Aesthetics of Design: a Case Study of a Course

Ms. Katherine Goodman, University of Colorado, Boulder

Katherine Goodman is currently a graduate student at the University of Colorado Boulder in the ATLAS Institute, working toward a Ph.D. in Technology, Media, and Society. Her research is in engineering education, with a focus on fluids and design courses. She holds a B.S. in mathematics and a masters of professional writing. She has previously worked as a technical writer and project coordinator, and as an instructor in composition at the University of Southern California and the Community College of Aurora.

Dr. Hunter Porterfield Ewen, University of Colorado, Boulder

Hunter Ewen is a dramatic composer, educator, and multimedia designer. During the day, Dr. Ewen teaches students strategies for digital creativity. At night, he composes, solders, choreographs, and videographs solo and collaborative projects around the world.

His works rail against the faded borders that separate art from science, music from sound, and meaning from meaninglessness. Ewen values frenzy. He buzzes and sneaks and desperately loves. His work is soothing, startling, virtuosic, and absurd. It grooves with dense, layered textures. It lusts for yowls and yips and wails and squeals. For screams that masquerade as art. For clamor and deviance. His compositions swing from chandeliers.

At The University of Colorado, Boulder, Ewen teaches composition, music technology, and design for the colleges of Music and Engineering. Ewen also directs the 64 Bit Composition Competition, serves on faculty of Reel Kids Theater Troupe, and works as the editorial assistant for Music Theory Online.

Mr. Jiffer W Harriman Jr, University of Colorado

Jiffer's has his BS in Electrical Engineering from the University of Colorado and a MA in Music, Science and Technology from Stanford. He is currently a PhD student at the ATLAS Institute at the University of Colorado. His work focuses on interactive technologies for music, art and education.

Dr. Jean Hertzberg, University of Colorado, Boulder

Dr. Hertzberg is currently Associate Professor of Mechanical Engineering at CU-Boulder. She teaches graduate and undergraduate courses in measurement techniques, thermodynamics, fluid mechanics, heat transfer, design and computer tools. She has pioneered a spectacular course on the art and physics of flow visualization, and is conducting research on the impact of the course with respect to visual perception and educational outcomes. Her disciplinary research centers around pulsatile, vortex dominated flows with applications in both combustion and bio-fluid dynamics. She is also interested in a variety of flow field measurement techniques. Current projects include electrospray atomization of jet fuel and velocity and vorticity in human cardiac ventricles and large vessels.

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Overview

In a technical elective offered in the Mechanical Engineering department at the University of Colorado Boulder, students designed and built projects while developing a *design aesthetic*. Three instructors offered insights from multiple disciplines, including those outside mechanical engineering, such as electrical engineering, computer science, photography, and music. Students were placed in *resource teams*. In these teams, each student acted as a consultant on teammates' projects, and acted as team lead for his or her own project. Here we describe the novel course design, offer instructors' insights, as well as results from student surveys (n=20) and student interviews (n=4) both pre- and post-course. Results suggest a pent-up demand among students for an outlet to design and create physical objects. Also, student data highlight the gap between learning practices and professional practices in engineering. We suggest revisions to our pedagogical structure and broader implications for our teaching methods.

Introduction

In May 2014, a new technical elective, titled Aesthetics of Design, was offered at the University of Colorado Boulder in the Mechanical Engineering department. This elective was cross-listed for both undergraduates and graduate students, and offered students something rare: the opportunity to design and build something completely of their own choosing.
In many engineering design courses, multiple constraints restrict students' inspiration, and the aesthetic sense is de-emphasized or ignored completely. We wanted to emphasize aesthetic sense as a guiding principle in design specifically[1] and engineering more broadly[2]. As a result, course material focused on different notions of aesthetics to help students broaden their vision, and the instructors imposed only one constraint on the project: that the object be dynamic.

Background

Our work in engineering education is informed by the idea of the *transformative experience*. The transformative experience is a learning experience, after which a student will : 1) apply ideas from a course in everyday experience without being required to (also called *motivated use*); 2) see everyday objects or situations differently, through the lens of the new content (*expanded perception*); and 3) value the content in a new way because it enriches everyday affective experience (*affective value*)[3]. The transformative experience stems from John Dewey's seminal theory of experiential learning, and influenced by his work on the value of aesthetic experiences[4,5]. In other words, we want students to be able to perceive concepts they have learned in the larger world, put those concepts to work, and enjoy the experience. Framing our work using the transformative experience helps us keep in sight the ultimate goal of educating engineers, even while we dig into the details of devising our courses.

Design courses typically provide students with the opportunity to work iteratively, exercise communication and teamwork skills, and generally apply engineering science to engineering practice. These courses are often intended to mirror industry[6], an emphasis recognized by national efforts to define "real world" experiences[7] and attempts to measure a students' "contextual competence" or ability to function in the workplace[8]. Efforts are being made to more accurately evaluate these courses and to make them multidisciplinary[9]. Students' work is guided by user specifications or by a specified problem, as in problem-based learning, work that requires creative, convergent thinking[10]. What is often missing from the discussion is divergent thinking and innovation[11], the open-ended creativity most often associated with the arts[12].

Emphasizing this artistic or aesthetic element of design was the motivation for developing and studying the Aesthetics of Design (Aes Des) course. This also builds on our previous work, which focused on the pedagogical practices of another aesthetically-oriented technical elective, Flow Visualization (Flow Vis) [13,14]. Flow Vis is focused on the creation of beautiful and scientifically useful images of fluid flows (stills or short videos). Students must also provide written descriptions of the forces involved in their images. Several aspects of Flow Vis make it different from other engineering courses:

1. Groups are formed by the instructor to provide support for students, but each individual must still produce an individual project. We call these *resource teams.*
2. Students have wide latitude in what types of fluids they photograph. *Choice.*
3. Aesthetics is given equal emphasis with usefulness of the image. *Aesthetics.*
4. Novel images are valued over routine or highly similar ones. *Creativity*.
5. The students present each image and receive feedback from the instructor and each other. Work is posted online, and becomes part of the students' online persona. *Public presentation and critique.*
6. Flow Vis is cross-listed with both Film and Fine Arts Photography studio courses, and roughly a third of the students in the course are non-engineering majors. *Heterogeneity of students.*

A previous attempt to adapt these pedagogical practices resulted in a course called Perception of Design (PD), which focused on making images of objects to facilitate discussion and examination of design. This course mirrored Flow Vis by allowing *choice* in subject matter, emphasizing *aesthetics*, and including *public presentation and critique*. However, it was different in significant ways. Non-engineering students were not included, and the course was worth one credit, making it a significantly smaller time commitment than the three credit Flow Vis course. PD did not succeed in the same ways that Flow Vis has. It did not create a positive shift in affect for students, as measured in surveys[14]. Also, it did not draw the same enthusiasm from students, revealed by the waitlist for Flow Vis every semester while PD was never filled completely any of the three times it was offered. This is despite an ongoing need for technical electives of one or two credits in engineering. PD did not generate a significant level of artistic expression, and did not seem to help students understand design the way Flow Vis enhanced students' understanding of fluids. After being offered three times, with adjustments made each time, PD was discontinued[14].

While the reduced time commitment was surely a factor in how seriously students approached the course, other factors also seemed to have influenced the way students undertook the assignments. One possibility is that the creativity involved in photographing objects was an indirect experience. Whereas Flow Vis students create the experiments that they want to capture[a], the PD students only had to position the objects on a background, and almost all chose mundane backgrounds. Another is that PD did not group students into resource teams, a choice made due to the lesser time commitment for the course. Still searching for ways to apply the success of Flow Vis to other subjects, we developed a new course, Aesthetics of Design (Aes Des), with all the pedagogical practices except the heterogeneity of students. Specifically, we employed resource teams, choice, aesthetics, creativity, and public presentation and critique.

Course Description

Aesthetics of Design (Aes Des) is a three-credit technical elective, offered for the first time in the summer of 2014. It was held during a compressed, three-week summer session that met Monday–Friday for 3.5 hours a day. Students designed and built projects while developing a *design aesthetic*. Three instructors offered insights from multiple disciplines, including those outside mechanical engineering, such as electrical engineering, computer science, photography, and music.

Instructor Goals and Logistics

The learning objective for the course was to have students reframe their understanding of design to include aesthetics. The resulting projects were a secondary consideration, a vehicle for helping students change their assumptions about design tasks and to pursue a personal aesthetic. As a result, a main goal of the instructors became creating a safe environment, where students could take risks with their designs without worrying that a failing project meant a failing grade. As long as students were engaged in the process, they were considered to be succeeding in the course, even if the final project "crashed and burned."

The participatory nature of the course meant that even "lectures" were structured to encourage students to reflect, respond, and share new ideas. Early topics introduced different design aesthetics and covered broad background, such as the theory of design, a historical approach to design, or how design paralleled art in the 20th century. Other class sessions explored the aesthetic properties of styles from Romanticism and Gothic Revival to current trends like 8-bit and steampunk. Case studies from art, industrial design, architecture, music, and engineering included successful designs such as the Treepod[b], Philips Pavillion[c], Piaggio Vespa[d], Box Appetit[e], REMLshelf[f], Paipei 101[g], Soccket[h], Zendrum[i], Oyster Pail[j], London Telephone Booth[k], John Deere Tractor[l], and the Apple II[m].

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[a] Two of the six Flow Vis assignments require students to capture clouds, rather than create their own flows.
[b] http://www.shiftboston.org/competitions/2011_treepods.php
[c] http://en.wikipedia.org/wiki/Philips_Pavilion
[d] http://www.piaggiousa.com/history.html
[e] http://www.black-blum.com/products/box-appetit/
[f] http://design-milk.com/remlshelf-artistic-wood-shelving/
[g] http://en.wikipedia.org/wiki/Taipei_101
[h] https://www.kickstarter.com/projects/unchartedplay/soccket-the-energy-harnessing-soccer-ball
[i] http://www.zendrum.com/
[j] http://en.wikipedia.org/wiki/Oyster_pail
[k] http://en.wikipedia.org/wiki/Red_telephone_box
[l] https://www.deere.com/en_US/corporate/our_company/about_us/history/timeline/timeline.page

Lectures were interspersed with interactive workshops. For example, one activity, called an *empathetic design thinking* workshop[n], had each student articulate what he or she wanted to design to another student, who then had to outline a design for the first student. The goal of this was discover the underlying motivations of the first student (the interviewee), so that the second student could alter and improve the design without losing its core. This required that the interviewer listen with empathy to understand not only what the interviewee wanted to make but why. The activity also served an intended secondary function, helping teammates get to know each other. As the course progressed, organized whole-class activity tapered off to allow for more individual or team work.

Each instructor gave the lectures or guided the activities most closely affiliated with his or her expertise. That instructor was responsible for that portion of the materials, documentation, and content. The instructors started the course with a mutually agreed-upon general outline, and made detailed plans roughly two days in advance. The design of the course had to be adaptive, both for the shortened semester format and for the needs of the particular students. Activities were added, removed, lengthened or shortened based on the reception of topics in previous days. To facilitate this on-going instructional design, instructors met daily for 30-60 minutes after the class. Fortunately, their complimentary mix of expertise and teaching styles simplified keeping the course organized even while it remained fluid.

Outside of the post-class meetings, the instructors communicated primarily by email. They took turns reading the students' daily blog posts (see description below), flagging any that caused concern, and relaying those posts to the appropriate instructor. Reading and evaluating longer reports (which accompanied the design review presentations, see below) was done in the same manner, with one instructor taking lead on a particular set of reports, and relaying any issues to other instructors as needed.

[m] http://en.wikipedia.org/wiki/Apple_II_series
[n] Based on Stanford d.school's gift-giving exercise (http://dschool.stanford.edu/dgift/).

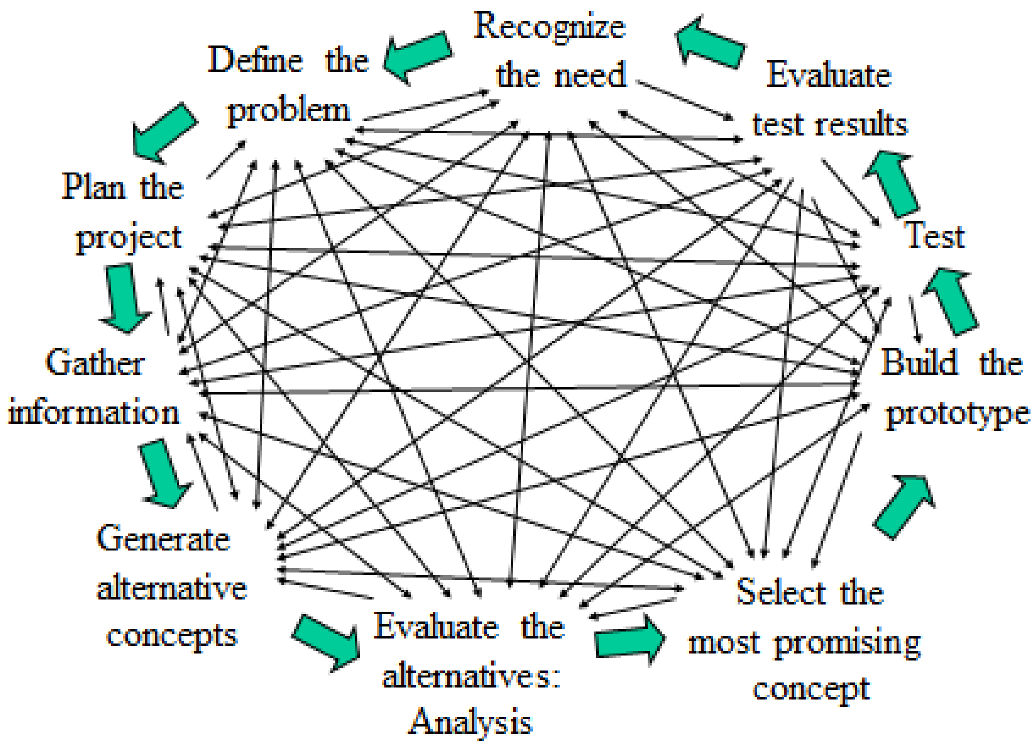

Figure 1: The Iterative Design Process[15]

As the course progressed, the instructors discovered that their emphasis had to be on the iterative nature of design. Students were understandably eager to jump to the building phase of their work, often without reflecting on their choices. Many of the course activities introduced had aims such as identifying users' needs, researching existing solutions, vetting a promising solution and possible alternatives, and problem-solving or redesigning once a solution failed to materialize as hoped. In lectures, workshops, and individual contact with students, the instructors worked to underscore the fluidity of good design, and encourage students' willingness to change, update, or otherwise iterate in their work. Figure 1 is a graphic used in class to explain the iterative, and often messy, process of design[15].

Team configuration
Students were assigned to teams using a CATME (www.catme.org) questionnaire[16], with 97% of the students participating. Instructors customized the categories so that students with similar commitment levels to the course and similar schedules were more likely to get grouped together. Race and gender information was used to ensure that no student from an underrepresented demographic was isolated on a team. Also, teams were formulated to have diverse backgrounds and skills among the team members. At the end of the course, students were invited to use the CATME peer evaluation tool[17], with 88% of the students participating. Those results were released to students at the end of the course.

Class assignments

The Project

Students were given the task of designing an object and building it, according to their personally defined design aesthetic. The only requirement was that the object be dynamic in some way. (We should note that logistics constrained students' projects in other ways. Students owned their final projects, so they were expected to buy the materials. Most students faced financial constraints. Due to time limitations, ordering parts or materials was not always feasible. Also, students were not able to secure projects on-site except in 4 ft^3 lockers, which created a size constraint for some students who preferred to have larger projects on-hand during class.) Examples of student projects are shown in Figure 2.

The Blog

Students were asked to create a new blog post each day, where they were expected to record design decisions and progress, reflect on influences on their aesthetic choices, and note other thoughts related to the course, a practice noted to help with reflective learning[18]. These were publicly visible (http://aestheticsindesign.blogspot.com/) and took the place of a physical design notebook for many students.

Design Review Presentations and Reports

Each of the three weeks ended with a design review presentation and accompanying report. The first week featured a brief preliminary design review. In week 2, for the critical design review, many students presented the difficulties they were facing and sought input from both instructors and other students. At the end of the course, a final review was presented publicly. The instructions for the final paper, due the day after the public review, asked students to not only detail traditional metrics, such as construction, costs, and functionality, but also address whether aesthetic goals were met. They were encouraged to reflect on the entire process of the course, describe their work on the project, and comment on what they learned along the way.

Figure 2: Samples of student projects, from top going clockwise, LED Poi by Patrick Maguire, The Grub Shrub by Max Anderson, Watch Box by David Bidwell, and Sea-t Anemone by Chelsea Young

Research Methods

Students were invited to participate in the research being done on the course during class and through email[o]. All students were asked to complete both pre- and post-course surveys. Those interested in being interviewed replied to an email invitation that went directly to the research interviewer without going through the instructors. There were 34 students in the course. In the pre-course survey, 24 students responded, and in the post-course survey, 22 responded. Within those responses were 20 matched pre/post sets for analysis. The survey contained both numerically scored items (on a Likert scale), and open response items. Numerical items were evaluated statistically, and open response items were coded with an emergent coding scheme, as were the interview transcripts. Four students were each interviewed twice, once during the first week of the course, and once after the course had completed.

[o] We completed IRB protocols for this work, and it was found to be exempt from IRB reporting.

Research Results

Survey Results

In our past work, one way we measured a course's success was by looking at increased perception of the content area in the world outside the classroom. An awareness, for example, of aesthetic principles in objects would be one indicator that students had learned the content of the course. This would be especially important if that awareness occurred without the prompting of a specific assignment. In Flow Vis, we found that the course increased student perceptions of fluid dynamics outside the classroom by using a survey, called the Fluids Perception Survey (FluPerS), which has been validated[14]. The survey for Aes Des used FluPerS as its basis, but the new survey instrument did not have enough range. The students hit the "ceiling" in the pre-course survey, giving no measurement of increased interest.

For instance, when asked to indicate their strength of agreement with the statement "Studying design is useful to me, professionally," most students responded with the highest level of agreement – in both the pre- and post-course surveys. Another indication of the ceiling effect is that the average response for both the pre- and post-course survey for "How often do you both notice and think about design outside of classwork?" was "several times a day." This indicates that student had pre-existing high levels of perception in the area of design.

All of the results from the numerically-scored portion of the survey showed a similar result, namely, that students were *already* intensely interested in design. Finding the difference from pre- to post- for each individual, we found that the mean change was less than 7%, and not statistically significant. We believe these survey results are an artifact of the survey not being fully adapted for its new context, and the compressed course format made revising and re-administering a new version of the survey unfeasible. To learn more, we turned to the open response questions and the interviews.

Interviews and Open Response

Achieving the Learning Objective

One way of analyzing the learning taking place in a classroom is by creating a learning conjecture map[19]. Figure 3 shows the learning conjecture map formed around the intended learning objective of the course, that students considers both function and aesthetics in future design tasks. Notice that embodiments are structures designed by the instructors. Mediating processes are the ways students take up or use those embodiments. Outcomes are what result, and if things go as planned, these are the learning objectives of the course. Arrows connect those embodiments, mediating processes, and outcomes we found to be linked.

When asked "What did you learn that was new to you?", 13 of the 20 respondents indicated some kind of aesthetic principle, either by listing a specific designer or artist ("Wayne White" Sub08) or by indicating a general new awareness of the connection between art and engineering ("really help me to see the artistic side of design" Sub16).

Regarding the blog, 13 of the 20 respondents indicated that it was a helpful tool in their work, although several commented that they wished other students had had time to comment on each other's blogs more, and a couple said they would rather have used a physical design notebook. One interviewee summed up his thoughts on the blog by saying, "we have these lectures on different aesthetics …the blog helps you to really reflect on what was talked about and let it kind of seep into your work that you're actually doing" (Sub22).

Marked with dashed lines in Figure 3 is an unintended outcome of the course. In line with typical course demands, which place a high value on finishing a functional product, some students short-circuited the focus on aesthetics in favor of a more complete final project. In one post-course interview, a student commented that discussion of aesthetics concepts were cut off by time pressure, because some students felt the "need to go to machine lab rather than asking questions about lecture" and "people were really focused on finishing their projects and less focused on getting the idea of aesthetics and maybe how to integrate them" (Sub13).

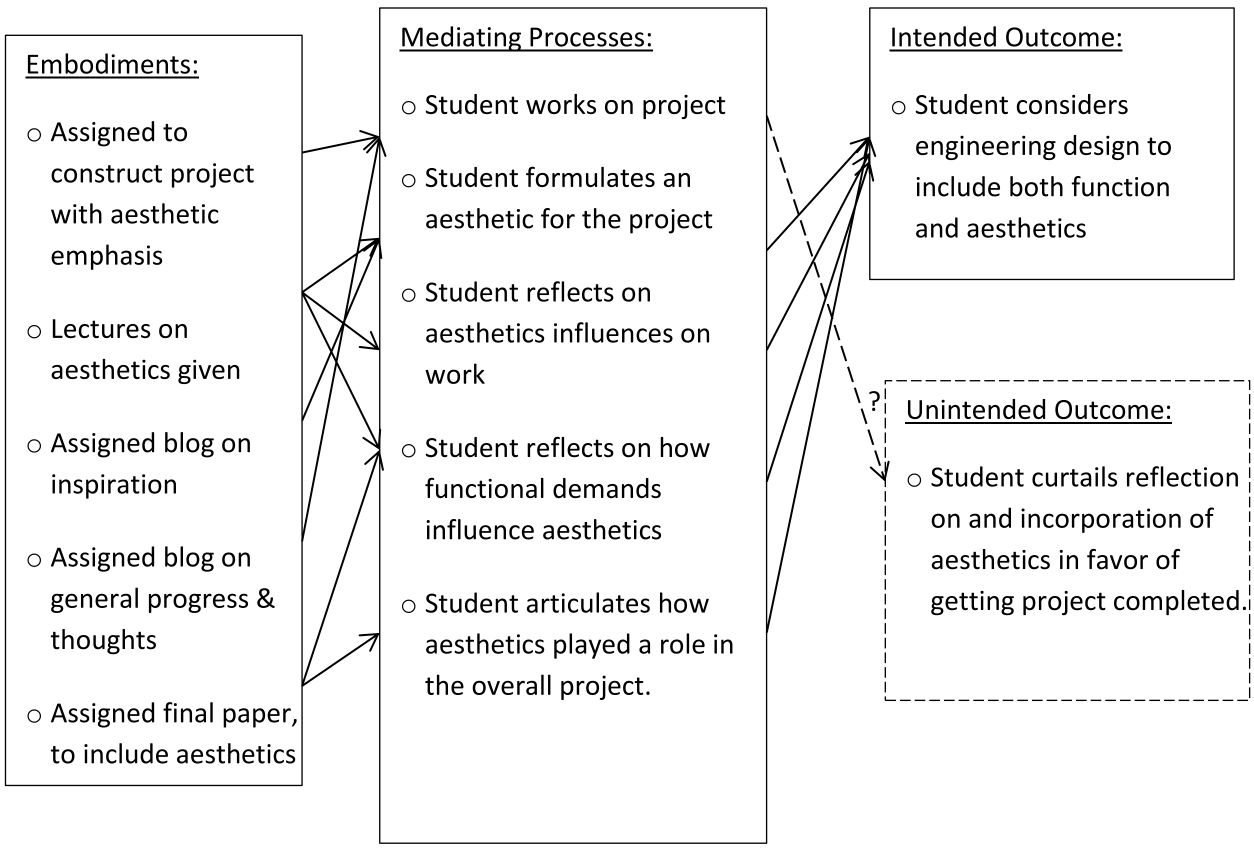

Figure 3: Learning Conjecture Map with Intended Learning Outcome

Echoing this, three survey respondents simply said "more time" when asked the question "Is there anything else you think this class should include?" On a related question, "What would you have done differently if this was a full semester class?", students indicated they would been more aligned with the goal of the course, if given more time:

"I would have focused more on aesthetics" (Sub01).

"More iterations, user testing for usability/aesthetics" (Sub06).

And they would have taken more time for reflection on their design choices:

"Thought more about the motivations behind my design. Also spent time engaging with other students about their designs" (Sub13).

"This material would have gotten more of the attention it deserves, with more contemplation" (Sub14).

Other Learning Outcomes

To consider whether Aes Des was a success, we decided to look beyond the intended outcome of the course. Reviewing the interview transcripts revealed repeated ideas that lead us to create a second learning conjecture map, Figure 4.

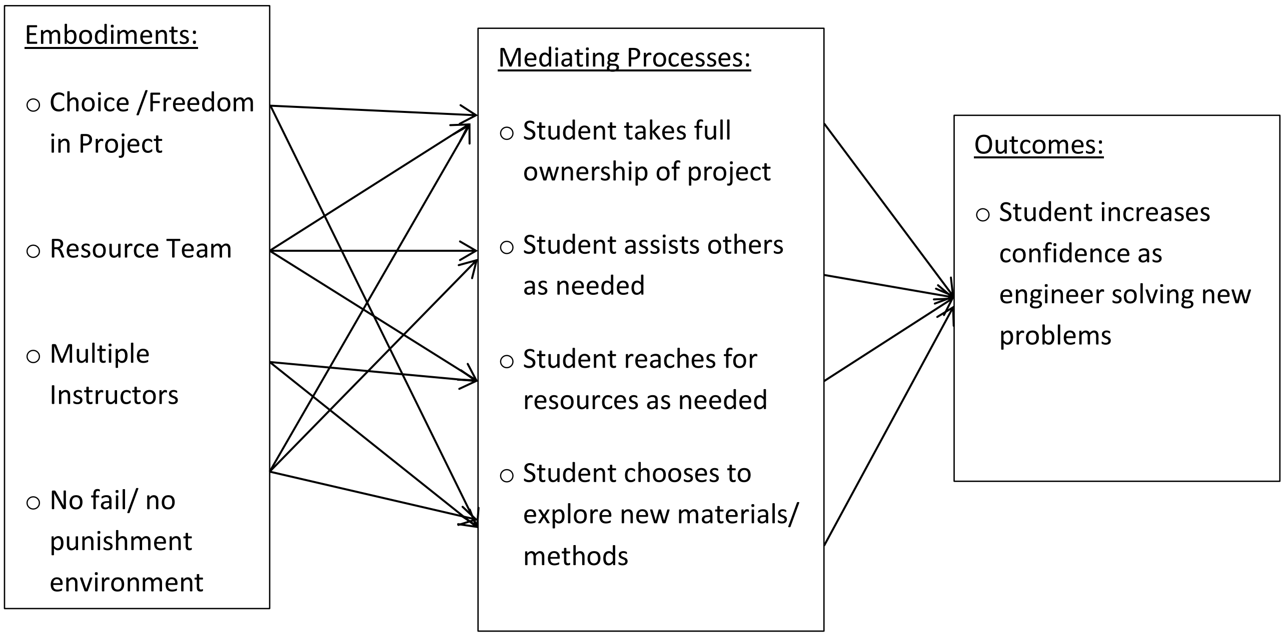

Figure 4: Learning Conjecture Map with Unintended Learning Outcome

Most interesting about this conjecture map is that its embodiments are similar to the pedagogical practices copied from Flow Vis. These embodiments work together to allow students to take risks and stretch their abilities, by dismantling some of the natural competitiveness of the students. Although they still judged their projects based on how "ambitious" they appeared to be in comparison with others, that tendency was softened by the mediating processes. The structure of the teams, with the diversity of skills, and the sense of collaboration while keeping ownership of their individual projects, contributed both to freedom of expression and sense of cooperation:

"[my teammates were helpful because] one of them had experience with manufacturing and the other one had more experience with electronics" (Sub02).

"There was definitely some good discussion for each project of possibilities …someone suggested using a particular manufacturing method and that was really helpful" (Sub22).

[When I had problems I told] my group about it, and they started giving me ideas and helped me scale back and re-envision what I wanted, which was nice…. [When another teammate ran into major difficulties] he ended up going another direction…that we kind of helped him with." (later in the same interview) “Since this class wasn’t curved or anything…**no one wants to see anyone else fail so everyone was helpful** in trying to give good advice.” (Sub21), emphasis added.

“The dynamic was a little different [than other group projects] but I really enjoyed it. I think people felt **more open to give opinions** because whether you use them or not it wasn’t really effecting them…. There can be tension in groups because you’re working together and people have opposing ideas and then you have to decide which one to implement and make everyone happy, whereas here … you could decide and **people weren’t offended if you didn’t like their ideas**” (Sub13), emphasis added.

Not all teams functioned smoothly, as four survey respondents specifically indicated, one of which also commented, “honestly the most useful thing I learned might have been to reflect on my behavior when working in a team setting” (Sub18).

This generally-supportive environment encouraged students to learn new techniques or work with new materials. Survey respondents cited new skills such as “learned about pumps” (Sub20), “gear modeling” (Sub04), or “a lot of new machining and construction techniques.” (Sub19), and several students sought out the instructor with an electrical engineering background to learn to program an Arduino. Overall, 11 respondents commented on specific new manufacturing methods they tried, new tools they learned to use, or new materials they worked with.

As illustrated in Figure 4, these features of the course (choice of project, resource teams, multiple instructors, no fail environment) combined to influence students to take ownership of their projects, to feel free to assist others, to reach out for resources as needed, and to explore new construction methods. For example, in one interview, the student indicated that the combination of choosing the project and feeling like there would be no punishment for failing encouraged him, even when his project did not function as planned:

“[The instructor] wants us to struggle, she wants us to go through, and in the same time not punish us for failing. It's not about how well you do compared to others, it's about how you really put in the hard effort and develop yourself, which is unlike any of the other classes. Other classes are based on competition. This one is totally based on self-improvement…because that’s what happened in the end when I sort of felt like I failed, you know. But she was like, look what you learned, which made me feel so great because I did learn a lot.” (Sub02)

This seems more significant in light of this particular subject’s other comments about competition, and that he judged his project to be “in the top five most ambitious projects.” Several survey respondents commented on the need for self-reliance as well as the importance of outside assistance. This seeming dichotomy mirrors the behavior in professional environments for engineers, where there is an expectation both to complete work independently and self-advocate to locate resources and solutions when setbacks occur.

Finally, these mediating processes combine for a striking outcome: students felt more confident in their ability to be engineers. From the survey:

[The best part of the class was] making something that is completely your own. All the mistakes are your fault” (Sub06).

“I managed to find way to incorporate aesthetics into engineering in ways that I had not before” (Sub13).

“I feel like I grew exponentially… I feel like the creation of [my project] really stretched my understanding about art, mechanical systems, manufacturing, tolerances and working with people” (Sub12).

From an interview:
“My confidence to succeed as an engineer has increased and in this class it was because I was able to tackle a whole new method that I didn’t know anything about and then do it successfully” (Sub22).

While other learning outcomes certainly occurred among the students, this recurring theme of intense growth or confidence in abilities appeared to develop from these particular balances: self-reliance with leveraging resources, offering and accepting honest critique, and risk-taking in a supportive environment.

Discussion

Was Aesthetics of Design a success?
In one sense, the course was an unqualified success: we did adapt and use the teaching practices we intended to carry over from the Flow Vis course. Like Flow Vis, Aes Des students were grouped into teams where the expectation was that each team member would act as lead for his or her own project, calling on teammates for assistance and ideas as needed. *Resource teams.* Students were given wide latitude as to the nature of their projects. The one stipulation was that that the object be dynamic in some way. *Choice.* Also similar in format to Flow Vis, students were expected to be *creative* and employ a sense of *aesthetics* that they could clearly express in their final paper. Also, student work was subjected to *public presentation and critique*.

There were other significant differences from Flow Vis in addition to the change in subject matter. Aes Des was offered during a compressed summer session, while Flow Vis is offered during a full-length semester. As a result, students had difficulty getting access to certain resources, such as the machine shop, which was not open during evenings or weekends. Also, the College of Engineering offered an incentive for courses in that particular summer session, which meant that multiple instructors could be hired for the course. Several students pointed to the variety in instructors’ expertise as contributing to success.

Moreover, the Flow Vis course features extreme heterogeneity of backgrounds and skillsets among the students, as seen in their diverse majors. The participation of film or photography students is frequently cited by engineering students in Flow Vis feedback as a positive aspect of the class. Aes Des had all engineering students[p], and nearly all came from mechanical engineering. However, the heterogeneity of the *projects* in the class surfaced the need for many different skills, in a way other design courses do not. Students were able to draw on their

[p] We attempted to recruit sculpture and other arts students, but this effort did not succeed. The class may have to become more established to engage this crossover group of students.

teammates' (and instructors') divergent skill sets, and many students pointed to their teammates' skills as different from their own and useful.

With regard to the learning objective, Aes Des was a success, with some qualifications. Many students commented on their improved understanding of aesthetics as part of the design process. However, a small but visible subset of the students chose to ignore or downplay the requirement for a dynamic object, building a static piece of furniture instead. This was mentioned by two of the four interviewed students as awkward for the rest of the class. It is easy to find the furniture-building students in survey responses, because when asked what they got out of the course, these students simply state "my [piece of furniture]". Other students who may not have grasped the full value of the course complained in the survey comments about not finishing their projects being a major downfall of the course, or that lectures and class activities were "pointless" (Sub01). As one student commented, one thing the class needed was "some better way to filter out unenthusiastic students" (Sub14).

Most encouraging were the results that led to Figure 4. Assigning projects that encourage the development of new skills and result in improved confidence to tackle future engineering problems should be central to a good engineering education.

Contributing to Engineering Education

In the context of engineering education, a course like Aesthetics of Design would appear to be a positive and much-needed addition, and should be studied alongside more typical capstone design courses[6,20]. Many of our students will enter highly competitive situations, such as those mirrored in traditional design courses, but students also need to learn to accept advice from others in a non-competitive way. They need to learn to function with teammates of diverse expertise, something that is difficult to provide in courses where the students have the same educational backgrounds and are working on nearly-identical projects. That same semester-constraint also tends to create a pressure to view failures as endpoints because they result in failed grades, when those "failures" should be viewed as temporary setbacks, part of the iterative design process and something every working engineer encounters.

Finally, engineers are often given specific design specifications, and this format is followed in traditional design courses. Yet, effective engineers ask not only what the specifications *are*, but *why* they are, to get to the core of what the end user desires from the product or system. Aesthetics of Design, with its emphasis on determining both users' functionality needs and preferred aesthetic, encourages students to embrace the whole challenge of design.

Future Work

Aesthetics of Design is now scheduled for a full-length semester (Spring 2016). Some of the logistical challenges students faced will be alleviated by the expanded time frame. We intend to revise and validate the survey used to assess student affect and perception, using the qualitative analysis shared here as a framework. The revised survey will need questions that allow for a higher range of responses, perhaps focusing on the aesthetics of design, rather than design in general. We also hope to use the conjecture maps as tools to design for more specific learning outcomes, rather than the broader outcomes that resulted from this first offering of the course.

In retrospect, many elements of design-based research (DBR) surfaced in our work, from the coordination and implementation of the course itself, to the methods of analysis[21,22]. For instance, instructors acted as co-designers of the course, and learned by the flow of the class and needs of the students where to focus their efforts. Others have highlighted the impact the learning sciences and specifically DBR may have in engineering education[23,24]. By being more deliberate in utilizing these areas of education research, we hope to find guidance as we expand our efforts, an extension that requires looking at problems of institutional change[25].

Conclusions

When enabled to work on personally meaningful projects, many students took risks, attempting projects outside their existing skillset, which resulted in students' increased confidence in their engineering abilities. The course's emphasis on design and reflection upon aesthetic principles prompted students to focus their energy on the creative side of engineering, an aspect often neglected in current course offerings. While one initial goal of the course was to improve students' perception of design, what we found was that these engineering students already perceive design in the world around them. What was lacking was an opportunity to develop and express a unique and personal design aesthetic.

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