Parallels in Teaching Visual Arts and Engineering Design

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Abstract

My diverse education has given me unique insights into the way design is taught in both visual arts and engineering. Although the specific tools, techniques, objectives, and constraints of each discipline may differ, I have found that their underlying process of design are similar. If we can accept this similitude, then educators in engineering should benefit from learning about the way design is taught in the visual arts. With this in mind, this paper reflects on the delivery of art studio courses and reflects upon its pedagogical value with respect to design in engineering. Further, it gives suggestions on how elements of art studio can been incorporated into the way educators teach engineering design.

Introduction

Many people view visual arts and engineering as disparate disciplines. The prevailing sentiment that individuals who are art-inclined are mutually exclusive from those who are science-inclined, and thus engineering-inclined, make it difficult for people to understand why I might be interested in both. Having had extensive exposure to both in my university education, I believe art and engineering share a stronger affinity than most would think, an affinity rooted in design. I claim that good engineering designers, like good visual artists, have the ability to generate and develop ideas, have strong technical skills, and are aware of the significant works in their field. Although their tools, techniques, objectives, and constraints may differ, their underlying processes of design are similar. If we can accept this similitude, then educators in engineering may benefit from learning about the way design is taught in the visual arts.

In this paper, I will describe the delivery of art studio courses I have taken and reflect upon their pedagogical value with respect to design in engineering. I emphasize that these parallels draw from my personal experiences as a student and are not intended to be applied definitively to the vast art and engineering worlds. Although this discussion of art education should relate well with all forms of engineering, I will have to limit my scope primarily to that of structural design since it is my area of study.

Some general comments on structural engineering curricula are needed before we make any parallels. Several experienced bridge designers have expressed that traditional civil engineering curricula have been inadequate in teaching design. Fritz Leonhardt[1] observes that traditional curricula are often unbalanced with an emphasis on statics, analysis, and computation with little attention given to the art of concept design. Paul Gauvreau[2] claims that as a result of this, graduates are generally ill-prepared to generate design concepts given a clear definition of requirements and constraints. This is the creative stage of design that lies between taking a blank page and producing a preliminary concept.[3]

Aesthetics plays an important role in structural design. Because bridges, and other structures, become part of the urban landscape, designers must be sensitive to how they look. The visual character of bridges are affected significantly by the decisions made during concept design. Unfortunately, engineering students are given very few opportunities to develop these skills in traditional curricula. Hence, engineers need comprehensive training in the visual aspects of design to improve the overall aesthetic quality of bridges.[4]

Some changes at the University of Toronto have been made to address the inefficacy of traditional curricula in teaching conceptual design. Whole courses dedicated to creating and justifying design concepts have been developed by Paul Gauvreau, a professor in the Department of Civil Engineering and NSERC (Natural Sciences and Engineering Research Council of Canada) Design Chair. Gauvreau is also my academic supervisor. Similar progress has been made at the University of Calgary through a recently developed, first year engineering design course that teaches visual literacy based on drawing methods from engineering and art.[5] Elements from these courses will be described throughout this paper as they relate to the elements of an art studio course.

From my experience, art studio courses have been almost exclusively project-oriented. Each project involved the production of an artwork: a drawing, a painting, a photograph, or a print. Professors would introduce projects by defining project objectives and requirements, by displaying and discussing relevant works by prominent artists, and by teaching technical skills specific to the medium; let us refer to this as pre-production. Students would then proceed to research, design, and produce their artwork; let us refer to this as production. Upon completion, all projects would be exhibited and then critiqued by the class and professor; let us refer to this as post-production. These three stages would cycle with each studio project throughout the course. Each of these stages will be discussed in greater detail and related to teaching engineering design in the following sections.

Pre-Production

Each studio project cycle was initiated by a clear definition of a project by the professor. Projects were generally crafted to develop specific technical skills and to develop conceptual thinking. One of my projects, for example, required students to create spatial depth by contrasting warm and cool colours in a painting. The painting also required a hand to be included in the composition; see figure 1. Conceptual requirements were always left simple and open to

Figure 1. *Self Portrait* (2004) by Salonga

engage students' creativity. The freedom also led to a diverse set of projects, exposing students to the many different approaches taken by their peers.

Engineering design projects should aim to do the same. They should give students an opportunity to exercise creative thinking, as well as give them the sense that there are many valid solutions that satisfy a given set of design requirements. Gauvreau provided this type of opportunity in his graduate course in bridge engineering, where students were given the task of designing a long viaduct crossing a river. As shown in figure 2, students were able to develop many different structural systems for their design concept.

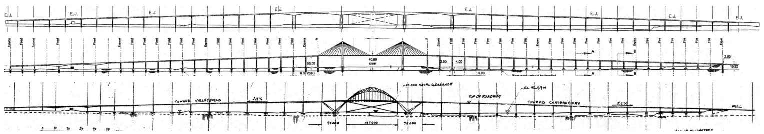

Figure 2. Bridge design concepts by (top to bottom) Visscher, Wiebe, and Salonga

Art professors would often introduce projects by presenting relevant works made by influential contemporary artists. For example, my professor displayed and discussed large scale portraits by Chuck Close, a renown American artist, before assigning us our own self portrait project. Studying related works inspires students and contextualizes the project at hand in the greater history of art. Emphasizing contemporary works gives the project an air of immediacy, since these works imply the presence of an active community of visual artists. Studying these works also gets students thinking about the opportunities and limitations afforded by the specified medium.

David Billington[6] presents a compelling account of how professors Wilhelm Ritter and Pierre Lardy from the Federal Institute of Technology in Zurich exposed their students to new technology through the study of completed structures. In addition to explaining how these systems carried load, these professors would critique works by commenting on their economy, construction, and aesthetic quality. Four of their students, Robert Maillart, Othmar Ammann, Heinz Isler, and Christian Menn would later become the leading structural artists of the twentieth century. Gauvreau[3] insists that Ritter and Lardy's teaching approach be reintroduced into the engineering curriculum. He recommends that structures chosen for critical study should be sufficiently complex to challenge students and to stimulate ideas for new alternative systems.

Billington[6] also commends the highly visual set of notes kept by Isler from Lardy's lectures. Annotated sketches of various structural systems and their visual form fill his notes. This style of lecturing and note-taking should help to broaden a student's visual literacy and understanding. This is not too far off from what I was used to in art history courses. Figure 3 shows my notes from a course in Greek Art. I found sketching during lecture allowed me to deconstruct style and form at a much deeper level than had I not sketched. I also believe that this practice led to a more intuitive understanding of the design elements being presented. In light of this, I suggest that professors should encourage students during lecture to put away their laptops and wield a pencil instead.

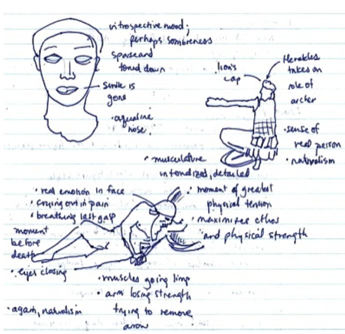

Figure 3. Notes from Greek Art lecture

The last activity in art studio before production is the teaching of technical skills. Let us focus on drawing since it is an essential skill for both art and engineering. Drawing, in general terms, involves the representation of three-dimensional objects in two-dimensional space. Lines are conventions of drawing and do not exist in the real world; they represent the borders between light and shadow, which are often the edges and silhouettes of objects.

An effective way of learning how to draw is through observation. As an exercise, art students may be asked to draw an arrangement of miscellaneous objects or a human figure or a nearby landscape. The objective, at least at first, is to create a drawing that accurately depicts the observed scene. Students grapple with pattern, shade, line weight and proportion. Proficiency in drawing tends to come from personal experimentation and evaluation rather than direct instruction by the professor; hence drawing well requires practice. Regular sketching from observation is an excellent habit I learned from my high school art teacher, Bernadette Phillips. She asked us to draw four small ink sketches every week depicting objects or scenes from our daily lives (see Figure 4). Because ink cannot be erased, it teaches students to be diligent and deliberate in their strokes. Despite that engineers rarely need to draw from observation, these exercises would help students build their confidence, improve their hand-eye coordination, and increase their efficiency. In addition, students would develop a more intuitive understanding of proportion and perspective.

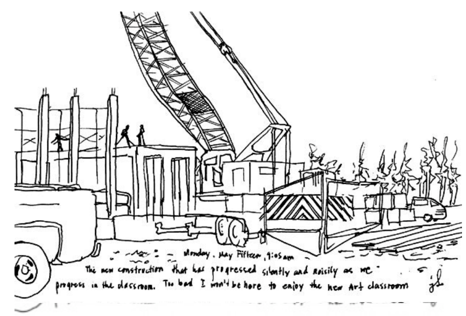

Figure 4. *Untitled* (2000) by Salonga

Unlike art students, most first year engineering students do not expect to be drawing and have convinced themselves that they do not draw, cannot draw, and will not need to draw in engineering.[5] Marjan Eggermont et al.[5] have developed a method of teaching drawing to 600 first year engineering students through demonstration. In this method, instructors guide students through the basic constructions of oblique, isometric, orthographic, and perspective drawing using a document camera. The camera feed is broadcast to every workstation; each workstation is shared by two students. They found that drawing along with the instructor tended to quickly dissipate these students' initial reluctance and anxiety toward drawing.

Production

Drawing is a tool for generating ideas; hence it often initiates the production process for art works. In the early stages of design, sketches can help explore composition, as well as relate form to conceptual ideas. Figure 5 shows how rough sketches highly influenced the final design of my etching. Written ideas were transformed into visual ideas within the same space. This page became a means of communication during my initial discussions with my professor.

In engineering, rough sketches are not enough to clearly define ideas. Gauvreau emphasizes in his engineering design courses that rough sketches need to be quickly transformed into sketches with scale. Scale grounds engineering ideas in the real world and allows for some preliminary analysis on a system's feasibility. Figure 6 shows some initial sketches I made for my graduate bridge design project. A problem with the concept's stability was quickly identified by the professor, which I addressed soon after.

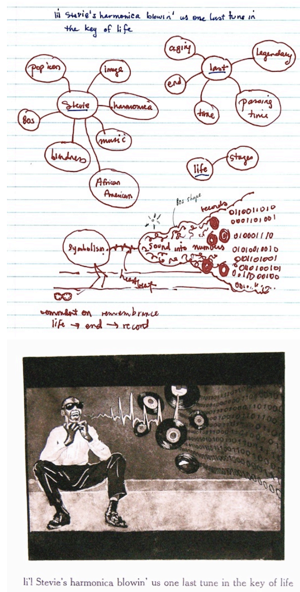

Figure 5. Initial sketches (top) and *Stevie Wonderful* (2004) (bottom) by Salonga

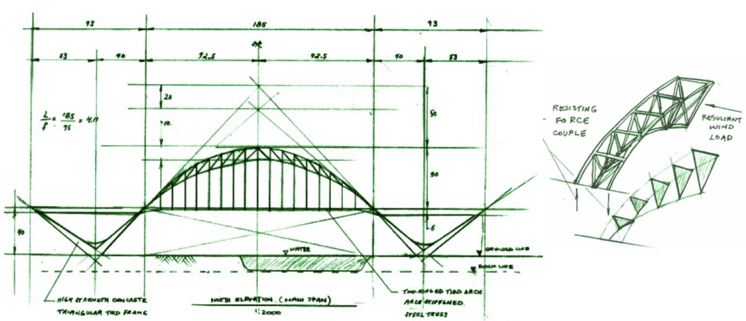

Figure 6. Initial sketches of arch bridge concept by Salonga

Drawing is also a vital communication tool that can overcome differences in discipline and language. In a collaborative studio course, each structural engineering student was paired with an architecture student. At the conclusion of the course, an architecture student remarked that the quality that was most important to the collaboration was the engineer's ability to draw. Drawing became the common ground to which each student could contribute ideas or discuss design decisions, despite differences in discipline. In another context, a recent trip to Taiwan gave me new respect for engineering drawing. The engineers I interviewed had varying levels of fluency in English. Regardless of their fluency, I found that I understood the concepts being discussed more clearly when drawings were presented than when they were not.

Reference works often play an important role in the design process in visual arts and engineering. In his book *Postproduction,* Nicolas Bourriaud[7] proposes that an increasing number of artworks are being made with reference to preexisting works. He challenges that artists no longer create original works, in the traditional sense of the art object, but instead reuse, remake, and reinterpret objects and materials that already have informed meanings from previous works. Bourriaud's theory was used as the basis for a project in my contemporary art course. Students were asked to produce an artwork that would respond to an existing contemporary artwork by inverting, shifting, or adapting it. This required students to deconstruct how the reference work operated in terms of visual expression and meaning, before they could intelligently respond to it. Acknowledging the reference work through research and documentation was a necessary requirement for the project.

Bourriaud's theory can be applied analogously to engineering design. Most engineering design deals with improving or adapting technology that already exists. Engineers generate ideas from an existing body of knowledge, that of completed works of engineering.[2] These reference works serve as excellent starting points for design. Like in the contemporary art project, the intent is not to mimic, but to understand reference works and adapt them for use in new design concepts.

After some sketches of concepts and some awareness of references, the design process for an art project continues and coincides with production. For structural design, this concurrence of design and production may occur in special design-build contracts, where designers to some extent can influence and change future production practice as they see fit. Traditional contracts for structures, however, tend to separate design from production.

The design and production of art projects take place during studio work periods. Some discussion on the nature of the studio environment may prove useful for engineers teaching design. A large share of studio time is dedicated to work periods. It is assumed that students will come to studio prepared with the proper materials and work independently. Students must continuously analyze, assess, and adjust their designs while working on them. Thus, this activity requires great concentration. Professors must maintain a disciplined demeanor in studio to foster student productivity. This does not mean, however, that students should work in silent isolation. The free exchange of ideas about projects is important to the studio environment. Normally, a professor will circulate the room and have brief conversations with each student about their designs and their progress. Students, too, will periodically circulate the room, giving them exposure to the diverse set of projects being developed. Because projects can respond uniquely to the project requirements, there is little motivation for students to copy or steal ideas from one another during studio. Instead, students tend to take ownership of their designs and, as a result, become self-motivated.

Post-Production

Once all art projects have been completed, they are usually displayed in some form of exhibition. Art is not private; it is meant to draw and engage a diverse audience. While studio promotes the exchange of ideas within a class, exhibitions promote the exchange of ideas with the public. Knowing that their works will be publicly displayed should motivate students to dedicate themselves to their projects and should instill a sense of pride and ownership. I have been involved in organizing and installing several engineering design exhibitions while at the University of Toronto, all of which were positively received. A flyer and photograph from last year's first-year engineering design exhibition are shown in figure 7. A short-list of the top ten projects from Gauvreau's engineering praxis course were displayed.

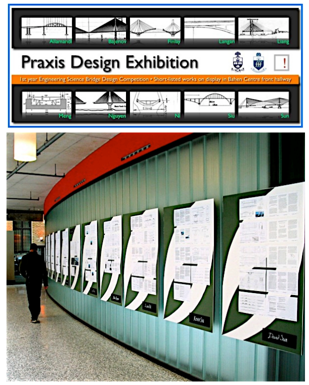

Figure 7. Praxis Design Exhibition 2007, flyer by Salonga, photograph by Gauvreau

Each art studio project cycle ends with a critique. At the beginning of a critique session, participants are invited to browse through the artworks produced by the class. After some time, a discussion about each artwork takes place. Because artworks are meant to be viewed without explanation, students are not usually asked to explicitly present their work. This helps evaluate how successful an artwork is in terms of conveying meaning through its visual elements. Reactions to artwork often vary; sometimes they are positive, sometimes negative, and sometimes conflicting. Although students may find this experience intimidating, they should consider it to be a valuable learning experience. Language becomes increasingly important in these discussions. Students are exposed to art terms throughout their education, and are expected to use them when deconstructing works of art. For novices, it helps to organize critical analysis into tangible subjects, such as composition, tone, colour, proportion, scale, focus, texture, repetition, balance, and harmony, among others. All these elements contribute to an artwork's style of visual expression.

Most engineering courses use digital slideshows as the default means of presentation. The problem with this format is that it establishes a lecturer-audience relationship that tends to inhibit critical discussion. The critique format previously described would translate well for engineering design projects, as long as group size is kept small. Critiques require an intimate setting to help facilitate discussion; I suggest a maximum of twenty participants. Because of the level of detail present in engineering projects, some brief introduction to the design and its main features may help guide discussion. This critique format has worked well in Gauvreau's graduate bridge design course.

Critical discussion helps hone a designer's skills. Comments made by peers and instructors can help identify technical issues and weaknesses in design thinking. For bridges, opinions on aesthetics can be crafted using the same terms used for describing artworks. Adopting art vocabulary will help formulate meaningful and critical thoughts on the visual aspects of bridges.

Having open, critical discussions on design is healthy. The visual arts community does this on a regular basis in studio, in publications, and in artist talks. Artists are constantly susceptible to the public opinions of others; so why not engineers? I believe engineering designers should actively critique design, especially with regard to aesthetics. These opinions should be founded on rational thinking rather than personal preferences. During my trip in Taiwan, I started recording my personal thoughts on bridges I visited. A brief description on the Nan Fang-ao Bridge (figure 8) follows:

> The Nan Fang-ao Bridge is a steel arch bridge in a harbour in Yilan County. Two steel ribs combine near the springing lines to form a single arch rib to which a single plane of cables are attached. The gradual angle change of the cables is reminiscent of an eyelid, a visual form that seems to suit the landscape. The triangular form of the arch ribs creates a traffic opening while maintaining transverse stability of the system. The three dimensionality of the bridge is striking; each vantage point offers a unique visual experience of the structure. I think the concrete piers and circular stairwell detract from the overall view; they could have been better integrated into the structure.

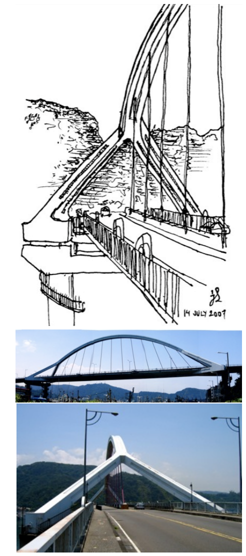

Figure 8. Nan Fang-ao Bridge, sketch and photograph by Salonga

Summary

The topic of critiques completes our discussion on the studio project cycle in the visual arts. To review, this paper has discussed the three stages of art studio and has related them to possible ways of teaching engineering design. Insights drawn from these parallels are summarized below:

- Like art projects, engineering projects should exercise creative thinking, and allow for a variety of alternatives.
- Engineering students should be exposed to the critical study of completed works of engineering, both classical and contemporary.
- Design lectures should be highly visual. Students should be encouraged to make annotated sketches during lecture to improve their understanding of the visual aspects of design.
- Drawing skills can be developed through observation exercises, regular sketching, or demonstration.
- For both disciplines, sketching is a tool for idea generation. Sketches of engineering concepts require scale in order to determine a system's feasibility.
- Most engineering design is informed by preexisting solutions. These reference works can serve as starting points for design.
- Studio work periods should be disciplined, but should allow for the free exchange of ideas.
- Exhibiting student projects should motivate students to take ownership of their work, thus improving the quality of design.
- Critiquing design is healthy and should be practiced in studio and in the greater design community. Adopting art vocabulary can help engineers formulate critical thoughts on aesthetics.

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Biographical Information

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