Writing as a Design Practice: A Preliminary Assessment

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This paper presents the results of a preliminary study that forms the basis of a proposal to the National Science Foundation Assessment of Student Achievement program. The proposal, entitled *Invention, Communication, and Documentation: Assessing the Impact of Writing as a Multi-Function Design Tool*, outlines a two-year project to develop methods of assessing the effectiveness of engineering students' use of writing as a design practice. Engineering educators have long recognized the importance of effective written communication skills, and many programs have incorporated an emphasis on written communication within their curriculums. Indeed, the ABET 2000 criteria not only emphasized writing skills but also specifically located responsibility for writing instruction within the engineering program itself:

> Competence in written communication in the English language is essential for the engineering graduate. Although specific coursework requirements serve as a foundation for such competence, the development and enhancement of writing skills must be demonstrated through student work in engineering work and other courses.[1]

Whereas the ABET criteria prior to 2000 had specified courses and content—providing essentially a curriculum checklist—these new criteria focused on objectives. Programs were asked to show that students had actually attained certain objectives and not merely taken prescribed courses.[2] This statement, often referred in the literature as EC3(g), thus implied that engineering students needed to have more than a generic mastery of written communication. Updates of the EAC since 2000 do not actually include this language, but the impact remains. With their emphasis on objectives, ABET has streamlined the criteria to the extent that there is now very little reference at all to courses as such. ABET now leaves it to individual engineering programs to articulate specific objectives and assessment methods that meet a general requirement for "effective communication." For example, at Rowan University, the ABET document listing programmatic goals states that all students should "develop communication skills so that they can perform engineering functions effectively."[3] The linking of communication skills to engineering functions echoes the intent of the 2000 statement and calls for engineering-specific objectives for the teaching of writing.

However, the assessment of effective writing in engineering work has primarily focused on competency as exhibited in the conventional textual features involved in report writing. While features such as clarity, correctness, and organization are certainly important, using them as the principal basis for assessment overlooks engineering-specific characteristics and functions of writing. One critique of writing assessment in engineering puts it this way:

> Applying EC3(g)—"ability to communicate effectively"—as an assessment criterion will require a reconsideration of what effectiveness means, because "effective communication" has become a cliché, used without consideration of its significance and implications. . . . Authors of [EC3(g)] implementation guides appear to have borrowed for communication assessment the procedures used in large-scale composition (freshman writing) testing without considering the wording of EC3(g).[4]

These assessment methods help neither instructors nor students to understand the ways in which writing is an engineering practice. Ultimately, such a view tends to characterize writing as a static artifact produced independently of and after the conclusion of the "real" engineering work of designing, modeling or fabricating, and testing.

In response to this problem, our project enlarges the scope of engineering writing to include not only its use as a tool to report knowledge at the **end** of the design process, but also as a tool to invent, communicate, and document knowledge **during** the design process. Writing can be used to create, share, and review ideas, and, if so used, can directly improve the quality of design process outcomes. We will use three approaches to assessment, targeting these three functions. **Invention**, defined as the ways in which writing is used to generate ideas and explore concepts, will be tracked through qualitative and quantitative analysis of the content of informal writing in connection with early stages of design such as brainstorming, reflecting on key theories and principles, and developing experiments or models to evaluate designs. **Communication**, an essential element of the team-based, real-world projects that many engineering programs are now built upon, will be analyzed through qualitative and quantitative assessment of correspondence among team members. **Documentation**, the systematic recording of activities during the design process, will be examined through auditing methods modeled on the procedures used for International Organization for Standardization (ISO) 9000 series certification in industry.

The first stage of the project, and the focus of this paper, involves preliminary analysis of student writing to develop categories to be used for assessment. For this phase, student teams were asked to keep written records of brainstorming and other creative or constructive stages of their design project, establish methods of communication among team members, and submit documentation plans. The next stage will involve a formal study including a control group, who will not be instructed to engage in intensive writing during the design process, in order to apply, evaluate, and further develop the criteria generated during the preliminary study. During this phase, methods of relating the use of writing during the design process to the quality of design products will also be defined.

We hypothesize that improved quality of design products will be seen, and that this improved quality can be empirically linked to more effective use of writing during the design process. The last stage will involve interpretation of the findings, refinement of the assessment methods, and dissemination of results. The overall objectives of the proposed project are twofold:

1) to develop specific rubrics for assessing student writing according to the functions described above
2) to develop guidelines for creating assignments that encourage effective student writing

This project centers on Sophomore Clinic I, a team-taught, integrated design and writing course at Rowan University. The hallmark of the Rowan engineering program is the multidisciplinary, project-oriented Engineering Clinic sequence and its emphasis on technical communication. The Clinics are taken each semester by every student. In the Engineering Clinic, modeled after the medical school concept, students and faculty from all four engineering programs work side-by-side on laboratory experiments, real-world design projects, and research. The Sophomore Engineering Clinics specifically serve the dual purpose of introducing students to formalized engineering design techniques and providing them with the necessary foundation for their careers as technical communicators. In order to achieve both of these key goals and to meet university-wide general requirements, Sophomore Engineering Clinics are team-taught by faculty from the College of Engineering and the College of Communication.

Conceptual Underpinning of the Study

Considering functions of writing beyond reporting is something of a challenge. It is relatively easy to assess how clearly a piece of writing communicates findings. Discerning other functions is more difficult, and formal definitions and theories of those functions are few and far between.

Invention will refer here to the use of writing to create knowledge. In composition theory, invention commonly refers to what is often called "pre-writing," or informal writing done prior to the composition of a formal piece. Pre-writing techniques involve various strategies for "unlocking" creative processes that are believed to be hindered when writers must attend to structural coherence and grammatical correctness, and include activities such as free-writing (fast-paced, stream-of-conscious writing), clustering (graphical mapping and expanding of associated ideas), and journals (informal, personal, exploratory writing).[5] Just as much a part of invention as this initial brainstorming phase is the review and further development that follows. Writing captures ideas and permits further interpretation, evaluation, and expansion. In human history, the move from the culture of "orality" to the culture of "literacy," when knowledge began to be transmitted in the form of texts, marked a dramatic and unprecedented developmental leap.[6]

The inventive function of writing is intuitive, yet it has proven very difficult to empirically demonstrate. Some indirect evidence is provided by studies of Writing to Learn curriculums, which consistently show that writing helps students understand course content significantly better. One such study of the use of journal writing documented a measurable improvement in student understanding of engineering material and, moreover, a measurable shift in student attitude towards the writing assignments, suggesting that the students themselves recognized a valid purpose for the writing.[7] Another study also found evidence that an intensive focus on journal writing had an important impact on student learning. Close analysis of the journal writing revealed that students gained much more than practice with writing skills. Through their written responses to the textbooks for their design course, students experienced a change in their understanding of design itself:

> To focus the design process on the needs of the user and customer rather than on the capabilities of technology requires a change in mindset, one often resisted by engineers. We were surprised to find that the journals helped to change their minds. Journals actually gave the students a place to think through their objections to the principles of user-centered design, allowing them to convince themselves of the value of these principles.[8]

These practical studies of the ways in which students benefit from writing that takes place during the "thinking" phases of projects give credence to the concept of invention, which has been dismissed by some as a romanticized mystification. Even though it is not yet fully theorized, this inventive function of writing, to the extent that we may say that the creation of knowledge occurs through the process of understanding, can be observed and assessed in student writing.

Communication, in this study, refers to writing that has to do with various team functions. As engineering curriculums, following trends in the engineering workplace, make more and more use of team-based projects, greater understanding of successful team dynamics has been sought. People do not seem to possess innate abilities to work with others, but rather must be taught to engage in self-reflection and to adopt deliberate cooperative strategies. Communication serves many practical functions as a cooperative strategy. Through communication, teams develop timelines, delegate tasks, and schedule project activities. On another level, communication fosters team cohesion. The rise of the "team charter" in corporate and administrative settings well illustrates how important it is for teams to "put in writing" their objectives and their philosophy. Beyond the practical purpose of agreement about goals, team charters actually constitute teams as entities. Charters commission teams, literally bringing them into existence. Teams that fail to effectively articulate this team identity do not function well.[9]

Documentation, similarly, has received increasing attention in the engineering workplace and, we predict, will begin to be emphasized in engineering curriculums as well. Documentation is of importance particularly in relation to quality enhancement. The International Organization for Standards (ISO) series of quality standards and management procedures is based on the notion that thorough, systematic record-keeping at all stages of the design and production processes is essential to quality. ISO documentation assessment requires the development of documentation objectives by the organization, which are then used by ISO certification agencies to audit the organization's records. The twin thrusts of the ISO approach—prior identification of objectives and standards, plus the creation of specific documentation procedures linked to those objectives and standards (rather than to arbitrary and/or external criteria)—are intended to result in more efficient and more effective processes.[10]

Methods

During the fall of 2001, students enrolled in Sophomore Clinic I engaged in a semester-long, team-based project that required them to design and build the following: a robot, constructed from a Lego MindStorms™ kit, that was programmed to accept a tennis ball from another robot, navigate a maze, and hand the ball to the next robot; and a microbial fuel cell that was used to charge the batteries necessary to power the robot. Student teams were asked to keep written records of brainstorming and other creative or constructive stages of their design project; to establish procedures for communication among team members for various purposes; and to submit specific plans for managing the records of their design activities to fulfill documentation objectives. Teams also submitted periodic progress reports describing all activities done in connection with their design. The progress reports summarized, and were to be directly drawn from, the invention, communication, and documentation writing students had done. With student permission, we collected copies of progress reports and selected process notes. To make the preliminary phase manageable, we confined the analysis to these progress reports, on the assumption that they would provide a good representation of the range of uses of writing by students. We are satisfied that this is the case. However, we acknowledge that all three functions of writing are actually being represented in a "secondhand" fashion in the progress reports; that is, the actual functions of invention, communication, and documentation occurred elsewhere and prior to the writing of the progress reports. Thus, relying on the progress reports does not entirely achieve our stated goal of transcending the focus on the **reporting** function of writing. To address this shortcoming, the next phase of the study will utilize the categories generated from the progress reports, but the content of student writing will be analyzed in its "firsthand" form in order to validly assess the functions of writing that we claim exist in addition to secondhand reporting.

Because our project seeks to understand functions of writing that current assessment practices do not recognize, we did not use a pre-existing, standard set of criteria to analyze student writing. We chose instead to utilize qualitative techniques loosely based on what are known as interpretive or ethnographic methods. Interpretive methods, originally developed in anthropology to study other cultures, were widely adopted by education researchers beginning in the 1970s. These researchers believed that controlled studies of educational settings failed to account for the complexity of the human activities occurring there. Specifically, interpretive methods focus on two key approaches. One is the use of "thick description," which refers to the inclusion of all details of the setting rather than a limited number of variables identified by the observer as important. The other is the use of an "emic" or insider perspective, which refers to the attempt to understand the meaning of human activities from the point of view of the participants.[11] From these two approaches, ethnographic researchers develop what is termed a "grounded theory," or a theory that is generated from within the data. Grounded theory attempts to interpret what has been described in all its complexity, taking into account the participants' understanding of what is happening. This mode of theory is in contrast to most quantitatively based methods, which hypothesize the role of certain variables and then test that hypothesis under controlled and objective conditions.[12]

Our preliminary study does not attempt a full-fledged interpretive methodology. What we did try to emulate in part is the "inside out" approach of grounded theory. The purpose of our preliminary study was to look at student writing in context, as it was actually produced during the design process, and to use this writing to generate the categories that will be used to characterize and, ultimately, evaluate it. This differs from assessment methods that are based on collecting controlled samples. Results from controlled samples, although perhaps more consistent and methodologically reliable, and therefore more readily generalizable, are also more artificial. In trying to understand how students are using writing during the design process, we are in a sense trying to understand what their writing means to them and how it functions in the human activity of design. Qualitative methods, we feel, can provide us with a richer account of how writing aids design. Eventually, for the purpose of developing a more conventional assessment rubric, we will also devise quantitative measurements of success.

Two sets of progress reports were analyzed, one written in October, shortly before the middle of the term, and one in December, written shortly before the end of the term. Students were simply instructed to describe everything the team had accomplished during the specified time period, and to refer to existing documentation (for example, lab notes, meeting minutes, etc.) containing details on team design activities. The progress reports are one to two pages long and written collaboratively. As noted, the progress reports do not actually constitute the kind of writing we are interested in and will eventually focus on, but for our purposes, they are a valid and manageable approximation.

The October progress reports were read first, and a simple set of categories for describing their content was developed. The October progress reports were then "coded" using these categories. Once the entire October set had been coded, the results were examined, and then the categories were expanded and modified to better capture the range of content and function. Coding is a technique used by interpretive researchers in which observed activities are described and sorted. In our case, the categories represent various kinds of content that are exhibited in student writing. Although coding can be used for some quantitative and comparative analysis, the actual purpose of coding is to reveal patterns and meanings that eventually form the grounded theory. Although coding is an attempt to analyze, it operates less to "contain" or "control" the data and more to literally open the data to interpretation. In coding the content of student writing, we continually had to ask, "What is happening here? What are the students doing with this? How does this statement function from the point of view of the students? Why did they say this?" and so on. Careful coding and analysis can reveal how the students themselves make use of writing, and in turn, can guide instructors to more effective facilitation of such "useful" writing. We want to develop a grounded theory that explains the specific ways in which students use writing for the three functions of invention, communication, and documentation, and, from this theory, create methods for eliciting, identifying, and finally assessing student writing in terms of these three functions.

Codes corresponding to the identified categories were assigned to units of content. A "unit" could consist of a single sentence, or a set of sentences discussing the same topic (an idea, a process, an activity, a phase, etc.). The categories generated from the October progress reports were as follows.

1. Invention (references to development of ideas)

a) Brainstorming, including assessment of preliminary parameters, objectives
b) Experimenting
c) Evaluating the design, including accepting or rejecting design features

2. Communication (references to intra- or inter-team functions)

a) Performance assessments, reflections on team dynamics
b) General plans and decisions
c) Delegation of duties

3. Documentation (references to data or to records of specific activities)

a) Referrals to specific documents
b) Recording of data
c) Recording of procedures

Following this coding, a revised and somewhat more detailed set of categories was developed, and applied to the December reports as follows.

1. Invention (references to development of ideas)

a) Brainstorming
b) Identification of parameters and objectives
c) Experimenting
d) Interpreting an experiment
e) Evaluating the design
f) Acceptance or rejection of design features

2. Communication (references to intra- or inter-team functions)

a) Performance assessments, reflections on team dynamics
b) General plans and decisions
c) Delegation of duties

d) References to team contact (discussion, meeting, other communication)

3. Documentation (references to data or to records of specific activities)

a) Referrals to documents
b) Recording of experimental data
c) Recording of specific design features
d) Recording of procedures

Even with the second analysis, there was some overlap between categories at times, and some categories are still not well-defined. For example, although invention is meant to designate engaging in conceptual activities and documentation is meant to designate recording of procedures, occasionally a description of an event, such as a set of experiments, could be construed as both conceptual and procedural and was therefore coded as both. Similarly, some content was more or less arbitrarily coded as one or the other. In fact, one could argue that everything coded as having an invention or communication function also fulfilled a documentation function. The design of the second phase of the study will involve ongoing improvement of these definitions.

Progress reports were also rated in two areas: level of detail, assigned as a holistic score of 3 for high level of detail, 2 for adequate, and 1 for low level of detail; and richness, assigned as a score of the number of categories exhibited out of the total possible. These ratings are not necessarily accurate assessments of the quality or effectiveness of the writing because some teams carried out extensive documentation of their activities in their lab notebooks or in the form of other "raw" notes and chose to not replicate the details in their progress reports. The ratings were assigned in order to give a rough indication of how richness and level of detail in student writing might be correlated to quality of design outcomes, which was also given a holistic score of 3, 2, or 1, with 3 indicating the highest degree of quality, primarily in terms of success and technical merit. This score is likewise not necessarily accurate, particularly since a great deal of variation in quality was sometimes seen between the two aspects of the project (the robot and the fuel cell). However, at this point, such inaccuracies are not a great concern. The principal purpose of the analysis at this stage is not so much to quantify and evaluate the writing in terms of the categories, but rather to identify and then further specify the categories themselves. For example, more important than finding out the number of times students made reference to a design decision was finding out that references to design decisions took various forms and involved various kinds of information. As a preliminary analysis, the objective was to gain insight into the data and, to put it most simply, give us an idea of what we should be looking for.

In keeping with the goals of this preliminary study, we will not undertake here to quantify and discuss all of the coding results. Rather, we want to focus on what we observed in the writing of the teams which we felt had the highest degree of success in their design projects. We also highlight noteworthy passages from other teams as well. Our purpose here is to suggest a link between quality of design and quality of writing, which we then intend to subject to a more thorough-going analysis in the next phase of our study.

Selected Results and Discussion

Invention: Because we used progress reports rather than firsthand writing for this preliminary analysis, invention is an especially difficult function to identify. If students engaged in any of what was described above as "pre-writing," the progress reports only refer to or summarize it after the fact. Still, we can reconstruct enough from the progress reports to permit speculation about what effective pre-writing involved, particularly because we know that most of the fuel cell designs and some of the robot designs were never actually fabricated, but rather existed only as graphical and textual representations. In other words, the designs were in large part worked out "on paper" only. We hypothesize that the more fully students endeavored to describe the concept for a design, the more developed the concept would become. The act of writing about a design would in fact generate further, and better, ideas. As noted above, one of the important benefits of writing is that recorded ideas can be reviewed and revised. The following passage, though quite informal and imprecise, identifies several key parameters of the design. Although this passage reports a prior discussion and is thus not truly "inventive," the availability of this written account lends rigor to this team's design process and suggests what productive writing at this stage could include:

> During our previous meetings the fuel cell beta-team discussed a few modifications that they might do on the fuel cell. These modifications dealt with the electrode material, what should be used. A test with a solder for the electrode has failed. They also mentioned using a different microorganism, specifically seratia in order to enhance the cell's voltage output. Size of the chambers was talked about, they just want to maximize the surface area of the film exposed to the chemicals, and more chamber volume so that they can use more of the microorganism as well as sugar, and they might use MP broth but not a lot if any. They talked about the shape of the chambers; should they be round or square, they went with square. They are also researching possible substitutes for the original chemicals provided.

Another example shows how writing was used to formalize and explain design features. A team that spent a day in the lab making modifications to its robot design without writing about what the modifications were and why they were made would lack the clarity of purpose and rationale suggested in this passage:

> We kept the main body portion of the robot but the attachments responsible for transporting the tennis ball and turning the robot went through several changes. The motor was not powerful enough to move the heavy apparatus, so the apparatus needed to be altered to make it lighter. A touch sensor was added to the body and it extends over the pivot wheel. Because the robot cannot drive properly with the pivot wheel in the front, a second touch sensor was added to the grabbing apparatus itself. The touch sensor on the back of the robot creates counterbalance against the weight of the grabbing apparatus in the front of the robot, preventing the robot from flipping or falling on its side during the grabbing

> maneuver. Reinforcing members were added to keep the pieces of the grabbing apparatus from coming apart during operational procedures.

This particular team received a high rating for the technical merit of their project.

Communication: Communication works to solidify team relationships and encourage good team function. Student teams in Sophomore Clinic wrote team charters at the beginning of the semester. References to agreements made in the team charter were periodically seen in the progress reports. Progress reports also referenced, or sometimes summarized, the minutes of team meetings. The keeping of minutes was a straightforward way to record team activities and decisions, and thereby formalize objectives and team commitment to them. Communication also fulfills an important role in accountability by noting responsibilities and contributions.

Students were invited to use the first-person voice in the progress reports if they felt it was appropriate, and it was interesting to note how many chose to do so. Progress reports also frequently used team members' names in discussing specific activities. Both of these stylistic decisions, we would suggest, fulfill a team communication function, and are effective writing strategies in appropriate venues. (Formal progress reports to business clients, for example, would probably not be.) Below are some representative examples. The first one conveys a sense of a team that is making an effort to "gel."

> September 24, 2001. Each group was given a Lego Mindstorms Robotics Kit and built the first robot design in the manual. The entire group took turns reading from the manual and putting together the robot. In addition, we worked through the tutorial software to learn how to program the robot. Through this, we began to learn the limitations and features of the Lego kit. At the end of class, we were given an assignment to research batteries, fuel cells, and the safety precautions associated with the chemicals needed to power a microbial fuel cell. Everyone in the group took a different chemical to research and we all looked up information on fuel cells and batteries.

A quite different team "style" is evident in this next excerpt. (The names of the students have been fictionalized.)

> October 11. Subgroup formation finalized. Darrell and Brent assigned to robot team detail. Entire team met briefly with Brent and Darrell, and voiced various ideas for designs. It was decided that the robot subgroup would keep the entire team abreast of developments on a weekly basis, as well as whenever necessary. Brent volunteered to keep records for the robot subgroup. Team designates Art as team manager responsible for keeping the team lab book, delegating tasks, and organizing meetings.

This team also included the following notation in their later progress report in December:

> Although the team has been functioning as a fine-tuned machine, some outside factors have affected our progress rate. Due to a shipping delay, vital components necessary for fuel cell completion were not available until the last week of November. However, Marlene worked overtime to finish the fuel cell once these parts came in, completing the fuel cell before all but one of the other teams, who did not require the delayed materials. This heads-up job was an impressive feat, since it provided us with an extra testing session. Also, the supply of chemicals and necessary materials for use in fuel cell lab experiments were lacking. However, the team improvised using only available materials. The team continues working towards completing a viable fuel cell/robot mechanism, and looks forward to the upcoming final rally.

Clearly, this team's progress reports provided a space in which to articulate a strong sense of team unity and commitment, a function worth further investigation. Their project designs, although not, in the opinion of the faculty team, the most ambitious or creative, were fastidiously and systematically carried out—a level of care and attention to detail that is reflected in their conduct of team communication.

Documentation: Documentation has a practical function, in that it records what has been attempted and accomplished, and therefore avoids problems with missing or duplicated procedures. Thorough documentation also permits quality assessment in the event of a failure. Our student teams were asked to present documentation plans explaining how they would use each of several possible methods to record their design and fabrication processes. Here, we were most concerned with making sure that students had procedures in place for writing down accounts of activities carried out when immediate documentation was not feasible—for example, when something was worked on in the lab or discussed over the phone. The progress reports primarily made reference to other forms of documentation, but occasionally reproduced accounts of procedures or experimental data more fully, as in this excerpt:

> The robot has been assembled according to the original design, with minor alterations. Extra pieces were added to stabilize the robot. Instead of using our own bumper design, we opted to use the single bumper design found in the construction manual. Two gears were removed from the drive wheels, reducing it from four-wheel drive to two-wheel drive. One of those gears was then used to lower the gear ratio in the arm of the ball carriage. Most of the programming was taken from the "line follower" program in the Mindstorms software. Extra programming was added for picking up and dropping of the tennis ball from one robot to the next. This programming was achieved through a guess and check method in order to determine time delays and fine-tune the program to reach the desired objectives.

A few shorter excerpts also illustrate documentation functions, if somewhat less precisely than formal documentation would require:

> At the beginning of the next class period, November 26, planing of endplates and chamber was completed. After, the screw holes and filling holes were drilled using the drill press. The initial specifications of the filling holes were altered. It was decided to use a larger bit than previously planned so as to make it easy to fit the electrode through.
>
> The gaskets were cut out so that the fuel cell could be finalized and assembled. The completed fuel cells were tested for leaks using tap water.
>
> After the machining of our fuel cells was completed, the tests that were performed with the prototype were performed on our fuel cells. At the time of the first testing of our fuel cells, we discovered we had many leaks in the cell. This problem was solved by using thicker gaskets, putting vacuum grease between the gaskets, and the chamber plates and also on the outside of the cell. When testing our fuel cell, the concentrations that gave the highest amp-hour value for the prototype were used in the testing of our fuel cell. For more information on the concentrations used as well as the amp-hours produced during each test, please see our lab notebook which will be provided upon request.

The above examples present accounts that would be useful for the kinds of purposes ISO documentation is designed to fulfill, such as tracking design decisions that later led to a problem or complaint, or verifying whether certain procedures had been followed.

Preliminary Reflections

As can be seen, no hard and fast conclusions can be drawn from this preliminary study. The study is nonetheless of great value. We were able to characterize the data and from this will be able to fine-tune our approach. In particular, we are now better able to plan the data collection and analysis methods to be used for the core study. The coding process will be more systematic and more nuanced. Further analysis of the preliminary data will be conducted. The planned focus on "firsthand" writing will constitute a rigorous test of our hypothesis that writing is a key tool during the design process and that its functions reach beyond reporting. Our coding categories will be more specific and will better enable us to make judgments about the quality of student writing, which is what we are ultimately aiming to do. One big challenge will be to clearly distinguish instances in which writing is concurrently driving and shaping the design process instead of just reporting on it. Intensive use of qualitative methods of analysis, including surveying and/or interviewing of students in order to check our interpretations against the "insider" perspective, will be necessary to validly make these distinctions. Another challenge will be to show that a genuinely causal relationship exists between the quality of the writing and the quality of the design outcome, as opposed to a mere correlation. We believe these challenges can be met through careful analysis, and that this project will ultimately yield a better understanding of how students use writing during the design process, as well as how we can guide them to make more effective use of it.

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