

Creativity for Engineers

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Abstract

This paper outlines the principles and our experiences of a first creativity course for engineering students. This course has run since 1998 at the Technical University of Denmark. The selected themes, the methods and techniques, the learning process and the achieved experiences are presented. Finally some recommendations and conclusions are outlined.

Keywords: Creativity, Problem solving, Facilitation, Methods.

Introduction

During the last decades, industrialised countries have experienced radical changes in many areas. New information, communication and biological technologies are reshaping the material, human and social basis of Society, giving new opportunities for development. At the same time this development creates new problems: pollution, depletion of resources, deterioration of the material world, deterioration of human beings, etc.

The above-mentioned development means that engineers as problem solvers are facing new demands: creative problem solving in collaboration with a group of stakeholders (actors, participants, clients and users) related to technological based problematic situations or messes. Therefore the need to teach engineering students of any specialisation methods and techniques to support and facilitate creative problem solving processes. These creative approaches will complement the traditional understanding of problem solving as a highly rational and programmed process.

In addition, engineers working creatively and facilitating creative processes experience a constant contact with the pleasure of creation; their work sometimes becomes artistic activities. This will contribute to having a good and enjoyable life. Creative thinking can also become a life style, a personality trait, a way of regarding the World, a way of interacting with others, a way of working in groups, a way of living and growing. Living creatively means developing your talents, tapping your unused potentials and becoming what you are capable of becoming through interaction with other people.

What is creativity?

It is difficult to give a simple and general definition of creativity. We will restrain to study creativity in relation to problem solving tasks. *Creativity is the ability to*

challenge assumptions, break boundaries, recognise patterns, see in new ways, make new connections, take risks, and seize upon chance when dealing with a problem. In other words, what you do is creative if it is new, different and helpful. In addition, it is important to enhance that *the creative process is heuristic* rather than algorithmic. A heuristic is an intuitive guideline or rule-of-thumb that can lead to learning or discovery opposite to an algorithm that is a complete rational and mechanical rule for solving a problem. In few words, creativity is an intuitive process for discovery that sometimes ends in a product, a process, an idea or just a new experience.

All individuals are to some extent creative, but creativity can be enhanced or blocked in many ways. Creativity in each individual has three components: expertise, creative-thinking skills and motivation. Expertise is knowledge in its many forms: technical, procedural and intellectual. Creative-thinking skills determine how flexible and imaginatively people approach problems and tasks. Individuals can learn to be more creative and can learn to use creative tools in problem solving. Motivation is the inner passion and desire to solve the problem at hand will lead to solutions far more creative than external rewards, such as money. The work environment in an organisation can support creativity by providing: Challenge, freedom, resources, work-group features, supervisory encouragement, and organisational settings.

Research work about creativity can be classified in the following five themes:

- *The product:* Focusing on the tangible that is new, useful, original, and surprising, including works of art, scientific discoveries, inventions, consumer goods, solution of problems, adaptations, modifications, etc.
- *The environment:* Focusing on which kind of surroundings encourage or restrict creativity.
- *The personality:* Focusing on the personal abilities that characterise a creative person. Some of them are: sensitivity to problems, capability to redefining problems, fluency of ideas, flexibility, originality, penetration, integration of synthesis and analysis, etc.
- *The process:* Focusing on how creative solutions are produced: In 1926, Wallas suggested for stages in forming a new thought: preparation, incubation, illumination and verification. Later, approaches for problem solving suitable for group-work have been developed under the name of Creative Problem Solving (CPS).
- *Cognition and learning:* Focusing on the recent results related to the structure and function of the human brain. It has been localised that the left hemisphere of the brain is a specialist with logical, abstract, analytical, digital, and rational approaches to problems, while the right hemisphere of the brain is a generalist with intuitive, analogical, synthetical, spatial, an non rational approaches to problems.

What is the course focusing on?

Our objective is to create a space to discuss, reflect and experiment with creativity, creative processes and creative methods of relevance for engineering students of any speciality. We assume that this reflective and experimental approach will indirectly influence on the development of the students own creativity. In this respect, the focus will be centred on the role of the engineer as supporter or facilitator of problem solving groups.

An essential topic is the five steps CPS approach:

1. *Fact finding*: Observe carefully and objectively, like a camera, while collecting information about the problematic situation. Explore and identify the facts of the situation. *Action*: Who? What? Where? When? Why? How (is and is not)?
2. *Problem finding*: Clarify the challenge or problematic situation by considering different ways of regarding and reflect on those possibilities. *Action*: In what ways might we...? How do we...?
3. *Idea finding*: Look for more diverse ideas, alternatives, options, paths, ways, and approaches, use various methods and techniques (divergent thinking). *Action*: Make new relationships, associations, connections, magnify, minify, combine, rearrange, change, reverse, turn upside down, and inside out.
4. *Solution finding*: Examine ideas in new and different ways, from even more viewpoints and criteria; become aware of consequences, implications, and reactions to tentative idea/solution. Select or combine ideas to create a plan of action (convergent thinking). *Action*: Effect on whom? Effect on what? How to improve?
5. *Acceptance finding*: Develop a plan of action, considering all audiences that must accept a plan. Seeks ways of making the idea/solution more workable, acceptable, stronger, more effective, and more beneficial. *Action*: What objections will different groups have with the idea/plan? How might be set this plan into action? Who is going to do that?

Experience has shown that it is recommendable in a CPS process, at each step to start with *divergent thinking* to produce as many ideas or solutions as possible and thereafter to switch to *convergent thinking* to select the few most promising ideas. It is not unusual that in a group some members will very easily diverge, that is build a list of alternatives, while others will converge very fast by trying to select the best solution from the list and the rest will be passive not knowing what is required of them. Hence the need of a facilitator, he or she designs a clear and visible process to align the group. The facilitator will support the process, will elaborate a plan of steps to be followed, will organise a work-shop, and will manage the whole problem solving process to secure that an action plan will be elaborated and implemented. The art of facilitation is an essential topic in our course, the students will work in groups, the group will be facilitated and a student will facilitate the group work using a rotation principle

At each step of the CPS approach some creative technique could be used. For divergent thinking the most popular tool is *brainstorming*, while for convergent thinking *mind mapping* is widely used. There are many other tools and methods as: Picture stimulation, SCAMPER, Force Field Analysis, Lateral thinking, Wishful thinking, Syntetics, SWOT-analysis, Scenarios, Rich pictures, etc. For further presentation of these and many other creative techniques see the following address: www.ozemail.com.au/~caveman/Creative/Techniques/index.htm. During the course the students will learn and practice several of these techniques.

Another theme of interest is that our course is based on what is known as Project-Based Learning, an approach pedagogically founded on constructivist learning in a setting represented by a learning cycle composed of four different ways of learning:

- Concrete experience (direct observation): By focusing in the solution of real-life problems.
- Active experimentation (synthesis, design): By solving problems in a participative way with the users.
- Abstract conceptualisation (modelling and analysis): by designing and facilitating problem solving processes.
- Reflective observation (evaluation, comparison): By evaluating the results of a creative process.

This cycle is repeated in our learning situation. The student are grouped in teams, learn to work together in a project oriented way following the above-mentioned cycle in a non-structured manner.

How does the course run in practice?

The course will usually have from 12 to 20 students. The whole course runs for 14 weeks. We meet one afternoon every week from 1 p.m. to 5 p.m. In the first part of the course (5 weeks), the introduction, the students work in groups of 2 to 3 persons preparing an oral presentation of some relevant topics. These presentations are based on a set of seminal papers and texts dealing with creativity, creative techniques, facilitation, group work, problem solving, etc. In addition, two guest lectures coming from the real world will give talks about the use of creative techniques in practice and innovation in organisations, respectively.

The following 9 weeks the students will work in groups with a practical project selected by them and supported/facilitated by the teacher. Some examples of projects are the following:

- Identification and design of a topic for a Master thesis.
- Application of some creative methods or a combination of them to a real-life problem.
- Solving a problem that has been solved before using a rational approach by a creative approach.
- Combination of rational and creative approaches to a real-life problem.
- Creative design of a home page.
- From an idea to business or how to start your own firm.
- Strategy development in organisations.
- Dealing with complex social problems
- E-facilitation.
- Design of computerised systems.
- Design of a product or a process

The students will search for information, apply the CPS approach, interview relevant stakeholders, discuss in groups, use creative techniques, and they will be supervised to write a paper about their project. The students are encouraged to integrate the activities that belong to different parts of the human brain, logical as well as intuitive, factual as well as imaginative, quantitative as well as qualitative. The course ends with a conference where every group presents the result of their work to the other students.

It is fun to run such a course. The atmosphere is very cosy. Creative persons have a very refined sense of humour. We laugh a lot during this course. The students show a great deal of participation, engagement and enthusiasm, although they have very different backgrounds and specialities. Motivation is the key for success.

It demands courage to run such a course as outlined above, because it is very much conditioned by student's participation and motivation. You cannot force students to be more creative but at least you can make them reflect about the importance of creativity. The rewards for the teacher are many: developing experiences in creative learning, getting in contact with creative students, enjoy the work as a creative supervisor, etc. But it is hard work; you have to be open to new ideas and willing to learn all the time.

Final remarks

Our experiences have shown that it is possible to design a course for engineering students with the purpose to teach creative thinking, creative problem solving and creative methods using a project-based learning process. Within this context learning to learn is a creative problem solving itself. In this way learning gets very close to reality, in the sense that the learning situations are quite similar to one engineers experience in their jobs as consultants, experts, advisors or facilitators.

In this course the teacher will be an adviser, an expert, a supervisor or a facilitator depending on the actual situation. The teacher will also learn during such a course, each person, each group, and each project have their own idiosyncrasies that deserve special care. The teacher has to be a very creative person, he has to have experience in facilitation of groups and he should be willing to experiment and enjoy solving new problems.

You do not achieve radical changes just by one course. This course is part of a set of courses dealing with strategy development, planning, operational research, system sciences, computer sciences, management, etc. Moreover, the students in many other courses in connection with problem solving could use some of the simple techniques and the CPS approach. It does not matter what you learn, it always pays to be creative.

The references below gives further discussion of some of the themes presented in this paper and a rather complete list of relevant papers and books.

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