients whether they thought the recipients in Question 11 used the technical communication from science and engineering consultants

different to how the clients themselves used it. They overwhelmingly indicated they did for all genres (67–100%) except for presentations, which was not selected in the study by clients. Consultants agreed with clients for complete reports (59%) and technical memos (72%). Consultants indicated those who were transferred high-level summaries or presentations used them the same way clients did (70% and 71%, respectively). The following paragraphs are representative comments from clients or consultants on all three categories.

Client comment sample. "Yes, they use it differently. If I'm a project team member, I often use high-level summaries to support my strategic and tactical decision-making on a scope that I'm responsible for delivering. Senior recipients typically have a review and risk assessment role, so they may just want to assess whether the issue is above a risk threshold and requires action on their part or below a risk threshold in which case they leave it to the project team to manage."

Consultant comment sample. "Yes, the client is normally the supervisor who needs to understand the problem and solution/recommendations. The site personnel read to understand how they can improve their work. Regulators would look to see if their tick box is ticked."

Question 13 (Appendix M) focused on what formats clients thought would improve use or transfer of technical communication prepared by science and engineering consultants. Most indicated Word, PowerPoint, and PDF worked fine: 44% for complete reports, 100% for high level summaries, and 70% for technical memos. Otherwise, presentations viewable by web browser and interactive information viewed by touch screen appeared to be desirable formats for delivery. Around 11% percent of clients indicated video was a viable delivery option form complete reports or technical memos. Consultants generally agreed Word, PowerPoint, and PDF

were adequate delivery formats. However, like clients, they also appeared to favor on-screen format viewing options for all genres including presentations.

Finally, Question 14 (Appendix N) asked clients and consultants how scientists and engineers might improve their technical communication. Answers varied widely, so I codified them into five categories: clarity (writing clarity), genre (other than complete report, high-level summary, presentation, or technical memo), length (amount of content), mode (linguistic, visual, or numerical representation), and structure (segmentation and organization of content). Clarity, mode, and structure had the highest number of suggestions for improvement. Among clients, clarity appeared to be the area of most concern followed by mode and structure about evenly. Among consultants, mode stood out slightly, followed by clarity and structure (in that order). The following paragraphs contain representative comments from clients and consultants on how to improve structure and mode of communication.

Structure. "Reams of boilerplate are not appreciated as it takes longer to digest the information" (client). "Keep it concise with details included as an attachment not in the main body" (client). "I think there is room to structure these documents to more easily target two very different types of audience" (consultant). "Report structure, clear concise language, TOC, Index, glossary, hyperlinks, referencing" (consultant).

Mode. "Figures are especially helpful in communicating complex information" (client). "3-D models available to view in screens" (consultant). "Graphical representation is more efficient than paragraphs and tables" (consultant). "Replacing text with figures, diagrams, flowcharts, photos, videos, and audio" (consultant). "An interactive version of the report, that enables a reader to quickly navigate through the issues in the reader's preferred order, would make our reports much more accessible" (consultant).

Chapter V: Discussion, Conclusions, and Recommendations

In this study, I set out to document how clients use the technical communication they receive from scientists and engineers at SRK Consulting. I also wanted to determine whether that use matched the expectations of the consultants who prepared it. A review of the literature relative to science and engineering communication revealed two themes important to this study: structural patterns and multimodal argumentation. With these themes in mind, I prepared and carried out two virtually identical surveys—one given to clients and the other given to consultants—with wording changes to suit each participant group. I then analyzed the surveys and documented the results within three categories: demographics, general feedback, and genre-specific feedback. In this section, I will briefly discuss key findings relative to client use and consultant expectations of client use as well as the general themes found in the literature, i.e. structural patterns and multimodal argumentation. Finally, I will provide key conclusions and recommendations based on this study.

Discussion

Although the clients who participated represent a relatively small number of SRK's total client base, I was surprised that no clients selected "presentations" as the most common type of technical communication received from science and engineering consultants. This is especially perplexing given 9% of consultants indicated presentations were the most common type of technical communication they produce. Perhaps, some explanation can be found in Buehl and Benson (2016) who lamented the struggle for multimodal argumentation in the sciences needs to gain full rhetorical value. If that's true, it is possible the client participants in the present study do not recognize presentations as technical communication as readily as they do textual forms like reports, memos, and summaries. However, it could simply be a misunderstanding of the question

in that presentations are “attended” and complete reports, high-level summaries, and technical memos are “received.”

Another interesting observation among the data relates to how clients transfer technical communication received from consultants to others. Between 60 and 67% of clients transfer a complete report or technical memo to others along with a written summary or excerpt. The fact that clients must so frequently create summaries of the technical communication they receive from consultants may indicate an inadequacy in the way the communication is structured. Lin and Evans (2012) indicated structural patterns like IMRD—a pattern almost always used in SRK reports and memos—while providing a framework for presenting content may cause authors to focus more on the structural pattern rather than audience needs. In other words, consultants may be delivering reports and memos in IMRD format, but what clients really need is something else entirely. For example, one client commented that instead of a report or memo, consultants should consider providing technical information in a case study format for conciseness. This breaks from traditional science and engineering structural patterns to focusing on audience needs by delivering information in a more appropriate genre for them—at least in some instances. Another client commented that the IMRD structural pattern in technical memos amounts to little more than a “block of words.” Instead, the client suggested memos should present an easy-to-follow narrative. Wolfe (2009) supports organizing content in this way, so content is easy to locate and understand, despite its structural pattern, if one exists.

I was disappointed to learn most clients and consultants felt Word, PowerPoint, and PDF were sufficient formats for delivery of technical communication. This was especially true for the two main genres SRK produces, the complete report and technical memo. I believe this strong hesitancy to adopt other formats of delivery (e.g. via web browsers or interactive touch screens),

speaks more to consultants' reliance on using text to explain visuals rather than equalizing the two to present a cogent argument. As evidence, more than twice as many clients and consultants prefer viewing technical communication on-screen as opposed to printing it out. Therefore, the aversion to formats outside the norm (i.e., Word, PowerPoint, and PDF), must be based on reasons other than format, whether they are known to the technical author or not. Establishing exactly what those reasons may be is outside the scope of this study. However, Whithaus (2012) may provide some explanation. He noted that textual, linguistic, and visual modes should work together to establish a claim and present related evidence. Moving away from this tried and true approach to argumentation presents risks because visual forms alone can be, as Buehl and Benson (2016) put it, easily manipulated, intentionally or otherwise. While Groarke (2015) generally agrees with these risks, he provides convincing arguments for using non-verbal modes of communication to present complete arguments. For example, he notes maps or photographs can provide more information than can be delivered in "a reasonably sized set of sentences" (p. 139). In the end, I sense the hesitation to adopt the multimodal forms of argumentation by clients and consultants comes down to the difficulty of connecting modes of communication to form an argument versus the familiarity of arguing textually with supporting figures, as is common practice in reports and memos in science and engineering communication.

Conclusions and Recommendations

The results of this study show how clients use technical communication produced by science and engineering consultants at SRK. The study also shows that consultants generally understand how their clients use the technical communication SRK produces. The problems clients seem to be having with our technical communication, indicated mostly through their comments, does not appear to be happening at a macro-level. In other words, clients seem

generally happy with the genres of technical communication and delivery formats. However, they appear to be less happy with the how arguments are formed, communicated, and supported.

To help resolve these concerns, I recommend consultants focus more on delivering clear, readily understandable arguments based on the needs of their clients as opposed to initiating technical communication solely on structural patterns as a default practice. For example, when planning a report, consultants should meet with clients to discuss how they plan to use and transfer the information. Then, design a structure for the communication deliverable around those needs. I also recommend experimenting with content delivery formats such as video, including animation and interactive presentations. Doing so naturally encourages multimodal and even non-textual argumentation. For instance, interactive infographics are ideal devices for communicating information found in a typical technical memo. Instead of the IMRD structural pattern, viewers can navigate to content that interests them within the infographic in the order that most appeals to them. Rather than relying on the textual mode of communication to present the argument, the interactive infographic can use visual, linguistic, kinetic, and audio modes to deliver the argument.

References

Buehl, J., & Benson, T. W. (2016). *Assembling arguments: Multimodal rhetoric and scienctific discourse (studies in rhetoric/communication)* . Columbia, USA: University of South Carolina Press.

Groarke, L. (2015, May). Going multimodal: What is a mode of arguing and why does it matter? *Argumentation, 29*(2), 133-155. doi:10.1007/s10503-014-9336-0

Lin, L., & Evans, S. (2012). Structural patterns in empirical research articles: A cross-disciplinary study. *English for Specific Purposes, 31*(3), 150-160.

Nordrum, L., & Eriksson, A. (2014). Data commentary in science writing: A discourse model for multimodal result presentation in science publication. *Academic communication in a digital age: Poster proceedings of the 2014 Languages for Specific Purposes Conference* (pp. 5-7). Stockholm: Department of English, Stockholm University.

Warnock, S., & Kahn, M. (2007). Expressive/Exploratory technical writing (XTW) in engineering: Shifting the technical writing cuuriculum. *Journal of Technical Writing and Communication, 37*(1), 37-57.

Whithaus, C. (2012). Claim-evidence structures in environmental science writing: Modifying Toulmin's model to account for multimodal arguments. *Technical Communication Quarterly, 21*(2), 105-128.

Wolfe, J. (2009, September 17). How technical communication textbooks fail engineering students. *Technical Communication Quarterly, 18*(4), 351-375.

Wolfe, J., Britt, C., & Alexander, K. P. (2011). Teaching the IMRaD genre: Sentence combining and pattern practice revisited. *Journal of Business and Technical Communication, 25*(2), 119-158.

Appendix A: Responses to Question 1

Client/Consultant

Which best describes your highest level of education?

Responses	Client	Consultant
Associate's Degree or Postsecondary Diploma	5%	4%
Bachelor's Degree	40%	33%
Master's Degree	50%	50%
Doctorate	5%	13%

Appendix B: Responses to Question 2

Client/Consultant

Which best describes your level of work experience?

Responses	Client	Consultant
Less Than 5 Years	0%	8%
5 to 10 years	20%	19%
10 to 15 years	25%	15%
15 to 20 years	25%	14%
More Than 20 Years	30%	43%

Appendix C: Responses to Question 3

Client/Consultant

What is your primary field of expertise? Examples include mine closure, geology, business management, geotechnical engineering, and so on.

Responses	Client	Consultant
Business	15%	10%
Engineering	60%	52%
Science	25%	38%

Appendix D: Responses to Question 4

Client

How often do you receive technical communication of any type from science/engineering consultants? "Technical communication" includes figures, memos, reports, presentations, and so on, but does not include primary (raw) data.

Consultant

How often do you send technical communication of any type to clients? "Technical communication" includes figures, memos, reports, presentations, and so on, but does not include primary (raw) data. A "client" is anyone you prepare technical communication for, directly or indirectly, outside of your organization.

Responses	Client	Consultant
Daily	20%	21%
Weekly	60%	44%
Monthly	20%	27%
Quarterly	0%	7%
Once or Twice a Year	0%	1%

Appendix E: Responses to Question 5

Client

Do you mostly like to print out the technical communication you receive from science/engineering consultants or view it on-screen?

Consultant

In your opinion, do clients mostly like to print out the technical communication you send them or view it on-screen?

Responses	Client	Consultant
Print It Out	37%	33%
View On-screen	63%	67%

Appendix F: Responses to Question 6

Client

Which best describes the most common type of technical communication you receive from science/engineering consultants?

Consultant

Which best describes the most common type of technical communication you send to clients?

Responses	Client	Consultant
Complete Report	45%	33%
High-Level Summary	5%	10%
Presentation	0%	9%
Technical Memo	50%	48%

Appendix G: Responses to Question 7

Client

How often do you receive a [Question 6 Response: All] from science/engineering consultants?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Daily	0%	0%	0%	10%
Weekly	22%	100%	0%	50%
Monthly	33%	0%	0%	40%
Quarterly	33%	0%	0%	0%
Once or Twice a Year	11%	0%	0%	0%

Consultant

How often do you send out a [Question 6 Response: All] to clients?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Daily	3%	20%	13%	7%
Weekly	13%	40%	63%	44%
Monthly	45%	40%	25%	44%
Quarterly	29%	0%	0%	4%
Once or Twice a Year	10%	0%	0%	0%

Appendix H: Responses to Question 8

Client: Complete Report

What parts of a [Question 6 Response: "Complete Report"] do you view or transfer and how often? "Transfer" means copying or summarizing content and/or sharing content with others for their use.

Responses	Do Not View	View Once	View and Transfer	Not Applicable
Summary	0%	33%	67%	0%
Introduction or Similar Context	0%	89%	11%	0%
Methodology	11%	56%	33%	0%
Results	0%	22%	78%	0%
Discussion or Interpretation	0%	33%	67%	0%
Conclusions	0%	22%	78%	0%
Recommendations	0%	22%	78%	0%
Figures	0%	22%	78%	0%
Tables	0%	33%	67%	0%
Supporting Material (e.g. Appendices or attachments)	0%	89%	11%	0%

Consultant: Complete Report

In your opinion, what parts of a [Question 6 Response: "Complete Report"] do your clients view or transfer and how often? "Transfer" means copying or summarizing content and/or sharing content with others for their use?

Responses	Do Not View	View Once	View and Transfer	Not Sure	Not Applicable
Summary	4%	14%	71%	7%	4%
Introduction or Similar Context	4%	50%	11%	32%	4%
Methodology	15%	37%	11%	33%	4%
Results	4%	32%	46%	14%	4%
Discussion or Interpretation	4%	42%	35%	15%	4%
Conclusions	0%	14%	82%	0%	4%
Recommendations	0%	7%	89%	4%	0%
Figures	0%	39%	43%	18%	0%
Tables	0%	46%	29%	25%	0%
Supporting Material (e.g. Appendices or attachments)	14%	46%	14%	25%	0%

Client: High-Level Summary

What parts of a [Question 6 Response: "High-Level Summary"] do you view or transfer and how often? "Transfer" means copying or summarizing content and/or sharing content with others for their use.

Responses	Do Not View	View Once	View and Transfer	Not Applicable
Summary	0%	0%	100%	0%
Introduction or Similar Context	0%	100%	0%	0%
Methodology	0%	100%	0%	0%
Results	0%	100%	0%	0%
Discussion or Interpretation	0%	100%	0%	0%
Conclusions	0%	0%	100%	0%
Recommendations	0%	0%	100%	0%
Figures	0%	0%	100%	0%
Tables	0%	100%	0%	0%
Supporting Material (e.g. Appendices or attachments)	0%	100%	0%	0%

Consultant: High-Level Summary

In your opinion, what parts of a [Question 6 Response: "High-Level Summary"] do your clients view or transfer and how often? "Transfer" means copying or summarizing content and/or sharing content with others for their use?

Responses	Do Not View	View Once	View and Transfer	Not Sure	Not Applicable
Summary	0%	10%	80%	10%	0%
Introduction or Similar Context	0%	44%	22%	33%	0%
Methodology	11%	44%	11%	33%	0%
Results	0%	0%	80%	20%	0%
Discussion or Interpretation	10%	30%	50%	10%	0%
Conclusions	0%	0%	90%	10%	0%
Recommendations	0%	10%	80%	10%	0%
Figures	0%	20%	50%	30%	0%
Tables	0%	30%	40%	30%	0%
Supporting Material (e.g. Appendices or attachments)	11%	44%	11%	33%	0%

Client: Presentation

What parts of a [Question 6 Response: "Presentation"] do you view or transfer and how often? "Transfer" means copying or summarizing content and/or sharing content with others for their use.

Responses	Do Not View	View Once	View and Transfer	Not Applicable
Summary	0%	0%	0%	0%
Introduction or Similar Context	0%	0%	0%	0%
Methodology	0%	0%	0%	0%
Results	0%	0%	0%	0%
Discussion or Interpretation	0%	0%	0%	0%
Conclusions	0%	0%	0%	0%
Recommendations	0%	0%	0%	0%
Figures	0%	0%	0%	0%
Tables	0%	0%	0%	0%
Supporting Material (e.g. Appendices or attachments)	0%	0%	0%	0%

Consultant: Presentation

In your opinion, what parts of a [Question 6 Response: "Presentation"] do your clients view or transfer and how often? "Transfer" means copying or summarizing content and/or sharing content with others for their use?

Responses	Do Not View	View Once	View and Transfer	Not Sure	Not Applicable
Summary	0%	0%	63%	25%	13%
Introduction or Similar Context	0%	50%	25%	13%	13%
Methodology	0%	38%	13%	38%	13%
Results	0%	13%	63%	13%	13%
Discussion or Interpretation	0%	14%	57%	14%	14%
Conclusions	0%	13%	75%	0%	13%
Recommendations	0%	0%	88%	0%	13%
Figures	13%	0%	88%	0%	0%
Tables	13%	13%	75%	0%	0%
Supporting Material (e.g. Appendices or attachments)	13%	38%	25%	13%	13%

Client: Technical Memo

What parts of a [Question 6 Response: "Technical Memo"] do you view or transfer and how often? "Transfer" means copying or summarizing content and/or sharing content with others for their use.

Responses	Do Not View	View Once	View and Transfer	Not Applicable
Summary	0%	30%	70%	0%
Introduction or Similar Context	11%	78%	11%	0%
Methodology	20%	70%	10%	0%
Results	0%	40%	60%	0%
Discussion or Interpretation	0%	60%	40%	0%
Conclusions	0%	10%	90%	0%
Recommendations	0%	10%	90%	0%
Figures	0%	50%	50%	0%
Tables	0%	70%	30%	0%
Supporting Material (e.g. Appendices or attachments)	50%	30%	20%	0%

Consultant: Technical Memo

In your opinion, what parts of a [Question 6 Response: "Technical Memo"] do your clients view or transfer and how often? "Transfer" means copying or summarizing content and/or sharing content with others for their use?

Responses	Do Not View	View Once	View and Transfer	Not Sure	Not Applicable
Summary	2%	16%	77%	2%	2%
Introduction or Similar Context	9%	73%	9%	9%	0%
Methodology	16%	59%	9%	16%	0%
Results	0%	53%	47%	0%	0%
Discussion or Interpretation	2%	55%	40%	2%	0%
Conclusions	0%	30%	70%	0%	0%
Recommendations	0%	12%	88%	0%	0%
Figures	0%	50%	45%	5%	0%
Tables	2%	55%	32%	11%	0%
Supporting Material (e.g. Appendices or attachments)	30%	42%	5%	23%	0%

Appendix I: Responses to Question 9

Client

How often do you transfer all or part of a [Question 6 Response: All] to other users of the information?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Frequently	67%	100%	0%	40%
Sometimes	33%	0%	0%	60%
Never	0%	0%	0%	0%

Consultant

How often do you think your clients transfer all or part of a [Question 6 Response: All] to other users of the information?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Frequently	43%	60%	50%	43%
Sometimes	57%	40%	50%	55%
Never	0%	0%	0%	2%

Appendix J: Responses to Question 10

Client

Which best describes how you transfer all or part of a [Question 6 Response: All] to others?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
As Is	11%	0%	0%	0%
As Is With a Written Summary or Expert	67%	100%	0%	60%
Written Summary or Excerpt Only	11%	0%	0%	10%
As Is With a Verbal Summary	11%	0%	0%	20%
Verbal Summary Only	0%	0%	0%	10%

Consultant

In your opinion, which best describes how your clients transfer all or part of a [Question 6 Response: All] to others?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
As Is	65%	20%	25%	33%
As Is With a Written Summary or Expert	12%	30%	50%	35%
Written Summary or Excerpt Only	4%	20%	0%	12%
As Is With a Verbal Summary	12%	20%	25%	16%
Verbal Summary Only	8%	0%	0%	2%

Appendix K: Responses to Question 11

Client

Who do you transfer all or part of a [Question 6 Response: All] to? Examples include regulators, other consultants, site personnel, and so on.

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Client Staff	67%	100%	0%	80%
External Stakeholders	22%	0%	0%	30%
Regulators	56%	0%	0%	20%
Science/Engineering Consultants	89%	100%	0%	60%
Site Personnel	44%	0%	0%	50%

Consultant

Who do you think your clients transfer all or part of a [Question 6 Response: All] to? Examples include regulators, other consultants, site personnel, and so on.

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Client Staff	48%	60%	63%	62%
External Stakeholders	28%	10%	0%	7%
Regulators	64%	40%	50%	55%
Science/Engineering Consultants	68%	40%	50%	33%
Site Personnel	4%	60%	75%	48%

Appendix L: Responses to Question 12

Client

Do you think the above recipients use the information in a [Question 6 Response: All] differently than you? Why or why not?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
No	33%	0%	0%	30%
Yes	67%	100%	0%	70%

Consultant

Do you think the above recipients use the information in a [Question 6 Response: All] differently than your clients? Why or why not?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
No	36%	70%	71%	28%
Yes	59%	30%	29%	72%

Appendix M: Responses to Question 13

Client

Which of the following formats would most likely improve your use or transfer of the information contained in a [Question 6 Response: All]? Mark any that apply.

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Video Summary	11%	0%	0%	10%
Presentation Viewable by Web Browser	44%	0%	0%	30%
Interactive Information Viewed by Touch Screen	11%	100%	0%	30%
None of the Above—Word, PowerPoint, and PDF work just fine	44%	100%	0%	70%

Consultant

Which of the following formats would most likely improve your clients' use or transfer of the information contained in a [Question 6 Response: All]? Mark any that apply.

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Video Summary	15%	0%	25%	18%
Presentation Viewable by Web Browser	35%	22%	50%	23%
Interactive Information Viewed by Touch Screen	54%	22%	25%	25%
None of the Above—Word, PowerPoint, and PDF work just fine	54%	78%	50%	59%

Appendix N: Responses to Question 14

Client

Other than format, how might science/engineering consultants improve a typical [Question 6 Response: All] to enhance your use or transfer of it?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Clarity	44%	100%	0%	50%
Genre	33%	0%	0%	10%
Length	11%	0%	0%	10%
Mode	44%	0%	0%	30%
Structure	33%	0%	0%	30%

Consultant

Other than format, how might you improve a typical [Question 6 Response: All] to enhance your clients' use or transfer of it?

Responses	Complete Report	High-Level Summary	Presentation	Technical Memo
Clarity	13%	38%	0%	28%
Genre	6%	0%	40%	9%
Length	13%	13%	0%	25%
Mode	38%	13%	40%	22%
Structure	6%	38%	20%	9%

Appendix O: Responses to Question 15

Client

Any other general comments, criticisms, or complaints about the technical communication you receive from science and engineering consultants?

Consultant

Any general comments, criticisms, or complaints about the technical communication you see from other science and engineering consultants?

Responses	Client	Consultant
Content	57%	38%
Function	21%	10%
Writing	71%	50%