UNDERSTANDING IDEALOGGING: THE USE AND PERCEPTION OF LOGBOOKS WITHIN A CAPSTONE ENGINEERING DESIGN COURSE

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ABSTRACT

This paper documents the early phase of a broad study of the impact of idealog media on the creative design process. It summarizes initial findings on the use and perceived value of paper-based idealogs within an engineering capstone design course. It is common practice for engineers to record their design work in the form of a logbook, design journal, or idealog. As information resources have become increasingly digitized, and drafting has been replaced by CAD software, there is an accompanying trend toward replacing paper logbooks with electronic tools, such as wikis and blogs. This is driven, in part, by the perception of the logbook as a knowledge record or information resource, and with the intent of making it searchable and accessible to more people or for future project reference. Findings, however, indicate that the value of the logbook is not primarily as an information repository but as a medium for design thinking, particularly to support designers' visualization and development of ideas. This understanding of the role that paper-based idealogging plays in the development of design ideas is key to informing the effective design of future idealog platforms and other tools to support creative design ideation.

Keywords: Idealog, Logbook, Design Journals, Creative Ideation, Documentation

1   INTRODUCTION

In order to increase innovation in engineering design, it is important to better support creativity in design, particularly creative ideation in the early stages of the design process [1]. This paper documents a preliminary part of a broad research study on the impact of various idealogging media on the creative design process. The purpose of this paper is to summarize and present initial findings on the use of paper-based idealogs within an engineering capstone design course. These findings will serve as a basis for understanding the role that idealogging plays in supporting creative ideation, with the ultimate purpose of informing the design and use of future idealogging tools and techniques.

Engineers often keep idealogs, (also called design journals or logbooks) in which they record daily progress on their projects, in the form of sketches, calculations, notes, and analysis of potential solutions to the overall problem and sub-problems, which arise throughout the design process. These are largely considered repositories of engineering and design knowledge, whose purpose is to provide a detailed record of the process of investigating and solving the engineering problem at hand. As such, they have been the subject of research into their content and use in the management of engineering knowledge [2].

We know from prior studies that graphical representations comprise a good percentage of the content of logbooks [2,3], whether paper-based or digital. They are widely recognized as important in engineering and design [4,5,6,7]. Researchers have also noted a high frequency of annotations accompanying these visual representations, in the form of text, calculations, and dimensions [3].

Additionally, logbooks are valued for their legal authority in providing proof of invention for the purpose of securing and maintaining patent rights for the designs contained therein. Patents, however, are unlikely to be awarded if the work itself is not novel and beneficial. And while much research has been done in the area of sketching in creative design and innovation [8,9,10], much of the research on logbooks centers on their interface design [11] and their information content [2,12]. Additionally, there is a strong focus in research on the medium of the idealog, studying the use of various electronic media such wiki-based idealogs [13] and hybrid media based on the Anoto pen system, [14]. We,

however, turn our focus primarily to the process of idealogging and consider how idealogging as an activity can support creativity and innovation in design. Results indicate a discrepancy between perceived value of the

The focus of this research study, therefore, is not on the logbook as a knowledge repository or a record of invention, but rather as a medium to support the process of creative ideation, specifically in the context of student engineering design projects. We hope that, as this study continues, the knowledge generated will support the development of principles to guide the creation of new idealog technologies and practices.

2   IDEALOGS AND LOGBOOKS

Logbooks in engineering are analogous to lab-notebooks in the sciences. In the case of the lab-notebook, a scientist may record protocol and results of experiments, while a designer might document meeting minutes, design sketches, and material properties. But while both are used to record and document work, they are also used as a tool to support thinking. Scientists may derive new equations or theories describing the phenomena they observe in their experiments. Designers, alternatively, use logbooks to develop ideas through sketches from initial need statements, to novel product designs. Our research examines this use of the logbook, as a tool for creative ideation.

The logbook, or idealog, as it will be termed here, can be a physical or electronic medium, in which an engineering designer documents their work in the form of sketches, notes, references, etc. throughout the course of a design project. Some designers may use electronic tools such as wikis or blogs in place of a physical logbook. In this investigation, the designers studied were engineering students enrolled in one section of a senior capstone design project course, and the medium was a 7x10 or 8.5x11 wire-bound, unlined paper sketchbook.
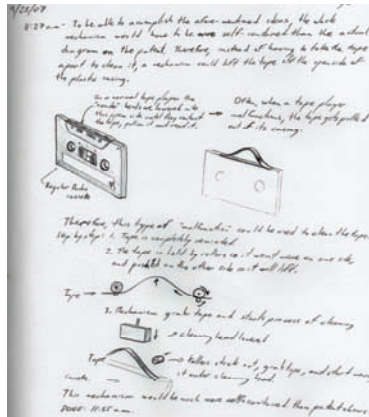

Figure 1. Idealog page from early stage of main project

The capstone course took place over one semester and included a short design project to introduce the students to the design methodology, and a long final project, which spanned the remainder of the semester. During the first two weeks of the semester, the entire class engaged in a common introductory project, to design and build paper boats and race them in competition. In the main project, which varied from team to team, students designed and presented a series of prototypes culminating in a final full-system working prototype. They also created detailed design documents to accompany their prototypes. Their idealogs served as a primary medium for working out and documenting their design ideas in the time between and leading up to the delivery of each prototype. They also used other media, such as CAD and analytical software, to varying degrees depending on the specific project and the students' skills and inclinations.

The paper boat project provided contextual consistency in the early use of their idealogs. Main projects varied in type and focus, from low-tech mechanical product design, to mechatronics system design, to precision laboratory measuring equipment design. Thus, much of the content of their

idealogs varied significantly from team to team, and within teams, depending on each student's skills and contributions to the project.

Idealog use in the capstone design course

Throughout the semester, all students submitted electronic scans of their idealog work roughly every two weeks. We gave them a brief tutorial in sketching techniques, and encouraged them to sketch their design ideas in their idealogs. The syllabus contained general instructions for idealogging as follows:

> *Idealogs will play a big role in this course. An idealog is a tool used to capture, develop, and create new ideas. In this course, each student will be required to keep an individual idealog in paper notebook form.... all individual design work should be recorded in the students' individual idealogs. Students will be required to submit their idealog work regularly…*

Students were encouraged to update their idealogs regularly and to document their work with clarity and detail. Instructors graded idealog scans on a credit/no credit scale, to serve as an incentive to use their idealogs, not as an evaluative measure of idealog quality. Students decided on individual project tasks within their teams. The instructors' primary means of assessing individual project participation and contribution was through peer reviews.

3 METHODLOGY

We did not define in the syllabus how their idealog work should look, how many pages they should fill, or how many sketches they should make. Designers, like all people, have a variety of skills both creative and analytical, and they do not all think alike. Some think more visually while others rely more heavily on external tools to visualize their design ideas. Since the intent was to explore the ways in which idealogging can support creative ideation within a diverse group, we allowed the students to decide the specifics of how they would use it to serve their particular design project and associated personal design tasks. Instructors gave idealog credit if students made at least a minimal effort to use them regularly, and did not use grades to evaluate idealog style or quality.

3.1 Subject involvement and data collection

All students in the class kept idealogs as a course assignment, and were invited to participate in this research on a voluntary basis. Participation involved approximately 20-30 minutes, outside of the required course assignments, in filling out two surveys (10-15 minutes each). Subjects received no compensation for participating, nor did participation have any effect on their grades. Thirty students from the class elected to participate in the research study. By the end of the semester each subject had submitted his or her complete idealog in electronic form and had submitted answers to two surveys taken regarding their use and perception of idealogs (except one subject who only submitted answers to the first survey).

Survey Questions

The first survey focused on subjects' idealog use in completing a common short project, which served as an introduction to the design process as taught in this course. The focus of the second survey was on the subjects' idealogging throughout their main semester-long project. Some subjects included comments on both projects in one or both surveys. We will therefore examine their answers with this in mind.

Survey Questions were as follows (with bolded questions representing those analyzed here):

Survey 1
 1.1 Please describe your experience using idealogs on the paper/first project.
 1.2 *What did you put in your idealogs?*
 1.3 What is your current impression of idealogging, and its purpose in design projects?
 1.4 *What are your plans for how you will use your idealog for the rest of the semester?*
Survey 2
 2.1 Please describe your experience using idealogs on the main/other project(s) so far.

2.2 Describe your idealogging methods (what you put into it, techniques, how you present your ideas the idealog, etc…).

2.3 Did you do anything unique or different in your idealogging or use any alternative methods in yo idealogging (3D idealogging, cut and paste methods, etc…)?

2.4 How did these things work for you?

Did any of these things help you in particular in your design work?

Did you learn anything valuable from them?

3.2 Investigating designers' use of the idealog

In this early stage of our research on idealogs, our primary interest is in investigating reported use and perceptions of idealogging activity, rather than idealog content. This focus helps to better determine their understanding of the purpose of idealogging, and their perception of the role that it plays in the process of their design work on a daily basis. It helps uncover their personal motivations and expectations in idealogging, and any variation in their idealogging activity throughout the design process.

We asked broad and open-ended questions so as avoid leading the subjects, and to solicit honest responses and a broad array of answers. The answers included a wide variety of statements and descriptive accounts in their own words of the content of their idealogs, personal assessments of their idealogging activity and their sketching or artistic skills (in some cases), and reflections on the role idealogging has played in their design work.

In this paper we discuss the findings from questions 1.1, 2.1, and 1.3, as they relate closely to subject's perception of the purposes of idealogging.

3.3 Identifying and characterizing usage types

A pilot study conducted in the year prior to this study suggested the following three main categories, or themes, of idealog use:

- Ideation – to assist the designer in the design thinking process
- Communication – to assist in communication of ideas to others
- Documentation – to record ideas and design activity, for later recall and reuse

This is consistent with research on sketching [5,6,7] and served as a starting point for gathering evidence of common perceptions of idealogging activities. The initial read-through was conducted in an observational manner, rather than an analytical manner, to monitor for any repeating themes, which may not have been indicated by the pilot study. A second read-through was then conducted with attention to repeating themes indicated by the pilot study and the first read-through, and to identifying their various verbal descriptors. This led to the compilation of a list of key words and phrases, and subsequent tallies of their occurrence in the survey data.

4   ANALYSIS AND RESULTS

Our initial read-through led us to the following preliminary themes of usage:

- Ideation – creating and developing new ideas (generating ideas, brainstorming, mindmaps, etc.)
- Thinking – visualizing, reflecting on ideas, etc.
- Organizing – keeping track of activity and information throughout the design process
- Communication – sharing and describing ideas to others (mainly teammates)
- Documentation/recall – recording ideas, notes, meeting minutes and other information, presumably for reuse or reviewing documented ideas at a later date

Following the second read-through, we compiled a list of key words from the answers to questions 1.1, 2.1, and 1.3. Similar or repeating words and phrases emerged, which were assigned the following category tags: "sk" (sketch), "not" (note), "i" (idea), "d/r" (document/reuse), "calc" (calculate), "c" (communicate), "stage" (project stage), "proj" (particular project), and "t" (think). We compared these category tags with the themes of ideation, documentation, and communication, to find those that fit well under one of the themes.

After reviewing the answers and key words together, we noted commonalities between thinking and ideating, and saw that subjects presented an array of keywords that spanned the stages of design thinking from initial idea generation through visualization to idea development and refining. We

consider these all to be representative of various levels of ideation, so we combined the "t" and "i" tags together. Additionally, we folded the keyword "organizing" into the "d/r" tag, as answers with keywords related to organizing tended to suggest organization for the purpose of documentation and recall.

Document/reuse was initially represented as one tag, but on noting how few answers with this tag actually included keywords that referenced the concept of reviewing or reusing, we separated the tags to distinguish between document and reuse, though still kept them both under the general documentation theme. Communication keywords were grouped under the communication theme. Other tags we felt did not fit specifically under any of the themes and so they were not counted. Out of the 89 total answers submitted to these three questions, 70 had at least one tag that placed them under one of the three themes (25 for question 1.1, 24 for question 1.3, and 21 for question 2.1). This confirmed the initial three themes of usage from the pilot study. Table 2 shows several common keywords as grouped under these themes.

Table 2. Final themes and common key words from survey questions

Themes	Ideation	Communication	Documentation
Keywords	Idea generation	Share	Record
	Concept generation	Relay	Log
	Brainstorm	Communicate	Document
	Think of new ideas	Show	Organize
	Develop ideas		Keep track
	Refine ideas		Review
	Visualize		Recall

We also tallied documentation keywords and noted that relatively few answers with documentation keywords coincided with recall/reuse/review type keywords, as shown in table 1.

Table 1. Incidence of documentation and recall/reuse keywords in survey answers

Survey Question	1.1	2.1	1.3	Total
Number of general documentation references	7	4	9	20
Number of recall/reuse documentation references	1	2	3	6

Survey answers showed negative documentation comments as well, regarding recall/reuse from two different subjects:

1.1 It was helpful in communicating my ideas to my team but I didn't really refer to the drawings after everyone understood the concepts.

1.3 I think the sketches are useful, but I don't think they need to [be] kept in an idealog. Beyond showing the sketch to a team member 5 minutes after I made it, I have never gone back to look @ it, so sketching on loose leaf paper & tossing it away later would have the same effectiveness.

These observations led us to question whether idealogs have a limited useful life-span, with respect to the design process. The act of documenting and idealogging may be important primarily in the moment, and the artifact of each idealog entry (sketch, note, etc) may lose its value soon after it is completed. Ullman [10] discusses the use of sketches and notes as an extension of the designer's short-term memory. That is not to negate the importance of long-term retention of documentation for the legal or organizational purposes. But we differentiate between the value of the idealog artifact with respect to the process of creating design vs. the protection of designs already created.

We tallied the number of questions with key words or phrases whose tags we had included under the three main themes from questions 1.1 and 2.1 and then from question 1.3. These numbers are shown

in the following charts. A few answers referenced keywords or tag categories in the negative sense ("I have never gone back to look @ it", "not very helpful in communicating"). These were given a 'negative tag' (e.g., -c or –R) and not added in the tally for their respective theme.
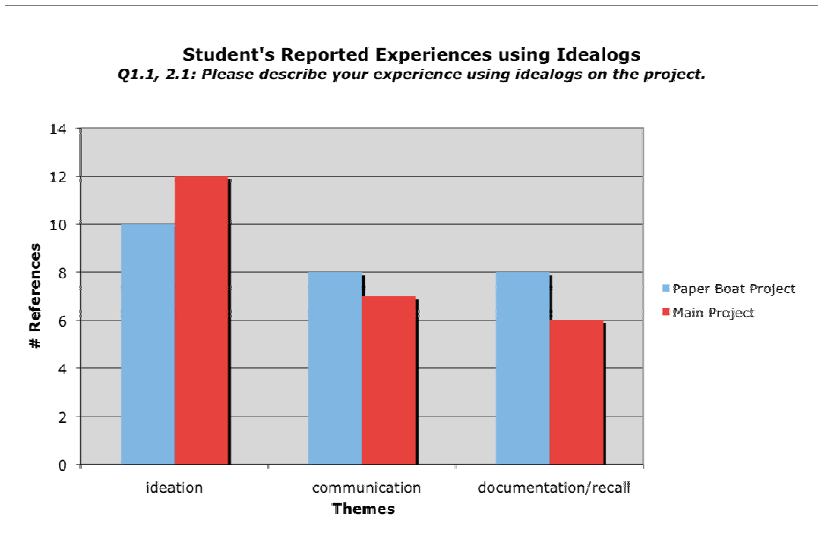
Student's Reported Experiences using Idealogs
Q1.1, 2.1: Please describe your experience using idealogs on the project.

Figure 2. Occurrence of three main themes in questions 1.1 and 2.1

Subjects' reported impression of idealogging, and its purpose in design projects (both projects)
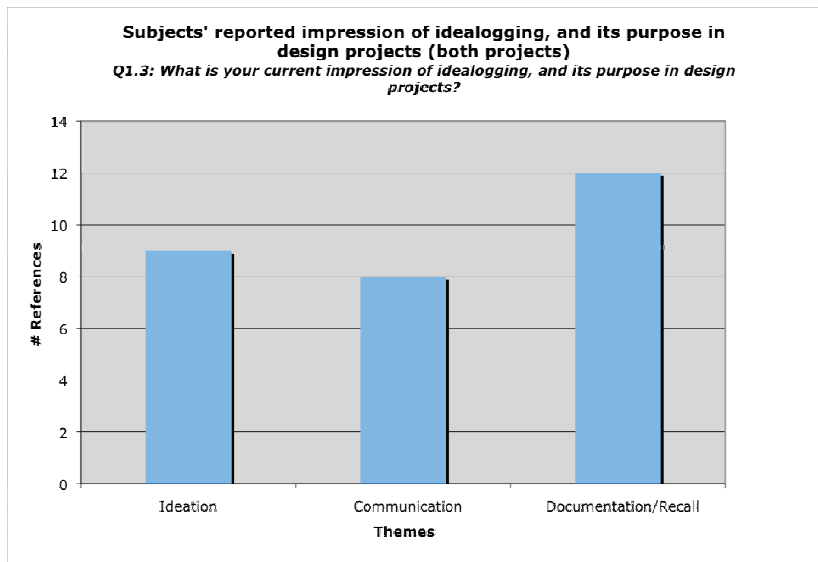*Q1.3: What is your current impression of idealogging, and its purpose in design projects?*

Figure 3. Occurrence of three main themes in question 1.3

We observed that while subjects perceived documentation/recall to be the primary purpose of idealogging, their reported experience of idealogging suggests documentation to be secondary to ideation. While this may be due, in part, to the relatively low concern about intellectual property in the educational setting, it is still surprising given the fact that they were required to generate detailed

interim and final design documents for a total of 35% of their course grade and the fact that Idealogging was introduced to them in the context of both documentation and ideation as noted in section 2 above.

5   DISCUSSION

We noted some comments indicating misunderstandings on the subjects' part regarding the course requirements and instructor expectations of idealog use in the class. The following is one example:

> 1.1 They became an inconvenience because ideas do not flow as rapidly/frequently as pages are required. It is helpful to get my ideas on paper, but in this late stage of the project I'm pretty fixated on one design. It's confusing to have to create new ideas when one that works has already been discovered.

This suggests that students may need to be instructed more specifically on the purpose and requirements of idealogging, in order to benefit more from the idealogging process. It also points to the need for further research on the changing use of idealogs and the shift in function from early to later stages in the design process.

On the other hand, perceptions of documentation being the primary purpose in idealogging did not result in subjects' experiencing documentation as the primary purpose.

While the subjects did receive a short tutorial in sketching techniques, the wide range of sketching ability among subjects is a variable that was not controlled for in this study. Some subjects remarked that their artistic skills prevented them from effectively using idealogging as a design tool. This points to the need for more extensive training in sketching as a part of design education.

Others hold the misconception that CAD is appropriate or preferred for use over the entire design process, reporting that they prefer CAD as a replacement for sketching, which was observed also by Grenier [15]. Observations on this project suggest that failure to incorporate analog idealogging tools early in the design process will have a detrimental effect on design outcome even for fluent CAD modelers with strong preferences for CAD modeling. However, the rate at which CAD programs have evolved in recent years, combined with the increased fluency among designers may increase their applicability as a tool for creative ideation *alongside* analog tools. We believe there is opportunity to learn from further study in this area.

6   CONCLUSIONS

This research study has led to a better understanding of the ways in which engineering design students perceive the purpose and value of idealogging. Subjects reported a strong understanding of idealogging as a tool to help create and develop ideas. They also showed common use of idealogs for communication with others, mostly within their team. Lastly, they indicated a preference for documenting their work and ideas, but with little reference to future reuse and recall.

This research has also led us to ask further questions regarding the practice and value of idealogging in engineering design:

- How might the documentation value of idealog content vary over time?
- Are there benefits in distinguishing between the idealog (a tool to support the process of design) and the logbook (an artifact to establish and protect intellectual property), and to maintaining each separately?
- Is it really important to retain a permanent idealog record or can the artifact be discarded with minimal impact to the design process?
- Should instructors change how they present the notion of the logbook/idealog to students to maximize the benefits students get out of the idealogging process?
- What other factors besides sketching skill influence how designers use idealogs for creative ideation?

These questions lead into the focus of the next stage of this project, which is to explore the impact of reflection in the idealogging process. There is a continual implicit reflection process contributing to and influenced by the process of idealogging, particularly sketching. Designers use sketches to externally visualize formerly abstract ideas, and the sketches reflect their ideas back to them in new ways, enabling a reflective dialog between the designer and their ideas. Reflection in this context, however, eludes observation and measurement by outside researchers. We don't see this as an impediment to research on reflection, but rather as an opportunity to study what happens when

reflection is made explicit. The next phase of this research will look for correlations between frequency of forced explicit reflections (in the form of blogs or video blogs) and design outcome.

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