Critically Thinking About Engineering Through Kinesthetic Experiential Learning

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***Abstract*—In recent years, use of and interest in active learning techniques has been on the rise. In this special session, participants will be immersed in kinesthetic experiential learning activities that emphasize the "active" in active learning. Participants will be guided through a number of in-class activities and the underlying pedagogical philosophy. The session will end with open discussion and Q&A, allowing participants to consider how they may incorporate these activities into their own courses and explore opportunities to develop kinesthetic experiential learning activities to suit their own classroom needs.**

Keywords—kinesthetic learning, experiential learning, active learning, game-based learning

I. Goals of the Session

This session is primarily intended for any individual involved in teaching engineering, and/or interested in kinesthetic experiential learning. We broadly refer to this population as "instructors."

The session will provide instructors with an opportunity to learn about, and participate in, innovative kinesthetic experiential learning activities to promote critical thinking about engineering. Participants will leave with a repertoire of activities they can use in their courses to provide an alternative educational experience. These experiences allow students to see both the engineering process and various technical concepts multiple perspectives, and can tap into different modes of learning by engaging students with the material in multiple ways [1-3].

II. Justification of Novelty

This session re-considers "active learning." Rather than engage directly with "technical" material through "active" problem solving activities, it focuses on activities where students actively play a role in creating a live scenario. This forms the basis of reflection-guided class discussion. It is in this discussion that the "learning" occurs, as the instructional objectives often organically become a focal point of discussion, and are underscored by the experience the students have just had.

Many activities rely on using analogies to connect the experience to the main content ideas developed. Analogies are a powerful tool for communicating ideas, as they allow for connections to be built on existing and familiar knowledge [4].

III. Description of Session Content and Agenda

Participants will be led through a series of activities, each with a specific pedagogical purpose. These will mimic the student experience of engaging in the activities; participants will receive directions for each activity and reflect on the principles revealed. Each activity will conclude with a summary of the pedagogical purposes and potential variations, as well as time for participants to reflect on the activity and generate a list of any questions or ideas. To help with timing, we will have a discussion of and question and answer (Q&A) for all the activities at the end.

The session will cover a variety of topics that relate to technical engineering material and understanding the engineering process. Each topic will be highlighted by a different activity, in a detailed agenda as follows. Broadly speaking, the term "facilitator" refers to the individual running the activity (typically the instructor). For the workshop, the facilitators will be the authors. All activities can be done with a single facilitator for small class sizes (under 30). Larger class sizes may benefit from or require additional facilitators.

A. Part 1: Diversity of Perspectives (5 minutes)

This activity uses a divergent thinking test to show the utility of diverse perspectives [5]. Divergent thinking is the ability to come up with multiple unique (and perhaps unusual) solutions to a problem. The contrast, convergent thinking, is the ability to find a single correct answer. As the name may imply, a divergent thinking test measures divergent thinking [6]. For this activity, the facilitator(s) administer a divergent thinking test by prompting participants for a solution to a specific question (which usually requires making a list of some sort) first individually, then with a partner, and finally with pairs of pairs working together. At each stage, participants are asked to compare their list to others, looking for similarities and differences, and noting any new ideas for

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the list that come up through these interactions. At the end, the facilitator(s) will explain how diverse perspectives contribute to a longer list of solutions, and how individuals tend to be able to come up with fewer solutions than groups.

B. Part 2: The Nature of Problem Solving (15 minutes)

Many students hold the misconception that problem solving is equivalent to the common plug-and-chug type problems used in homework and classrooms, or to final course projects hacked together in a short period of time [7, 8]. This "River Game" activity is designed to highlight some of the realities of problem solving. It is an adaptation of a free online game where the solver must come up with a method for getting a group of people across a river with a boat subject to constraints.

Participants are usually split into groups with enough people to represent each of the characters that need to get across the river (about 10). The large group serves two purposes: (i) participants must learn to work together, and (ii) participants who recognize the mapping between the group size and number of people in the problem can test solutions by physically simulating it with their group members. The problem solving time is about 7 minutes. This is intentionally short to force participants to be efficient and focused in their solution strategy. Groups seldom finish in the allotted time, at which point the entire population will work together with the facilitator to produce a solution. The remaining time is spent on a post-activity debrief highlighting the main lessons: real problems have goals and constraints (rules of game), real problems are ambiguous (missing information and unclear requirements requiring further conversation or making assumptions); problem solving is a non-linear iterative process (to solve the problem various characters have to go back and forth multiple times to create opportunities for other characters to successfully cross the river); and a problem can have more than one valid solution (there are at least two known solutions to the River Game).

C. Part 3: Communicating Design (15 minutes)

This activity uses tangrams (geometric puzzles) to demonstrate the importance of communication between multiple stakeholders engaged in a common mission. In brief, a pair of participants sit back to back, with one member (the builder) given tangram puzzle pieces and a work surface and the other (the designer) given the tangrams puzzle to be built (a shape that can be made from the tangram puzzle pieces, but how it is made is undefined). The designer describes the puzzle to the builder, and in the first round, only the designer is allowed to speak. In the second round, the designer and builder are allowed to speak with each other. In the post-activity debrief, participants discuss the experience of each round, how successful they were in building the puzzle, and strategies they used to succeed. This will be related to the engineering design process, particularly understanding a design need and communicating a design. Common experiences of running the activity with students will also be presented.

D. Part 4: Human Interactions (15 minutes)

Engineers must be able to communicate with a variety of audiences, in a variety of contexts [9]. Not only must engineers be able to verbally (in writing or orally) address audience and significance appropriately in communication, but they must also be able to interpret nonverbal cues, tone, and other communications from peers, colleagues, supervisors, clients, etc. Open Scene is a common activity used in acting classes to highlight the importance of everything that is not expressed in the verbal message alone. Participants are split into groups, and each group is given the same, simple, context-free dialogue. The characters and setting are, however, distinctly different. Thus, the content of the entire scene is built "between the lines" using body language, tone, and interaction. Groups perform their scenes, and the audience records their perceptions of the relationship, setting, and event that is taking place. This activity highlights not only how body language and tone effect our interpretation of interactions, but also how personal experiences affects our perceptions of what we see.

E. Part 5: Kinesthetic Experiential Learning Applied to Technical Content (10 minutes)

Participants will choose one of two kinesthetic experiential learning activities applied to an area of technical content, either: (1) principles of sensing phenomena, or (2) principles of dilute vs. concentrated extraction systems.

1) Principles of sensing phenomena (electrical and computer engineering): For the principles of sensing phenomena, the participants will go through the process of brainstorming how to measure one of their colleague's walking speed. One volunteer participant will be the test subject whose speed is to be measured and the rest of the group will take part in setting up the measurement system we devise (usually this includes marking a distance and timing using a stopwatch). We will then have a discussion of the different elements of sensing phenomena, based on the process by which we came up with the measurement system and the information we actually gathered.

2) Principles of dilute vs. concentrated extraction systems (chemical engineering): For the principles of dilute vs. concentrated extraction systems, participants will model a "mixer-settler" liquid-liquid extraction system in which solute is extracted from the diluent phase into the solvent phase by exploiting differences in solubility. Participants will be given designated roles (diluent, solvent, solute) and will be guided through an activity where they simulate the "mixing" of the system by moving around when music is playing and then "settle" when the music stops. A dilute system example will be done first, in which there are relatively few "solutes" in the system. This will be followed by a concentrated system example, where the number of solute particles is considerably greater.

F. Part 6: Discussion and Q&A (20 minutes)

We allot a portion of time at the end for discussion and general Q&A. We anticipate that participation in this session will generate rich discussion and new ideas for active-learning in the classroom. The activities can be adapted for different disciplines, learning objectives, and time constraints. The presenters will be facilitating this portion, but hope to engage the entire workshop participant population in the discussion.

IV. Expected Outcomes

As mentioned, we expect participants to leave this session with both a new repertoire of potential kinesthetic experiential learning activities and inspiration for reconsidering active learning approaches for their particular classroom needs. Further, we hope to build a community of interest and practice that allows session attendees to remain connected, share experiences, brainstorm new ideas, and follow-up on their implementation in the classroom.

References

[1] I. Phase, *Educating the Engineer of 2020:: Adapting Engineering Education to the New Century*: National Academies Press, 2005.

[2] C. Mitcham, "The true grand challenge for engineering: Self-knowledge," *Issues in Science and Technology,* vol. 31, pp. 19-22, 2014.

[3] L. Bordoloi and J. Winebrake, "Bringing the liberal arts to engineering education," *Chronicle of Higher Education,* 2015.

[4] C. B. Bingham and S. J. Kahl, "How to use analogies to introduce new ideas," *MIT Sloan Management Review,* vol. 54, p. 10, 2013.

[5] S. E. Page, *The difference: How the power of diversity creates better groups, firms, schools, and societies*: Princeton University Press, 2008.

[6] J. Guo, "The Development of An Online Divergent Thinking Test," 2016.

[7] G. A. Brown, J. Bull, and M. Pendlebury, *Assessing student learning in higher education*: Routledge, 2013.

[8] C. f. T. Excellence. (2017). *Teaching Problem-Solving Skills*. Available: https://uwaterloo.ca/centre-for-teaching- excellence/ teaching-resources/teaching-tips/developing-assignments/cross-discipline-skills/teaching-problem-solving-skills

[9] ABET, "Criteria For Accrediting Engineering Programs," 2014.