Keywords:
Creative engineer, Mixing courses, Fostering creativity, CTS studio

The future of tech-market belongs to Creative Engineers, a new creative class. Every product is an engineering event, and its sister – design. There is no design with no engineering and otherwise. Every product delivers, beyond quality and functional use, tight psychological interaction with the user mind: the product faith of reliability, perceived quality, friendly use and experience, elegance and trendy look. Media and viral trends create emotional needs, sometimes fake needs for people; persuade or force them to consume the last hot item. Being gadgets fashioned update became a main part of common lifestyle. Nowadays, innovative products play important role in the high speed economics, short-term design and tight time-to-market process. New and renew products help keep the firm competitive in a changing market and maintain growth of the firm. Innovative products can make a crucial difference between falling behind a leading competitor in the marketplace and being the competitor who provides leadership. Indeed, the world now is flat with lot of mega players, which compete all over the globe, with the same products categories. The key aspect of this competition addresses the concern about the number of new products launched each year. Creative engineers will need to
lead the responsibility of creativity, in order to provide the next “money maker” products of the firm. Innovative products development has to start with studying and understanding the dynamics drivers of the consumers/users; identify their needs, wants, preferences in the category, and trend tendency. These consumers/users vote every product for life or death, success or failure. Creativity became the main roll of product design in modern economy. Tom Peters, the business idol of the Nineties, has already declared to the world of management: "Welcome to a world where imagination is the source of the economy."

**Creative Engineer versus Design Engineer**

Circling The Square (CTS), is a strategic method present two options: one, to enrich and broaden the Mechanical Engineering learning, by peripheral creative courses; to fuse Creativity Thinking courses in the Mechanical Engineering education, when balancing it with the major Science, and engineering, and elective courses. It is intended to be a strategic design tool, a format of cluster courses that can be inserted along the eight semesters, in the most needed place and time. Fine tuning needed to get the right result by inserting Creativity Thinking, Innovation-based Design, and Entrepreneurship courses – along the years (black arrows), or split it among the semesters (white arrows). Every arrow strategic decision will result different emphasis on the students. For example, We can start CTS with fresh class, just in the first semester, to let creativity thinking insights help them on the way to graduate; Otherwise, first to start deepening their foundations in the first semester or year, by science courses. There are no any shortcut path, but long faculty brainstorming and discussions, based on academic school needs and goals. In any case, this elastic method will change engineering curriculum, just like spices in cuisine: which and how much.

**Pic 1:** MECHANICAL ENGINEERING PROGRAM

Second, this method present a new domain discipline, Creative Engineering. A discipline that can earn its professional resources from mutual disciplines: Design Engineering and Industrial Design. The role of Design Engineer is to apply the principles of engineering, physics and materials science for analysis, design, manufacturing, and maintenance of machines, tools, and
mechanical systems. On other side, the role of an industrial designer is to integrate engineering aspects of a machine or tool to a marketability artefact form. Creative Engineer will bridge the two sides, because it will mix the essence of them, and give birth to new force in mechanical industries. He will focus on entrepreneurship, ideation, product aesthetics and symbolism sensitivity, cognitive and emotional brand values, and whole user experience- from marketing and psychology aspects. Creative engineers will light the most important factor in economics today- innovation and new concepts of products, in so many different markets, from medicine, agriculture, transportation, and computer, to toys, packaging, and food industries.

PIC 2: CREATIVE ENGINEER BASED ON TWO DOMAINS’ KNOWLEDGE

Their technological knowledge background, from Nano Science to newest smart materials, from advanced and high-end robots to ingenious crafts production - will be trampoline base of creative resources, besides their own resource flavour of personal and cultural background. This will be the rise of new class: Creative Engineers will lead products innovations. Designers, artists, marketers, and advertisers will follow their advanced concepts. These really will increase firm competitive strength, of products and machines designed by completely literate creative engineer in manufacturing and processes qualities.

**Fostering creativity in engineering education**

Fostering creativity in engineering is not one shot of a ready-to-use course, but a holistic assimilation approach, when faculty and students are involved, changing state of mind, about the method of teaching and learning: shifting student skills training from 'Problem Solving' approach to highest creative stage of innovation-based design. The main problem is to find a pedagogical way to detect, smoothly, patterns of opportunities, and rigid thinking. To move students from blocked approach to some emotionally aspects of creative process, such as an attitude of playfulness, looking at the other side, design with intuition packed with flexible imagery. Other obstacle could be the engineering teacher’s feedback to this change. The curricula pedagogical challenge of this phase of fostering creativity in engineering education, is to integrate and interact the so called ‘circle and square’, to a whole innovative approach.
The Training clusters of mechanical engineering students, besides science and engineering courses need to be circled by creative courses, to develop students’ wider skills in synthesis processes during critical and creative thinking. CTS aimed to unleash their potential for innovation and invention, to shift from reproduction to production, to change thinking attitude from “what” to “how”, to generate novel alternative images from their mind, and to make their thoughts visible. This perspective switch can be achieved by fostering sensitivity to beauty, thinking ‘like a child’ approach, and rapid flow of ideas. Creativity courses may focus on practical free-hand sketching, process of conception, ‘Trial and error’ praxis, and aesthetics methods; The most important topics of Innovation-Based Design: Product Design, Design Methods, Design Research, Aesthetics in Design, and UI graphics – should be involved with marketing and retail understanding. Marketing is the key tool in confronting the nowadays challenges; studying its wide perspectives, such as International Marketing, Industrial Marketing, Market Segmentation, Packaging, Branding, and consumer behaviour, and Social Psychology; The last one, Design, relate to the main reason for modern consumers to buy any kind of product.

Creative Engineers supposed to be the best machine leaders of their kind, innovative leaders of commercial and industrial projects. Curricula planner has to use sophisticated strategy for placing the creativity courses in two optional dimensions: one, (pic. 1), fusing Creativity (“C”) along the eight semester timeline; second, (pic. 3), by fusing courses contents. It is a bold change a program, not academic routine only, but also by the syllabus structure. Another challenge: faculty, will or not, accept to be involved in these new mixed courses, to change teaching style from passive to active class.
Learn to Learn: CTS Studio versus Traditional Classroom

Square is not an entity from Nature, but visual appearance of artificial form. Nature circles our existence, everything we can experience by our senses. It is easy for our rounded eyes to perceive wavy lines and concrete forms such as sun, fruitless, tree trunks, hills, worms, human organs, etc. Square and circle versus abstract and concrete. 'Square' is an old cliché, started as a positive meaning for straight norms, fair character, and diligent functioner. The first jazz clubs, in the 1930th, coined 'Squares', people who couldn't stand this Avant guard music, it got a negative meaning: conformist, rigid and not creative. By time, the 'square' becomes a 'box'. The nowadays cliché, ‘thinking out of the box’, is a metaphor derived from known "nine dotes" puzzle, means to think from a new perspective, unconventionally, differently. "Let’s think outside the box!", became common and daily expression, describe an easy way of, “Let’s” creativity mindset. Engineers are always blamed of being ‘squares’. Is it just a cliché?

The circle is a universal symbol for unity and wholeness and the form of meeting in circle is ancient. Seating in a CTS circle is the most democratic way for learning, with no physical barrier, free and loose atmosphere, creates energy to act, demonstrate and to have fun; students are in a mindset of openness to experience, focused and involved during the session. CTS emphasise its relationship to curriculum, to teaching, and to the issues of sequencing, readiness, and transfer. Psychological perspective of CTS describes how teacher transform to guide or mentor, create practical opportunities for the students to construct new knowledge, how it emphasizes the learners’ individual responses to experience, and how students build or “construct” knowledge by engaging actively with their emphasizes. It offers self-awareness of talent and skills appreciation when classroom become a tribal ground circle; a care circle everyone is welcome to expand inner horizons, everyone is equal, no matter ethnic or racial background, who sat around this tribal bonfire.

As a sharing knowledge circle, CTS has been created to promote and experience various types of knowledge and skills by auditory, visual and kinaesthetic practices, in three modes of senses, emotional, and physical experiences. In this kind of active learning studio the students engage material through two pedagogical levels: one, enhancing Critical Thinking by talking, writing, reading, reflecting, or questioning. Second, fostering Creative Thinking by Circle meditating, Sounding, Drumming, doodling, moving, dancing, playing, telling stories, painting, claying, etc. In these activities students can work individually or in groups, and assignments can take as little as two minutes or as long as an entire session. There are many benefits in studio active learning, such as sharing thoughts, memoirs, dreams, and fantasies; nurturing self-creative skills, daring to fly, feeling safe to generate own ideas. Learning by doing improves students' understanding and retention of information and can be very effective in developing higher order cognitive skills. The core goal of this method is to shift from linear and ‘right thinking’ to
authentic and different view of thinking. 1+1 can be 2, but can be also an opened-end answer such as “apple + tomato”, or even a question mark. Innovation and creativity skills need a brave and risky self-exploration, a spontaneous room to respond authentically. Our long academic experience have point out the fact, that lot of design and engineering students do not feel free and safe enough to imagine wildly; losing their self-confidence when it comes to delivering new ideas. Last decade, students are loaded with so many tools, tempted by attractive software’s personal gadgets, net and social-net, and all kind of easy-to-get data. In spite of that - there are low production of ideas and new innovative concepts. We, professionals, always complaint that our client cause lot of obstacles, stress and narrow the horizon flow of our creativity – but we never blame our curricula education that hardly changed for decades.

We learn by doing. Hands-on Experimentation help us to load our empty toolbox, with some know-how in wood, plastic, metal, cardboard, etc. Besides, we just need safe place to explore imagination, to get an opportunity to evolve our curiosity, to free our mental images, to accept our failures, to hug ambiguity. The pedagogical concept of ‘CTS’ method is a self-creative discovery, letting students to explore their skills and faculties by self-introspection, reflecting consciously thoughts and feeling, letting images pop out. Creative discovery is also the embrace of the unknown is the way one’s trust the process (10) of freely exploration, is the way ideas and images emerge through self-introspective session. This kind of ‘voyage of discovery’ (8) involves an immersion in the creative imagination, that allows to find one’s own way to innovate spontaneously without the need to control outcomes, in an irrational self-track. These activities can cause ‘AHA’ experiences, suddenly understating, flowing performance of images and visions and deep insights. Virtual correspondence between imagination and execution causes tacit knowledge of “knowing more that we can say” (13, p.51); plenty fertility of creative sources, based on his Personal and Cultural background, encourages self-confidence of the creator and lead to a personal insight, own voice, and distinctive output. This contextual thinking is also a kind of self and life-long learning that acquire new insights, knowhow, skills, and values about personal and cultural roots; may involve synthesising different type of data, visuals and output.

**Case Study: ‘Pita Bread’ as Creative Exam**

In SCE we run a program, inspired by CTS method, focused on student-centred instruction teaching, hands-on learning, and team work projects. Students experience two kind of structural seating in classrooms; one, Science and engineering courses in traditional class designed in frontal lines of tables; second, CTS studio format: free spaces and class seating in a round circle. First year program in Mechanical Engineering department is focused on foundation studies; than student split into two disciplines: ‘Mechatronics’ and ‘Mechanical Engineering in Product Design’ (MEPD). The teaching style in MEPD involves two instructors in
the same core course, in the same time and class space: Engineer and product designer. The mix of two type instructors and disciplines in the same time was a great challenge; by time, after couple years, it became more synergetic and benefits the students. The concept of the program is ‘project oriented’, tangible prototype of a product, from two levels, engineering and design. Creativity Courses circled Design Engineering core courses, focus on four domains – based on six sub-domains; **Ideation**: Unblocking, Flow, Self-Discovery, Internal Motivation, Invention & Innovation, Methods. **Design Arts**: Product Design, Design for All, Interaction Design, Visual Synthesis, User experience design. **People**: Cognitive Psychology, Engineering psychology, Ergonomics, Socio-Cultural Patterns, Demographics, Ethics. **Marketing**: Needs and Trends, Consumer Behaviour, Marketplace, Pricing Strategy, Creating Competitive Advantage. It seems that integration and Interaction among these sub-domains focused students to an inventive and broad perspective of Human-Centred-Engineering. CTS designed to encourage students to engage and use their own self-imagery and authentic ideation potentials - by autonomic and self-exploration in a class.

CTS structure: creative courses circles (c1, c2, c3, c4) Science and Engineering knowledge in two levels bond: analytical and creative thinking, to set a synergetic process of facing a product innovation or solving a machine problem. This integration of thinking is crucial step to get the ability to synthesis data, alternative, and detailed design. Students are experienced by two kind of structural seating in the classroom; one, traditional class designed in frontal lines of tables; second, CTS studio format: free spaces and students and instructor seating in a circle. This symbolizes physically the need to fuse creative thinking with analytical thinking and otherwise.

PIC 4: CREATIVE ENGINEERING BY CIRCLING THE ‘SQUARE’

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C = CREATIVITY COURSES

C1 = Innovation – Based Design
C2 = Creativity Practices
C3 = Inventive Thinking
C4 = entrepreneurship

ENG>SC + C (1,2,3,4) = Creative Engineering

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PIC 4: CREATIVE ENGINEERING BY CIRCLING THE ‘SQUARE’
Creativity courses bridging 'memorization of formulas' teaching method with ‘Free ‘Style’ of sharing knowledge, values, and mental images. Self-exploration journey deliver artefacts from student’s inner world, to discovery of self-ideation, and innovation. Creative thinking follow a crucial steps of analytical such as reasoning, compare and contrast, judgment, evaluation, and analysis. This mixed thinking process will generate creative mechanism - to think differently, unconventionally, to look farther and to try not thinking of the obvious things, but to try thinking beyond them, from a new perspective. This mechanism can manifest itself suddenly by understanding how to solve a difficult problem, or getting an Aha! Effect - suddenly seeing the problem in a new way, connecting the problem to another relevant idea, releasing past experiences that are blocking the solution, or seeing problem in a larger, coherent context. Unexpected ideation from meditation practices, break among practical activities, creating in a better mood, breaking design process fixedness.

In theory everything is just easy. Actually, engineering students are of different types compared to design students, they are much more practical, grounded, and mathematical oriented. They are already wrong blamed of ‘squaring and non-creative‘. During last years, we found the opposite: majority students are creative, technologically grounded but can fly when they are teased and provoked, when they get free-style teaching, when 1+1 can be everything.

To improve our program and teaching we run a Chindōgu Exam, in two SCE campuses, with 55 undergraduate second and third year students in ME in Product Design department. The theme was “Pita Bread – imagine!” Literally, no explanation was given to students for this task. No brief gravitation was a great obstacle they need to overcome. They never got an answer to their PITA questions, in order to provoke their imagination. “Just imagine” is a weird task, but give students a break of regular project, loaded with data and facts, and tight timetable. Pita is a flatbread slightly leavened wheat bread, flat, either round or oval, and variable in size. It is used in many Mediterranean, Balkan and Middle Eastern cuisines. This is used also as container of street food, in DIY concept, when client can refill all kind of Israeli salad, side to main course such as Falafel, Shawarma, Kebab, or Hummus.

Every student presented three irrational or useless ideas; some wild, some cliché, some with personal meaning. The importance of this exam was to provoke flexible and original thinking, by irrational and absurd problem, as the key to authenticity. Indeed, no outstanding output was delivered by the end; but main artefacts insights unfold the ‘square cliché’ about the creativity potential and capability of engineering students. It seems that open-end task stimulus, with no one right answer, may engage students to their own childish curiosity of playing, making fun, and generating ‘absurd’ ideas. Strengthening student’s imaginative skills, and self-esteem as creative personalities, will post them as creators of inventive products, ready onboard to challenge the market fast changes and high speed of starving needs to new products.
**Originality instead of Cuckoo’s Nest Design**

Creativity, a gift that give meaning to human being life, spiritual muscles that allow him to bear all the effort enable to survive. Monkey swinging between branches; sometimes he leaps within very large, skilfully athletic without hesitation - represents a closed genetic system, which operates according to a fixed repertoire of stimuli and responses. Animals come with a fixed genetic program, of an exclamation point, stability and activity. Human being has a genetically open model, it should be taught the skill, athleticism and decision-making process. Man, however, comes with a weak 'software' loads with potentials, but essentially is a Question Mark - permanent basis ambiguity for stability operations. This explains why in fact human being need so many years of study and initiation to adulthood, compared with many animals to natural conditions dictates rapid functional maturation. However, the long maturity process that caused the person to change so radically in the living conditions for thousands of years, using tools, symbols and contents vary.

It seems that schools of design became in the last decade more “Skin Stylers” of products, less technology and marketing wise. Good product relate to a wide and deep understanding of whole product environment: from smart material to advanced manufacturing, from logistics to packaging, from personal and social needs to visual persuasion. Most important is to find a creative way which compose all these knowledge to an innovative concept. The old method of starting a project from an idea, need to be changed, to use first step from research of newest technology perspective, sophisticated pricing, updates methods of product launching, free niches on the shelves, and social networks markets.

We argue, there is now a crucial need for Creative Engineer that besides his technology understanding, is highly autonomous, individualist, imaginative, intuitive and very high will powered, not conformist, with style and personal taste, dare to behave and think differently, not deterred from conflict, not afraid to experiment, not afraid to walk against the current, ready cope with failure, optimistic and single-minded, brave to be "me", playing with ideas, situations and processes, looking for new ways, surprisingly, set re-issues, continues to innovate, and especially – use his own personal and cultural resources, and allows the child to come inside out. Mechanical engineering education needs to shift to the ‘Conceptual Age’, the nowadays market-driven lead by creative people. Fostering creativity skills and developing creative talents in mechanical engineering education, can face today fast time-to-market challenge.
In Conclusion

In this paper, we provided a new method of creativity education in engineering, as well as introducing a possible way to create a flexible curricula strategy for generating creative products. The global high speed markets, with time-to-market and fast launching of innovative products, create a new need of discipline in Engineering Education, and a new type of engineer. Creative Designer will generate the future products, composed creatively from design and engineering product aspects: Fresh, unusual, trend able, sale appeal; from other side well-crafted, and valuable, and user friendly. Curricula will provide new perspective of courses when creativity is well fused among science and engineering courses. Students should be trained in an creative atmosphere of entrepreneurship, innovation and invention. ‘CTS’ practice is based on two parts of elastic stimulus. One, personal traits like physical, emotional, relationship, memory, dreams, skills, and talents; second, cultural traits such as mother tongue, tradition, Religion, life style, life circle, and family values. This method enriched the class atmosphere, turned it up to a safe place that allow every participant to share his personal life and emotional spectrum with others, team or class. For professionals, this method open up a safe umbrella of contextual micro-themes under their project brief, and allow them to upload their very own self into their creative work. Creativity courses are going to be the linking and key process of Mechanical Engineering in Product Design learning, focusing on four aspects:

1. **Autonomy:** Environmental and emotional factors in Safe place generate good mood for creation. This kind of energy let evolve emotional memories and dreamy images during creative processes. Drive, motivation, and goal-oriented become autonomic to dare, to be brave and courageous, when challenge local or global products trends.

2. **Inspirations:** Mixing themes in creativity is not a mathematical calculation. 1 +1 could be everything in design thinking, 3 or an apple, cloud or a question mark that can inspire ideation and be a door to innovation. Meditate introspection upwards images and emotions to a conscious level that will transform to new ways of creative engineering.

3. **Ideation:** Open-ended problems challenge students, infuse their own imagination, and teases them to fly to place of curiosity. Long-term of tracking facts, procedures, principles, processes, concepts - end with self-guided discovery implementation level of ideas and innovations.

4. **Authenticity:** the use of personal and cultural background, and safe environment, ensures authentic and unique outcome. The self-process of absorbing, doing, interacting and reflecting will track the student to his own authentic path, good or bad – but always original.
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