SALMON CHALLENGE METHOD (SCM):
MECHANICAL CREATIVITY IN NEW PRODUCT DEVELOPMENT

Iko Avital(*)
Gedalya Mazor
Shamoon College of Engineering, Beer Sheva, Israel.

(*)Email: ikoavital@gmail.com

“We teach critical thinking more than creative thinking”
James Adams, Stanford University
(“Good product, Bad products”, p.24)

ABSTRACT

SCM is a Hands-On Engineering learning method, based on challenging Mechanical Engineering students to focus on inventive creativity, just one step before processing a brief project; a crucial phase before starting gathering pertinent information, generating conceptions and multiple solutions, analyzing and selecting a solution, testing and implement the solution. In this genesis stage there is a sharp separation between the ideation praxis and all other engineering design issues, such as System Requirement Review (SRR), Preliminary Design Review (PDR), and User Requirement Specification (URS). This is a creative thinking session stimulate students to perform their own authentic ideas and promote originality as a main value of new product development (NPD). No any involvement of other data and design considerations, such as engineering, raw materials, manufacturing, logistics, costing, marketing, and so on. SCM is a project oriented framework that interact three phases of concrete and abstract perspectives learning (drawing 1): three courses of Creativity, two courses of Product Sketching, and ongoing hands-on through semester projects. These courses energize mechanical engineering courses, and lead students to a holistic approach of authenticity and self-expression. Test case done by mechanical engineering students, will present what happen to the imaginative output when limitations are unleashed in the ideation process. In this research, Salmon journey was an inspirational motivation for students’ overcoming limitations and obstacles, and try to design upstream the global market. At the same time there are some academic conditions under which SCM can flourish and really affect teaching of science and engineering courses.

Keywords: clouding, salmon motivation, inventive creativity.

INTRODUCTION

Creativity plays a larger role than ever before in these nowadays economics globalization. The demand expectations for innovative products and new creative ideas have high expanded in the competitive global market dynamics. This situation set mechanical engineering to become increasingly innovative, entrepreneurial, and multidisciplinary in the race of competitive products. It also change the roll of mechanical engineer per se, from problem-solver to Creative Engineer: one who supposed to generate and launch new innovations and to be total involved in the product development from A to Z - from idea genesis, to research, conception, design detailing, production, packaging and branding, Figure 1.

-1273-
New Product Development (NPD) process include idea generation, Idea screening, Concept development and testing, Marketing strategy development, Business analysis, Product development, Test marketing, and Commercialization. We tend to list the reasons for new product failure such as overestimation of market size, poor design, incorrect positioning, wrong timing, priced too high, ineffective promotion, management influence, high development costs, and competition. No one mention the lack of inventive idea. How about placing the launched product on 1 to 10 innovation scale? How far is it from other products’ competitors?

Existing methods of new product development (NPD) are not locating creativity and innovation in its proper place. Mechanical engineer's practice is loaded by brief project, information, technical data, cost, marketing, and logistic considerations; drown and lost by tight limitations. SCM bridge the gap between ideation and other go/no-go processes in NPD, and let engineer breaking down the barriers of creativity, free him to create authentically with his own-voice.

Today engineering education mission is to use the power of engineering principles, techniques, methods and systems to graduate creative engineers, entrepreneurs and tomorrow's leaders who possess inventive creativity, socio-cultural awareness, and industrial curiosity-driven, besides deep technical excellence, and acknowledge of contemporary issues. Students earn the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice, an ability to identify, formulate, and solve engineering problems; Our research relate to project-based training that bridge the intangible knowledge with free imagination, to create tangible output by unlocking creativity potent.

Usually, Mechanical engineering education provide tech knowledge that combine science, engineering, and laboratories by teaching concept of memorization and solving theoretical tasks, with emphasis on systematic and analytical thinking. Students receive a broad base that allows them to design a product or system through calculations, formulas, physical laws, regulations, and data brief. Classes generally focus on step-by-step methodology, analysis, features, manufacturing and solutions - but does not give space to creative phase for innovative ideas. In SCE we developed a unique undergraduate program: mechanical engineering in product design; it is identified by four faces. One, three Creativity Courses for second and third year batches: These courses are challenging the student's creative potential and encourage unblocking his imagination, to dare dream, and to let his authenticity to pop out. Second, two courses along a year of Product Sketching, hand on of freehand drawing and rendering techniques. Third, Integrated Teaching Method: two faculty
lecturers from different disciplines teach ten students in the class, a design engineer and an industrial designer, in a project oriented task; circled by other lecturers that enrich the relative knowledge needed for the chosen project. Fourth, hands-on workshops, student’s practices wood, plastics, metal, and soft materials, besides engineering laboratories. They start from ideation stage by free hand sketching, then design onscreen with digital tools and outputting to desktop fabrication machines, including 3D printers. This Project Oriented Method try to graduate creative engineers that are in mindset to innovate and invent from bottom up, in an highly entrepreneurial motivation, ready to play on the stage of increasing global competition. Creativity is vital knowledge, crucial skills and attitudes for the future of mechanical engineering education. But what is authentic creativity and how can we teach it to engineering students? The authors survey how creativity and innovation are approached in the classroom and offer mental tools to make creativity a part of every mechanical engineering design. We created a classroom climate where students feel mistakes are acceptable and risk taking is encouraged, when noise, mess and autonomy are accepted. But we feel that for creativity to flourish it needs to be built into the whole college ethos. Hands-On in ‘Mechanical Engineering in Product Design’ program, focuses on practical, experiential, and student-centered learning. It is done by teaching small group of 10 students only, instead of giant lectures of hundreds, and offering innovative tasks that are wired for nowadays problem-solving. Meditation is the main preparatory practice; it purifying hindrances caused by outside distractions, and empowering students’ mind to emotional attention, and to imagination release.

But, we found out that majority of the students still hesitates to dare, struggle with this new concept of learning, and prefer to stay grounded to traditional ‘engineering box’ learning of “lecture-homework-quiz” format of well-defined problems and single correct answer. Therefore, we decided to run an open-end project that will focus on unleashing all brief limitations: from technologies and materials to costing and marketing. This raises many questions and debates for class discussions. A brief with no limitations is a real embarrassing problem of mental fixation. How can you design a product or system with future material and technologies? How can you ignore ergonomics, engineering, analysis, materials strength calculations, and manufacturing issues? Is it possible to plan without analysis of the real user needs, marketplace, and the strategy of costing? Do these students will accept to challenge this free-wild-thinking learning when all their courses still promote learning by heart, analyze and calculate? We actually were also some skeptic about their acceptation of “flying”, “dreaming”, “clouding” and using their own senses, emotions, and mental images when design a product. Students are encouraged, in this imaginative project, to ask about “know-why” as well as “know-how”. These processes may generate original and authentic ideas, a real shift from, what Tom Peter coined in his book Re-Imagine, “what it is?” to “what can be?”.

CREATIVITY IN MECHANICAL ENGINEERING

Our creativity courses are a tight mix of practical and spiritual activities assemble of hands-on “doing” with “clouding” meditations to achieve two crucial teaching goals: Product Quality and Good Design. Creativity is a self-mindset, innate emotional state, and an experience of Aha! Students are invited to let ideas popped out, a self-moment of an idea that appears suddenly without “thinking”, or converting it to words. Opening words in Bohm book On Creativity were “Creativity is, in my view, something that is impossible to define in words” (1998, p. 1). Creativity courses in our department have different structure in content and the
way of learning. Sitting in a circle, as a safe place: no tables, no barriers, students and together in a bonfire tribe. The circle energize just by breathing together. Breathing Meditation is a spirit process of re-centering awareness, stopping multitasking distractions, and engages consciousness to ‘here and now’. In many spiritual traditions the same word is used for both breath and spirit. In Judaism: *Neshama-Neshima*; in Christianity: *Spiritus*; and *Atma* in Hinduism. The breath and the emotions are interconnected, and generate reflections of experiences, mental images, and floating ideas from closed self-drawers, sometimes locked. Students try to integrate flow mind images with two stages of thinking: first, convergent thinking – logical insights in new situation by crunching and reproduction of existing data; second, divergent thinking - production of new ideas by flexibility and originality. The result of this learning process would generate always authenticity and self-expression, or as we coined it in class: “my object may be not so good, but very mine”. We sharply focus on originality instead of Cuckoo’s nest design.

James Adam, mechanical engineering professor emeritus from Stanford, focus on “product quality” he list seven attributes when on top is “Creativity: the ability to have good ideas, and implement them. Second, comfort with many intellectual disciplines: either knowledge of them or ability to interact easily with those who do have this knowledge. Third, cost consciousness: constant awareness of how much the product will cost to create. Fourth, coordination abilities: close interaction with manufacturing, marketing, general management, and other related functions. Fifth, knowledge of the customer: ability and desire to acquire a deep understanding of the customer or end user. Sixth, understanding of overall quality: a highly developed sense of what creates quality, the ability to distinguish high quality from low. The last, “whole brain” thinking: ability to work with inputs based on knowledge, science, and analysis, but also on feeling, Intuition and judgments.” (p.38).

Dieter Rams (b. 1932) German industrial designer coined ten principles to the term "Good Design" (GD): **GD is innovative** - The possibilities for innovation are not, by any means, exhausted. Technological development is always offering new opportunities for innovative design. But innovative design always develops in tandem with innovative technology, and can never be an end in itself. **GD makes a product useful** - A product is bought to be used. It has to satisfy certain criteria, not only functional, but also psychological and aesthetic. GD emphasizes the usefulness of a product whilst disregarding anything that could possibly detract from it. **GD is aesthetic** - The aesthetic quality of a product is integral to its usefulness because products we use every day affect our person and our well-being. But only well-executed objects can be beautiful. **GD is honest** - makes a product understandable - It clarifies the product’s structure. Better still, it can make the product talk. At best, it is self-explanatory. **GD is unobtrusive** - Products fulfilling a purpose are like tools. They are neither decorative objects nor works of art. Their design should therefore be both neutral and restrained, to leave room for the user’s self-expression. **GD is honest** - It does not make a product more innovative, powerful or valuable than it really is. It does not attempt to manipulate the consumer with promises that cannot be kept. **GD is long-lasting**: It avoids being fashionable and therefore never appears antiquated. Unlike fashionable design, it lasts many years – even in today’s throwaway society. **GD is thorough down to the last detail** – Nothing must be arbitrary or left to chance. Care and accuracy in the design process show respect towards the user.**GD is environmentally friendly** – Design makes an important contribution to the preservation of the environment. It conserves resources and minimizes physical and visual pollution throughout the lifecycle of the product. **GD is as little design as possible** - Less, but better –
because it concentrates on the essential aspects, and the products are not burdened with non-essentials. Back to purity, back to simplicity.

As educators we often face the student’s difficulty of mixing “doing” and “clouding”, helping to engage creativity to constructive design practices. The problem is to hit the student’s innate resources, to teach using this self-spring to inventive creativity, to authenticity, by intuition and imagination. As Deepak Chopra state: “When you depend on consciousness, you are creative, deeply in touch with the laws of nature, close to the source, the boundaries around you fade, and your intentions turn into results”. Changing of regular learning patterns leads to greater creativity, to new state of daring to guess, to fall, to feel, to wonder, to associate, to day dream - to jump up through problems and difficulties, like Salmon fish challenge.

CONTRAST AND CONSTRUCTION

Creativity is a mental construction of the Universe structure, leads us to some dreamy doors of floating images, thoughts, memories, reflections, and ideas; lot of ideas. We, human being, were created with flexible mental traits that allow us to create a variety of tangible and intangible outputs through six functions: perceptual, cognitive, behavioral, inter-personal, emotional, and spiritual. Main Creation principle of our world is the Contrast Concept, divided to three main paths. First, Nature presentation such as: dark and light, flowing and solid, dry and humidity, cold and heat. Second, Ethics such as: good and evil, wealth and poverty, joy and sorrow, beauty and ugly, love and hate, hyperbole and understatement, pride and humility, Justice and exploitation, right and wrong. Last, design, in two levels; one, Design Components such as dot, line, shape, scale, direction, color, texture, material, sound, motion. Second, Design Qualities such as depth and flatness, boldness and subtlety, transparency and opacity, activeness and stasis, variation and consistency, randomness and diffusion, distortion and accuracy, complexity and simplicity, asymmetry and symmetry, instability and balance, fragmentation and unity, exaggeration and understatement, intricacy and economy.

Philosophers, psychologists, and artist tried to find out the human choice of creativity in front of Nature, Ethics, and design method. Rabi Moses Maimonides, 1135-1204, the preeminent medieval Spanish, Jewish physician and philosopher, stated his ethical faith, coined it ‘The Middle Way’, for those who track their life routes by making their own faith efforts to pursuit honesty and goodness. Artists and designers researcher such as Kandinsky, Itten, Malevich, Albers, Moholi Nagi, Dali, Magrit - tried to bridge design elements with human senses, emotions, imagination, memories, dreams, and fantasies, through spiritual qualities in form, color, letters and images. Carl Jung developed the Active Imagination for bridging the self-authentic creativity to the magic world of subconscious. Hillman, Moon, McNiff, Moor, Rogers - presented their own thoughts of how to engage creativity to soul by artistic practices.

Our holistic method include also ‘Contrast Indicator’ learning, that presents a duality of two halves that together complete wholeness; creatively set ideate a range of opportunities on every stop of the scale - from A to Z, to endless options. Such as Yin Yang shady side versus sunny side, there are lot of contrasts that stimulate creative generations: Connecting / subtraction, Division / multiplication, Reduce / Enlarge, Contraction / expansion, Motion / position, Overstatement / understatement, Disruption / Repair, Assembly / disassembly, Expanding / contracting, Breath / inhalation, High / Low, Hard / soft, Light / dark, Flexible / rigid, Straight / curved, Smooth / Rough, Dull / clear, Sharp / blunt, Sad / happy, Quiet / Loud, Incoming / outgoing, Opens / Closes, Bending / straightening, Turn on / off, Sitting / standing, Running / going, Raises / lowers, and so on. Using Contrast Indicator (Figure 2) can
circle new perspective of relationship such as A>B, B<A, A=B, A#B on scale from 1 to 5. Students insert their own contrasts as well, trying to get stimulated, and set their own insights. This phase is a kind of self-learning, as Arthur Koestler, (1905-1983), claimed: “Creative activity could be described as a type of learning process where teacher and pupil are located in the same individual”. Contrast adds variety to the total design and creates unity and construction.

![Diagram](image)

**Fig. 2 - Left: SCM Strategy Mix of three open-mind practices. Right: Thinking on contrast generate varied alternatives**

**CREATIVE SALMON:**

**The Courage to Swim Upstream and to leap up waterfalls**

The journey of salmon reflects the path of creating authentically: courage, motivation, skills to overcome obstacles, facing fear, and focuses on target. This is one of the most amazing phenomena in nature. After years in the sea, they can locate the exact stream in which they were born and pursue their upstream return home. The salmon journey from the sea to freshwater is unusual, epic and fraught with danger. It is a fascinating mystery, no one knows how salmon return home. Perhaps they use their sense of smell, or maybe they use the Earth's magnetic fields to navigate. Salmon spend their adult life in the sea. When they are ready to breed, salmon can travel up to 1000 miles to fresh water. The salmon live in the sea until they mature - between 1 and 7 years, depending on the species. When they are ready to breed, they return to where they hatched. In a fresh water stream or pond high in oxygen, the female salmon digs a nest with her tail. She pushes thousands of eggs into the nest for the chosen male to fertilize. Then, most salmon die. There are some dangerous obstacles that often interrupt the salmon’s return home. For example, **Pollution:** Pollution affects water quality, and thus, affects salmon; **Predators:** Salmon face ravenous predators like bald-headed eagles, sea lions, whales, sharks and bears; **Raging Currents:** They swim against raging currents. Often storms can bring too much rain, which leaves the salmon swimming against a ferocious current; **Sedimentation:** Excess amounts of silt and other particles entering the water can smother salmon eggs and trap or block salmon; **Loss of Cover:** Without cover, salmon have no protection or shade relief. If stranded in shallow waters they can be at risk for parasites and infections.

SCM is a learning journey ‘back home’, meeting the creative child they used to be, and returning to students authentic selves. This kind of learning can be scary, disorienting, thinking upstream and full of ‘obstacles’. It requires a leap up of the self-mindset, letting go of habitual thinking, and engage to intuition. Salmon journey is an unique kind of inspiration for creative learning.
CASE STUDY: UPSTREAM IDEATION

The research conducted in four B.Sc. classes, 105 subjects studied creativity along a semester. The task was to invent new mobility product for children, with no limitation: No issues of engineering, raw materials, production technics, marketing, cost. The mission was just to generate futuristic product with any go/no go consideration and brief limitations. In this SCM method students challenge their own creativity killers by four main experiences stages: Meditation: free from overwhelmed facts distractions, staying in a mode of safe and self-place. Doodling: unconscious sketching by left hand like a toddler, to engage the right hemisphere; Ideation: self and in team session. Pop up ideas with no critical response by team members. Visualization: Product sketching, freehand, rendering, and functional details by a ‘Solidwork’.

The results from this research shown that very few students really could letting go their previous technical knowledge, and unleash habitual thinking of “how to solve” to a mode of “AHA” moments. The most significant shift happened to majority when they were encouraged to use other exist or futuristic engineering and science domains knowledge, without having any idea if their product can be really implemented. This study shows that there is a crucial need to teach creativity to foster students’ thinking skills, to let them earn self-confidence to invent authentically, and create new ideas, not others’. Even if the students outputs were not so outstanding, the importance of these three courses, Creativity, Product Sketching, and Hands-On practices, is by generating students enthusiasm, curiosity, and implementation of their own ideas; although their tight exams and homework’s timeline - majority found extra time, out of credit consideration, for this assignment independently. SCM will succeed only if engineering and science courses will adapt some of its principles and values, or the current engineering teaching will shift to advanced methods. The future of Product engineering belongs to innovators and creative engineers ideas, Figure 3; “But how the idea comes is, at least for the time being, a certain mystery” (Gyorgy Kepes, ‘On Design’, 1964).

Fig. 3 - Some examples: upper line, from left: Magnetic Playground; Personal Vehicle; Pissing tool for a sleepy guys. Below, from left: Flying Shooos, Convertible Bag Car, Flying ‘train-copter’ Toy.
RESULTS AND CONCLUSIONS

1. **Authenticity:** The traditional schooling system does not encourage critical thinking and original and independent ideation, but more ‘memorization and testing’ concept. Initially it was not easy for students to create their own ideas. However, when we encouraged them to think and create in an original way, many were happy for this opportunity, and let themselves to engage to their own sources. Few succeed to dig out unusual originality.

2. **Metaphor:** Biomimicry framework the use a metaphor from Nature in class; functions, structures, system, and sustainability made great learning curiosity among students; following the ‘flying machine’ research of Leonardo da Vinci, students tried to study ‘Salmon Run’ phenomena, struggled to ideate by mimicking the ‘upstream swimming’; in the end, they use it as a metaphorical inspiration to their own creativity and motivation.

3. **Method Limitation:** This teaching method may be effective and fruitful, provided other engineering courses will adopt the method’s concept and values of independent and original thinking; other lecturers will need also to change their traditional teaching attitudes. Currently, project-oriented courses offer few credits, when students struggle to find time for sketching, detailing, and modelling - beyond their tight engineering courses.

4. **Ideation Flow:** The students enjoyed weekly meditation session; we witnessed their difficulty to convert this practices values to a practical move. The difficult to maintain inner energy that will favor their creative potential. Five students, each of the four classes, connected to their own springs, and demonstrated an interesting ideation flow. They also performed good concept alternatives, focused on visualizing their own ideas.

REFERENCES