Using Design Journals to Uncover Information Literacy Habits of First-year Students

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Abstract— **Students engaged in a design process need to diagnose their information needs, gather resources, evaluate their quality and apply them appropriate to make evidence-based decisions about potential solutions to their problems. Much of students' information management process typically is hidden from instructors, which makes evaluation of their underlying information literacy skills difficult. In a first-year engineering technology Introduction to Design Thinking course, the instructors introduced a design journal requirement to help students capture their path through the design process and manage the knowledge they acquired and utilized during their final project. The design journal can also be used by instructors to monitor students' progress and thought processes as they work through their project. In particular, when attempting to identify students' information literacy skills in the context of engineering design, the design journal can shed some light on students' processes. Utilizing the InfoSEAD protocol for analyzing technical documentation, the authors sought to characterize the level of information literacy skills demonstrated by students through an analysis of structured design journals assigned by the course instructors. Preliminary results indicate that the design journals provide a robust window into students' thought processes as well as the quality and quantity of information gathered in the design process, how proficiently that information was used in the development of potential solutions, and whether the information gathered and utilized was documented in the students' final reports.**

Keywords—first year engineering; information literacy; design journals; InfoSEAD

I. INTRODUCTION

Expert engineers make informed design decisions, with information gathering increasing with the experience of the engineer and quality of the engineering design [1]. Engineers often struggle with maintaining a 'problem-focus' and often fixate on a solution early on in the design process [2]. Fosmire and Radcliffe [3] suggest a model to facilitate the integration of information into the design process as a way to explore more ideas for addressing stakeholder needs and make better decisions about which solutions to develop.

However, relatively little research attempts to identify the role of information in the design process. Verbal protocol analysis of 'toy' design problems [1,4] can provide insight into the cognitive processes of individuals engaged in the design process, albeit in a typically artificial environment. Video or audio recordings of students engaged in authentic design tasks provides robust data streams of activities [5], but the amount of data can be overwhelming to interpret. Design journals can provide a deep look into the design process students engage in when developing solutions [6]. Design journals may provide the only documentation students create in the design process. An analysis of design journals, then, may provide clues to student processes, as well as the quality of information they use in making design decisions.

The authors, two librarians and an engineering technology educator, have collaborated on the development and implementation of information literacy in a first-year engineering technology Introduction to Design Thinking course. The information literacy component focuses on making informed decisions in the design process, utilizing a variety of appropriate and relevant resources to provide evidence for both their understanding of the problem and the quality of the solution.

II. RESEARCH BASIS

Design journals can be used to identify the thoughts and actions students use when solving a design problem, which is a first step to developing best-practices for effective design. Westmoreland [6] developed a coding scheme to identify which part of the design cycle students were engaged in and how much time they spent in different cycles. Sobek and Jain [7] used design journals to determine that students focused on problem definition and information gathering developed higher quality designs than those focused on idea-development, detailed design, and refinement. Petkau and Mann [8] using Sobek's method, found that advanced students spent more time in idea-generation, while beginning students spent more time in 'routine tasks' related to detailed design.

Meanwhile, Lamancusa, et al. [9] describe a benchmarking tool that improves product performance and product quality. In this study, we use a structured design journal that includes a dedicated benchmarking activity in an effort to improve the use of information by first-year engineering technology students, and secondarily to improve the quality of their designs.

III. EDUCATIONAL INTERVENTION

The investigators introduced a design journal requirement into a first-year engineering technology course to help students

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manage the information they collect and knowledge they generate. In previous iterations of the course, the authors had not introduced the concept of a design journal to the students. The students were required to complete a poster for their final project, without a formal written report. The posters typically did not include bibliographies or other indications of where students got the ideas for their solutions despite a bibliography being a graded component of their poster [10]. Consequently, the instructors could not evaluate students' use of information or other information literacy skills.

In this iteration of the course, the instructors wanted to capture students' information processes as they worked on the project. We felt that a design journal would provide insight into students' work. The design journal was structured so that students would have some guidance about the kinds of work to document and what expectations instructors had for them.

The journal was structured like a draft outline of the report, starting with an introduction that included the statement of the problem, a list of stakeholders, plans for gathering data, and benchmarking against prior art. It also included methods, results, discussion, and conclusion sections and a final recommendation for a solution to the problem. Within the document template, there are detailed instructions about each section and what types of information may be included in the section. For example, the introduction section contained a note that the problem statement paragraph should also include a 'point of view' statement. The journal template was shared as a Google Document within the course Blackboard page.

For this study we were most interested in the benchmarking activities students engaged in. In a preliminary design activity, they were asked to research how others had identified problems in specific situations, namely, pedestrian safety on campus or improving the dining hall experience. Students were asked to find reliable, relevant, and appropriate resources to inform their understanding of the problem they were addressing.

Early in the course, students were given instruction on how to search for information and characteristics of high quality information resources. Information literacy instruction was delivered via online videos and face-to-face librarian instruction. Later in the course, when working on their final projects, each team member brought relevant academic and technical papers they found into class to discuss with their team. They identified the highest quality resources and the ones most relevant for their project. They were expected to use those sources to inform the design of their final project, and these types of information activities were expected to be recorded in their design journal.

Specifically, for the final project design activity, which was carried out over the last half of the semester, students were asked to present a solution to local problem related to one of the National Academy of Engineering's Grand Engineering challenges. The local solution should be scalable to a global environment, but be focused on meeting the needs of a local group of stakeholders.

Once they had determined the problem they wanted to address, each student was asked to find 3 different information sources to benchmark three different potential solutions to their design problem. They created a weighted decision matrix for the solutions they found, based on what they learned from their research. The students should then have added those sources to their design journal in the benchmarking section and done more research to fill information gaps about how well a solution would meet a particular requirement.

For example, one group identified residence hall water pressure issues as a local problem related to the access to clean water challenge. For information, they interviewed facilities coordinators, community partners, and fellow students about existing needs and challenges. They also found related printed and online resources, e.g., academic articles, videos, and reports that also related to their project. Using those information sources, a decision matrix helped them decide on a viable solution. Information from those sources would inform and be recorded in their design journal.

For the final project the primary deliverable was formatted as a Kickstarter document to request funding for their idea. Students were instructed to include references and citations as appropriate, to justify assertions they made, and we stressed that any assertion they made needed to be backed up with evidence for its validity.

IV. METHODS

To evaluate the quality of information used in decision-making, the authors relied on the InfoSEAD protocol [11], which provides a rubric for identifying the quality, reliability, relevance, and appropriate use and documentation of information in physical documentation. This protocol lends itself to use in analyzing design journals for appropriate information literacy behaviors.

The instructors analyzed work from one section of the aforementioned Introduction to Design Thinking course, which contained 40 students, divided into eight teams. The students were new to the university and had no previous experience with the library system or design thinking. Five teams turned in their design journals at the end of the course and three did not. All 8 teams turned in a final paper, modelled after a Kickstarter proposal, seeking funding for their design solution.

To analyze the design journals, we looked at the benchmarking section of the journals. We used the InfoSEAD protocol to categorize the sources on several facets. InfoSEAD quantifies the Seeking, Evaluation, Application, and Documentation quality of student work. The seeking component analyzes the quantity and variety of information

sources used by the students. The evaluation component characterizes the purpose and audience of the information source. The application component focuses on the use of the

information and whether it addressed the problem the students were working on, or whether the resources were not relevant. Finally, the documentation component evaluated how well students could reference the sources they used; that is, whether they included all of the citation information that was needed so that the reader could actually find the information source the students were referring to.

We analyzed the data in two stages. First, we looked at the sources used in the benchmarking section of the design journal. We looked at the Quantity, Currency, Audience, and Purpose of the sources identified, and for each source gave a one or zero depending on whether the source met the requirements of that category. We also determined whether the sources were relevant to the question that students were trying to answer (Application) and whether they produced a complete, correctly formatted citation (Documentation) for the source.

We also looked at the final Kickstarter document in the same manner, to see how students transferred the information gathering process to their final report. We used the same measures for currency, audience, and purpose as in the design journal analysis. For the application and documentation facets, we gave the source a one or zero depending on whether the source was used correctly to advance the argument in the paper and if it was documented appropriately (i.e., cited correctly and referenced appropriately in the text).

V. RESULTS

The results are summarized in Tables 1 and 2, for the design journal and Kickstarter report, respectively. The quantity of sources in the benchmarking section of the design journal is the first number in the Quantity column in both tables, and the number in parentheses is the number of sources in the final Kickstarter paper. The three teams who did not turn in design journals, are indicated by '-' in the first element of the Quantity column. The other columns represent a fraction of sources that met the requirements of the column (i.e., currency, audience, purpose, application, and documentation). Perhaps not surprisingly, of the three teams who did not turn in their design journals, only one final report contained a reference to an information source.

The number of sources in the design journals (Table 1) varied from 3 to 11, with an average of 6 sources used (mean and mode). Most students were able to find appropriate sources according to each of the facets. They found current sources, largely for a scholarly audience, and the purpose of the sources they found was largely to inform, rather than to sell something or actively persuade a particular point of view. Almost all of the sources were also relevant to the problem students were working on. Most teams could also accurately create a complete citation for their source.

Table 1: Analysis of Design Journal Sources Used

Table 1	InfoSEAD Ratings Averages					
Design Journal #	**# Ref Used**	**Currency**	**Audience**	**Purpose**	**Apply**	**Doc**
1	11 (2)	0.5	1.0	1.0	0.5	0.5
2	6 (6)	1.0	0.5	0.8	1.0	0.0
3	3 (2)	0.5	0.5	0.5	0.5	1.0
4	6 (1)	-	-	-	-	0.5
5	3 (1)	1.0	1.0	1.0	1.0	0.7
6	- (1)	1.0	0.0	1.0	1.0	-
7	- (0)	-	-	-	-	-
8	- (0)	-	-	-	-	-

The number of sources used in the final Kickstarter document was much fewer than in the design journal. Part of this was due to the fact that many of the sources students found while benchmarking were related to the solutions they didn't pursue in their final solution. While the number of sources was much lower, the sources used were, more often than not, relevant to the project (Apply column). The sources were fairly current, but the mixture of sources was much more varied in terms of quality (Audience, i.e., more web sites or newspaper columns rather than journals or reports). That said, students found sources with appropriate purposes (i.e., sources that tried to inform of a technology or the parameters of a problem, rather than commercial sites looking to 'sell' a particular solution). The documentation of sources was mixed, with half of the teams consistently citing their sources. The fourth entry in Table 2 (with Quantity 6(1)) made an in-text citation to a source, but did not provide the actual reference, so it was impossible to analyze the quality of that source.

Table 2: Analysis of Kickstarter-style Report Sources Used

Table 2	InfoSEAD Ratings Averages					
Design Journal #	**# Ref Used**	**Currency**	**Audience**	**Purpose**	**Apply**	**Doc**
1	11 (2)	0.7	0.6	0.8	1.0	0.5
2	6 (6)	1.0	0.5	0.8	1.0	0.0
3	3 (2)	1.0	1.0	1.0	0.3	1.0
4	6 (1)	0.5	1.0	1.0	1.0	0.5
5	3 (1)	0.3	1.0	1.0	0.7	0.7
6	- (1)	-	-	-	-	-
7	- (0)	-	-	-	-	-
8	- (0)	-	-	-	-	-

VI. DISCUSSION

Overall, students who completed the design journal assignment were able to locate appropriate resources to inform their design decisions. The resources were current, they were

written for an appropriate audience, and the sources were informative, rather than ones trying to convince the reader of a particular solution the source was selling. We also found that students who didn't complete the design journal assignment did very poorly in finding sources to document their design decisions in their final projects.

While the student teams in general did not use many sources in their final projects, and the quality of the sources was less high than their benchmarking examples, the number and quality of resources were much improved over previous semesters' final projects, in which only 58% of final projects contained any citations, despite part of the grade depending on the citation of sources [10]. This year, 75% of final papers included at least one source, and the quality of the sources was better than in previous years.

Overall, we feel that the inclusion of a structured design journal to the first-year design course facilitated students incorporating external information into their design process. Qualitatively, the students' solutions were more novel and well-reasoned than in prior years. Rather than making bold (and groundless) assertions about the nature and extent of a problem, students often could articulate through an external source, a quantitative rationale for their problem. For example, while in prior years, students frequently said 'air pollution is a really serious problem,' and were unable to articulate why under subsequent questioning, this year, students included much more specific statements, such as this from one of the team reports "According to Jos Lelieveld, 'The United States, with 54,905 deaths in 2010 from soot and smog, ranks seventh highest for air pollution deaths.'"

While more improvement needs to take place in student outcomes, we feel that the design journal exercise provides a model for students to locate and incorporate external information into their design projects. There was a limited transfer of the skills demonstrated in the design journal to the final project, which was encouraging and something to build upon.

In this iteration of the course, we didn't ask students to turn in their design journals until the end of the project. Although we told students they needed to maintain their design journal and throughout their final project reminded them of specific content that would be useful to add to their journal, we did not check that they had in fact updated their journals. As a result, we believe the teams who did not turn in their journals may not have even started them. In the future, we are considering having students 'turn in' their design journals every two weeks so that we can better keep track of their progress on their design project. It will also show us their progress over time throughout the class, rather than giving us a snapshot of their work after the project was done. Since the students are using a common Google Doc, by having them share a link to their design journal with the instructors, we can surreptitiously monitor their progress and make suggestions throughout the project, rather than just reacting to the project at the end.

Overall, we have found the design journal activity to be useful for both students and instructors. Students located more information sources and used them appropriately when they had the structure of the design journal, and the instructors had more insight into the students' process as a result of this project. By making the design journal a more interactive experience (i.e., making the journal available to the instructor throughout the course rather than just at the end) in future semesters, we believe the student outcomes will be even better.

REFERENCES

[1] C. J. Atman, R. S. Adams, M. E. Cardella, J. Turns, S. Mosborg, and J. Saleem, "Engineering Design Processes: A Comparison of Students and Expert Practitioners," *J. Eng. Educ.*, vol. 96, no. 4, pp. 359–379, 2007.

[2] Ball L.J., Evans B.T., and I. Dennis, "Cognitive processes in engineering design: a longitudinal study," *Ergonomics*, vol. 37, no. 11, 1753-1786, 1994; D.G. Jansson and S.M. Smith, "Design Fixation." Design Studies, vol. 12, no. 1, pp. 3-11, 1991.

[3] M. Fosmire and D. Radcliffe, *Integrating Information into the Engineering Design Process*, West Lafayette, IN: Purdue, 2013.

[4] N. Mentzer and M. Fosmire,"Quantifying the Information Habits of High School Students Engaged in Engineering Design," *Journal of Pre-College Engineering Education Research (J-PEER)*. 5(2) Article 3, 2015. http://dx.doi.org/10.7771/2157-9288.1108

[5] K.A. Ericsson and H. A. Simon, *Protocol analysis: Verbal reports as data.* MIT Press: Cambridge, MA, 1993; C. Kruger and N. Cross, "Model cognitive strategies in creative design," in J. Gero & M. Maher (Eds.), *Computational and cognitive model of creative design V.* University of Sydney, Australia, 2001.

[6] S. Westmoreland and L.C. Schmidt, "What engineering designers leave behind: developing a cognitive coding scheme for student design journals." *Proceedings of the ASME international mechanical engineering congress & exposition. IMECE,* 2010.

[7] D.K. Sobek II and V.K. Jain, "Relating design process to quality: A virtual design of experiments approach." *Journal of Mechanical Design*, vol. 129, pp. 483-490, 2007.

[8] Petkau, D. S., and D. D. Mann. "Evaluating Student Design Activity in Engineering Design Projects." *Proceedings of the Canadian Engineering Education Association*, 2011. http://queens.scholarsportal.info/ojs/index.php/PCEEA/article/download/3808/3770

[9] J.S. Lamancusa, J.E. Jorgensesn, and J.L.Fridley, "Product Dissection – A tool for benchmarking in the

process of teaching design," *Proceedings of FIE*, pp. 1317-1321, 1996.

[10] M. Fosmire, A.S. Van Epps, and N.E. Johnson, "Badging Your Way to Information Literacy." *Proceedings of the 2015 ASEE Annual Conference and Exposition. 2015*. 10.18260/p.23614.

[11] R.E.H. Wertz, Ş. Purzer, M. Fosmire, and M.E. Cardella, "Assessing Information Literacy Skills Demonstrated in an Engineering Design Task. *Journal of Engineering Education*, vol. 102, no. 4, pp. 577-602, 2012.