

2006-258: LEARNING/ASSESSMENT: A TOOL FOR ASSESSING LIBERATIVE PEDAGOGIES IN ENGINEERING EDUCATION

Donna Riley, Smith College

Donna Riley is Assistant Professor in the Picker Engineering Program at Smith College. Her work focuses on implementing liberative pedagogies in engineering education.

Lionel Claris, Smith College

Lionel Claris holds a master's degree in education from Smith College and currently teaches Spanish and French to elementary school students in Springfield, MA. He is a passionate advocate for new ways of thinking about learning, involved locally in the Holistic School Project of Amherst and the Re-radicalization of Hampshire College.

Nora Paul-Schultz, Smith College

Nora Paul-Schultz is a student at Smith College.

Ida Ngambeki, Smith College

Ida Ngambeki is a student at Smith College.

Learning/Assessment: A tool for assessing liberative pedagogies in engineering education

Abstract

Recently some engineering educators have introduced liberative pedagogies (including feminist and critical pedagogies) in their classrooms. These pedagogies promise to impact student interest, motivation, and performance as they create democratic classrooms that encourage all voices, grounding learning in the authority of student experience. Liberative pedagogies differ from other learner-centered pedagogies in that personal transformation and social change are at their heart, with the key outcomes of critical thinking and reflective action. With new goals and outcomes come new measures of success, which require new assessment tools.

A liberative assessment tool has been developed and implemented in an engineering thermodynamics class. The tool uses weblog (blog) technology to measure student learning as well as enhance it, encouraging reflection and enabling students to connect classroom content with personal experience. In the blog learning structure, each student develops an individual page of entries over the semester, using guiding questions that require about half an hour per weekly entry. The course begins with introspection, in which students articulate their aspirations and locate the course in relation to their identities and scholarly pursuits. Prior to the introduction of each new topic, students reflect and articulate their knowledge and experience related to the subject matter. As material is presented, students then reflect on what they have learned and how it relates to their lives. Critical thinking is a central part of this process, as students ask questions of themselves, the discipline, and one another. Finally, students explore certain questions of their choosing, developing new ideas that they pursue independently and interdependently.

Narrative analysis of blog entries measures achievement of three key goals of liberative pedagogies. First, blog entries reflect the development of student understanding of course material through time. Student pre-conceptions were extracted from entries written before a new topic was introduced to provide the instructor with insight into personal context and student preconceptions, which were then addressed in class. Student reflections on what they learned in class and through assignments were used to measure students' progress and gain insight into student learning and thinking. Critical thinking was evaluated by examining the frequency and quality of reflective questions about both course material and student learning. Reflective action was measured in student descriptions of their pursuit of independent ideas that grow from the entries themselves.

Other assessment measures were used to supplement the blog in course assessment and provide evaluative insight into the blog's effectiveness as both a learning and assessment tool. These measures included focus groups, interviews, written surveys, and student course work. Discussion focuses on the promises and limitations of the blog itself, the notion of integrating learning and assessment, and the pros and cons of using blogs as opposed to traditional journals or online discussion groups. The blog is a promising tool for integrated learning and assessment that can be used to measure the achievement of the goals of liberative pedagogies, and can be adapted to measure the achievement of a variety of other learning goals.

Introduction

Recently some engineering educators have introduced liberative pedagogies (including feminist and critical pedagogies) in their classrooms. These pedagogies promise to impact student interest, motivation, and performance as they create democratic classrooms that encourage all voices, grounding learning in the authority of student experience. Liberative pedagogies differ from other learner-centered pedagogies in that personal transformation and social change are at their heart, with the key outcomes of critical thinking and reflective action. This paper seeks to discuss the development and early implementation of a process-oriented approach to assessment for liberative pedagogies, one that is grounded in the classroom and integrated with student efforts to become intentional learners.

Liberative pedagogies are radically student-centered approaches to learning, which develop in students the capacity for critical thinking and reflective action (praxis). The ultimate goal of these pedagogies is liberation, of the students first through ending oppressive education systems, but ultimately society through the reflective action of students. Liberative pedagogies is an inclusive term, incorporating elements of critical/radical pedagogy of Paulo Freire¹ and others, elements of feminist and critical race pedagogies, and the engaged pedagogy described by hooks² that weaves these together. Liberative pedagogies are directed toward creating a more equitable distribution of power in the classroom. Liberative pedagogies seek to recognize the authority and experience students bring, giving them opportunities to teach, and professors to learn from the students. Drawing from student experience emphasizes student authority, the relevance of the material, and its relationship to other subject areas. This kind of learning is integrative and relational, with a strong focus on the learning process.

Liberative pedagogies emphasize students' responsibility for their own learning. Learning becomes highly student-centered, active, cooperative, and often problem- or community-based. In addition to their practical orientation, liberative pedagogies strongly value a liberal arts education – one that at its core promotes critical thinking, not merely knowledge or awareness of social issues, but the ability to think originally and act in response. This reflective action -- or *praxis* in Freire's terminology -- along with critical thinking makes up the central outcomes of the liberative learning process.

We sought to develop an appropriate approach for assessing this process-oriented pedagogy; such an approach would focus on the learning process as the means to ensuring the achievement of the outcomes of critical thinking and reflective action. Liberative assessment would need to involve students as active participants, and integrate assessment with the learning experience as a tool for intentional learning. Such a tool could simultaneously measure and enhance student learning, encouraging student self-assessment and metacognition by inviting and documenting reflection, critical thinking, relation of course material to life experience and aspirations, and capacity for lifelong learning. Finally it would invite questions about both the course material and the learning process. This work does not emerge from a blank slate but builds on previous assessment tools. Some elements of our learning process can be assessed using standard methods that have already been validated and documented in the literature, like those for self-directed learning³.

Assessment can become a motivator itself for supporting intentional learning, if the focus of the assessment is the entire learning process rather than knowledge outcomes alone. Liberative assessment should fit into a larger picture related to the entire curriculum, in which courses are linked to who students are as individual learners, and what motivates them to pursue engineering. In the first year, our institution's introductory engineering design course engages student identities and introduces the ethics and social relevance of engineering. It is critical at this point to hear students' voices to learn what they bring into the program and how they think about engineering. Their questions can become a motivating force for the entire four years.

We sought to create an assessment tool that allows for the inclusion of who one is as a learner, what one knows already, what one brings in through life experience, what instructors wish to teach, and what learners wish to learn, with a sensitivity to ethical issues and how technical and ethical considerations fit together. The assessment tool itself must be sensitive to the complexity of what is learned – not just facts – and attend to the relation between the learner and learning of knowledge. The assessment tool ought to go back and forth between theory and practice, and between the qualitative and quantitative. Liberative assessment is not only about measuring knowledge, but also about proactively addressing learning itself. Qualitative and quantitative measures are integrated so that we can measure not only how much a student knows, but also how well she knows it.

In other words, there is a reflective component that needs to be measured qualitatively, while certain technical knowledge or knowledge of engineering practice can often be measured more quantitatively. These qualitative and quantitative aspects of engineering go hand in hand, linking to other disciplines in the humanities and social sciences, and linking to ethics and social justice concerns as well. Such integrated thinking must be taught and assessed as part of liberative pedagogies. We believe that one of the best ways to teach integrated thinking is to create a learning process that is itself as integrated as possible. We have integrated the teaching and the assessing, so that the very assessment is now part of an ongoing teaching tool; and does not just, for example, come at the end of a unit.

Additionally, we believe that the implications of such integrated thinking are wide-reaching, affecting the environment, the role of technology in society, and ethical decision-making. This is because when thought is engaged liberatively (with space for both information and question) in the classroom in the way we are describing, a great potential is then unleashed for reflective action that brings about social change.

Methodology, Tool Description & Implementation

We developed a weblog (electronic journal, or blog) as the primary vehicle for our integrated learning/assessment. Based in intentional learning approaches that encourage metacognition, the blogs link what students know with how they know it and what they think of it. They provide a record of student development, measuring critical thinking in terms of student-generated questions and reflective action in terms of how they pursue these questions in their daily life. We implemented the blogs in a core engineering thermodynamics class at Smith College that had been previously adapted to incorporate liberative pedagogies;⁴ however, this approach could be used in any engineering course and is compatible with many learner-centered pedagogies.

Students in the course had some experience with metacognitive approaches introduced in the sophomore statics class, and with narratives introduced in the first-year design-based introduction to engineering. Students continue to self-assess in other courses in the curriculum, including the capstone senior design clinic. However, blogs are unique to this course, and metacognitive approaches are featured only in certain core courses. Smith's liberal arts setting helps reinforce the importance of reflection and written expression of ideas, while this aspect of the engineering curriculum helps build linkages to other disciplines.

The blog is an individual journal, one for each student, with each successive entry appending onto the earlier ones, so that progress can be easily reviewed and followed. Guiding questions structure student reflections and responses directly related to course material for the coming week. Regular weekly questions create a process in which students reflect on and articulate what they learned in the last week and pose further questions to explore. Connected to the blog were independent questions each week related to ethics, in which they were given a case to reflect upon and discuss. The students were asked to identify how the ethics case related to both the course material and their personal or professional lives. This is discussed in more detail in another paper.⁵

The methodology for the blog structure comes from the inquiry-based learning literature⁶ and can be applied in any course. Our blog was designed to tap three levels of challenge mentioned in the literature. At the first level students log questions they have to share with the professor and class. By writing about questions that puzzle them, professors and other students are better able to answer them. By articulating questions, students can often answer them on their own. Students assess their own understanding and begin to think ahead. This creates a new kind of relationship to the subject matter that doesn't always have space in classrooms. It is important to emphasize the quality and depth of self-reflection and the ability of the student to make it her own.

The second level of challenge for the blog is for students to explore and answer questions independently. This provides opportunity for self-directed learning, so that students can tailor their learning experience to their interests and develop lifelong learning skills. The third level of challenge is the transfer of knowledge into reflective practice. One way of assessing liberative learning is to ascertain the degree to which students' proposed actions are reflective and bring in the concerns discussed in class around ethics and social justice.

The blogs connect to other course assignments including quantitative (problem sets and tests), hands-on (group project, individual assignments relating thermodynamics to everyday life), and qualitative (essays) work. The blogs connected directly to the questioning process in the classroom. The course began with a worksheet on the first day of class in which students posed questions about energy/thermodynamics, discussed what they were interested in regarding the course, and how their interests fit into the overall engineering program and into their longer term career goals. The blog tool was then introduced, emphasizing self-reflection and self-evaluation as important learning processes for the course. Connected with the blog was a group project that stemmed from questions posed on the blog. Groups of four read each other's blog entries throughout the semester, commenting and supporting each other's lines of inquiry, culminating in a project related to dissemination of thermodynamic knowledge in the service of the community in some way, broadly interpreted.

The blogs were useful to the instructor in preparing for class. They permit the articulation of student preconceptions, both correct and incorrect, which are very useful to instructors for class planning, so that classes can build on what students already know, address key errors in thinking, and facilitate students learning from each other effectively. The blogs give students a weekly opportunity to engage metacognitively, to assess their own learning experience, and to record and review their progress over the semester. For some students, the blogs are also a welcome outlet for reflection and writing – a change from most engineering classes, which do not make much room for this type of learning style. Thus the blog is an integral part of liberative pedagogies and of multiple learning activities in the course. The blog does not come at the end of a unit or the end of the semester, it is a continuous process in which assessment goes hand in hand with curriculum and learning.

The blog was worth 30% of the course grade - 10% for the ethics component, 10% for the group project, and 10% for the weekly reflections, which are the primary focus of this paper. Due to time and resources constraints, the blogs were graded using a simple rubric; the ethics and weekly reflections were graded together, with 2 points for completeness, 2 points for the quality of reflection, and 2 points for critical thinking. These were separately analyzed more in depth for the purposes of this paper (discussed below). The blogs provide the instructor with evidence of progress for an individual student and also permits comparison across students in the course.

Analysis

We engaged in textual analysis of student blogs, with careful attention to measuring three key learning processes, as illustrated in the rubric on the following page: depth of reflection, critical thinking and reflective action. Each category was ranked on a 5-point Likert-type scale for student blog reflections excluding the ethics work, which was analyzed separately.

Reflection was deep where students engaged with the questions seriously, brought in prior knowledge, demonstrated a clear understanding of the issues at hand, and related course material, personal experience, and engineering practice. For example, expressing a curiosity to learn how pressure cookers work and explain this to family members was considered reflective. Another key measure of reflection was how students wrote about their previous conceptions and how they had changed throughout the week in the course. Critical thinking was measured in terms of the quality of questions, specifically the degree to which questions went beyond the scope of course material previously presented. Questions about why certain models apply, why physical phenomena occur, or why the textbook presented things in a certain way demonstrated critical thinking and a student's desire not to accept material at face value but take it to the next level. Reflective action was measured in terms of actual actions students took as a result of their engagement with the course and blog experience; some of these relate to their own learning, and some to actions taken in their professional or personal lives.

Numerical scoring followed the descriptions on the rubric; students received a 3 if they made a few interesting points and reasonable effort in completing the blog. Students received a 4 if they provided some exemplary engagement with the skill considered but were not consistent with it each week. Students received a 5 if they performed at this level on a regular basis. Students received a 2 if they made an effort but did not seem to connect with what was asked of them.

	1	2	3	4	5
To what extent are the following qualities practiced and achieved?	Not at all (fails to engage with the skill at hand)	Not very much (manages to engage with the skill but does not show much interest in it)	A fair amount (engages with the skill and shows interest)	Quite a bit (engages with the skill and is clearly interested and curious)	A lot (engages actively with the skill and manages to make it her own)
Reflection – student is reflecting extensively on the questions and taking them seriously. Values are articulated honestly. Student is referring to her experience, using prior knowledge, as well as experimenting with new knowledge. Connections are made to the course and subject matter at hand, engineering practice, and the student's life. Connections illustrate a solid understanding of the issues.					
Critical Thinking – student asks incisive questions that probe the meaning and implications of the reading. Student articulates new ideas to pursue that go beyond the course material					
Reflective action (praxis) – Student took action that grew from her engagement with the course. Action reflects her personal development (in terms of responsibility or moral imagination), utilizes previously unknown skills and knowledge, and relates to her identity as and engineer in the larger context of the profession and society. Student made a conscious active change whether practical, cognitive-emotional, or both as a result of the insight gained from self-reflection or relational interaction.					

In addition to the textual analysis, three focus groups were conducted with 14 students in all. All students in the course were invited to participate, with a response rate of 47%. Students were asked to discuss how they were learning in the class, and described strategies they and the instructor were using for learning in the class. This led into a discussion of the blogs, in which participants discussed how the blogs changed their views of themselves in relation to engineering, and the ability of the blog exercise to introduce new thoughts. The final question focused on what the class, in their view, was helping students to learn to do, how that fit with their overall goals, and what difference learning thermodynamics made in their lives. Other student feedback on the blog was received through written and informal course evaluations.

Results

First we present some examples from student blogs to illustrate the kinds of reflection, critical thinking, and reflective action we observed.

Reflection. One student connected what she was learning in thermodynamics to what she had already learned in electrical engineering classes. In this example the student is better able to understand ideal gases by making an analogy to a subject with which she is more familiar:

I was very interested by the problem and chart in the book that talked about the error in assuming water vapor is an ideal gas. It would be interesting to look at other gases and determine the errors in assuming that they are ideal gases. It is always a good exercise to think about how the ideal case differs from an actual case because the real world is often not ideal. I have especially found this to be true in circuit analysis. Although there are great analysis techniques for simple, "perfect" circuits, these do not always work for real circuits like those that I encountered during my internship.

Critical thinking. Some instances of critical thinking involved students not taking what they learned at face value but trying to understand why things like the first law are true:

The only questions that I still have are how can we prove that energy can't be created... How could people have a law that makes something impossible? There is no scope to that law. Gravity is an unbreakable law, but it changes depending upon where the mass in question is. The law doesn't change, but gravity can. It's just hard for me to grasp that science is saying something so concrete with out exception."

Some critical thinking involved critiquing the textbook directly:

I must make a few comments regarding the exercise problem in our homework. I was a bit disconcerted to see a problem that had someone lose 5kg in 13 days. It is recommended that a person only lose up to 2 lbs per week, .9 kg, or 1.68 kg for 13 days.... I realize that this is only a book problem, and that book problems are not suppose[d] to have any bearings on real life. Still, it would be nice if a book at least did not use highly unhealthy behavior as an example without some commentary.

Reflective Action. Most of the reflective action was measured through an assignment that grew from students' reflections and questions in the blogs. In teams of four, students were asked to

commit “an act of engineering that benefits someone outside of your group” that grew out of a collective exploration of their blog work. Projects included making dormitories more energy efficient, developing resources for encouraging girls in engineering, educating the public about lowering energy costs in a time of price hikes, and designing and building a vegetable cooler from low-cost, widely available materials, taking advantage of evaporative cooling rather than electrical power.

The blogs contained some examples of reflective action. For example, one student engaged her peers in conversations about thermodynamics:

I have spent the past week talking to my friends about weight loss with a thermodynamics perspective. I think that it's just because most of my friends have body issues and it's a way to get them to be interested in what I am doing rather than just staring at me when I talk about class...

Lack of Reflective or Critical Engagement. Some students fell short of deep reflection or critical thinking. Typical examples focus on the course material in a superficial way and do not go beyond what was presented in the text or discussed in class. These may reflect important questions to bring to office hours or a help session, but are not responsive to the call for deeply reflective or critical questions.

When looking over the topics we covered in class, I found that I understand what enthalpy is, but I would like to know how to use this concept in a problem.

When is it appropriate to assume a system is closed and when can we not make this assumption?

Using the rubric presented above, each student's blog entries were evaluated for the semester as a whole. Summary statistics are presented in Table 1, and a histogram of the scores is presented in Figure 1.

Table 1: Summary statistics for blog evaluation			
Category	Mean	Standard Deviation	Median
Reflection	3.33	0.769	3.5
Thinking Critically	3.28	0.817	3
Reflective Action	3.05	0.547	3

With an average of about 3.3 in our analysis of reflection and critical thinking, it appears that students on the whole were learning to engage in the ways we asked but did not produce high-level responses much of the time. This has two possible explanations; one is that students were new to this type of engagement, and thus demonstrated a novice's level of performance. The other is that students, as reported through the focus groups, were overworked and did not put as much time and effort into the blogs as they might under other circumstances. Student self-reports on the end-of semester evaluation are consistent with the idea that students were learning to engage in these ways but did not feel they had quite mastered it.

It is clear that the evaluation/grading rubric needs to be revised to break down each of the three categories for separate evaluation, as too many different abilities are being evaluated in each category. This will take more time in grading, but will result in better feedback to students and ultimately better performance overall.

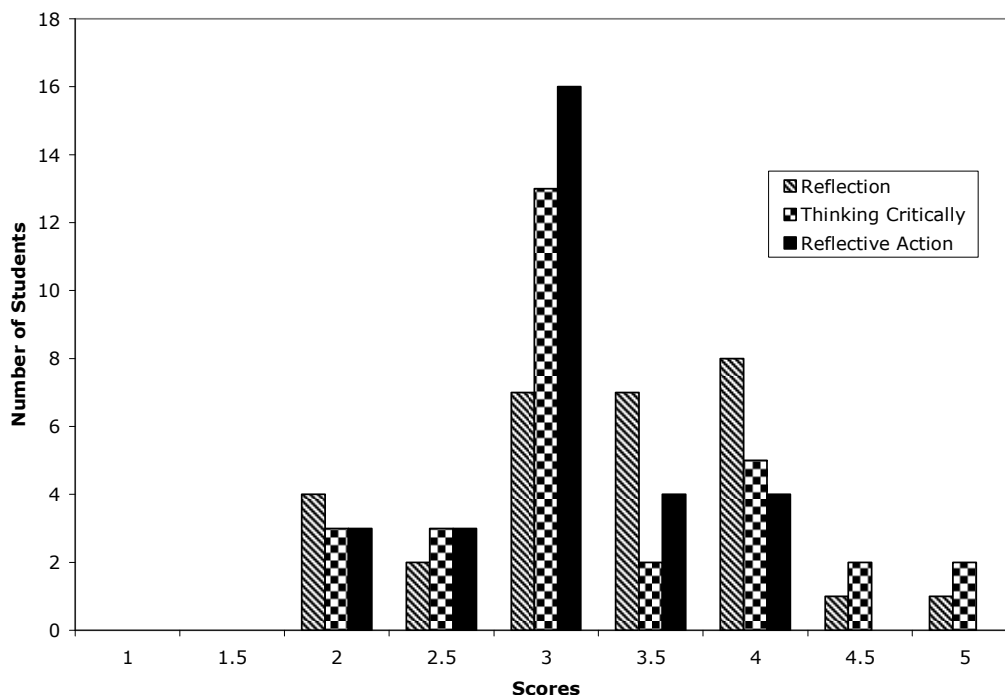


Figure 1: Achievement of Blog Outcomes

Focus Groups: Students talked about the role of the blogs in their learning and offered their ideas for improving the blogs. Some students discussed how the blog helped them relate thermodynamics to their everyday life:

This program is helping us to be ready for anything and with this class I am more able to relate things to my life. I was taking a shower the other day and I suddenly caught myself wondering if maybe there was no vent in here. I am now able to see more of the beauty of thermo...

Another student described how this process of linking thermo to life supports her confidence and self-directed learning:

The blog – the third question especially – made me think, pull knowledge and make connections that I would not have before. Usually I would just have gone to classes and learn about something versus thinking about it and trying to figure it out myself. That made me feel a bit more confident that I could actually do something rather than just learn, I can actually create or come up with something myself rather than learn what people have already done.

Other students had trouble making these connections:

- *It was not always easy or even possible to link things to your life at Smith, but if you did not do so you would not get a good grade.*

- *But the most frustrating part of the blog is that there was no thermo in it. I am told there are connections between ethics and thermo but I am sorry I do not see those connections. Maybe if she'd made the connections clear in class...but most of the time I was just lost.*

Several students described the blog changing their approaches to learning by fostering critical thinking:

- *I think that one thing that has changed about how I approach problem sets now through this course is that I think before I would just dive into problems and try to solve them right away, whereas now before I even start I take a few minutes to look at the problem and just like really think about it. I ask myself about what I know about the problem. It is interesting to me because I have never done this before until this class – I try to see how it all relates together.*
- *I am more critical; critical about the problems we solve, about the issues we cover in class and the discussions we have there also. There have been so many deep thoughts that have come to me that I don't think I would have had or would have seen things that deeply if I had not taken this thermodynamics class. It was not just the sciences, the technology, and all the math behind it, it was also this other side that helped me develop these critical thinking skills.*

Some students felt the blog did not help them learn thermodynamics, but had other side benefits:

- *As far as professional development I thought the blogs were very helpful because some of the readings were very interesting and completely relevant. For me this was so welcome because I felt our program lacked such perspectives. However, as far as helping you learn thermodynamics principles, I would say "yes and no" but it has definitely made me think about thermo on Saturday mornings and get me thinking but I don't think it helped as far as my deep understanding of thermo is concerned.*
- *I don't think it helped me learn thermo. At the same time it did help me to connect things more and to see how things relate to real life and real issues. It has also helped me to become clearer about who I am becoming as an engineer.*

Some students felt that the blog helped them by encouraging a process of articulating preconceptions and reflecting on what they learned:

- *The most helpful question of the blog for me was the one that asks you to start thinking about the topic that's coming next – that was really helpful. It got me to think before having to really push further to think later in the week when we were actually in the midst of the new topic – it helped putting things in perspective and relating to them.*
- *I actually liked reflecting back every week because it made me really learn things better than if I would see things once. It makes it more concrete in my head.*

Other students did not find reflection helpful and found it difficult to articulate what they had learned in a given week:

- *However, I was not a big fan on reflecting about this week's learning – once it's gone you know it's just gone. Once I know it I know it, now that I understand why should I have a question about it.*
- *The "what did you learn this week?" question was frustrating because if I did not have anything to say I would be told that I was not thinking very critically, but the fact of the matter is that most of the time there was nothing we would do in class that would change or expand my thoughts from one week to the next – I would just have nothing to think critically on. We keep talking about critical thinking but maybe if that tool would have been given to us in class then maybe we could have stretched it on to the blog and all.*

While some students recognized connections between the blog and the classroom, many students were under the impression that the instructor was not reading the blog.

- *The fact that she reads the blog and mentions what she gets from it in class was very good – it showed us how the blog mattered.*
- *When I have put energy into the blog I feel that I did learn a lot and learned to apply thermo to everyday life and everyday situations. But a lot of the time I have questions about it because we don't really apply it in class, and since she does not read the blogs I feel that all the questions that I ask each week don't get answered.*

Two students found the questions repetitive because they were phrased the same, although each week's answers ought to differ as what is learned ought to be different each week:

- *I did not like that every week it was the exact same set of questions and it got so repetitive that by the end I just got so exhausted of the questions. I was probably not thinking as much about them at the end because they were the same questions.*

Three students suggested that the blog should provide more information to students, though this seems to represent an abdication of responsibility for learning:

- *The blog should also give you more definitions to work with so that you're not working in a vacuum. Honestly, I don't read the book before coming to class, who does? And so for the blog to give us some concise definitions – something not text bookish – that would be great, especially if you want me to think critically about these things. I still have no idea what entropy is, I have to look it up every time.*
- *The thing I don't like is that they ask me about what I don't understand but they never tell me what I need to do to finally get to understand...*

Many students expressed concern about the time it took to do the blogs and the overall course workload. Some students reported that it took 30 minutes a week, but others said they spent up to four hours. (Students were instructed not to spend more than 30 minutes on the ethics reflection and 30 minutes on the learning reflection, one hour total.) Some complained that the blogs were due on a Saturday, though some students had requested this time because it took some pressure off the week. In the words of two students:

It was almost like taking two classes – thermo on one side and the rest on the other. There was too much, so that by the end of the week I would not have taken anything in,

and not really therefore internalize all these things. In order to make it more effective they should just pick fewer things to focus on.

But honestly, with the amount of work we were somewhat stretching ourselves too thin. You did not really have time to take the time to think about things deeply – you had to do the work as fast as you could.

Students articulated an appreciation for the community of care that liberative pedagogies create:

- *This is the first time for me that I had a teacher that actually wanted to learn and cared about her learning and different strategies and was always open to critique. I know from other classes that usually teachers just stand there and lecture and be extremely impersonal. [The instructor] is just the opposite, always open to question, always happy to learn and clearly cares about how we learn, and also how she changed her teaching methods for us, I thought was a really really good thing and it made me want to learn even more, and approach her even more and take the class even more seriously.*
- *I think her Liberative Pedagogies are very helpful because as women, and in my case, as a woman of color I love how she integrates everything in the class, because I feel that I can speak up. My voice is going to count and is going to be appreciated and it just makes me more comfortable of actually speaking up. The questions she asked are conducive to having me participate and she gives good feedback in class that encourages me to talk – before this class I would never have said anything in an engineering class. What was really helpful also was when she introduced the liberative pedagogies at the beginning of the semester, it just made sense and made me hope that things could be different for me in this class, and they were.*

Interestingly, this last comment sparked a conversation among three white students about their understandings of liberative pedagogies:

Participant 1: *I still can't figure out what liberative pedagogies are.*

Participant 2: *Is it a method of teaching through communities? I just wanted a definition of it and I felt I never got it.*

Participant 3: *I think the theoretical behind it is trying not to teach the mainstream white male, trying to teach in a way that women and minorities will feel more involved because of the way women think – more socially conscious. In practice, however, I did not really see it happening. I am not really sure what she is doing to try to do that.*

Students in other focus groups made similar comments that reflected varying degrees of understanding of liberative pedagogies:

- *I think liberative pedagogies are ways of teaching people so that you're being more inclusive and not just teaching white male students, but teaching that is geared for all kinds of students, but other than that and the large load of writing we had to do, I don't really see the difference; because we still have to learn the thermo, you still have to learn how to do the problems...*

- *To me it was all about becoming an empowered learner and with that you learn how to ask questions that will enable you to learn more about thermo and take the class to the next level.*

Course evaluations (Table 2) suggest that students understood the goals and expectations around critical thinking and reflective action, and felt that classroom learning was active. Students felt the objective of relating thermodynamics to everyday life was relatively fulfilled, but gave a lower fulfillment rating to their abilities to assess and direct their own learning. Based on comments written on the surveys, it is possible that students didn't evaluate the fulfillment of objectives as requested, but their feelings on the relative importance of these objectives. For example, next to the item on self-directed learning, one student, who had given it a 1, wrote "I hate this." The blog assignment was not as popular as some other assignments, notably a three-part project relating thermodynamics to everyday life.

Table 2: Selected Course Evaluation Data related to Blogs

Instructor Performance	Mean	med	stdev		mean	med	stdev
Fostered my responsibility for learning	3.82	4	1.09	Assignment Quality:			
Helped me relate concepts to everyday life	3.78	4	1.09	Thermo to Life	3.52	4	1.09
Fostered critical thinking	3.89	4	1.20	Blogs	2.82	3	1.16
Empowered students to be active participants in classroom learning	4.32	4.5	0.82				
Linked the technical subject to real world and ethical issues	3.84	4	0.99	Objectives fulfilled:			
Was explicit in her expectation that students think critically and act reflectively	4.21	4	0.69	The ability to relate thermodynamics principles to everyday life	3.91	4	0.88
Was interesting and stimulated my thinking and reflection	3.48	4	1.13	The ability to assess and direct my own learning, and to reflect on that process	3.54	4	1.23
Engaged the class with material rather than simply giving the answers	3.96	4	0.92				

Discussion

The blog worked well as a tool to allow students to explore their own learning process. This is a crucial element of effective intentional learning. Students become actively engaged, articulating assumptions and questioning course content, thinking critically about material and reflecting on how it applies in their personal and professional life. As students go about explaining the material in and out of class, and particularly by writing out their ideas, they are able to better understand the material at hand and at times they are able to connect it to material that they learned in other classes. This allowed students to reflect more clearly on their learning and better understand how the material they are learning can be connected to their everyday experiences as well as material they have learned in previous classes. The blog challenged students to go beyond the textbook and classroom into the relevant real world to forge for themselves the connections that will make their learning last.

Having the blogs online allowed students to read and respond each other's entries. This fostered an informal learning where students could offer answers to questions other students asked and inspire one another with new ideas. Ideally this type of interaction fed into the group reflective action project, but in practice it will be necessary in the future to support the team interactions more in order to ensure their effectiveness. The lower average for reflective action in our evaluation partly reflects this factor.

There was also a learning curve for our team in implementing the blog. We had trouble communicating what we wanted from the students at the outset. Mid-semester we added a question that asked students to look back on their previous blog entries and describe what they have learned since the previous week, with respect to their previously articulated preconceptions. We had expected this of the students, but found they had not understood how to do this. Both the blogs and the focus groups show that students articulated their learning process better after this change was made. Initially we had not made that instruction explicit, but we created a question that directed students to do this work, to significant success.

We have learned that such a directed question is also needed to assist students with the reflective action piece of the class. While the student projects reflect achievement of the reflective action objective, the connection between the blogs and this assignment could have been made more clear by asking students to articulate the process better. A second difficulty with this aspect of the course was a lack of positive engagement in teams due to a combination of factors including time constraints, a lack of regular reporting, unclear expectations, and lack of student initiative. One group outperformed the others in this regard; their example can be used as a template to communicate expectations with the next class.

Another lesson learned relates to the grader feedback. Graders need training in liberative pedagogies and what is meant by reflection, critical thinking, and reflective action. Such training will likely result in better feedback that will help students get more out of the blogs. Feedback was administered electronically to save paper, and unfortunately many students did not look at grader comments and thus did not improve on their blog assignments. More effective feedback in terms of content and delivery, and a clearer explanation of expectations for the blogs will produce better results.

References were made to student preconceptions in class, but perhaps students did not identify those references as relating to their specific questions. A logistical problem with using Blackboard's Digital Drop Box to provide students feedback on their blogs contributed to this perception; students failed to check the drop box and thus were unaware of feedback that was delivered to them. Many questions were not answered in class because they were not deep critical thinking questions, but definitional questions students could have answered themselves by reading the text. Interestingly, the focus group data includes several students expressing that they did not read the text at all; some found it decidedly unhelpful. The text was selected by a previous thermodynamics course after reviewing the available texts; they found it to be the most accessible and understandable, but perhaps engineering educators have further to go with textbook development.

It may be helpful in the future to track two types of critical thinking, one about the course material and another about the learning process. The feedback from students about their experience in the course certainly suggests that their acquisition of critical thinking skills applies as much to their learning as to the technical material.

There was an overall concern expressed in the focus groups about the workload related to the blogs. It may be that “less is more” in the future. Streamlining the questions based on what we’ve learned on the first iteration can help students feel that they are getting more out of the time they are putting into these assignments.

The blogs can be adapted for use in any core or elective engineering course. Most questions posed were focused on helping students reflect and articulate their learning process, and thus are not subject-specific. Only the “think ahead” questions contained subject-specific material, and it would be straightforward to generate these for other courses.

Conclusion

The blog is a promising tool for integrated learning and assessment that can be used to measure the achievement of the goals of liberative pedagogies, and can be adapted to measure the achievement of a variety of other learning goals. It provides a pedagogical space in which students and professor are both engaged in self-reflection, one on their learning and the other on their teaching, allowing each to do their job better. The blog is indeed not only a powerful tool for integrated learning, but it is also a highly instructionally sensitive instrument.

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