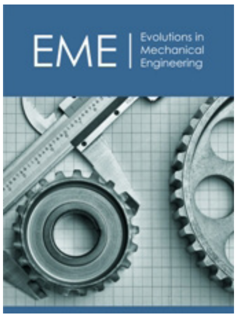
Creativity and Innovativeness in Engineering Evolution

Kalman Ziha*

Professor emeritus of the University of Zagreb, Croatia

ISSN: 2640-9690



***Corresponding author:** Kalman Ziha, Professor emeritus of the University of Zagreb, Croatia

Submission: March 10, 2026

Published: March 24, 2026

Volume 6 - Issue 4

How to cite this article: Kalman Ziha*. Creativity and Innovativeness in Engineering Evolution. Evolutions Mech Eng. 6(4). EME.000644. 2026.
DOI: 10.31031/EME.2026.06.000644

Introduction

Scientific discovery and innovative engineering concepts, plans, designs, building, maintenance and construction are complex cognitive, social, sociological and technical acts that contribute to the evolution of engineering and wellbeing. Creativity and innovativeness were studied for a long time by different experts and at many different levels. However, engineers were not commonly perceived in public as creative professionals [1]. A Harris Poll sponsored by the American Association of Engineering Societies and IEEE-USA found that only 2 percent of the public associate the word 'invents' with engineering and only 3 percent associate the word 'creative' with engineering [2]. This article aims to reaffirm the creative and innovative work in engineering, which impacts all vital aspects of life, society, safety and reliability. With the complexity of surrounding every engineering project mounting as natural resources dwindle, the world population increases and the global infrastructure and economy grow ever more intertwined, the creativity and innovation necessary to address the big issues facing civilization- maintaining the infrastructure; providing food, water, pollution prevention, shelter, health and power to the population; and growing sustainably and safely- will only increase in importance [1]. Engineers tackle hard problems of survival and long-term sustainability, which require creative solutions.

Creativity and Inventiveness

Creativity is frequently associated with notions such as talent, spontaneity and coincidence, i.e., factors that cannot be influenced or determined but ultimately are left to chance. However, the literature on creativity reveals that, although factors such as luck or chance certainly play a role, creativity in higher education may be enhanced (or hindered) by specific institutional and environmental situations as well as cultural factors. Favourable conditions include teamwork, cross-cultural exchange grounded in socio-cultural diversity, trans and interdisciplinarity, time and resources and a risk-taking culture that tolerates and even encourages failure [3,4]. This has led to the hypothesis that higher education institutions and their external stakeholders may influence their level of creativity by enhancing these conditions through specific processes and structures at different levels and in different spheres. Torrance, the "Father of Creativity", defined creativity as "the process of sensing problems or gaps in information, forming ideas of hypotheses, testing, and modifying these hypotheses and communicating the results. This process may lead to any one of many kinds of products-verbal and nonverbal, concrete and abstract" [5]. Groundbreaking research in educational psychology [6] led to a benchmark method for quantifying creativity. "Torrance Tests of Creative Thinking" effectively demystified the common assumption that IQ alone determined creativity. It also led to the now accepted belief that creative levels can be increased through practice [7].

Several other educators have offered definitions for creativity as it applies to engineering. It has been described as "the awareness, observation, imagination, conceptualization and rearrangement of existing elements to generate new ideas" [8,9]. Pereira [10] defined creativity as "the capacity to perform mental work that leads to an outcome both novel and applicable. The creative thought, then, is something that leads to the creative act or the creation of something new-an idea, theory, or physical product.

When approaching technical matters, terms "innovation" or "invention" are often used instead of creativity to describe the process that leads to insight or progress in a field, with a technique or with a physical product. While innovation connotes a sense of inventing a thing as opposed to an idea or a theory, it is essentially a synonym for the creative process. Perhaps technical people prefer to be "innovative" rather than "creative" [1].

The Creative Process

Creativity techniques serve to encourage and provoke original thoughts, different thinking and new ideas to stimulate the creativity process. Some techniques require groups of two or more people, while other techniques can be accomplished alone. Most creativity techniques use associations between the goal (or problem), the current state (which may be an imperfect solution to the problem) and some stimulus (possibly by improvisation or random selection). Problem definition also requires creativity, sometimes even more than its solution. Notions of instantaneous inspiration or a lone genius thinking up something brilliant and changing the world are myths, which have been debunked [11-13]. Most people who study creativity now accept the notion that creativity is not something that happens in a vacuum.

The definitions presented above articulate the notion that creativity is a process rooted in the real world [1]. The creative process must go through a series of four stages:

A. a notion or need (sensing, problem definition and orientation);

B. an investigation of that notion or need (testing, preparation, incubation, analysis and ideation);

C. an articulation of a new idea or solution (modifying, illumination and synthesis); and

D. a validation process of that idea or solution resulting in an idea, theory, process or physical product (communicating, verification and evaluation).

These four stages should be familiar to engineers, as they mirror the design process itself, which, never forget, is (or should be) a creative endeavour [14]. Many groundbreaking design concepts stem from simple, often sublime reformulations of current thinking and practice and these creative breakthroughs are often fed by study and observation outside of engineering paradigms [15]. Yet while "creativity is an essential component in engineering design," focused interviews with leading creative engineers have found that "engineering schools do not adequately prepare students for creative endeavours or for the realities of modern industry" [12]. This observation needs further investigation. Some commonly known methods for enhancing creative processes in engineering education are presented in the APPENDIX.

Traditionally, engineering education emphasizes problem-solving abilities based on professional knowledge. There are strong connections and distances at the same time between professional knowledge and creativity. The lack of expertise can hardly produce creative ideas or enable engineers to recognize a creative solution among all alternatives. On the other hand, a highly extensive expertise can result in a tendency to jump to the first solution, which solves the imposed problem in a conventional manner, which doesn't promise any inventive ideas in tackling new problems. The archaeological discovery of the bronze age log boat 5000 years old shows the ingenuity of our ancient ancestors in building lighter and stronger boats by primitive wooden stiffening [16].

Moral, Ethics and Codes in Engineering

Ethics and morals, in general, both personal and industrial, provide guidance for all engineering activities. The two main goals are to maintain constant positive progress and prevent the possibility of bad outcomes, whether accidental (negative creativity) or deliberate (malevolent creativity) [17]. There is a vital difference between engineering ethics and the arbitrary view that a risk-taking culture that tolerates and even encourages failures can stimulate creativity [3,4].

The long experience of engineering practice resulted in strict codes of ethics. The two important ethical highlights from the preamble of the ethical code created by "The National Society of Professional Engineers (NSPE)" are that engineers are expected to exhibit the highest standards of honesty and integrity, and dedication to the protection of public health, safety and welfare. However, the code encourages engineers to make improvements, plans, designs, inventions or other records that can justify either copyrights or patents.

Safety, Reliability and Risk Elimination in Engineering Creative Efforts

Regardless of the other properties of engineering objects with respect to their purposes, functionality and efficiency, the decisive goal is to provide the required safety and minimize risks. Engineers deal with objects of many different components, which are planned, designed and fabricated under unreliable workmanship, often from materials of uncertain properties and dimensions and commonly operating in uncertain environments exposed to random loadings and possibly improper management and maintenance. Therefore, the term reliability better describes the random condition in which engineers strive to fulfil their missions. The integral system safety in engineering [18] is based on 'calculated risk' using probabilistic reliability calculations instead of 'ignorant risk' [19].

Conclusion

Creativity helps to see the world in a new way. Creativity also helps in considering multiple angles instead of just one and helps create bridges between different fields of knowledge and between innovation and the tried-and-true. There is no right way to approach creativity, but an atmosphere encouraging divergent thinking (what people in creativity studies call innovative thinking) and uncensored thought generation is conducive to deriving novel solutions. This period of free play, no matter how long or short, must eventually be constrained to derive tangible, practical solutions [10].

However, if one concentrates on practicality at the outset, it is likely that ordinary, tried-and-true solutions will result. For productive problem-solving is equally important to creatively generate and critically evaluate ideas. Usually, innovative and creative ideation is the most exciting and appreciated part of the problem-solving process. However, critical evaluation is a necessity, because if ideas are immediately and without hesitation converted into action (without being wisely evaluated), that can lead to unsatisfactory results. Asking the right questions is also an important part of a new creative solution and therefore, unsupervised solution generation is not sufficient.

Engineering educators are responsible for stimulating creative thinking among students. Taking a creative look at engineering education does not mean ignoring or disregarding the common engineering practice. Instead, using creativity can mean generating excitement in students as they approach engineering problems in original ways [20-23].

Creativity and innovativeness are complex social and technical phenomena that foster permanent evolution in engineering based on the full responsibility and dedication of active engineers to:

1.The highest standards of honesty and integrity based on engineering codes of ethics; 2. The protection of public health, safety, natural environment and overall welfare; 3. The improvement of the current state and invention of new and more efficient solutions in engineering.

Appendix

a) Brainstorming is a group creativity technique designed to generate a large number of ideas for the solution of a problem (Osborn 1953).

b) Brain writing 6-3-5 is a group creativity technique used in marketing, advertising, design, writing and product development (Rohrbach 1968).

c) Lateral thinking is a term coined by Edward de Bono, for the solution of problems through an indirect and creative approach (de Bono 1970).

d) TRIZ is a Russian acronym for 'The Theory of Inventive Problem Solving', which was originally developed by Genrich Altshuller, (Altshuller, 1956, 1979).

e) The Disney Creative Strategy based on observations of the process Walt Disney used while creating (Dilts 1991, 1994).

f) Design for Six Sigma (DFSS) also known as DMADV-(Define, Measure, Analyze and Verify) is a systematic approach for manufacturing companies to address product and process issues at the early development stage (Yang & Basem 2003).

g) Synectic's is a creative problem-solving method that stimulates thought processes of which the subject may be unaware (Gordon 1961, Prince 1970).

References

1. Stouffer WB, Russell JS, Oliva MG (2004) Making the strange familiar: Creativity and the future of engineering education. Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, Copyright 2004, American Society for Engineering Education.
2. Bellinger R (1998) Professional development sessions dominate; new poll on engineers' image released PACE conference hits 'a year of transition'. Electronic Engineering Times.
3. Landry C (2000) The creative city; a toolkit for urban innovators. Earthscan & Comedia.
4. Tepper SJ (2004) The creative campus: Who's no. 1? The Chronicle of Higher Education.
5. Torrance EP (1963) Creativity, national education association. Washington, D.C. USA.
6. Torrance EP (1977) Creativity in the classroom. National Education Association, Washington, D.C. USA.
7. Childs M (2003) 'Father of creativity' E. Paul Torrance, UGA Professor Emeritus of Educational Psychology, Dead at 87.
8. Farid F, El-Sharkawy AR, Austin LK (1993) Managing for creativity and innovation in A/E/C organizations. Journal of Management in Engineering 9(4): 399-409.
9. Santamarina JC, Akhoundi K (1991) Findings in creativity and relevance in civil engineering. Journal of Professional Issues in Engineering Education and Practice 117(2): 155-167.
10. Pereira LQ (1999) Divergent thinking and the design process. International Conference on Design and Technology Educational Research and Curriculum Development Conference Book, pp. 224-229.
11. Bogen MA (1991) The creative mind: Myths and mechanisms. Basic Books, New York, USA.
12. Richards LG (1998) Stimulating creativity: Teaching engineers to be innovators. Proceedings of 1998 IEEE Frontiers in Education Conference 3: 1034-1039.
13. Weisberg RW (1986) Creativity: Genius and other myths. W.H. Freeman and Co., New York, USA.
14. Santamarina JC (2002) Creativity and engineering-education strategies. In Proceedings of the International Conference/Workshop on Engineering Education Honoring Professor James T.P. Yao, February 21-22, 2003, College Station, Texas, USA, pp. 91-108.
15. Peters TF (1998) How creative engineers think. Civil Engineering 68(3): 48-51.
16. Ziha K, Stanković T (2024) Evolution of stiffened panels in engineering. Evolutions Mech Eng 5(5): 1-4.
17. Cropley DH (2014) Engineering, ethics and creativity: N'er the Twain shall meet? In: Moran S, Cropley D, Kaufman JC (Eds.), The Ethics of Creativity, Springer Nature, Palgrave Macmillan, UK, pp. 152-169.
18. Ziha K (2023) Evolution in engineering on the way to safety. Evolutions Mech Eng 4(5): 1-3.
19. Fredrik H (2021) Ignorant risk vs calculated risk (The creativity suite. Episode 19.), Medium.
20. Raskin A (2003) A higher plane f problem-solving. Business 2.0, pp. 54-56.
21. https://thecreativityexplorer.medium.com/ignorant-risk-vs-calculated-risk-the-creativity-suite-episode-19-4b373c4ad3f9
22. Ziha K (2010) Creativity and engineering education.
23. Ziha K (2000) Redundancy and robustness of systems of events. Probabilistic Engineering Mechanics 15(4): 347-357.