EXTENDING CREATIVE ACTIVITY IN THE ENGINEERING CLASSROOM

Ken Tallman and Christina Mei

University of Toronto

k.tallman@utoronto.ca; christina.mei@mail.utoronto.ca

Abstract –This ongoing research project focuses on creativity in undergraduate engineering education. Following the research reported at CEEA 2017, the current research asks whether undergraduate students taught in a Fall 2016 and, now, a Fall 2017 class, will develop enhanced creative skills in other learning and professional learning environments as a result of having taken the course. As well as studying the students' creative growth, the research tracks the students' metacognitive development. Are students more aware of themselves as learners? Are they able to better articulate their creative processes and learning processes once they have finished the course? The results from interviews conducted in April 2018 with nine students, five from Fall 2017 and four from 2016, suggest that students lack concrete awareness of changes in their creative paths after completing the course but have conspicuous awareness of changes in their metacognitive skills and in their confidence to "speak their minds."

Keywords: Creativity, Engineering, Metacognition, Life- long learning

1. CREATIVITY AND METACOGNITION

This research follows a long-standing interest in creative activity both inside and outside the engineering classroom. Undergraduate engineering students are often gifted creatively, but do not know it, or they do not think creativity will be important in their careers, but often it will. These two misconceptions have motivated my research, paired with my own interest in creativity in education in a broader sense. I have outlined the background for this research project in my CEEA 2017 paper, so I will summarize here by simply saying that this research started with APS325: Engineering and Science in the Arts, a course I created in Fall 2012 as a Humanities Social Science elective course for undergraduate engineering students at the University of Toronto. In the course, as the main project, each student creates an original works of art connected to engineering or science in some way and presents it to the class at the end of term. The goal is that students develop creative abilities in a setting that is familiar (with classmates from all engineering streams) but

with different aims (creating connections between the arts and engineering).

Last year, I presented on research with students who completed APS325 in Fall 2016. As part of this research, Christina Mei, a graduate student who completed APS325 as a student in 2013, and I interviewed seven of the 19 students enrolled in the course, asking them seven questions related to both their creativity and their knowledge about themselves as learners. I included those questions in the CEEA 2017 paper, and I will include them again, as we asked the same questions this past year in our continuing research:

1. What is your current understanding of the term "creativity"?
2. Did your understanding of creativity change during the course? If so, how? Is there evidence of this?
3. Have you been able to use this new understanding of creativity anywhere else since taking the course?
4. Did the course give you any new approaches or new knowledge that you can take with you to new situations?
5. Did this course affect your experience in your capstone design course? [For 4th year students]
6. Overall, did this course teach you anything about how you learn?
7. Which creative activities in the course could be improved?

In regard to creative activity connected with the course, all seven students interviewed in April 2017 responded by identifying the following themes: 1) Collaboration; 2) Interdisciplinary thinking; 3) Scope and Complexity; 4) Process; 5) Transfer. As presented at CEEA 2017, we suggested different ways both students and instructors might make use of these themes in developing lesson plans and course curricula.

In April 2018, having completed a fresh round of interviews with five students who completed APS325 in Fall 2017, and four who had completed the year before in 2016, Christina and I agreed that we were not learning new things about student creativity and its growth for these students. In the 2018 interviews, students noted that after

taking the course they had an increased comfort with ambiguity in their decision making in other situations, but this was something students had commented on the previous year, in our April 2017 interviews. We did, however, notice that many students commented on a new level of confidence in speaking about their creative process and speaking about themselves more generally, in job interview settings, for instance, as a result of taking the course. One student noted that he was able to “speak his mind” in a job interview, giving the interviewer a picture of himself, his personality, the way he thinks. The student claimed that his enhanced confidence was a result of the discussions we regularly scheduled into the weekly classes in APS 325. Two other students noted in their interviews that class activities and the interviews themselves helped them to develop self-reflective practices that guided them in developing their term projects.

Christina and I recognized that the students we were interviewing were pointing to the value of the metacognitive class discussions and the individual research interviews in giving them enhanced confidence in speaking about their personal perceptions and perspectives. Recognizing this prompted us to initiate a literature review into the relationship between confidence and metacognition, trying to find in the literature either verification of the relationship between metacognition and self-confidence, or evidence of other corollary benefits of metacognition.

2. METACOGNITION AND STUDENT CONFIDENCE

Uncertainty often challenges our sense of confidence and generally occurs when some important information about future events “cannot be known at the moment of decision” [1]. In respect to this, creativity can be interpreted as “an ability to imagine a future that is, at least in some respects, radically different from the present” [1], suggesting that creativity is a mechanism that, at least in part, responds to uncertainty. Real world situations often involve uncertainty in differing degrees, and “action selection” in these situations becomes challenging, making a person less confident about his or her decisions [7]. Confidence with decision making increases when “sensory inputs are stronger” with “successive samples of information totted up until they reach a critical level or ‘bound’, upon which a commitment to action is made” [7]. In this regard, confidence should reflect both the quality and the quantity of the evidence [7]. Determining the quantity of evidence is usually straightforward, while determining the quality of evidence is often achieved through error monitoring, a “metacognitive process by which we are able to detect and signal our errors as soon as a response has been made” [7]. Often, this detection, we

might expect, occurs through external feedback, either feedback, for example, from others, as would occur in group discussion, or physical feedback, as would occur when a mechanical device, for example, does not function properly. This line of observation has led researchers to hypothesize that people are attenuated not only to the strength of evidence but also to its reliability in decision-making, a kind of “evidence precision” that could influence metacognitive analysis [7].

Those who engage metacognitively in their learning are more likely to perform at higher levels than “unaware” learners [6]. One finding suggests that metacognitive knowledge “plays a compensatory role in cognitive performance by improving strategy use” [6]. In this way, metacognition is directly related to how much people know about themselves, about their strategies as learners, and which strategies might be most appropriate in which situations [6].

While researchers have noted the positive relationship between self-confidence and cognitive competencies, research on the relationship between self-confidence and metacognition is limited. One study, however, makes the explicit case that self-confidence, broadly speaking, has a “meaningful relationship” with metacognitive processes [5]. In this study, metacognition is measured through The Metacognitive Awareness Inventory, a 52-item questionnaire developed to evaluate people’s awareness of their metacognitive processes, measuring both knowledge about cognition and regulation of cognition. The cumulative results of the research team’s experiments show that while cognitive abilities contribute more significantly to a person’s overall confidence, metacognitive abilities are also important [5].

3. CONCLUSION

While our research on the relationship between creativity, metacognition, and self-confidence is preliminary, there is reason to believe from our own research and from the research of others that this direction is promising and could have practical applications in our approach to teaching creativity.

References

- [1] David Dequech, “Expectations and confidence under uncertainty,” *Journal of Post Keynesian Economics*, vol. 21, no. 3, pp. 415-430, 1999.
- [2] Ronald E. Goldsmith and Timothy A. Matherly, “Creativity and Self-Esteem: A Multiple Operationalization Validity Study,” *The Journal of Psychology*, vol. 122, no. 1, pp. 47-56, 2001.
- [3] Felix J. Heunks, “Innovation, Creativity, and Success,” *Small Business Economics*, vol. 10, pp. 263-272, 1998.

- [4] James C. Kaufman, "Creativity and Confidence: Price of Achievement?" *American Psychologist*, May, 2002.
- [5] Sabina Kleitman and Lazar Stankov, "Self-confidence and metacognitive processes," *Science Direct*, vol. 7, pp. 161-173, 2007.
- [6] Gregory Schraw and Rayne Sperling Dennison, "Assessing Metacognitive Awareness," *Contemporary Educational Psychology*, vol. 19, pp. 460-475, 1994.
- [7] Nick Yeung and Christopher Summerfield, "Metacognition in human decision-making: confidence and error monitoring," *Philosophical Transactions of the Royal Society*, vol. 367, pp. 1310-1321, 2012.