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Creative Ideation: A Review of the Literature

Prof. (emeritus) Shlomo Maital
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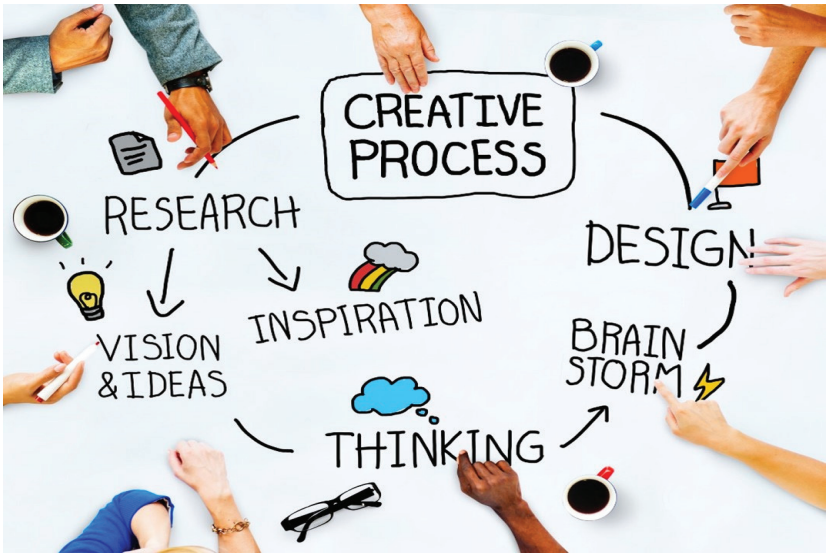

March 2021

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Technion, Haifa 3200003 Tel. 04-8292329 Fax. 04-8231889
info@neaman.org.il

Creative ideation: A Review of the Literature

Creative ideation, in Aristotelian terms, has both function and form. In function, it comprises ideas that are both novel and useful. In form, Ruttenberg and Maital[1] define the creative process as "widening the range of choice". They survey some 50 years of creativity research and find a wide and growing variety of approaches to both creative form and to creative function.

Up to the 1930's, psychology as a relatively new discipline showed little interest in creativity research. Hutchinson[2], published in 1931, finds "very little psychological literature …on this subject". The pace of research accelerated, after Nobel Laureate in Economics Robert Solow found in 1956 that two-thirds of the rise in global growth was due to creativity (which he termed technological progress).

Some of the studies focused on the key issue of measurement [Wu[3]], including the new field of neuroscience.[i] Others tackled creativity as a key skill; Gube et al.[4] focus on adaptive thinking, expertise, skills and attitudes as a key skill that supports creativity and should be imparted at universities.[ii] Henriksen et al.[5] review the link between creativity and technology in teaching and learning in the classroom; they find, pessimistically, "little practical ground for practitioners and in some ways, tends to avoid the reality of engaging with practice.". This paper stresses, in our view, the vital need for an operational theory of creativity – one that can lead to action.

Some interesting creativity research focuses on highly creative individuals and their thought processes. Sternberg[6] argues that "creativity can be of different kinds and it is important that teachers reward all kinds of creativity". Maital[7] describes over 100 creative case studies, involving stellar innovation, revealing a wide variety of effective creative processes. Gelb[8],[9] explores the creative processes employed by da Vinci (a 7-step method) and Edison (5 competencies). Karwowski et al.[10] focuses on the "malleability of creative mindsets", citing Einstein, Picasso, Marie Curie and Bill Gates. Rothenberg[11] uses a document discovered in 1979 in which Einstein describes in writing the "actual sequence of his thoughts leading to the development of the general theory of relativity" – based on "actively conceiving 2 or more opposite or

[i] "A tool that measures creativity with high reliability and validity is essential". Wu [22], p. 1.

[ii] Adaptive thinking is the ability to ""recognize unexpected situations, quickly consider various possible responses, and decide on the best one."

antithetical concepts, ideas or images simultaneously". A specific method for such "Janusian" thinking has shown promise, when implement, as shown by Sak and Oz[12]. Later, we will explore in depth the literature on such paradoxical thinking.[iii]

Ruttenberg and Maital[1] review the literature on 'domain specific' creativity, in movies, jazz, standup joke-telling, etc. Baer[13] argues that "creativity theory needs to set more modest goals of domain-by-domain theory development" rather than seeking overarching global creativity theory, one size fits all.

Can creativity be taught? Evidence of a decline in creative thinking among children since 1990 is presented by Kim[14], based on the Torrance Test of Creative Thinking; this is worrisome, given that IQ scores have risen during the same period.[iv] Gregory et al.[15] review a large literature, and find that to some extent creativity can be taught in the classroom, but cognitive functions (knowledge) must also play a major role. Perhaps the stress on teaching existing knowledge is displacing the innate ability of young people to question and create their own ideas.

Sitorus et al.[16] explore Wallas' four-stage model of creativity (preparation, incubation, illumination, verification) and add an earlier stage, orientation. They show that creative thinking in math can be improved using this "Realistic Mathematics Education" approach. Perry et al.[17] show a measured rise in "belief in their own creative abilities", but explain a significant decrease among some students. Lambert et al.[18] describe the impact of a creative thinker in bone pathology, healing, and fracture fixation, in clinical medicine, through creating "active learning environments".

Megawan et al.[19] explore measurement of divergent thinking (a process that leads to more than one solution to problems) in physics education – when many teachers focus on a single answer to problems. Sumami et al.[20] review learning strategies for improving creative skills, and conclude strongly that "problem-based learning is the most studied model to improve creative thinking skills" among high school students. (p 1). The survey paper by Maital and Barzani[21] strongly confirms the efficacy of project-based learning.

[iii] The American writer F. Scott Fitzgerald defined this aspect of creativity very well: "The test of a first-rate intelligence is the ability to hold two opposing ideas in mind at the same time and still retain the ability to function…"

[iv] "The decrease for kindergartners through third graders was the most significant". Kim [14].

Creative ideation comprises ideas expressed in words and in pictures. Visualization of ideas is an increasingly important aspect of creativity, given that today's generation, raised on plasma screens, thinks visually. Jankowska et al.[22] explore how pre-schoolers use their creative visual imagination in constructing their mental models. Komany et al.[23] use "constructivist" theories to combine the theory and the design of learning environments.[v]

Insight is regarded as an important aspect of creativity, defined as 'the capacity to gain an accurate and deep intuitive understanding of a person or thing.' Insight involves "a change in the representational spaces (insight tasks) or require solutions new to the solver". Gilhooly et al.[24] introduce a special issue of the journal *Thinking & Reasoning*, devoted to this subject. Some of the papers in this issue describe the unique blend of Type 1 (intuitive, insightful, unconventional) and Type 2 (routine, deliberative) thinking, leading to creative solutions that Type 2 thinking alone may not attain.

Researching 'insight' is difficult. Pringle et al.[25] use a creative approach, by asking groups of gardeners to "think aloud" as they work on a garden design, comparing designers, artists and non-artist controls. They find that associative (intuitive or creative) and analytical thinking processes predicted the creativity of the final garden designs, but *only when these two processes "were tightly coupled in time".*

Earlier, we noted so-called dual-process theories of creative thinking, sometimes defined as automatic fast (intuitive) thinking and effortful, logical, analytical thinking. Allen et al.[26] observe that while "both types of thinking are active in creativity, the extent to which they are active and the nature of their contribution to creativity will vary between stages of the creative process" (presumably, from early ideation to ultimate implementation). Miron-Spektor and Argote[27] explore the effect of paradoxical cognition on creativity performance in teams, defining paradoxical cognition as "frames and processes that recognize and embrace contradiction". Sowden[28] explores the idea that "creative thinking may rest upon the nature of a shifting process between Type 1 and Type 2 dual processes" (defined earlier).

[v] Constructivist theory says that learners construct knowledge rather than just passively take in information. As people experience the world and reflect upon those experiences, they build their own representations and incorporate new information into their pre-existing knowledge (schemas). Visualization is an important part of constructivism.

Neuroscience has contributed to creativity research. Fink et al.[29] review the use of brain-research tools (EEG, functional MRI, NIRS or PET) and survey results of having subjects perform experimental tasks to uncover brain correlates of creativity. Fox et al.[30] show a profound analogy – "perhaps even a direct relationship" -- exists between mind-wandering (defined as self-generated thoughts unrelated to a task or the surrounding environment) and creative thinking. They conclude that "much mind-wandering can be considered novel and useful" (a common definition of creativity), and in direct opposition to the negative connotation attached to "daydreaming" and "dreamers".

How important is it for creative thinkers to understand the rather mysterious process that generates creative ideas? Metacognition deals with "cognition about cognition". Jia et al.[31] tackle this issue, in their literature review. They identify three aspects of metacognition (knowledge, experience, and monitoring and control) and summarize neurocognitive mechanisms "that support metacognition during creative thinking."

One theory of creativity involves memory search that connects concepts that are distant from each other, or only weakly linked. Beaty et al.[32] use brain imaging studies to examine whether highly creative people have brains that are "wired differently" from the rest of us. In a remarkable finding, they note that "we could reliably estimate a person's creative-thinking ability just by knowing the pattern of their brain network connections." (p. 5). They conclude: "It seems that creative people are characterized by a distinct pattern of brain connectivity, allowing them to co-activate brain networks that don't usually work at the same time."

Implicit theories are theories of people about themselves and the world they live in. Redifer et al.[33] examined whether our own theories of creativity contribute to creative thinking. The short answer is, No. However, they do find that cognitive load (the amount of information that working memory can hold at one time) does in fact mediate the link between implicit theories and creative thinking, and specifically, higher working memory allows us to consider a greater number of possible answers.[vi] One operational conclusion from their research is that "finding ways to reduce extraneous cognitive load" (i.e. distractions) may be an "avenue to improving creative thinking."

[vi] Recall that in this section, we referred to a definition of creativity as "widening the range of choices".

Finally, we note the “evolving systems approach” to creative thinking, analogized as “inching our way up Mount Olympus” (Gruber[34]). Creative thinking is a highly complex process, and if we are to deeply understand and dissect it, it will be necessary to model it as a kind of ecosystem, linking a great many processes, brain regions, cognitions and skills.

References

[1] Ruttenberg, A., & Maital, S. (2014). “What Scholars Know about Creativity: a Journey through the Literature”, Chapter 7, Cracking the creativity code: Zoom in/zoom out/zoom in framework for creativity, fun, and success. SAGE Publications India.

[2] Hutchinson, E. D. (1931). Materials for the study of creative thinking. Psychological Bulletin, 28(5), 392.

[3] Wu, C. L., Huang, S. Y., Chen, P. Z., & Chen, H. C. (2020). A Systematic Review of Creativity-Related Studies Applying the Remote Associates Test From 2000 to 2019. Frontiers in psychology, 11.

[4] Gube, M., & Lajoie, S. (2020). Adaptive expertise and creative thinking: A synthetic review and implications for practice. Thinking Skills and Creativity, 35, 100630.

[5] Henriksen, D., Creely, E., Henderson, M., & Mishra, P. (2021). Creativity and technology in teaching and learning: a literature review of the uneasy space of implementation. Educational Technology Research and Development, 1-18.

[6] Sternberg, R. J. (2003). Creative thinking in the classroom. Scandinavian Journal of Educational Research, 47(3), 325-338.

[7] Maital, S. (2016). Innovate your innovation process: 100 proven tools. World Scientific. Singapore.

[8] Gelb, M. J. (2004). Da Vinci Decoded: Discovering the Spiritual Secrets of Leonardo's Seven Principles. Delacorte Press.

[9] Gelb, M. J., & Caldicott, S. M. (2007). Innovate like Edison: The five-step system for breakthrough business success. Penguin.

[10] Karwowski, M., Czerwonka, M., Lebuda, I., Jankowska, D. M., & Gajda, A. (2019). Does thinking about Einstein make people entity theorists? Examining the malleability of creative mindsets. Psychology of Aesthetics, Creativity, and the Arts.

[11] Rothenberg, A. (1979). Einstein's creative thinking and the general theory of relativity: a documented report. The American journal of psychiatry.

[12] Sak, U., & Oz, O. (2010). The effectiveness of the Creative Reversal Act (CREACT) on students’ creative thinking. Thinking Skills and Creativity, 5(1), 33-39.

[13] Baer, J. (2012). Domain specificity and the limits of creativity theory. The Journal of Creative Behavior, 46(1), 16-29.

[14] Kim, K. H. (2011). The creativity crisis: The decrease in creative thinking scores on the Torrance Tests of Creative Thinking. Creativity research journal, 23(4), 285-295.

[15] Gregory, E., Hardiman, M., Yarmolinskaya, J., Rinne, L., & Limb, C. (2013). Building creative thinking in the classroom: From research to practice. International Journal of Educational Research, 62, 43-50.

[16] Sitorus, J. (2016). Students' creative thinking process stages: Implementation of realistic mathematics education. Thinking Skills and Creativity, 22, 111-120.

[17] Perry, A., & Karpova, E. (2017). Efficacy of teaching creative thinking skills: A comparison of multiple creativity assessments. Thinking Skills and Creativity, 24, 118-126.

[18] Lambert, S., Mischler, D., Windolf, M., Regazzoni, P., Dell'Oca, A. F., Gueorguiev, B., & Varga, P. (2021). From creative thinking to scientific principles in clinical practice. Injury, 52(1), 32-36.

[19] Megawan, M., & Istiyono, E. (2019, June). Physics Creative Thinking Measurement using Two-Tier Multiple Choice to Support Science, Technology, Engineering, and Mathematics. In Journal of Physics: Conference Series (Vol. 1233, No. 1, p. 012068). IOP Publishing.

[20] Sumarni, W., & Sekarini, A. P. (2020, June). Review of learning strategies to improve creative thinking skills. In Journal of Physics: Conference Series (Vol. 1567, No. 4, p. 042050). IOP Publishing.

[21] Maital, S., & Barzani, E. (2019). Project-Based Learning: How Great Schools Motivate & Inspire. S. Neaman Institute, www.neaman.org.il

[22] Jankowska, D. M., Gajda, A., & Karwowski, M. (2019). How children's creative visual imagination and creative thinking relate to their representation of space. International Journal of Science Education, 41(8), 1096-1117.

[23] Komany, K., & Chaijaroen, S. (2020, November). Theoretical and Designing Framework of Constructivist Learning Environment Model that Enhance Creative Thinking and Creative Expression of Science for Medical Illustration Students. In International Conference on Innovative Technologies and Learning (pp. 189-195). Springer, Cham.

[24] Gilhooly, K. J., Ball, L. J., & Macchi, L. (2015). Insight and creative thinking processes: Routine and special.

[25] Pringle, A., & Sowden, P. T. (2017). Unearthing the creative thinking process: Fresh insights from a think-aloud study of garden design. Psychology of Aesthetics, Creativity, and the Arts, 11(3), 344.

[26] Allen, A. P., & Thomas, K. E. (2011). A dual process account of creative thinking. Creativity Research Journal, 23(2), 109-118.

[27] Miron-Spektor, E. L. L. A., & Argote, L. I. N. D. A. (2008, August). The effect of paradoxical cognition on individual and team innovation. In Academy of Management Proceedings (Vol. 2008, No. 1, pp. 1-6). Briarcliff Manor, NY 10510: Academy of Management.

[28] Sowden, P. T., Pringle, A., & Gabora, L. (2015). The shifting sands of creative thinking: Connections to dual-process theory. Thinking & Reasoning, 21(1), 40-60.

[29] Fink, A., Benedek, M., Grabner, R. H., Staudt, B., & Neubauer, A. C. (2007). Creativity meets neuroscience: Experimental tasks for the neuroscientific study of creative thinking. Methods, 42(1), 68-76.

[30] Fox, K. C., & Beaty, R. E. (2019). Mind-wandering as creative thinking: neural, psychological, and theoretical considerations. Current Opinion in Behavioral Sciences, 27, 123-130.

[31] Jia, X., Li, W., & Cao, L. (2019). The role of metacognitive components in creative thinking. Frontiers in psychology, 10, 2404.

[32] Beaty, R. E., & Kenett, Y. N. (2020). Mapping the creative mind. American Scientist, 108(4), 218-224.

[33] Redifer, J. L., Bae, C. L., & DeBusk-Lane, M. (2019). Implicit theories, working memory, and cognitive load: Impacts on creative thinking. Sage Open, 9(1), 2158244019835919.

[34] Gruber, H. E., & Davis, S. N. (1988). 10 Inching our way up Mount Olympus: the evolving-systems approach to creative thinking. The nature of creativity: Contemporary psychological perspectives, 243.

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Samuel Neaman Institute
for National Policy Research

Tel. 972-4-8292329 | Fax. 97-4-8231889
Technion City, Haifa 3200003, Israel
www.neaman.org.il