Education Lab for Creative Engineer

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…it is necessary rigorously to avoid the arrest of spontaneous movements ... Free the child's potential, and you will transform him into the world.

 **Maria Montessori**

... changes in the opportunities for construction could ... lead to deeper changes in the learning ... than changes in knowledge about instruction.

 **Seymour Papert**

读万卷书不如行万里路

dú wàn juǎn shū bùrú xíng wàn lǐ lù

Having read ten thousand books is not as having walked a road of ten thousand miles.

 **Chinese proverb**

*If a bed were to sprout, not a bed would come up, but an oak tree.*

***Aristotle, Physics, II, 1; 193b10***

**Abstract**

Engineering education is about thinking. Therefore, it is about learning. Therefore, it is about teaching. Therefore, it is about school. More specifically, it is about curiousity. Even more specifically, it is about creating. Therefore, it is about learning 21st century creative engineering skills (in the broader sense). If it is about practical engineering education. Therefore, it is about how to create an engineering educational environment that is a playground and a lab for play/learn/imagine/innovate/create. Engineering education should start from birth and never stop. At every age the Engineering Educational Playground is age-adjusted.

Engineering Education is even more about children. They are the alpha of it, as well as its omega. Therefore, it is about how to help them become happier, smarter, more knowledgeable, more talented, more curious and more creative. Therefore, it is about helping them to build their mind to the utmost, helping them to acquire the most tools and knowledge to continuously evolve as moral, happy and creative adults.

To combine all the ambitious aims in one field of research: it is about the creative **joyful** engineer - from how to raise one to how her lab looks like, what are the mental tools and techniques in her mind. We shall call such a mind MACE (Mind of Active Creative Engineer). The environment where MACE is best developed and used cradle to grave will be called the MACE lab.

**Keywords:** Engineering, Engineering Education, Creative Engineering, Lab-based Education

**Introduction**

The authors have worked on this problem for more than a quarter of century (since the first longitudinal experiment of 1994-2004). Since 2008 a MODEL school was established as a MACE lab for children and young adults, B-U-R&D (birth to university graduation in engineering and creating engineering projects).

The MACE paradigm is about two central elements: Organic Knowledge (OK) as the ontology and Organic Dialog (OD) as the epistemology.

This paper is intended for the widest of audiences – from being a textbook used in an academic course to academic educational or engineering researcher, from parent who seeks guidance about rearing his child to engineering R&D CEO, from teacher to head of school, from kindergarten teacher to university lecturer, from head of engineering lab to an engineer.

We ask these questions. What the hack is wrong with our educational system? How come children go into it full of curiosity and creativity and come out not with more but with much less? How come their IQ is not increased but decreased? How come we have such a shortage of engineers? And where are the legendary innovators like Edison? How come after all the technological advancements our children are not happier and certainly not more successful? And our engineers are not more creative or enjoying their work? Why children (and university students) would be glued for hours and days to their computer but get boring after minutes of homework on the same one? Why, given all the huge differences, do practically all students hate school and practically all engineers prefer not to be in the office?

The paper will try to answer these crucial questions by proposing a novel practical as well as theoretical paradigm of MACE. Hereunder are some aspects, principles and ideas of MACE approach and technology. By necessity, they are presented not in an orderly fashion, sometimes overlapping, sometimes leaving gaps, sometimes in too technical a terminology, sometimes in too simplistic popular terms. Sometimes too precise to be understood and sometimes too understandable to be precise. The aim here is just to give the reader an inkling into the paradigm, its look and feel, its preferences and ideas, its tools and technology, its history and context, its future and relevance.

The twenty axioms on which MACE is based:

1. Engineering is not math or logic
2. Engineering has a much wider sense – scientific and technological approach and toolbox of creativity
3. Engineering should be used to raise an engineer and to be an engineer
4. Engineering environment is a special one – the lab
5. Creative Mind needs more than information, skills or knowledge
6. Creative mind needs active (proactive) enthusiastic drive - mobilization
7. Mobilization can and should be encouraged and developed from birth
8. Learning and creating are highly individualized, deep and internalized, involving all mechanisms of the mind and psyche
9. Learning and creating are very similar
10. Learning is constructing
11. Engineering, learning and creating are a continuous Darwinian process of evolution through lab or mental testing of competing prototypes of solution with adding the feedback to knowledgebase
12. The results are improving the process itself as the construction process and the construction results are two sides of the same knowledge
13. Creativity is all about dialectic multidisciplinary checks and balances of seeds of truth of the thesis and antithesis, with a great multitude of different approaches that could and should be used
14. Human level dialog, especially verbal is extremely important
15. Joy and gamification are central
16. MACE is about habit, motivation and knowledge, agency and proactivity so all the mental ABC
17. Educational robotics is any tech-environment that uses much more student inputs and outputs
18. MACE Lab is a special environment using modern technology to teach and engineer
19. Engineering is a toolbox much wider than STEM
20. Engineering intelligence can make a joyful enthusiastic child and a successful happy adult

The ten commandments of MACE:

1. Help the child’s mind to be all he can
2. Make as the goal the active creative mind, not passive knowledge
3. Maximize creative activity through gamified, curiosity based (but not chaotic) lab environment
4. Start from birth and never stop
5. Be pragmatical not dogmatic
6. Never cease experimenting - use intelligent trial-and -error (PIP) to the utmost
7. Encourage freedom, joy, curiosity and experimentation while preventing danger
8. Channel and direct to maximal all-round growth and learning without feeling of imposing
9. Make reading and academic research the best game in town
10. Make active creative engineering integral happy part of the joyful curious child and the happy successful adult