Examining the Literacy Practices of Electrical Engineers: A Comparative Case Study

Purpose: This study, part of a larger research project focused on disciplinary literacy within engineering (Authors, 2018), is a comparative case study of the literacy practices of two electrical engineers. The goal of this comparative case study was to understand how electrical engineers read, write, and evaluate multi-representational texts in the context of their professional lives. We used the findings from this study to construct a model of disciplinary literacy in electrical engineering, whose purpose is to prepare students for the electrical engineering workforce by teaching them to interpret and produce texts using authentic disciplinary frameworks.

This paper examines the literacy practices of two electrical engineers to answer the following research questions:

(1) What texts do the electrical engineers read and write?
(2) What disciplinary frameworks do they use to read and write different texts?
(3) How do engineers use internet searches to locate and evaluate information?
(4) What role does argumentation have with respect to their literacy practices?

Perspectives: In accordance with sociocultural perspectives of literacy (O'Brien & Rogers, 2015), this study is based on the assumption that people interpret and produce texts in socio-historically situated contexts, such as engineering workplaces, in order to achieve common sets of goals (Author, 2011; Barton & Hamilton, 2000). An early sociocultural theorist and researcher of literacy, Heath (1982) defined *literacy events* as "occasions in which written language is integral to the nature of the participants' interactions and their interpretive processes and strategies" (p. 50). In expanding this definition, Street (2000) later noted that literacy events often form stable patterns as people within social groups work toward common goals. For example, electrical engineers may create *circuit diagrams* in order to communicate their ideas for a circuit. Street asserted that these patterned interactions around texts (including multi-representational texts) are *literacy practices,* a term which encompasses texts as well as the interpretive and evaluative processes used to understand or produce those texts.

Building on this situated view of literacy, scholars of disciplinary literacy have identified how advanced practitioners in a discipline read and generate particular types of texts in order to meet the needs of their profession (e.g., Shanahan & Shanahan, 2008; Wineburg, 1998). Using information generated from professional settings, these scholars then developed models of disciplinary literacy for K-16 students (e.g., Shanahan & Shanahan, 2014; Wineburg, Martin, & Monte-Sano, 2013). The purpose of these models was to help K-16 students interpret and produce texts with features or purposes that were similar to those in the workplace, using interpretive frameworks similar to those used by advanced practitioners in each discipline. Disciplinary literacy instruction has been shown to lead to positive student outcomes in disciplines such as history, science, and English/language arts (Goldman et al., 2016), with even greater gains for those from underrepresented groups (e.g., Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Lara-Alecio et al., 2012). In short, this type of instruction holds the potential for helping students understand and master content in deep ways.

This study builds off of our previous research on disciplinary literacy in engineering (Authors, 2014, 2017), as well as work on information gathering in engineering (Fosmire, 2014), communication in engineering (Tenopir & King, 2004), and literacy in engineering (Giroux & Moje, 2017). Collectively, this research has indicated that textual interpretation and production is central to the engineering profession. However, much of this research has not included situated, multi-site ethnographic data, including think-aloud data in which engineers elucidate the thought processes behind their reading and writing. Therefore, this study represents a contribution to the literature by identifying how two electrical engineers read and write a range of authentic texts while at the workplace, and how they seek for information on the Internet as a literacy practice. Finally, in accordance with the assertion that instruction on argumentation is a core component of disciplinary literacy instruction (Goldman et al., 2016), we sought to describe the ways in which literacy practices intersected with the arguments they produced.

Methods: To develop a preliminary model of disciplinary literacy in electrical engineering, we conducted an exploratory qualitative study of two purposefully-selected engineers. Specifically, we conducted a comparative case study (Carmel, 1999) of two electrical engineers: an electrical engineer specializing in software and an electrical engineer specializing in hardware. We selected these engineers because their supervisors recommended them as excellent communicators and engineers. Thus, we intended that these engineers would shed insight on the literacy practices of successful electrical engineers. Previous studies of professionals' literacy practices have been conducted with two people from each discipline (e.g., Bazerman, 1985; Shanahan & Shanahan, 2008); therefore, we anticipated that a double case study would be sufficient for us to develop a tentative preliminary model of disciplinary literacy in engineering.

Data Sources and Analysis: Over the course of six months, we collected four sources of data. First, the engineers kept a *written log* in which they recorded the texts they read and wrote. Second, we wrote field notes during bi-monthly, two-hour *observations* at each workplace. As we took those field notes, we recorded the types of texts that the engineers read and wrote, as well as the social interactions that surrounded those texts.

We used the first two data sources to inform our third data source: monthly one-hour *semi-structured interviews* with each engineer. Specifically, we used findings from the observations and the log to generate questions for the interviews. For example, if the engineer recorded that he frequently wrote a particular type of text, we asked him more about that text during the monthly interview. Finally, our fourth data source was monthly hour-long *retrospective protocols.* During each retrospective protocol, each engineer described what he was thinking while he read and wrote a text, which we had observed him read or write during the interview. These protocols provided insight into the disciplinary frameworks that informed the engineers' literacy practices in the context of their work.

We analyzed transcripts from the interviews, observations, and think-aloud using constant comparative analytic (CCA) methods (Thornberg & Charmaz, 2014). These methods enabled us to develop codes regarding the types of texts that the electrical engineers read and wrote (RQ1), the frameworks they used to read and write those texts (RQ2), the processes they used to gather information on the Internet (RQ3), and the literacy practices they used to engage in argumentation at the workplace (RQ4). Table 1 provides an example of a chart with inductively developed codes in relation to RQ1.

To ensure quality in the analytic process, two people read through the entire dataset and mutually agreed on the assignment of each code. Moreover, an electrical engineer, who had been practicing in the field for over 30 years, provided feedback on the codes. Finally, people with doctorates in engineering or literacy, including engineering ethnographers, reviewed our codes and our data generation protocols. They confirmed that our protocols were sufficient for gathering information in relation to our research questions; that our field notes were a thorough representation of engineering practice; and that our codes seemed to adequately fit the data.

Results: The findings from this study highlighted both similarities and differences between the software engineer and the hardware engineer. In relation to the first research question, we found that the software engineer most commonly read code and code outputs in order to fix or debug problems, whereas the hardware engineer commonly read manuals in order to determine how to do something (e.g., how to set up a harness). Despite these differences, however, both engineers often read and wrote schedules so they could structure and divide their work across teams. They both also often read technical texts—or texts that provided information about a device, process, or system—such as an Amazon Website Services Developers Guide (software engineer) or information about a videorecorder (hardware engineer).

In regards to the second research question, we found that both engineers usually read and wrote texts in the context of testing a device. For example, the software engineer read developer guides and notes embedded within code, then rewrote code and tested it by seeing if the new code resulted in a successful outcome with a data acquisitions device that was sitting on his desk. The hardware engineer read manuals, used them to assemble devices (e.g., a harness for a motor), and then tested whether the device performed as it should. Thus, a common disciplinary literacy practice seemed to be that both software and hardware engineers interpreted texts by comparing them against them the performance of a device.

In regards to the third research question, both engineers frequently conducted Internet searches to help them complete their workplace tasks. Interestingly, both engineers read blogs or open internet forums, as well as more “official” information published by companies, in order to gather information that would help them to complete the task at hand. Thus, the findings from RQ3 related back to RQ2 in the sense that the engineers tended to view a text as being high-quality if it led to positive outcomes in relation to their device; and they did not necessarily view a text as high-quality because it was published by an authoritative source versus a more questionable source (e.g., a manufacturing company’s website versus a lone blogger’s personal page).

In regards to the fourth research question, we found that both engineers engaged in a range of literacy practices that related to argumentation. For example, the software engineer joined email chains in which company engineers were having larger philosophical debates about “what are metadata?” The software engineer used evidence to support his claim that metadata are slow data. Both engineers also made claims that existing designs should be modified: for example, claims regarding whether software engineers needed to install warning files to discourage lay users from deleting code. However, a common argumentation practice in both engineering firms seemed to be argumentation in relation to testing conditions. For example, the hardware engineer often argued that testing conditions should be changed in order to produce more accurate and predictive results related to prototypes; while the software engineer read arguments that devices should be changed to be more user-friendly based on results from beta-tests with humans in the field.

Conclusions: Although there were literacy practices that were distinct to each individual engineer's work, many literacy practices extended across both engineers' work. These common practices included reading schedules to manage work; reading technical texts to better understand evolving technologies; evaluating information from texts in regards to how well the information helped them to produce successful devices as determined by tests; and arguing in relation to testing conditions. By implication, we envision K-16 engineering education in which students were deeply involved in developing and justifying iterative tests of prototypes through evidence-supported arguments, as well as K-16 education in which students compared information from texts to the performance of physical devices.

Scholarly Significance of the Study: Disciplinary literacy instruction has been shown to improve discipline-specific thinking, reading comprehension, and ability to transfer knowledge to other contexts in areas such as history (Monte-Sano & de la Paz, 2012) and science (Cervetti & Pearson, 2012). The outcomes of these studies suggest that DLI is a beneficial approach to improving student outcomes in various subject areas. Furthermore, Gee (2015) argued that children from underrepresented groups are less likely to be engaged with dominant literacy practices in technical fields compared to children from White, middle class families. Similarly, research (Archer et al., 2012) has suggested that children from middle class families are more likely to identify with scientific texts and literacy practices compared to those from working class families Furthermore, research has suggested that DLI improves performance in both women and minority groups (Cervetti et al., 2012). Therefore, women and underrepresented groups can be exposed to disciplinary literacy instruction to improve representation in the workforce. These ideas encourage future research on DLI to improve student outcomes and promote diversity to support those who are traditionally underrepresented in engineering disciplines, such as electrical engineering.

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