EXPLORING DESIGN IDENTITY THROUGH A “REVERSE ENGINEER AND IMPROVE” VALUES ELICITATION ACTIVITY

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Abstract - This paper presents a 60-90 minute reverse engineering activity that has been used in a variety of contexts to connect design and leadership education and to demonstrate the need for leadership education in effective design work. This activity elicits participant values by having them identify the key design decisions embodied in familiar artefacts, that have been sourced from multiple suppliers who themselves have distinct and recognizable values. Anecdotal observations and trends between sessions of this activity held in different contexts are discussed, alongside an activity plan so that others can replicate the activity.

Keywords: engineering leadership education, engineering design education, development of identity

1. INTRODUCTION

A recent trend in engineering education is towards helping each student develop an individual engineering identity. This is in contrast to traditional engineering education in which students are largely expected to adopt prescribed, usually singular tools, processes, and perspectives. In the area of design, an engineering identity includes both tactical (e.g. preferred design processes and tools) and strategic (e.g. “What gaps or problems are ‘engineering’?”, “Which stakeholders should be consulted?”, “Which ‘Design for X’ practices are privileged?”) considerations. Where a traditional engineering education produces students who are essentially fungible commodities, this new approach seeks to produce students who each bring a unique value proposition to their employers and the profession [1]. This change in approach also seeks to enhance student engagement in their studies by making them an active stakeholder in both their engineering design activities and in their engineering education.

A similar trend is emerging in industry, specifically in firms engaged in product design. The traditional notion of a corporate “brand” is being augmented with explicit discussion of engineering and design values that are adopted at both corporate and team levels. Apple is leading this trend, as is evidenced in the content of the

product introduction videos shown at their World Wide Developer Conferences (WWDCs). These videos habitually reference Apple’s philosophies of design and engineering, and how those philosophies are manifested in their products. Other companies from different industries, such as Ford, have also begun to explicitly reference their philosophies in their advertising (e.g. for the Ford F-150 series of trucks).

Many students are introduced to engineering, and engineering design, through small-scale design challenges, either in the classroom or as part of extra-curricular activities or competitions. These challenges generally involve having their participants design and build physical artefacts (e.g. bridges, towers, vehicles) which are then judged primarily on function (e.g. supported load, distance travelled), physical characteristics (e.g. height, weight, volume), and cost (as a function of materials). While some of these challenges may formally incorporate additional characteristics (e.g. aesthetics, sustainability) few if any incorporate the notion of individual or team values. Some students may choose to incorporate their values into their artefact (e.g. by incorporating or discussing issues of safety, the environment, or ease of manufacturing), but integrity with those values is rarely a formal part of their response to the challenge (e.g. through discussion or presentation) or is assessed during judging. As such these challenges do not reflect emerging engineering design practice, and do not prepare the participants for the difficulties inherent in identifying and incorporating their values into their engineering (design) practice and career.

Within the engineering education community, instruction that specifically targets “identity”, “values”, and “beliefs” is found within the emerging field of engineering leadership. Some goals of engineering leadership education are to produce more self-aware and well-rounded engineering graduates that are competent in many levels and types of leadership. The engineering leadership education community at the University of Toronto has primarily adopted authentic leadership in its teaching efforts. Authentic leadership education focuses on developing the individual’s ability to self-lead through a reflective understanding of their individual values, perspectives, and abilities [2]. Authentic leadership also requires that students demonstrate integrity between their

self-identity and their practice. Incorporating engineering leadership principles into small-scale engineering design challenges has the potential to better sensitize the participants to, and prepare them for, emerging engineering design and leadership practice.

2. ACTIVITY ARTEFACTIVES AND REQUIREMENTS

Our objective was to develop an introductory activity that explicitly introduces and justifies the importance of individual and team values in engineering design. Additionally, the activity aimed to provide a link between the leadership and design education of the students by presenting leadership concepts in a more native environment to the students (namely engineering design).

Specifically the activity aimed to teach the participants:

1. How to see the values embodied in existing (engineered) artefacts
2. How to recognize the personal values they bring to their design activities
3. How to embody their personal values in redesigned (or new) (engineered) artefacts they are developing
4. The importance of both having and demonstrating integrity with values when engaging in (engineering) design

The only constraint on the activity was that it takes no more than 90 minutes to complete.

The criteria used to develop this activity were:

- a. Ease of facilitation (e.g. time needed for facilitator training, number of facilitators, number of stages in the activity; less is better)
- b. Cost of consumables (cheaper is better)
- c. Applicability to a breadth of ages (e.g. from primary school through to design educators; broader is better)
- d. Applicability to a breadth of backgrounds (e.g. teachers, guidance counselors, current engineers, etc.; broader is better)
- e. Transferability of learning objectives and materials to existing small-scale introductory engineering design activities (greater is better)

3. THE REVERSE-ENGINEER AND IMPROVE ACTIVITY

The reverse-engineer and improve values elicitation activity aimed to have participants compare and contrast physical artefacts that were familiar to them, but were

sourced from multiple distinct suppliers. These suppliers were selected based on their having distinct and recognizable values, such that a participant would be able to see and differentiate the ways in which the different values were embodied in each artefact.

3.1 Materials

The artefacts selected for the activity were disposable “coffee cups” from three coffee chains located in Toronto with distinct values and customer bases: Tim Horton’s, Second Cup, and Starbucks. Each participant (either individually or within a team) was provided with the opportunity to see and deconstruct a “coffee cup” from each chain which could comprise the physical cup, sleeve, lid, and/or lid opening enclosure based on what each chain provides its customers. One facilitator was required for approximately every 15 participants to guide them through the activity and point out subtle differences in the ways in which participants were reviewing the artefacts, and in the artefacts themselves. Handouts to guide participants through their observations and analyses of these artefacts were provided to each participant.

3.2 Activity Sequence

The activity was purposely structured to promote cycles between reflection-and-action and individual-and-team. This structure allows for individual observation and analysis, and for group-level comparison of observations amongst different artefacts and different individuals. This was intended to allow individuals to elicit their own values, and then note the differences in personal values that i) are seen in the different artefacts, and ii) that are seen by different individuals when looking at the same artefact.

Preliminary Observing (5 min)

Individually, have each participant look at their assigned artefact only, and record what they observe.

Abstracting From Observation (5 min)

Individually, have each participant reflect on what they observed. Have them attempt to determine what types of design decisions (or physical perspectives) they were looking at (e.g. materials, geometry, components, etc.)

Sharing (5 min)

Have participants form into groups such that each group has one artefact sourced from each vendor and share the observations and types of design decisions seen. Develop a shared list of the physical perspectives that everyone used to view the design decisions seen in their artefacts.

Final Observing (5 min)

Have participants look at their original artefact again, this time consciously adopting each perspective from the group list. Record any new observations.

Extrapolating (10 min)

For each observation, have the group make an educated guess as to the consequences of that choice (in terms of its limitations on future design decisions or implementation methods). Based on those consequences, have the participants make an educated guess about the designer's value(s) for each of the artefacts.

Personal Valuing (5 min)

Have each participant individually decide whether they agree or disagree with the designer's values.

Forming, Storming, and Norming (15 min)

Have the groups reform, and decide as a collective what their most important values and respective physical perspectives are.

Designing (10 min)

Have each group design and sketch their ideal version of the artefact.

Presenting and Defending (10 min)

Have each group deliver a two-minute "elevator pitch" of their new artefact to the other groups. Each group should have to defend their design, their values, and their decisions against the critiques of other groups.

Debrief (10 min)

Have each participant reflect on the critiques their team received, and on the values they as a group embodied in their design. Do these group level values and decisions reflect their personal values? What would they have done differently and why?

Discussion (10 min)

Bring the whole group together for a discussion on the importance and embodiment of individual- and team-level values when designing an artefact.

4. DISCUSSION

4.1 Audiences Reached

To date, this activity has been run with secondary school math, science and technology teachers and guidance counsellors, grades 9-12 students in an engineering enrichment summer program, and undergraduate engineering students. All audiences received the activity with the materials and sequencing discussed above, but with varying levels of facilitation provided by facilitators (i.e. grades 9-12 students required more observation level facilitation as compared to secondary school teachers who required more extrapolation level facilitation).

4.2 Observations from Facilitators

Overall for each audience the activity was a success, and did get the participants to identify some of the values they bring to their design work. Activity facilitations and observations varied across different audiences based on their familiarity with the artefacts and companies selected. In particular the two problems of "We don't drink coffee" and "We know nothing about these companies" surfaced in every session of the activity. In such situations, participants would become removed from the activity and found it more difficult to extrapolate from the observations-level to the values-level of the artefacts. These issues surfaced more prominently in the session with the high school students, at which point it was found that asking the students to build towers with the artefacts got them to engage with the artefacts with sufficient depth that they were able to note the differences between them based on their physical attributes (e.g. stackability). At the teacher and undergraduate levels, participants were encouraged to look at the companies' websites, or discuss with others in the group that were more familiar with the companies about their experiences with them.

We did not expect to need to give participants permission to destruct the artefacts to see how they were assembled/manufactured. However, once participants began destroying the artefacts to see how they fit together, they became much more engaged with the activity.

The *Final Observing* section was the hardest to facilitate as it was difficult to get participants to view the artefacts from a perspective that was not natively chosen by them. When asked to comment specifically about a particular physical perspective, participant observations were significantly less detailed than those of their own perspectives. Encouraging participants to look across all three brands of artefacts did help facilitate this process by pointing out some of the differences between them, and some of the different ways a physical perspective can be embodied in the same type of artefact. Greater scaffolding in terms of "how" to make such a transition is needed in future iterations of the activity.

The *Extrapolating* section was also a challenge, as having participants determine the consequences of a particular design decision was difficult. Participants were usually able to identify the values of each company's designer, however the effects of these values on bounding the possible decision space were difficult to identify. Having multiple brands of one type of artefact (a coffee cup) did help with this issue as it allowed the facilitators to move components across cups and ask participants "Now, what would happen if they had chosen to go with this type of a component here? Would this [other part of the artefact] still be able to be designed in the same manner?" This particular movement of components across

vendors was not something participants did instinctively but turned out to be one of the greatest teaching moments to get participants to identify distinct values and decision implications.

When working with participants who are familiar with engineering design, the activity included far too many transitions. These participants wanted to take the time to explore the artefacts at a level that required more than 10-15 minutes per section; this was most apparent in the discussion sections which were very difficult for the facilitators to cut off. For such audiences, we recommend spending more time on the latter half of the activity, in particular the *Presenting and Defending* and *Debrief* sections as these allow the participants to negotiate (at a group level) the importance and impact of different values on the engineering and design professions as a whole, as well as the impact of values on the way in which design artefacts are used and perceived.

4.3 Key components for success

Based on our experience running the activity in multiple contexts, we have identified the following design decisions as being key to the activity's success:

- having the participants work in a small, heterogeneous groups
- investigating a common, familiar object that requires no description as to its purpose and use
- providing multiple instances of an object that serve the same function but from different vendors, organizations, etc. that have clearly identifiable and distinct values
- pre-analysing the artefacts for the obvious and the non-obvious characteristics that identify specific values - this was particularly important for participants who are not familiar with the object or one brand of the object
- moving the activity at a speed that forces participants to focus on instincts and impressions so as to elicit their natural inclinations in terms of perspectives viewed
- scaffolding "reflective to active" and "individual to team" transitions

4.4 Scoring against Criteria

Having run the activity multiple times with a variety of participants, we can assess it against its design criteria:

- the activity scores well for ease of facilitation - the activity has never needed more than two facilitators, nor has the time to prepare a facilitator taken more than 90 minutes

- cost of consumables - coffee cups are cheap, from our experience only one brand charges for empty cups, and the total cost to obtain enough materials for any session is approximately \$1 CAD per participant
- applicability to a breadth of ages - the activity is highly applicable to multiple ages, however selecting the artefacts to be more representative of specific age brackets would increase the applicability of the activity
- applicability to a breadth of backgrounds - the activity ran well for all audiences so far
- transferability of learning objectives and materials to existing small-scale introductory engineering design activities - the (undestructed) coffee cups have been used in activities either directly before or after this one, in particular the construction of a tallest tower out of the coffee cups; transferability of learning objectives is to be assessed.

As the design ranks well against its design criteria, and does not violate its design constraints, we assess that it adequately meets its objectives.

To improve the activity's design, we recommend that:

- for audiences with a greater design background, have each of the groups look at a different type of artefact to investigate how similar values are embodied in different artefacts
- artefact sets be customized to specific participant populations more closely (i.e. avoid the "but I don't drink coffee" dilemma)

5. FUTURE WORK

Future work includes using this activity as a means to explore the differing (engineering design) values, and awareness of values-held, between novice and expert engineers, engineers from different disciplines, and engineers and other populations.

References

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