Use of Journals to Evaluate Student Design Processes

Durward K. Sobek, II
Montana State University

Abstract

Journals can be an effective tool to enhance student learning and simultaneously provide the instructor with unique insight into students' mental processes. In re-introducing journaling into the ME senior design course, we discovered that students need significant guidance in journaling. I describe here several interventions to improve journal quality and their results, and conclude with key lessons learned.

1. Introduction

Engineering journals (or engineering/design notebooks) were once standard practice in the profession, but in recent years the practice has waned as digital technologies have provided new ways to represent and store engineering information. In the same bent, the Mechanical Engineering program at Montana State University once required students to keep design journals, but abandoned the practice when journal quality became poor. While the faculty intuitively felt that journals could be valuable to aspiring engineers, especially in design courses, they had difficulty assessing journals consistently and guiding students in good journaling practice.

As part of a larger research effort to better understand student design processes, I proposed re-instituting journals in the senior capstone design course as a data collection method. The Mechanical Engineering design instructors agreed, and starting in Fall 2000 students were required to document their activities, ideas, and reflections in a design journal as part of the senior capstone experience. Journals were evaluated and assessed a score, which constituted part of each individual's course grade.

Although the primary motivation for implementing design journals was to collect data on student processes, the cognitive benefits of the practice are potentially substantial. So this paper will first summarize some of the education literature on writing to learn in general, and on journaling in particular. It will then describe journal re-introduction into the senior capstone course, initially with poor results (i.e., journals of low quality) but eventually producing significant increases in thoroughness and quality through instructional interventions. This work does not attempt to measure learning enhancement resulting from journal writing. It simply reports on techniques used to help students create better journals, and concludes with lessons learned from the re-introduction process and student reactions to journaling.

2. Background: Journaling and Writing to Learn

One need not look far to find articles expounding the pedagogical virtues of writing to enhance student learning. Numerous authors from diverse disciplines have discussed the merits and techniques of using writing to solicit deeper learning at all levels of education. As Wheeler and McDonald summarized in a recent article,[1] many espouse that writing helps students learn because it forces them to organize their thoughts, ideas, and facts; enables them to develop and elaborate those ideas to a deeper level of understanding; and causes students to engage the material directly and personally bring about more active learning. Writing forces students to 'exercise their reason,' and to think more comprehensively, more broadly about the issues at hand. Wheeler and McDonald also point out that the writing process mirrors the engineering design process: numerous alternatives are possible, there is no one correct answer, and a good product usually requires a fair amount of iterative revision. Furthermore, the prominent cognitive psychologist, L. S. Vygotsky, theorizes that human thought and consciousness are inextricably linked to language. [2] Thought and word are inseparable as language is the tool we use for knowledge construction and higher-level reasoning. As Kerka pens, "Writing is a critical ingredient in meaning making, enabling learners to articulate connections between new information and what they already know."[3] Thus, writing can be a powerful method to enhance the cognitive abilities and learning in and outside the classroom.

Instructors can incorporate writing in their courses in numerous ways—from the dreaded term paper, to short writing assignments to describe a concept, process, or device, to five-minute essays written at the end of the class period. Another effective way to incorporate writing is journaling.

Journaling can be defined as 'expressive personal writing about ideas that the writer perceives as important.'[4] Often the writing is done in short segments over a period of time (e.g., a half-page entry every day or three entries per week over a semester). Journals have been found useful in numerous educational contexts, including English composition,[5] mathematics,[6,7,8] English as a foreign language,[9] and engineering.[10, 11]

The benefits to students of journaling appear to be primarily that students write more frequently and about more diverse topics than they would otherwise, thus leveraging the many cognitive benefits of writing to learn. When the constraints of grammar, spelling, and formal organization are not required, journals provide a safe place to practice writing. Journaling not only helps students become more expressive, it facilitates the thought process and can help students create meaning from the information to which they have been exposed. In fact, Zacharias claims that journaling seems to aid the following thought processes in particular:[3]

- Comparing and contrasting
- Summarizing
- Observing
- Classifying
- Interpreting
- Hypothesizing
- Critiquing
- Looking for assumptions
- Imagining
- Collecting/organizing data
- Applying facts/principles to new situations
- Decision-making

Teachers can benefit from journaling as well. Journals can enable teachers to "get inside the student's head" and see what they are really thinking, how and how well they are processing the information. They can be a window into student mental processes. [3, 11]

Journals can take on numerous forms, such as the reflective journal.[3] Students are asked to reflect upon a certain concept or idea and create a written response that discusses, elaborates upon, or applies that idea. Entries can be more directed or more free-form (e.g., "How are decimals and fractions related?" versus "What is the most interesting thing you learned in class this week and why?"), and can be focused on content or on more meta-cognitive or affective issues (e.g., "How does a battery work?" versus "What procedure did you follow in preparation for last week's test? Was it effective?" versus "How has your attitude toward mathematical problem-solving changed over the last 4 weeks?").

Another journal form is the dialog journal.[12] Students write entries, which the instructor collects, reads, provides written responses, and returns to the students. The cycle repeats frequently, say on a weekly or bi-weekly basis, creating a conversation in writing between student and teacher. One experiment found that dialog journals helped teachers identify misconceptions early, give more individualized attention to students, and learn about students' affective concerns quickly.[6] A third form is the literary journal (also called literature or learning logs) where students generate written responses to assigned readings. [10, 12]

Despite the benefits of journaling, a number of difficulties often surface when using this learning tool. One of the foremost difficulties is superficiality. Journals can tend to serve merely a record-keeping function rather than a learning tool.[3] Entries can easily become purely descriptive, with little reflection, deliberation, analysis, or discussion.[10] When this happens, students are likely to view journaling as "busy-work." The open endedness of a journaling assignment can exacerbate the problem—students simply do not know what to write.[3] A second area of difficulty concerns privacy and right of self-expression issues. For journaling to work, students must have the right of self-expression in an atmosphere of trust and confidentiality.[4] This could potentially open up certain legal and ethical issues (e.g., how does one respond to blatantly racist remarks in a journal entry?).[12] Third, grading is problematic. It is time consuming and difficult to objectively and constructively evaluate journals.[12] And finally, although a number of authors claim that journaling appeals to multiple learning styles,[3] the fact remains that journaling may simply not work for some students.[12] Few studies to date have addressed this issue from a research standpoint. If these difficulties are not addressed, students are likely to revolt against journals and may even harden their dislike for writing (and thus defeat the purpose!).

3. Project Background

In years past, the Mechanical Engineering faculty at Montana State University required journals in their senior design capstone courses. The practice seemed based less on research data or the pedagogical merits mentioned above, and more on a generally held belief among some engineers and engineering faculty, aptly summarized by Waldron and Waldron: "Good design practice includes the use of designer's notebooks containing and documenting all written work

performed."[13] The faculty stopped requiring design journals a few years ago because it began to appear a meaningless exercise for the students, and extra burden on faculty. Apparently journal quality became so low and faculty frustration so high that the practice was abandoned.

When I became interested in delving into the design processes of engineering students, journals seemed a perfect fit. If students kept journals of their design projects, the written records could potentially produce a wealth of design process information that would not be attainable by other means. Convincing the ME faculty to re-institute journals as a requirement was fairly easy—they were already convinced that it was good design practice, so if I agreed to take on the burden of evaluation, they were game. Fortunately, the National Science Foundation also saw merit in the project and funded it.

Thus, design journals have been required in ME 404, the senior design capstone course, for the last 3 semesters. It is a 4-credit, one-semester (15 weeks) course. An instructor facilitates the course, meeting with the class once per week to cover course logistics and communicate deadlines and reporting requirements. The students are assigned to teams of 3-4, each team working on a different project, most of which are sponsored by outside organizations. Each team meets weekly with a faculty advisor (who could be the course instructor). Typical of many senior design courses, each team must interact with a client to define his needs, devise a solution to meet those needs, and deliver a product (set of engineering drawings and specifications, written report, oral report, and sometimes a hardware prototype) by semester's end.

Journals constitute 15% of each student's grade for the course. The journal grade is the only individual component of the grade (the remaining 85% are group grades). Students must submit journals periodically throughout the semester (a "journal check"), with the final submission deadline the same as that of the final written report. I have opted to use written journals rather than electronic journals to better enable the students to capture data and observations in the moment, rather than having to find a computer and recall events, and to enable a broader range of possibilities in representing their data, information, and ideas (e.g., manual sketching). It seems that the journal notebook would have greater utility to the students than keeping a relatively inaccessible electronic retrospective.

4. Recent Evolution of Journal Use in ME 404

In the Fall 2000 semester, students were given journals in the first class meeting. An oral explanation told them that the journals were part of a study sponsored by the National Science Foundation to improve the way we teach design, but that we also thought they would find the journals useful. I gave the explanation, not the course instructor. After a few comments on format, we asked them to "record everything" pertaining to their project, and explained that the journals would be evaluated on thoroughness, not 'correctness' of content.

One of the challenges we face in this project that is perhaps different than others' efforts to use journals in the classroom, is that we do not want to direct what the students record in their journals. To do so would bias the data, rendering the data unusable from a research context. So

we purposefully took a minimalist approach from the start—we left it wide open for the students to decide what information to record and in what form—despite knowing that there was a strong possibility that journal quality would be low.

Two-weeks later students handed in their journals for the first journal check. Unfortunately, results were abysmal. Most journals were severely lacking in content of any sort. Written comments in the journals and oral feedback had little effect. (Note: written comments were kept to a minimum and kept fairly general as, again, I did not want to influence what and how information was recorded. An example comment might be, "this entry seems sketchy for a two-hour meeting….")

Our minimalist approach was not yielding good journals, as the literature predicted. Mid-way through the semester, we implemented a design journal evaluation rubric (see Figure 1). Students received points for meeting the simple format requirements, thoroughness, and reflection. Journal quality significantly improved (though not without student complaint!) as our expectations became a bit clearer to the students. At semester's end we received 18 journals of differing quality levels, with most being of mediocre quality or worse.

Design Journal Evaluation Form

Form Point Values:	0	1	2	3
	Never	*Sometimes*	*Mostly*	*Always*
Date/Time				
Labeling				
Attendees				
Content Point Values:	0	2	4	6
Regular Documentation	Nothing	Large gaps	Most days accounted	
Thoroughness	Almost Nothing	Sketchy	Fairly Thorough	Very Thorough
Insight Point Values:	0	2	4	6
Insight	Almost Nothing	Sketchy	Fairly Thorough	Very Thorough
Totals				
Grand Total				

FIGURE 1: DESIGN JOURNAL EVALUATION RUBRIC

In the next semester (Spring 2001), we made several changes. First, the evaluation rubric was used from the outset, and in fact was handed out to the students along with the design journals on the first day of class. Second, the journal explanation came directly from the instructor and was couched purely as a course requirement with no mention of the NSF research project. Conversations revealed that many students from the previous semester saw the journals as part of "Sobek's project," rather than taking ownership of their own journals, so this was an attempt to correct this perception. Third, after each journal check, I met with the course instructor and gave him some summary comments on overall class performance on the journals. He would then

convey the constructive feedback orally in class ("what you're doing well, and what to work on for next time") and exhort them to be diligent in the journals. As before, we tried to give fairly general feedback and encourage thoroughness in order not to influence what information was recorded nor how.

The quality of journals at the first check was comparable to the Fall semester at the same point, but then the overall journal quality improved rapidly over the next several weeks. By mid-semester, the journal quality for the class far surpassed that of the previous semester. Then journal quality eventually leveled off, despite continued exhortations and feedback, with little improvement until near semester's end when quality dropped off some as students rushed to complete their projects.

Journal quality was high enough in this second semester that we were able to analyze the data from a design process standpoint (for these results, see the companion paper[14]). We can track, for example, how much effort each team put into idea generation over the course of the project versus other design activities such as engineering analysis—was all idea generation activity concentrated in the early weeks, or was it spread out over the semester? We eventually hope to correlate this process data to project outcome measures—does a pattern of consistent idea generation throughout the project, for example, contribute to better design outcomes versus a more "brainstorm early then iterate" approach?

Exit interviews conducted by the department head revealed that nearly all students viewed the journals negatively at the start, but a majority of students found them valuable to their projects by mid-semester. The students seemed to see the benefits of the journals stemming mostly from their record-keeping capacity, and not as much as a learning tool. They also asked for better explanation of our expectations for the journal content.

In the third semester (Fall 2001), we added several 'journal training' exercises. Students were given examples of good and poor entries, and in small groups discussed which was better and what made it better. We then compiled and summarized the discussions for the class as a whole. The first of these exercises was done in the second week, with two others following in subsequent weeks.

The journal quality at the first journal check was surprisingly good, comparable to the highest level achieved in Spring 2001. Thus the training exercises seemed to help. Journals continued to improve, but at a lesser rate than previously, and followed the pattern of semester 2—leveling off after about 6-8 weeks, then falling off slightly at the end. Figure 2 shows the high, low, and median rubric scores for six journal checks over the semester (the first 3 checks were 2 weeks apart, the remaining were 3 weeks apart). The increased variation seen in Check 5 is because two of the 17 students seemed to "give up" on their journal efforts, receiving substantially lower scores than their previous 3 checks.
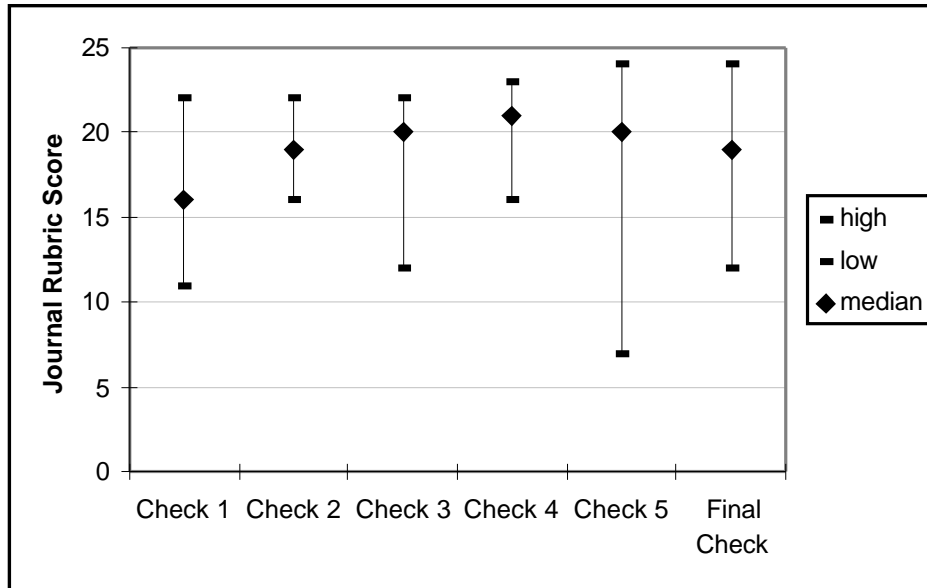
FIGURE 2: JOURNAL RUBRIC SCORES FROM ME 404, FALL 2001 SEMESTER

Thus, with the use of several tools and practices, we were able to see journals improve from sporadic, seemingly after-thought recordings to nearly daily entries. We also saw the content of entries improve from statements like, "We talked about our design ideas" as the complete record of an event, to reasonably complete descriptions of the design activities and results. While we were able to get much more complete records of activities than ever before, the journals still remained largely activity logs and places to record to-do lists, data, information sources, and ideas. They contained little by way of reflection, little record of higher-order thinking.

5. Lessons Learned

The first lesson learned was that only good journals are useful; poor journals truly are a waste of time. So it seems most students must be pushed pretty hard to get their journal quality up sufficiently so that they can realize the value that a decent design journal can bring to their projects. As one might expect, a number of students grumbled about having to keep journals. But, as a rule, these were the students with lower quality journals. Most students who maintained average or better journals, thought the effort required was significant, but admitted their usefulness.

A second observation is that, consistent with good teaching practice, being as explicit as possible in one's expectations about the journals is helpful. As one author states, completely open-ended journal assignments are "doomed to failure."[15] Thus, establishing an evaluation rubric, giving feedback, and example entries helped set expectations at an appropriate level. While it would have been nice to establish a rubric and provide examples from the outset, this is difficult without first having some experience and reviewing enough samples to really make explicit what one is looking for in the journals. The literature on journals, unfortunately, provides little guidance for the novice on establishing evaluation rubrics and almost no guidance on eliciting good journals

without directing journal entry content.

Third, to date we've been able to capture design process data pretty well at the activity log level, but we're not yet getting much insight into the mental processes. It seems additional interventions are still needed in this area. For the current semester, we have included a list of reflective questions for common project events (meetings, brainstorming, analysis, design sessions, and internet searches) to the instructions section of the design journals. We will be referring students to these questions as examples of some of the reflective thinking they could incorporate into their journals. If this fails to improve the reflective content of the journals, we may consider more directive reflective writing assignments, perhaps a series of scaffolded questions to which each student would respond in their journals

Also, journals tend to suffer as computer-based work increases, and at 'crunch time.' Exhortations to not let journaling slip during these times seem to help dampen the dip in quality.

6. Conclusion

We have re-instituted the practice of design journaling in the ME senior design course. Through this implementation process we've found that our students need a good deal of help to write good journals. Instructors cannot simply tell students to "keep a journal" and expect to receive good quality journals. While the quality is still not as good as we want it to be, we have made significant strides through the implementation of an evaluation rubric, periodic journal checks with feedback, and interactive exercises to help students define in their own minds what a 'good' journal entry looks like. These approaches contribute to the education literature on journaling by outlining specific interventions that can increase journal quality while minimizing evaluator influence. Most students are able to see the value of keeping a project journal, even if not right away. Although, the value of the journal in students' eyes still appears to be at the level of record keeping rather than as learning tool. Additionally, we've found journals a good tool for getting a better view into the design processes in use among our student teams.

Bibliography

1. Wheeler, Edward and Robert L. McDonald, "Writing in Engineering Courses," *Journal of Engineering Education*, vol. 89, no. 4, Oct. 2000, pp. 481-486.

2. Wertsch, J. V. and P. Tulviste, "L. S. Vygotsky and Contemporary Developmental Psychology," *Developmental Psychology*, vol. 28, no. 4, 1992, pp. 48-557.

3. Kerka, Sandra, "Journal Writing and Adult Learning," EPIC Digest No. EDO-CE-96-174, 1996.

4. Zacharias, Martha E., "The Relationship Between Journal Writing in Education and Thinking Processes: What Educators Say about it," *Education*, vol. 112, no. 2, Winter 1991, pp. 265-270.

5. Anderson, Jim, "Journal Writing: The Promise and the Reality,"*Journal of Reading*, vol. 36, no. 4, pp. 304-309.

6. Gordon, Christine J. and Dorothy MacInnis, "Using Journals as a Window on Students' Thinking in Mathematics," *Language Arts*, vol. 70, no. 1, Jan. 1993, pp. 37-43.

7. Jurdak, Murad and Rihab Abu Zein, "The effect of Journal Writing on Achievement in and Attitudes toward Mathematics," *School Science and Mathematics*, Dec. 1998, pp. 412-419.

8. "Journal Writing in the Mathematics Classroom: A Beginner's Approach,"*Mathematics Teacher*, vol. 93, no. 2, Feb. 2000, pp. 132-135.

9. Myers, James L., "Self-evaluations of the 'Stream of Thought' in Journal Writing," *System*, vol. 29, 2001, pp. 481-488.

10. Burrows, V. A., B. McNeill, N. F. Hubble, and L. Bellamy, "Statistical Evidence for Enhanced Learning of Content through Reflective Journal Writing," *Journal of Engineering Education*, vol. 90, no. 4, Oct. 2001, pp. 661-668.

11. Korgel, B. A., "Nurturing Faculty-Student Dialogue, Deep Learning and Creativity through Journal Writing Exercises, *Journal of Engineering Education*, vol. 91, no. 1, Jan. 2002, pp. 139-146.

12. Cobine, Gary R., "Effective Use of Student Journal Writing," EPIC Digest No. EDO-CS-95-02, 1995.

13. Waldron, M. B. and K. J. Waldron, "Methods of Studying Mechanical Design," in M. Waldron and K. Waldron (eds.), *Mechanical Design: Theory and Methodology*, Springer-Verlag New York, Inc., 1996, pp. 21-34.

14. Sobek, II, Durward K., "Preliminary Findings from Coding Student Design Journals", submitted to the 2002 ASEE Annual Meeting Conference Proceedings.

15. Sommer, R. F., *Teaching Writing to Adults*, Jossey Bass, San Francisco, 1989; as quoted in Kerka, Sandra, "Journal Writing and Adult Learning," EPIC Digest No. EDO-CE-96-174, 1996.

DURWARD K. SOBEK, II
Durward Sobek is currently Assistant Professor of Industrial and Management Engineering at Montana State University. He holds a B.A. degree in Engineering Science from Dartmouth College, and the M.S. and Ph.D. degrees in Industrial and Operations Engineering from The University of Michigan. His current research interests are in the areas of new product development, engineering design education, and health care. Please visit his web site for additional information: http://www.coe.montana.edu/ie/faculty/sobek.