Art-Inspired Pedagogies in Engineering Education

Using Comics, VR/AR, Gaming, and Music in Engineering Education

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In recent years, there is growing recognition in engineering education that creative, humanistic, and transferable skills such as emotional intelligence, ethical leadership, and teamwork, are essential to students' success, thriving, and contribution in university and beyond (Jarrahi et al., 2023; Lappalainen, 2015; Rottmann et al., 2015; World Economic Forum, 2020). However, most engineering students are used to rigorous curriculums that emphasize technical development, with little opportunity to experience and explore creative and humanistic subjects and to develop ethically and holistically (Cech & Sherick, 2015; Riley, 2008). Moreover, many engineering students who are used to highly reductionist and analytical thinking find it difficult to engage with "softer" learning and may experience lowered motivation in these subjects (Badenhorst et al., 2020). Underlying these challenges is a cultural belief within engineering that sees the rigour and rationality of math and science being superior to the creativity and emotionality of arts and humanities (Riley, 2017; Wisnioski, 2015).

Over the past three years, we have explored, developed, and experimented with a number of novel pedagogies at the intersection of art and engineering, with the belief that there is tremendous value in having students engage with art, technology, and the act of engineering at the same time. In this short paper, we will describe three pedagogies we have developed, and present six reasons we have gathered through our experience with these pedagogies in support of bringing more art into engineering education.

Pedagogy 1: VIVID Storytelling

Comics are a communication medium and art form that combines the captivating nature of visual art with the organized structure of written text to craft compelling narratives. In the pedagogical setting, comics can be uniquely accessible and engaging, but requires significant time investment and artistic skills to craft. Sketch-noting is a closely related art form that also combines visual and verbal elements. Sketch notes often make use of simple illustrations in conjunction with simple words, making them easy to create. The downside is that sketch notes lack the storytelling aspect of comics, making them less ideal for communicating ideas to people not involved in the creation process. Inspired by the art of comics and sketch-noting, we have developed the Visual Verbal Integrated (VIVID) Storytelling pedagogy for engineering education. VIVID Storytelling makes use of simple visuals and simple words in line with sketch-noting but adds a strong narrative element in the fashion of comics (Zhuang et. al, 2022).

In the context of engineering education, we have applied VIVID Storytelling to create lecture slides, study materials, as well as educational videos to teach a variety of creative and humanistic

skills – like ethics and teamwork – as well as more technical concepts – like computational thinking and engineering design. We found that this approach is not only engaging for students, but it also compels the instructor (or creator) of the VIVID comics to distill complex concepts into straightforward narratives, making the learning much more accessible for students (Zhuang et al., 2022). *Figure 1* below is an excerpt from a comic deck explaining the difference between groupwork and teamwork, a concept known to confuse many university students.
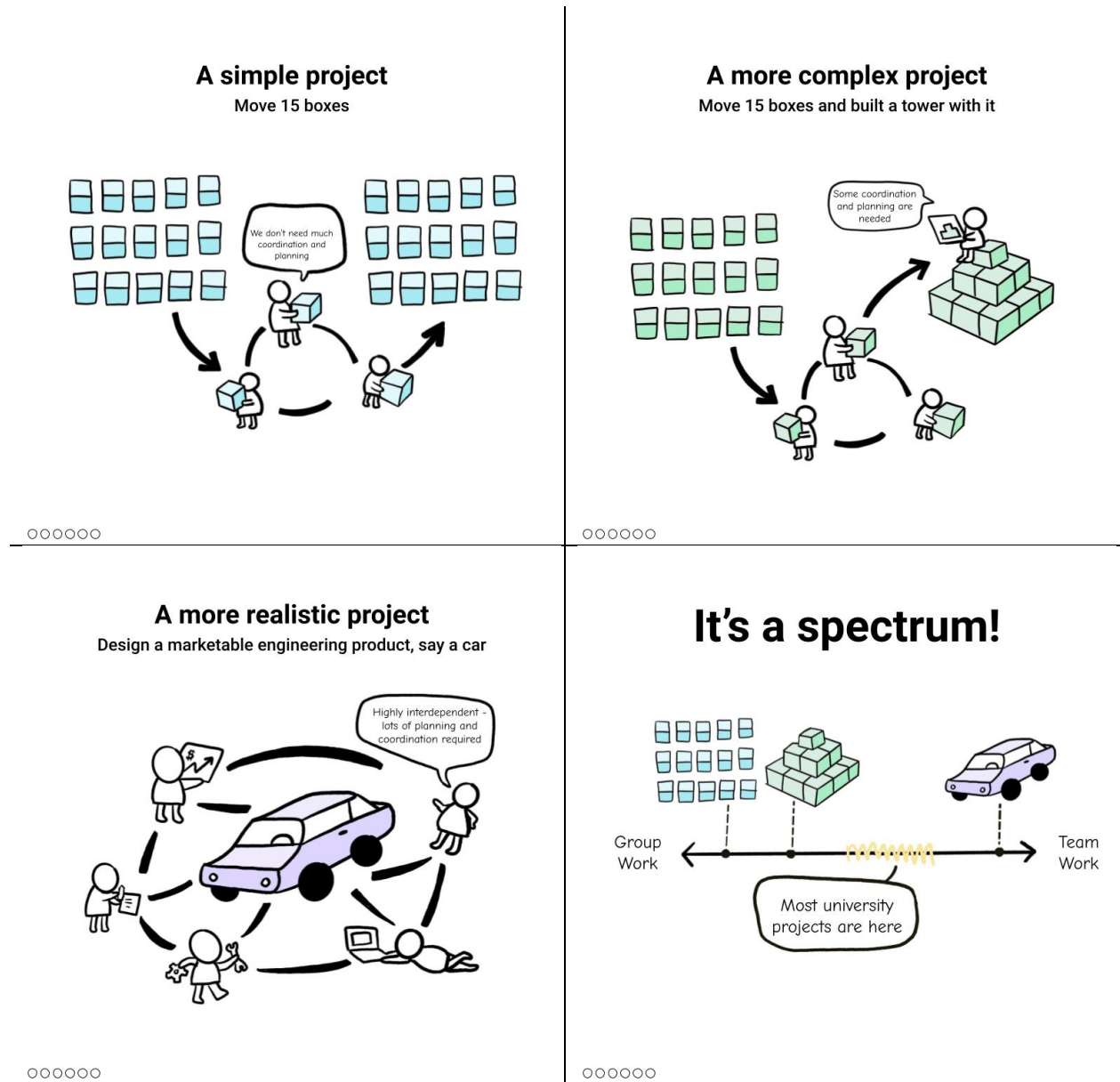

Figure 1: VIVID Comics Excerpt Displaying Teamwork from: Teamwork vs Groupwork. Artwork by Meaghan Veneracion and Kai Zhuang.

Pedagogy 2: Virtual and Augmented Reality

Learning complex engineering concepts in varying fields, from learning how to prototype a circuit on a breadboard, assembling drones, infrastructure health monitoring, energy consumption, wastewater system, and thermodynamics, all the way to learning about complex geological features requires hands-on experience as well as access to sophisticated equipment. For many educational institutions, especially those in poorer countries, the affordability of lab equipment and lab spaces can be challenging, and this presents a materialistic barrier to learning. Yet, without these hands-on experiences, students may become disengaged and unmotivated when faced with complex and theory-heavy topics (Boudreau et al., 2022).
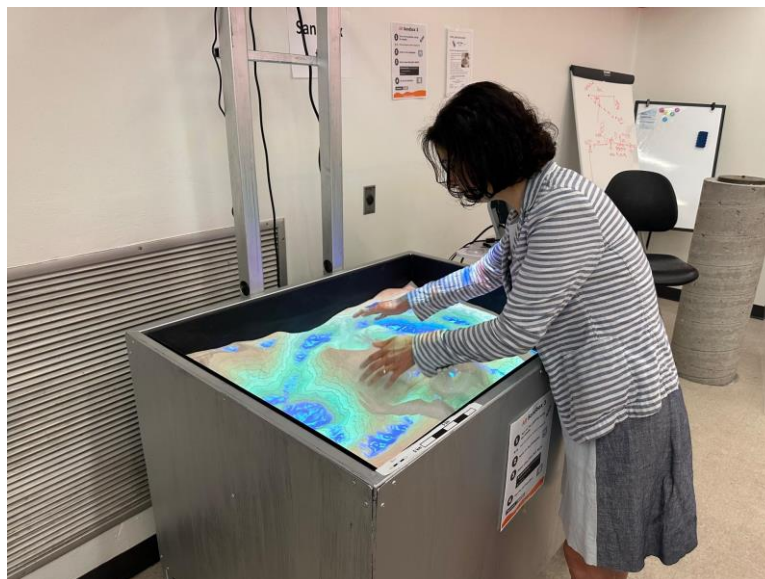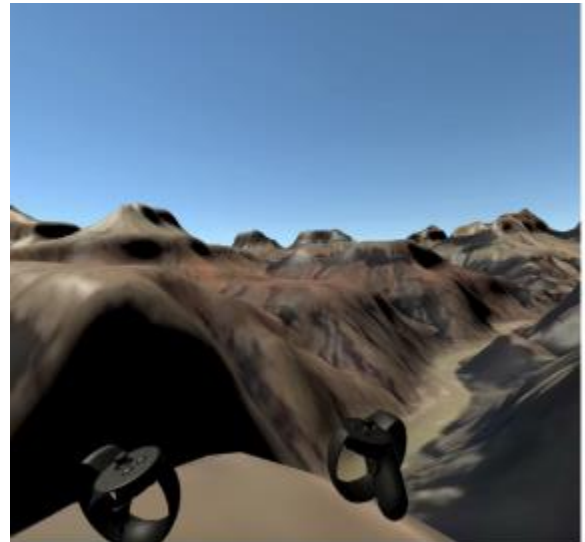

Figure 2: Left-top) VR sandbox to learn about the earth system, water systems, and more in the Grand Canyon; **Right-top)** In-game view of the Grand Canyon; **Bottom)** By morphing sand, learn about the earth system, water systems, and more using an augmented reality sandbox.

Emerging interactive technologies such as virtual reality (VR) and augmented (AR) present a novel approach to bypass the aforementioned materialistic barrier to learning. Using these technologies, we developed effective VR learning games and AR interactive sandboxes to teach students complex civil engineering topics (Bolkas et al., 2020; Jadidi et al., 2021; Jadidi et al., 2022; Tennakoon et al., 2022; Zhuang et al., 2022). Students found the artistic and interactive nature of these games and sandboxes engaging and enjoyable, giving them a boost of motivation for learning. *Figure 2* above presents a virtual tour of the Grand Canyon where the complex geological structure, earth landforms, water systems, and many more could be experienced and discussed using virtual reality and augmented reality technologies.

Future Work - Pedagogy 3: Coding through Music
Coding is an essential skill in the 21st century, particularly for engineering students. However, many 1st year engineering students find this highly practical skill difficult to learn conceptually and can become demotivated quite easily. To engage students' motivation for learning, we are developing a library of practical coding challenges and projects involving music and related creative arts. Music is selected as the art form to engage students because our experience tells us that many, if not most, of our students are interested in music in some way. Music is closely related to human emotions and provides a method for us to connect with our shared humanity (Peng, 2018; Wang, 2018). The first project under development is a procedural programming challenge that asks students to create a simple musical instrument using a microcontroller and a keypad. A second follow-up project we will develop is an objective-oriented programming project involving making a simple robot dance to music. The project has received funding and development will take place this summer.

The Potential for Art-Inspired Pedagogies: Six Reasons for Bringing Art into Engineering Education
Reflecting on our experiences developing and applying these art-inspired pedagogies, we have developed a list of six reasons (*Figure 3* below) for bringing more art into engineering education:

1. **Whole Head**: To help students develop both the methodical and logical mind, as well as the spontaneous and creative mind.
2. **Whole Heart**: To invite students to bring their passion and emotions into the world of logic, reason, and equations.
3. **Fun and Creativity**: To create spaces for students to explore their creativity and have fun with learning.
4. **Meaning and Purpose**: To offer meaningful opportunities for students to learn and create with prosocial purpose.
5. **Accessibility**: To make learning more accessible for students and create a backdoor into the ivory tower of learning built on erudite language and economic affluence.
6. **Leading by Example**: To create a new culture of engineering that recognizes the value of art, creativity, emotions, and humanity as essential to the act of engineering.

**Six Reasons for Bringing More Art
into Engineering Education**

Whole Head

Whole Heart

Creativity & fun

Meaning &
Purpose

Accessibility
Creating a "backdoor" into the
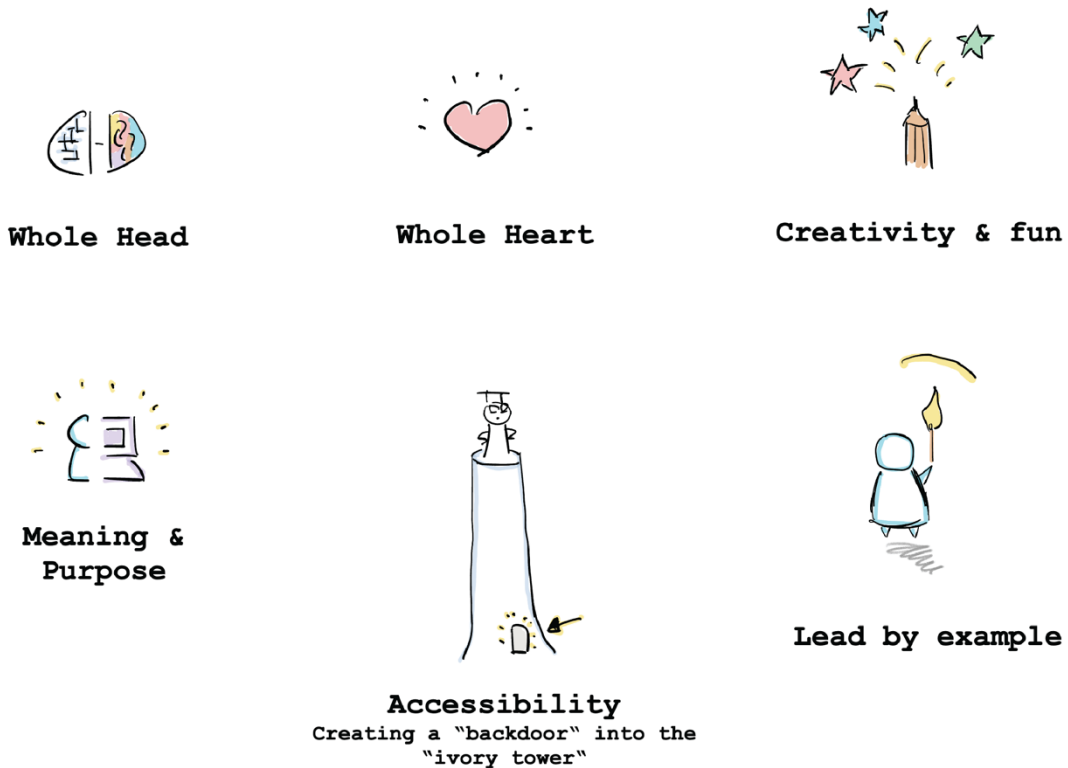"ivory tower"

Lead by example

Figure 3: Six Reasons for Bringing More Art into Engineering Education

We recognize that our work in using art to teach engineering is not wholly new. Art has been used to educate since the time of cave paintings and artistic practices such as drafting and CAD are integral to the practice of engineering. However, we do believe that there is a need for bringing more art with more freedom in creative expression into engineering education. We hope that by sharing our pedagogies, experiences, and reflections, we are inviting our fellow educators to join us in forging new pathways for developing engineering students holistically and readying them for the emerging future.

References

Bolkas, D., Jadidi, M.A., Chiampi, J. & Usman, M. (2021) *Web-based Game vs Virtual Reality Field Surveying Labs Towards Enhancing Experiential Education,* American Society of Engineering Education Conference 2021.

Boudreau, J., Nku, D., & Anis, H. (2022). Efficacy of Virtual Equipment Training. Proceedings of the Canadian Engineering Education Association (CEEA), Kelowna, BC.

Cech, E. A., & Sherick, H. M. (2015). Depoliticization and the Structure of Engineering Education. In *International Perspectives on Engineering Education* (pp. 203-216). Springer International Publishing. https://doi.org/10.1007/978-3-319-16169-3_10

Lappalainen, P. (2015). Predictors of effective leadership in industry - should engineering education focus on traditional intelligence, personality, or emotional intelligence? *European journal of engineering education*, 40(2), 222-233.

Jadidi, M., Tennakoon, D., Ullah, A., Usman, M., Vaileiou, A., Latchaev, S., Perras, M., Khan, U. T., & Baljko, M. (2022). *A New Realm of Experiential Education Using Mixed Reality Sandbox.* Canadian Engineering Education Association Conference, 2022.

Jadidi, M. & Usman, M. (2021) *"Virtual Field Surveying: A Gamification Approach"*, Canadian Engineering Education Conference 2021.

Jarrahi, M. H., Monahan, K. & Leonardi, P. (2023, June 2). What Will Working with AI Really Require? Harvard Business Review. https://hbr.org/2023/06/what-will-working-with-ai-really-require

Peng, C. S. (2018). Our Shared Humanity—Music as a Means of Facilitating Conversations on End-of-Life Care. *JAMA oncology, 4*(6), 771-772. https://doi.org/10.1001/jamaoncol.2017.4186

Riley, D. (2008). *Engineering and Social Justice.* Morgan & Claypool Publishers. https://doi.org/10.2200/S00117ED1V01Y200805ETS007

Riley, D. (2017). Rigor/Us: Building Boundaries and Disciplining Diversity with Standards of Merit. *Engineering Studies, 9*(3), 249-265. https://doi.org/10.1080/19378629.2017.1408631

Rottmann, C., Sacks, R., & Reeve, D. (2015). Engineering leadership: Grounding leadership theory in engineers' professional identities. *Leadership*, *11*(3), p.351-373.

Tennakoon, D., Ullah, A., Usman, M., Vaileiou, A., Latchaev, S., Perras, M., Khan, U. T., Baljko, M. & Jadidi, M. (2022). *Teaching Earth Systems Beyond the Classroom: Developing a Mixed Reality (XR) Sandbox,* American Society of Engineering Education Conference 2022.

Wang, G. (2018). *Artful design: technology in search of the sublime.* Standford University Press.

Wisnioski, M. (2015). What's the Use? History and Engineering Education Research. *Journal of Engineering Education, 104*(3), 244-251. https://doi.org/10.1002/jee.20075

World Economic Forum. (2020, October 20). The Future of Jobs Report 2020 | World Economic Forum. The World Economic Forum. https://www.weforum.org/reports/the-future-of-jobs-report-2020

Zhuang, K., Radebe, D., Jadidi, M., & Hu, E. (2022). *Visual Verbal Integrated (VIVID) Comics - A pedagogy for teaching transferable and humanistic skills in Engineering.* 2022 ASEE St. Lawrence Section Conference, Syracuse, NY.