

Engaging Creativity: Classroom Exercises for Enhancing Engineering Students' Creative Self Identity

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ABSTRACT

Social forces such as group dynamics and identity can nurture or inhibit creative behavior. Identity theories suggest both self-identify and group identity are mutable. In addition, engineers often make decisions with insufficient information and this *bounded rationality* may motivate historically-grounded, low risk solutions, which are challenging dispositions to innovation. Consequently, epistemology connected with engineering design and problem solving must include reliance upon factors outside the positivistic discourse, such as hunches, intuition, and creative exploration. This paper presents examples of creativity exercises for the engineering classroom and the context under which they should be undertaken. A variant of affinity diagrams is also introduced that reduces the creativity-inhibiting elements of group dynamics.

INTRODUCTION

Engineers love creating. They blend their knowledge of the physical and life sciences into inventing solutions to complex problems. The quantitative arena in which we profess expertise often demands a single, best answer. However, engineering often requires decision making rooted in incomplete information and intuition. Often there is not a “single, best answer.” One cannot analyze what has not been designed.

Finding a satisfactory solutions within the limits of human cognition, available time and information requires judgments described as *bounded rationality* [1]. Working within these constraints compels engineers to rely upon heuristics and intuition. Intuition is an amalgam of theoretical education, practical experience, cultural insight, and creativity. Contending with intuition can be challenging because it can be difficult to articulate, much less defend. However, intuition is the outflow from creative cognition [2].

Both psychological and sociological forces work against engineers embracing creativity. These include group dynamics and self-identification. Conducting creativity exercises in an engineering class by engineering faculty can promote an identity of the engineer as a creative explorer. These creativity activities reassure engineering students that they can pursue hunches and whimsy along with quantitative analyses.

BACKGROUND

Definition of Creativity

Many definitions of creativity exist and a salient question is whether class exercises foster creativity and are they a good use of time in classroom setting [3]. A good working definition is offered by Roger Schank, an artificial intelligence theorist and cognitive scientist:

In most cases we require an act to pass three tests before we call it creative. First, we must believe that the act is original. Second, we must believe that it is valuable. And third, it must suggest to us that the person who performed the act has special mental abilities [4].

Self-Identification and Group Dynamics

Creativity is influenced by social context. Groups can support or hinder creativity. Creativity can be part of a culture or dismissed. A group can view itself as being creative and therefore the individuals within the group must be creative as well. Groups that encourage creativity might schedule “brainstorming” meetings or organically engage in these frequently.

Investigating the relationship between individuals and groups have recognized that one’s self esteem is derived from the identity developed from social interactions. The sense of self is based on the roles that one assumes in a society or group with which one identifies [5]. A shared group identity can promote a desire to protect one’s group identity against those in other groups. Moreover, those who behave inconsistently with an ideal self will be made to feel anxious about facts that highlight their incongruous behavior [6].

This identity theory suggests that when self-proclaimed creative people gather in groups, they will deeply nurture each other’s creativity and at the same time excoriate other groups’ creative efforts. Therefore, while individual creativity is difficult to appraise, a group culture can have a predictable effect upon the individual members’ creative expression. This can be seen in art, for example the Impressionist, Guillaumin, Manet, Monet, Pissarro, Renoir, and Sisley, jointly developed a philosophy and identity in which they were a “persevering confraternity that was distrustful of the Academy and the art schools that emphasized hackneyed traditions at the expense of sincere, untaught ways of looking at the world and inventing new ways to express a personal vision” [7]. This can arise with technology clusters such as Silicon Valley, and with more moderate success in Cambridge, MA; Waterloo, Ontario; and the Skolkova complex outside Moscow. These areas have tried to blend companies, resources, talent, and opportunity [8].

Group Roles

Individuals typically assume roles in a group that either work towards accomplishing a task or in keeping the group bonded together [9]. Self-identification is a force in pursuing roles within groups. When an individual first encounters a group, he or she is ambiguous about his investment in the group. The existentialist philosopher, Paul Tillich describes this ambiguity as being based in the following concerns: 1) desire to be included in the group, 2) uncertainty of one's roles within the group, 3) fear of being influenced by the group, 4) desire to influence the group, and 5) desire to obtain intimacy with the group [10]. In addition, the group as a whole is ambiguous about its task. These uncertainties instigate the initial group dynamics in an effort to minimize ambiguity.

Group Rules

We quickly identify the “rules” for our group and try to defend our group identity. Most of these group rules are discerned by observing what happens when people break them or by how people actually behave. Collett suggests the following four approaches to characterizing the rules governing a group: 1) determine articulated rules, 2) recognize infringement of rules, 3) recognize sanctions for rule breaking and 4) observe behavior patterns [11]. Our ability to discern rules is rooted in seeking associations and making assumptions rooted in inference; however, we may be unaware of this inductive procedure or the fragile underpinnings of the inference.

Bounded Rationality

Creative expression often acts under the domain of the concept of bounded rationality. This concept describes how decisions are made using fragmentary information, where confirmation can only be achieved in the future. Bounded rationality recognizes that not all alternatives or information are considered before making a decision. Engineers must often sacrifice the optimum for the sufficient.

Bounded rationality relates to the design process because it requires rapid distillation of numerous ideas while contending with limitations on cognitive ability, time, and information. An engineer is required to use good judgment and be confident in anticipated results. Sometimes ambiguity must be tolerated, particularly in the ideation process.

CLASS EXERCISES AND OUTCOMES

Creativity Exercises

There are two goals in doing creativity exercises in an engineering class:

1. Engage creativity
2. Encourage group and individual identity as being creative

The following exercises compel students to think and act in uncommon ways. I developed the first three exercises to address a common student request for guidance in nurturing creativity [12]. The fourth exercise is another helpful activity that was developed by Ideo [13].

1. Draw an image with the following constraints: no representational art, use only abstract lines, shapes and textures. You can use some imagery as you see fit but make it more an expression of emotion and visual impact. The depiction should be of an abstract noun such as honesty or ambition. Use lines, curves, value and texture. (The students are assigned an abstract noun.)
2. Write a short poem about an abstract thought, such as how a beautiful sunset makes you feel. Free verse is okay.
3. Explain a painting in words alone. Good paintings for this exercise are Monet's "Impressions at Sunrise" or Munch's "The Scream".
4. A popular exercise used by Ideo is to quickly turn a page of circles into recognizable drawings. Commonly the participants are given a page of thirty circles and a pencil. Participants need to make as many drawings from the circles as possible within three minutes.

Bounded Rationality Exercises

Other design prompts can be developed that purposely provide fragmentary information and time constraints so as to explore the stress produced by bounded rationality.

One example is to design three variants of a boat that can cross the Atlantic Ocean using wind energy only. Participants are asked to sketch what the boat would look like and briefly describe how it would operate. This prompt specifically does not include such constraints as how many people (if any) it should hold, how fast it should travel, and cost. In order to keep the problem from getting too extreme, some specificity is provided, such as Atlantic Ocean, the term 'boat' rather than the more generic 'vessel'.

Developing Mind Stories and Imagery

Stories and imagery can help students learn and retain engineering concepts. The graphical portrayals of engineering principles and illuminating stories can help students preserve knowledge long after the final exam.

Students in an introductory mechanical engineering course are asked to draw images related to the following: 1) epistemology, 2) mechanics of materials, 3) thermodynamics, 4) fluid dynamics, and 5) heat transfer.

Examples of student work are shown in Figures 1 and 2.



Figure 1 –*Student painting representing mechanistic and non-mechanistic insights, sentient and transcendent knowledge.*

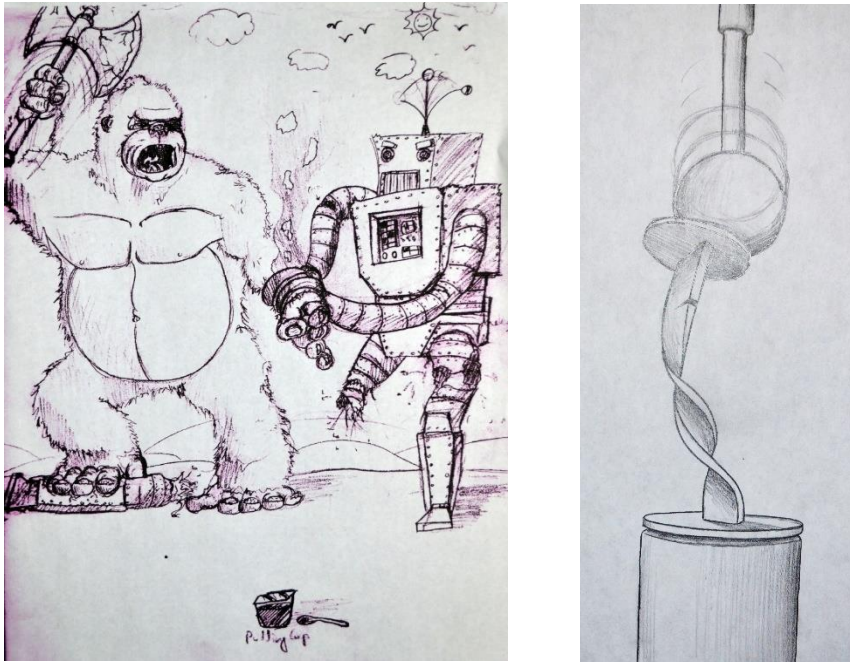


Figure 2 – Student drawings representing tension, compression, shear, flexure, torsion, stress concentrations, fatigue, buckling, impact, and corrosion.

Outcomes

The results of five years of conducting these creativity exercises in an introductory mechanical engineering class are anecdotal and are based on less than one hundred students. When asked about the abstract image project in which they were required to draw an abstract image of an assigned abstract noun, students reflected on their work in three ways:

1. The projects were interesting
2. The projects gave surprising results
3. They could not do the projects

The first two categories are similar, namely, the students were pleased with their work. The majority of the students were pleased with their work and some students expressed surprise at what they produced. Typical exemplar quotations were: “I didn’t know I was an artist” and “I was surprised at what I could do.”

The third category can range from the student not doing the project at all to results that violated the assignment guidelines. The students that did not do the project at all were a tiny percentage of the total respondents. I believe this was largely due to time constraints and lack of individual guidance. These students were either seeking rules or unclear about how to proceed. The students

were only given 5-10 minutes to complete the assignment and I would answer questions regarding rules if they arose.

Initially, I found students frequently wishing to refer to allegory rather than abstraction. Consequently, I would counter this with explicit instructions. For example, if the noun “honor” was proffered, students were told that they could not draw a knight in armor.

Figure 3 shows examples of student work in connection with the abstract image exercise.

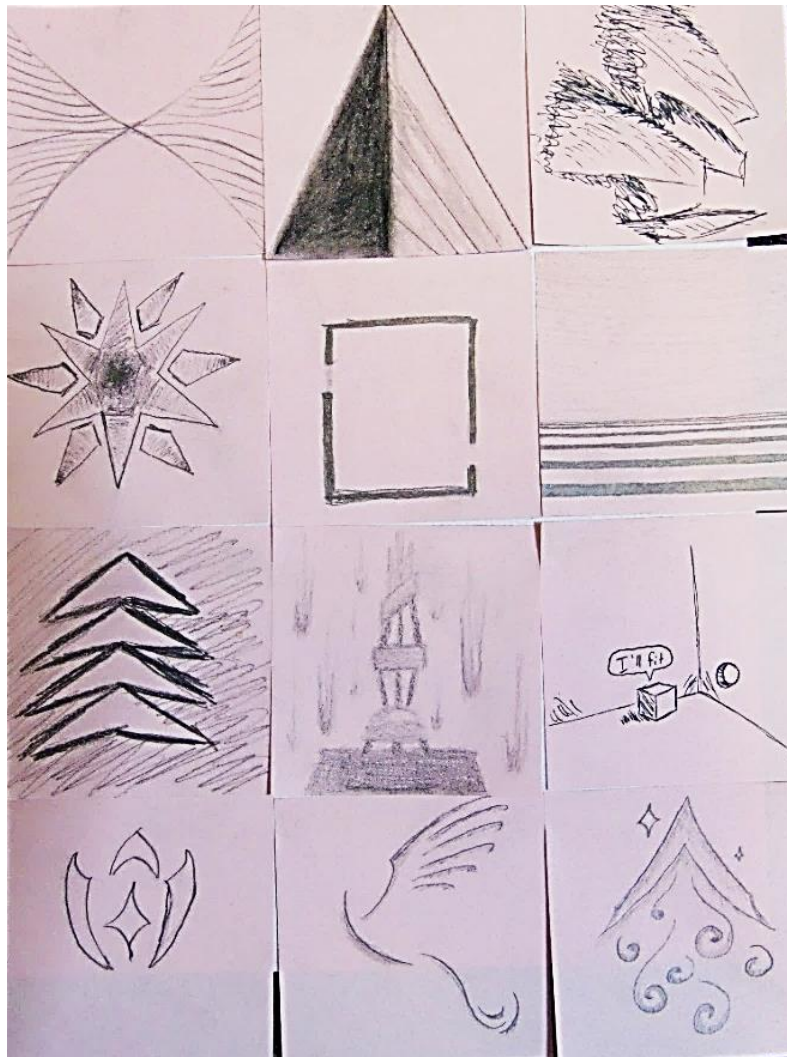


Figure 3 – Students’ drawings of abstract images representing “ambition” drawn on sticky notes. Notes some of these gently break the rules by showing representational images, such as the bird or the talking box that says, “It fits”.

One important element of these exercises is that they are being asked in an engineering class. The goals of these exercises are not only the creative expressions themselves but that they are encouraged by an engineer who is both the subject matter expert and establisher of an intellectual ecology in the classroom. When the “rule maker” encourages the range of expressions permitted in these exercises, he or she opens the ‘rules’ and widens the environment to encompass wide-ranging and free expressions of creativity.

Affinity Congregates

Many innovations come from those in marginal positions in a discipline, and these individuals therefore greatly benefit from the support afforded by like-minded people [14]. James Watson, co-discoverer of the double helix nature of DNA, stated the power of collaboration unequivocally: “Nothing new that is really interesting comes without collaboration” [15]. However, in some groups a dominating person might drive ideation. As discussed previously, group dynamics need to be recognized in group settings. Particularly in the case of new groups, such as in a classroom setting, an affinity congregation allows people to individually express their ideas before becoming engaged in a group situation. This is a small variation of affinity diagramming because affinity congregating focuses on initial, independent problem solving before bringing ideas to a group so that participants may collectively identify affinities. Affinity congregation preserves the independent voice of each student. This approach is intended to prevent group dynamics from taking over the ideation process.

With affinity congregating, the participants are presented with a problem or design prompt, they individually write solutions on a sticky notes or other suitable media. When they are finished writing proposed solutions, the notes are collected and assembled by a moderator and grouped by affinities or themes into an affinity diagram. The themes arise from the data, which is founded on *grounded theory*. Grounded theory is a method common in the social sciences that allows categories and concepts to develop based exclusively on data and not from predisposed theories [16].

While these affinity congregations shown by the groupings of notes is subjective, general themes or affinities arise in a logical fashion. A variation of this approach is to have the group identify themes rather than a moderator. In this approach, the group gathers around the notes and identifies logical groupings. The notes are reviewed and duplicate ideas are stacked on top of each other. Finally, the affinities can be discussed and each idea can be critiqued by the group.

Affinity Congregating Technique Summary

1. Problem statement or design prompt.
2. Individuals write proposed solutions on sticky notes.

3. Moderator collects notes and assembles by affinities or themes that arise (affinity diagrams). Alternatively, the group identifies affinities as a team.
4. Duplicates omitted.
5. Group critiques affinities and proposed solutions.

Outcomes of Affinity Congregation

Classroom.

In the classroom setting, design prompts have ranged from: “How can \$10 and 10 minutes of physician’s time be best used for medical care?” to redesigning an ultrasonic thickness gauge. From my personal experience of using this technique for nearly ten years, these congregates will tend to huddle around mechanistic themes. However non-mechanistic themes, such as visual appeal and material culture, will more readily arise with this technique rather than group ideation. The notion of group identity and intellectual ecology connected with engineering and engineering students discussed previously, tend to suppress non-mechanistic ideas. This congregation technique also has provided more radical and even unethical ideas, which I believe is related to the relative anonymity of the design solutions. Most importantly, all students participate. Even the most reclusive students will contribute ideas on their sticky notes.

Interestingly, the number of sticky notes provided or the number of ideas requested has a bearing on results. Some students will only have a few ideas while others will have a dozen. If compelled to create more ideas than a student can readily produce, the ideas either become small derivations of previous ideas or good natured humor.

The helpful elements of time and rumination are important in developing design solutions. This exercise can probably be improved by offering the design challenge before the classroom affinity aggregation exercise.

Professional practice.

One example of applying this technique to professional practice is addressing the issue of palliative care in the developing world. In this case, I invited two physician colleagues to partner with this investigation. Because we came from different disciplines (design, pain management and palliative care), the congregation technique was used to prevent the board-certified palliative care specialist from overwhelming the pain management expert and the engineer. This cooperation lead to identifying four tracks of palliative care: physical, psychological, relational, and spiritual as shown in Figure 4. These tracks were further divided into key concerns and we developed practical treatment options.

In this example, the most common concerns were identified as pain, dyspnea (air hunger), nausea and vomiting, delirium, anxiety, and terminal secretions ('the death rattle'). The affinity aggregation allowed artificial intelligence driven diagnosis systems to inhabit an equal space as recommending paracetamol or diclofenac for pain relief. This technique worked well in this interdisciplinary environment because we concluded with specific recommendations as well as the somewhat surprising result that the patient care should be the responsibility of a loving caregiver rather than a medical professional.

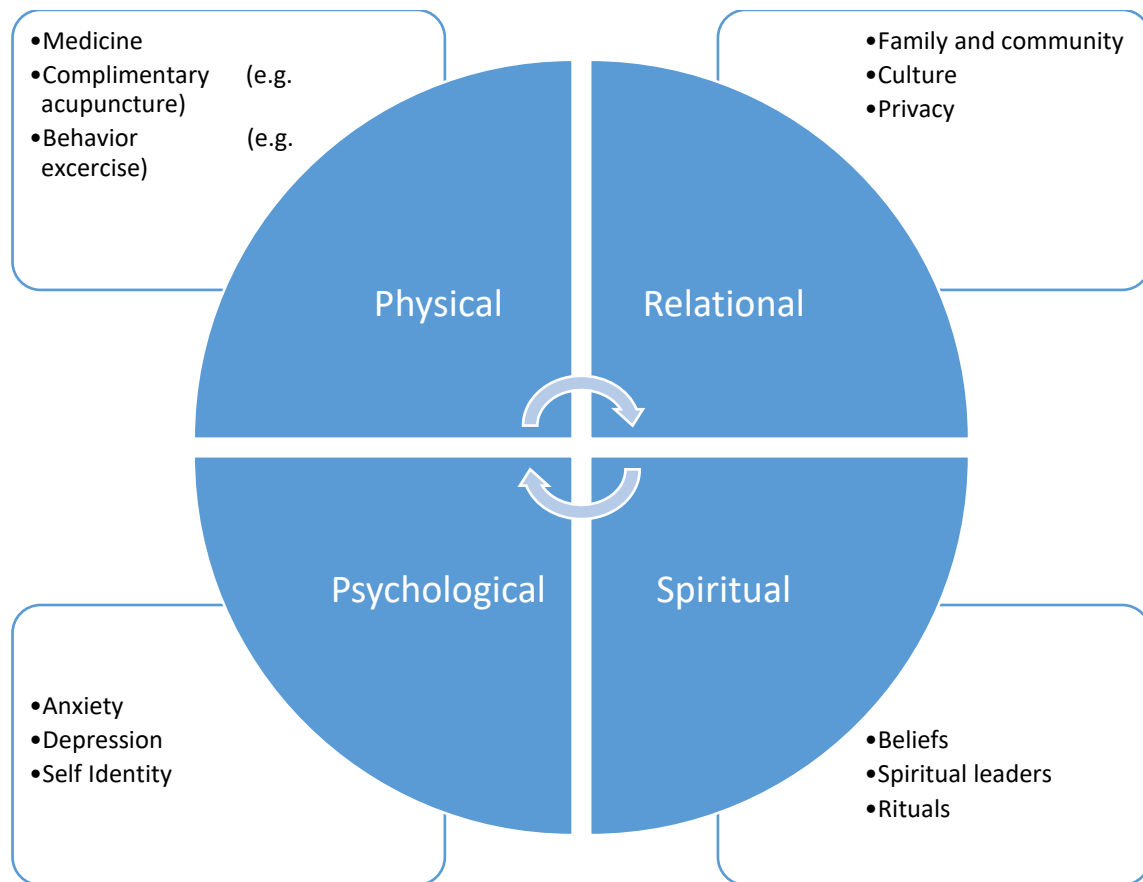


Figure 4 – *Integrative palliative care factors [17].*

CONCLUSION

Creative expression is encouraged by a self-identity of being a creative person. Creative ability and a reliance upon intuition is sometimes required in engineering practice because engineers often make judgments within the realm of bounded rationality.

Creativity exercises in the classroom can produce surprising results. Not only are some students surprised with their work, but they are also surprised that a faculty member who ostensibly prefers equations and technical jargon would ask them to write a poem and draw an abstract

image. These creative exercises can be disruptive activities that nurture an intellectual ecology that values creativity and risk taking. Moreover, recognizing the impact of group dynamics can foster ideation structures, such as affinity congregates, that draw innovative ideas from individuals who might be overwhelmed by other people's ideas when in a group setting.

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