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APPLICATION OF VISUAL TOOLS TO HELP ENGINEERS MAKE SENSE OF DESIGN AND PARADOXES

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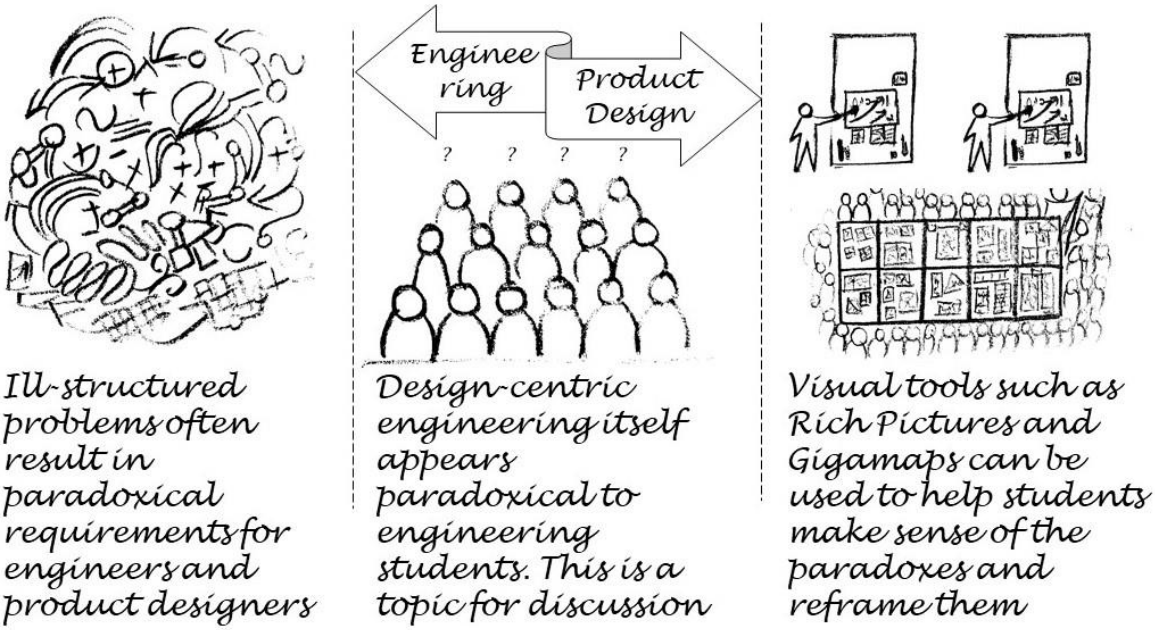
ABSTRACT



Keywords: Sketching, rich pictures, symbolic interactionism, engineering, product design

1 INTRODUCTION

One of the key competencies for engineers and product designers is the ability to understand and deal with paradoxes, often encountered in ill-structured problem situations [1]. But, how could we help students develop this capability in an academic context, other than through problem-based learning? This paper discusses a case where the paradoxes that emerged in the process of implementing a design-centric engineering curriculum were used to educate students. The methodology involves combining visual tools such as Rich Pictures and Giga-maps with sociological perspectives.

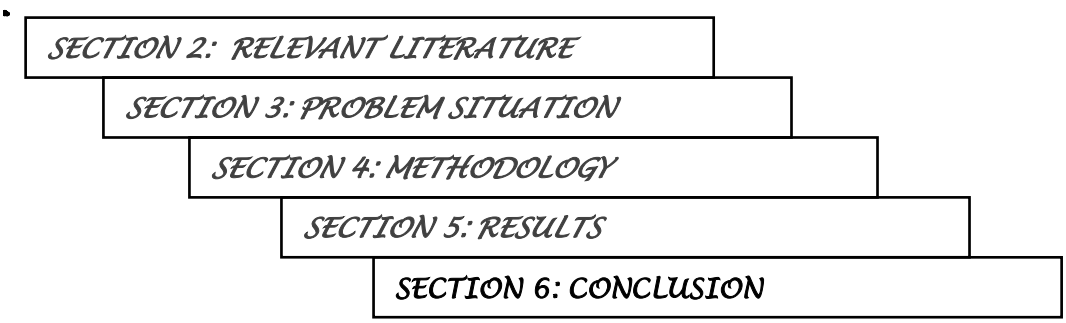


Figure 1. Content and structure of the paper

2 RELEVANT LITERATURE

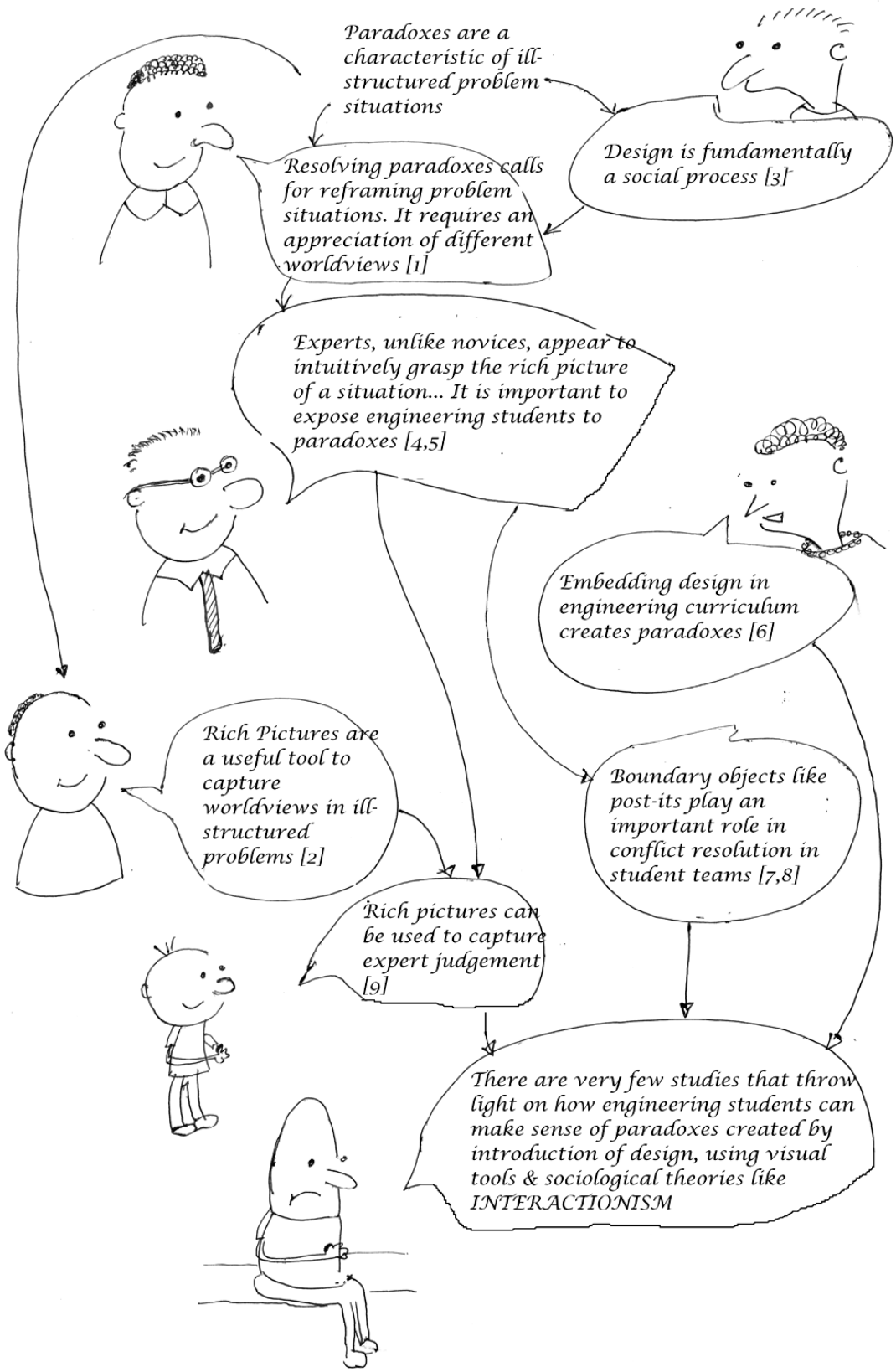


Figure 2. Literature pertaining to paradoxes in design and engineering education

3 PROBLEM SITUATIONS

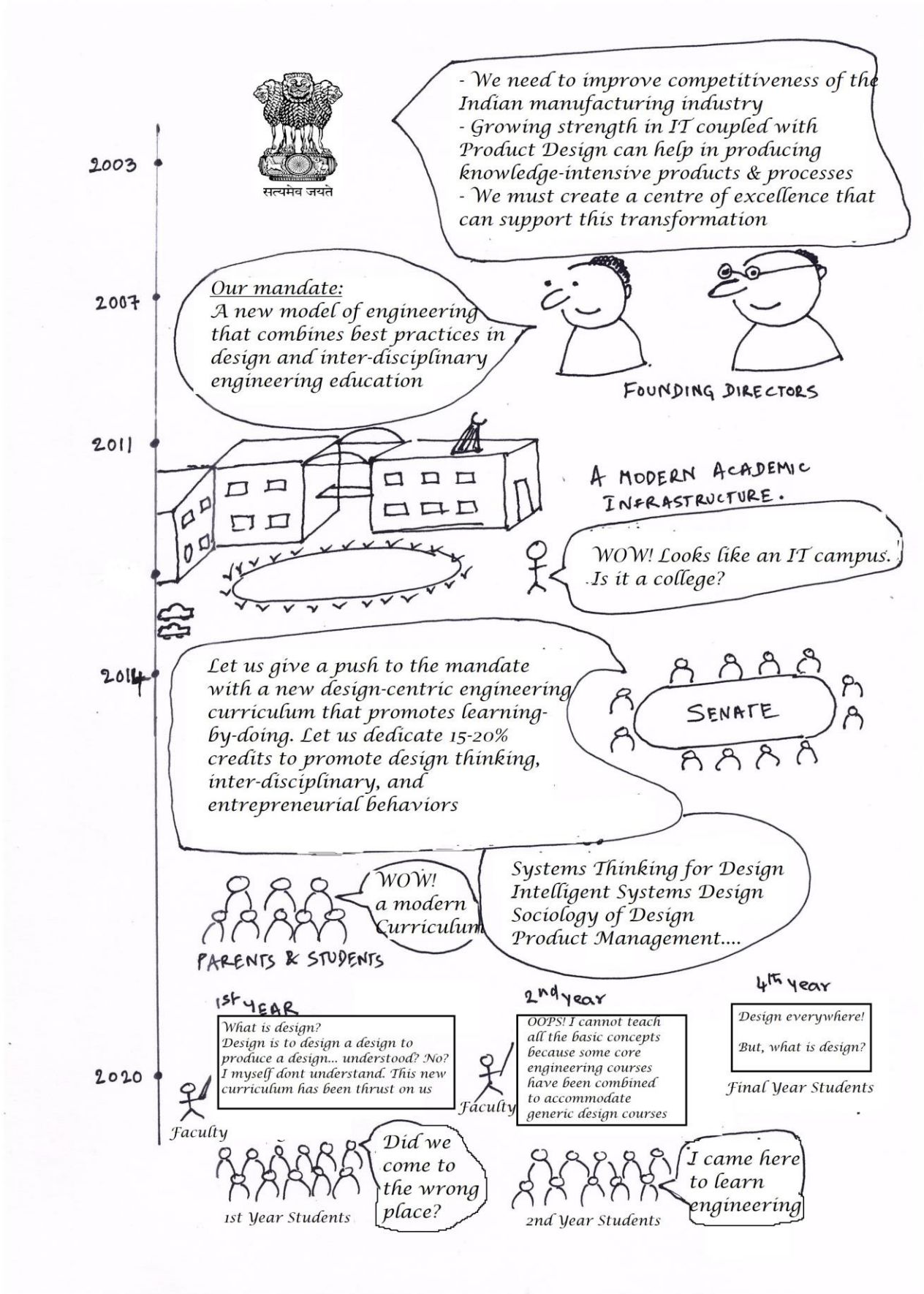


Figure 3. Introduction of design-centric engineering in a public-funded technology institution in India

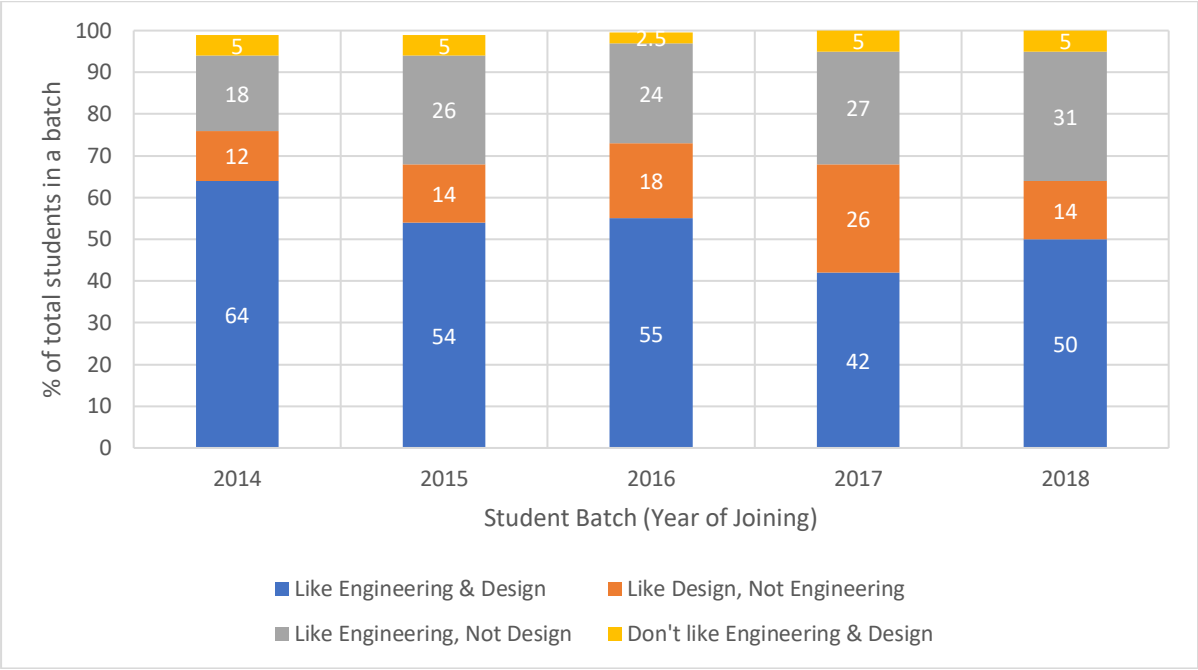


Figure 4. Trend in attitude of second-year engineering students towards design and engineering

Figure 4 depicts the rising conflict in the minds of students since the start of the new curriculum. The % students who said they "like engineering & design" declined from 64% in 2014 batch to 42% in 2017 batch. This decline is matched by increase in those who said they "like design, not engineering" (12%-26 %) or "like engineering, not design" (18%-27%).

4 METHODOLOGY

This research has been carried out as part of a course "Sociology of design" from 2016 to 2020. The course objectives include: (a) help engineering students understand how users make sense of products; and (b) how organizational contexts and tools shape the design work. The course content, as shown in Figure 5, includes an introduction to sociological theories such as Symbolic Interactionism and Actor Network Theory (ANT), followed by an exposure to ethnographic methods and semiotic analysis.

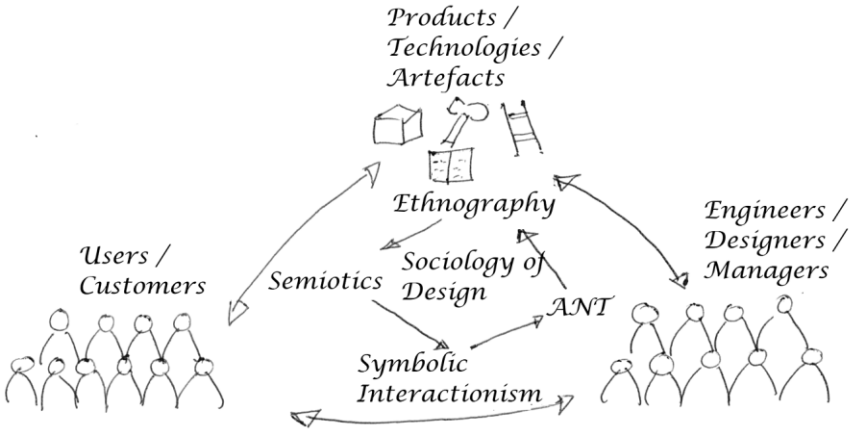


Figure 5. The content of Sociology of Design

One of the methods that is introduced to the students to capture the social aspects of a problem situation is the Rich Picture. Rich Pictures are generally used to surface the worldviews of key stakeholders, usually in small groups [2]. Another method is the Giga Map, which aims to capture the entire complexity of a problem situation.

This paper discusses a methodology that combines the ideas of Rich Picture and Giga Map. The rest of the paper discusses the application of the methodology to the 2018 batch of approximately 330 students. The first step involves encouraging students to draw a Rich Picture of their perceptions about design-centric engineering. An example of a Rich Picture drawn by a student is shown in Figure 6. It captures the individual's changing attitude towards design (from 2018 to 2020), other perceptions that pervade everyday talk, and the overall feeling (confusion).

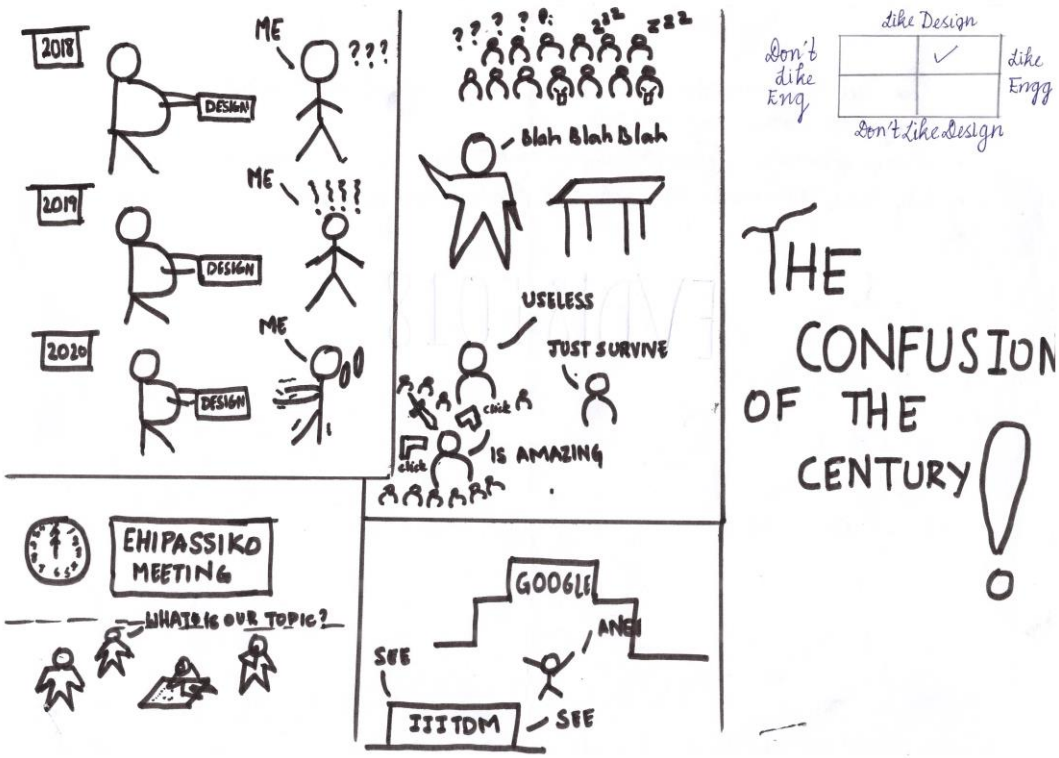


Figure 6. Example of a Rich Picture drawn by a student

In step 2, the students are asked to categorize the pictures into ten themes using an improvised form of Giga-mapping. Figure 7 depicts the details of the methodology.

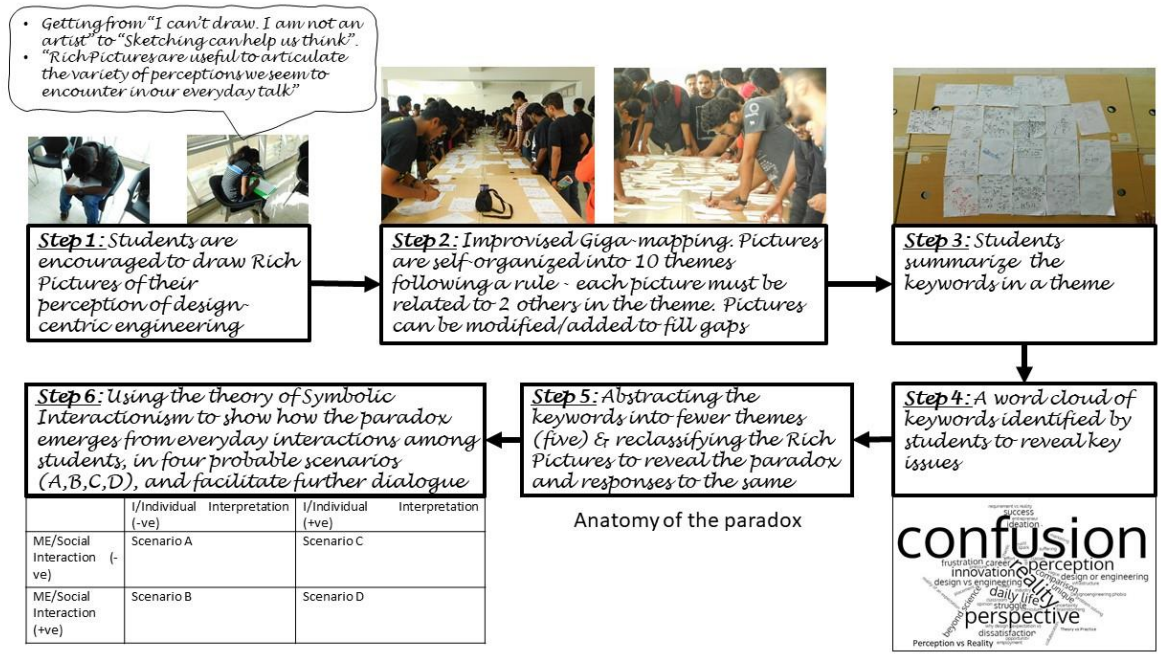


Figure 7. Methodology to categorize and make sense of the Rich Pictures

5 RESULTS

Figure 8 shows a word cloud of the keywords identified by students in step 3.

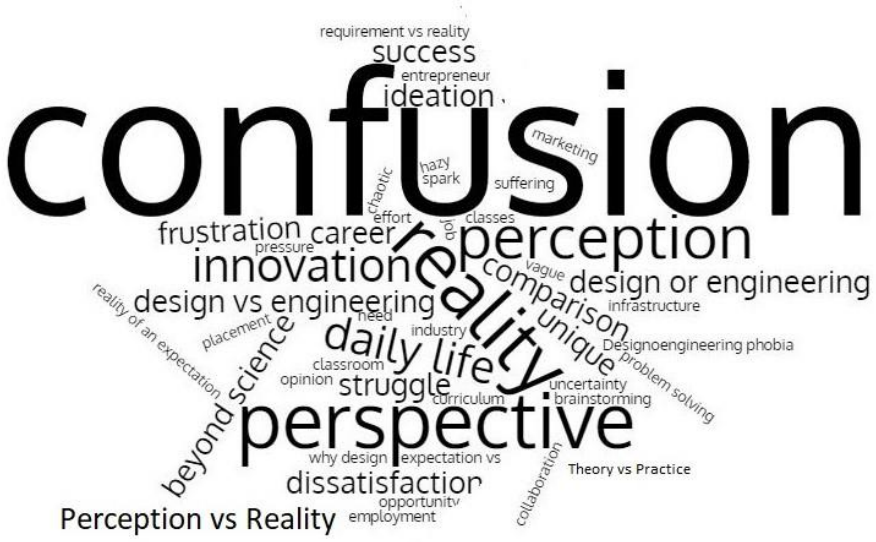


Figure 8. Word cloud highlighting keywords captured by students after self-organized giga-mapping

Further analysis of the keywords and Rich Pictures revealed five themes: (a) "I am in the wrong place", (b) "My daily life appears to be stuck in a routine", (c) "design and engineering are not compatible - frustrating, confusing"; (d) "design and engineering are complementary and critical for innovation", and (e) "I would rather try to distinguish good design from bad design". Themes 'c' and 'd' represent cases where the students saw the paradox as "EITHER Design OR Engineering" (39%) or "BOTH Design AND Engineering" (30%) respectively. In other words, for these 69% students, the 17% of credits for design subjects appeared like 50% while 82% of credits for engineering also appeared like 50% as shown in Figure 9. The fifth theme 'e' suggests cases where there is a potential reframing of the paradox (13%).

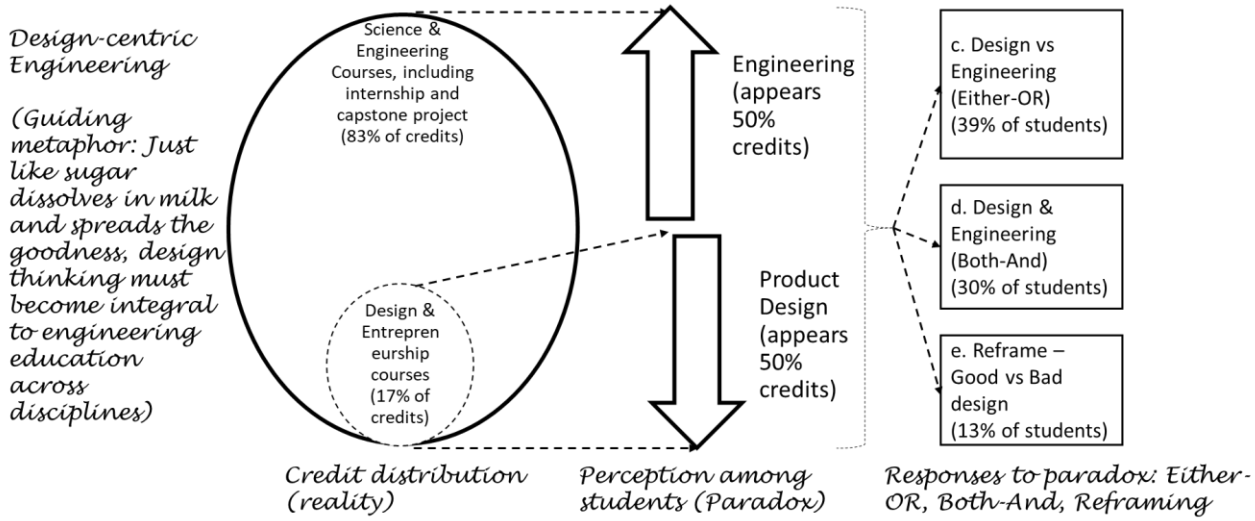


Figure 9. The anatomy of the paradox

To encourage students to reflect on how their micro-interactions created this paradoxical situation, the author synthesized the Rich Pictures into four scenarios using the theory of Symbolic Interactionism. These are depicted in the rest of the section.

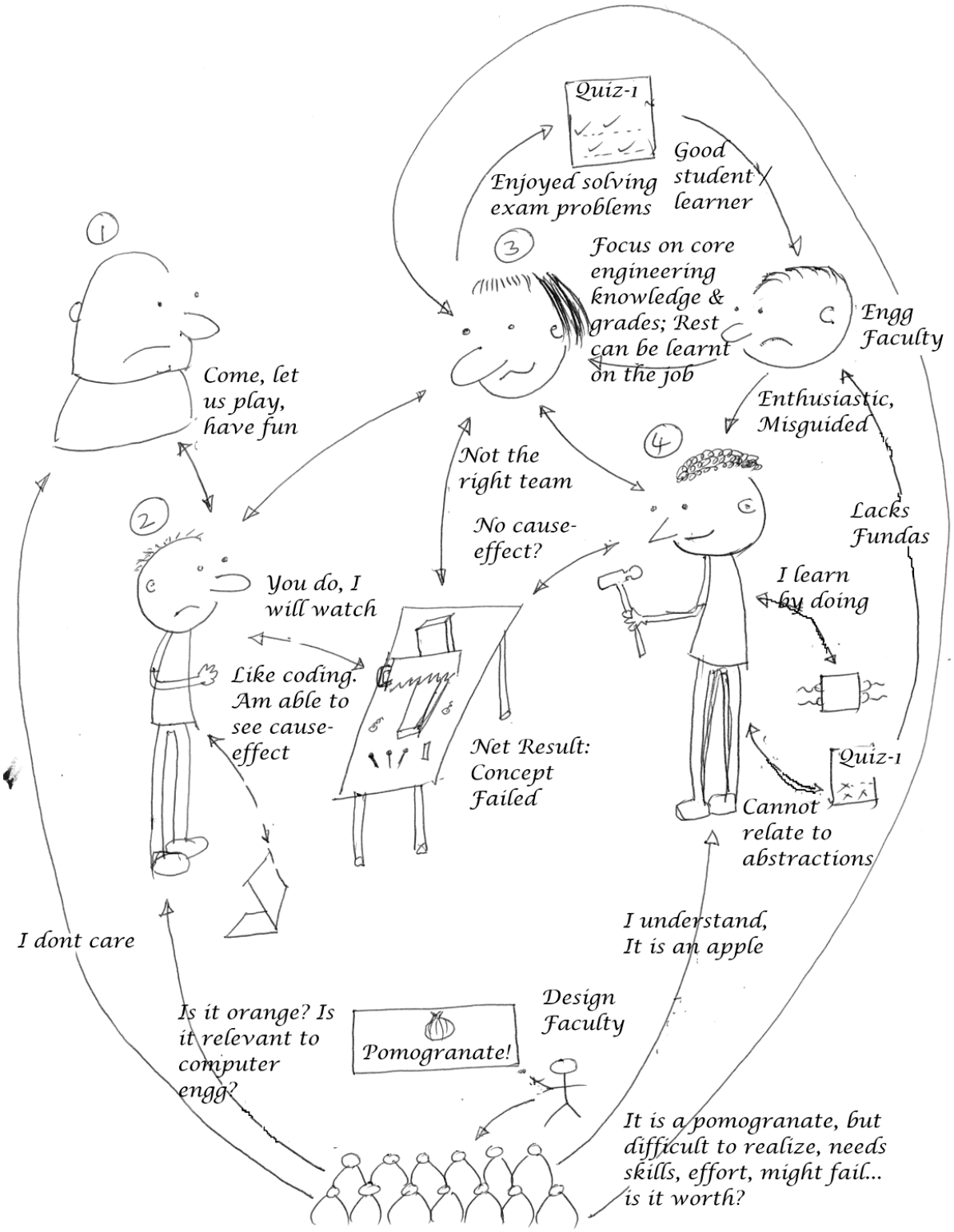


Figure 10. Scenario A - where both social interaction and individual interpretation promote the conflict of design vs engineering

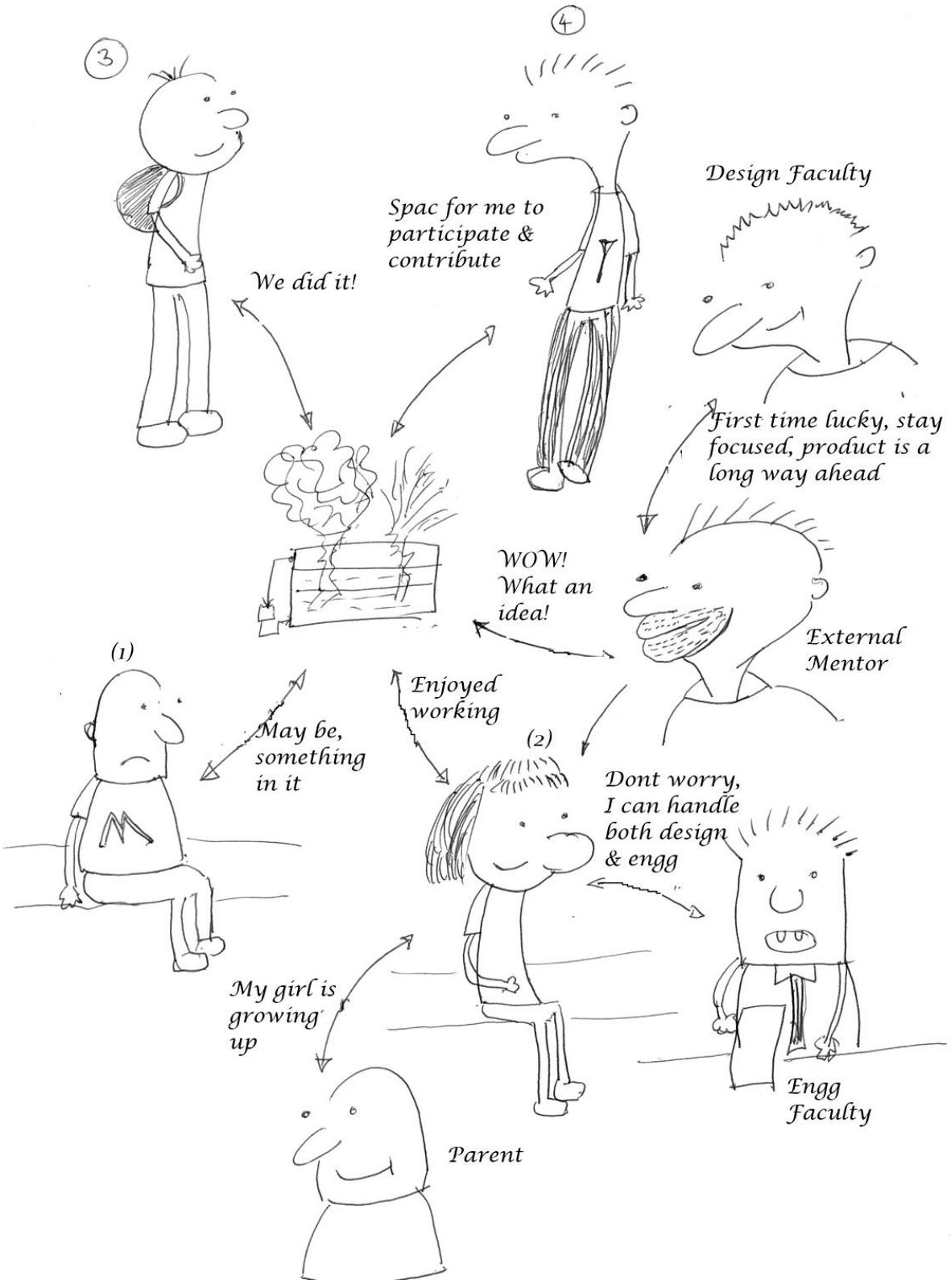


Figure 11. Scenario B - where the social interaction is positive while individual interpretation is open to doubt. Will the success repeat?

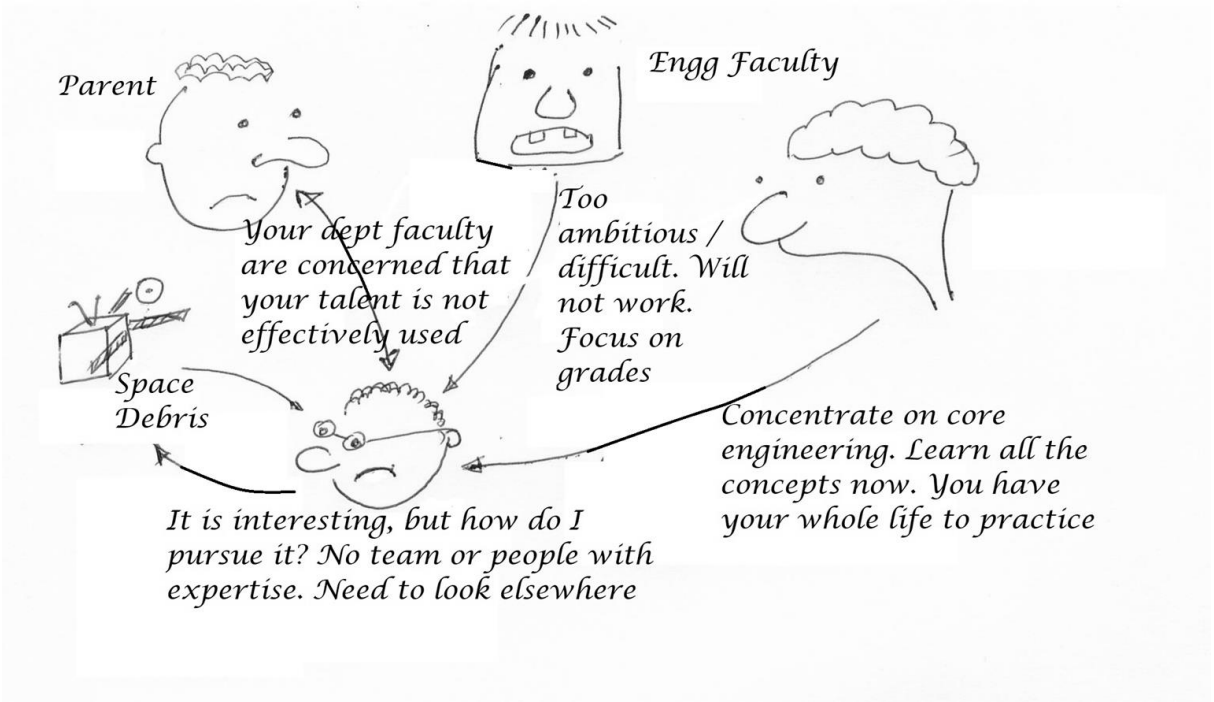


Figure 12. Scenario C - Where there is conflict between social interaction and individual interpretation

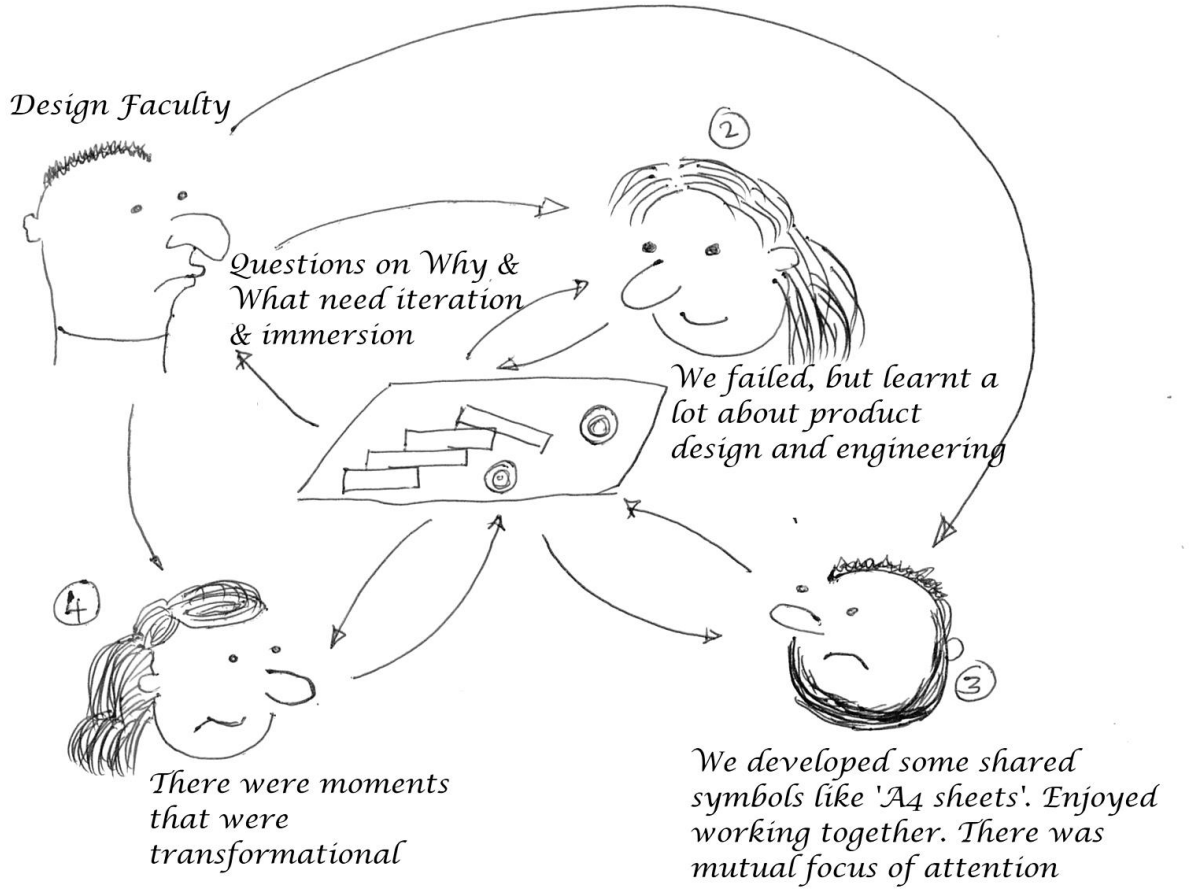


Figure 13. Scenario D - an ideal case where both social interaction and individual interpretation lead to a deeper reflection and learning from failure

Using the above scenarios, the students were asked to reflect on the real meaning of design-centric engineering. It was clarified that the 17% credits devoted to a set of design and entrepreneurship subjects were to encourage engineers to become self-directed learners, immerse in a situation, explore the unknown, experiment, take risks, learn from failure, and frame ill-structured problems in creative ways. In other words, it is to encourage engineers to embrace the design pedagogy. Most students appreciated this discussion and acknowledged its positive impact on their thinking and relating. A key takeaway for design and engineering educators is that exploring the contradictions in design-centric education itself can be a good way of helping students develop the capability to deal with paradoxes, especially when dealing with large classes.

6 CONCLUSIONS

One of the key competencies for engineers and product designers is the ability to identify and deal with paradoxes. This paper presented a case where the confusion that emerged in the process of implementing a design-centric engineering curriculum was used to help engineering students make sense of design and paradoxes. Students were encouraged to use visual tools such as Rich Pictures to articulate their perceptions. The Rich Pictures and their analysis were used to trigger a collective reflection on the real meaning of design-centric engineering education.

REFERENCES

[1] Dorst, K. Design Problems and Design Paradoxes, *Design Issues*, 2006, 22(3), 4-17

[2] Checkland, P. B. *Systems Thinking, Systems Practice*, 1981 (Wiley, Chichester).

[3] Bucciarelli, L.L. *Designing Engineers*, 1994 (MIT Press, Cambridge, MA)

[4] Dorst, K. and Hansen, C.T. Modelling paradoxes in novice and expert design. In *International Conference on Engineering Design, ICED'11*, Denmark, August 2011.

[5] Lönngren, J. Ingerman, A. and Svanström, M. Avoid, Control, Succumb, or Balance: Engineering Students' Approaches to a Wicked Sustainability Problem, *Res Sci Educ*, 2017, 47, 805–831. DOI 10.1007/s11165-016-9529-7

[6] Nieusma, D. Engineering/Design Frictions: Exploring Competing Knowledge Systems via Efforts to Integrate Design Principles into Engineering Education, In *Proceedings of the American Society for Engineering Education*, Salt Lake City, June 2018

[7] Miranda, C., Goñi, J., and Hilliger, I. Orchestrating conflict in teams with the use of boundary objects and trading zones in innovation-driven engineering design projects, *International Journal of Technology and Design Education*, 2019, https://doi.org/10.1007/s10798-019-09552-2

[8] Morgan, T., and McMahon, C. A. Understanding group design behaviour in engineering design education. In *Proceedings of the 19th International Conference on Engineering and Product Design Education*, 2017. 56-61. Design Society.

[9] Cristancho, S., Bidinosti, S., Lingard, L., Novick, R., Ott, M. and Forbes, T. Seeing in Different Ways: Introducing "Rich Pictures" in the Study of Expert Judgment, *Qual Health Res.*, 2015, 25(5), 713–725. doi:10.1177/1049732314553594

[10] Bell, S. & Berg, T. and Morse, S. Towards an Understanding of Rich Picture Interpretation, *Systemic Practice and Action Research*, 2019, 32, 601–614, https://doi.org/10.1007/s11213-018-9476-5