TEACHING AND LEARNING CREATIVITY IN ENGINEERING EDUCATION

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ABSTRACT

The development of engineering education must in the future take into consideration a broadening of the students' awareness of the true Space/Time nature of our world. By accepting and using the world-view that Einstein defined we have been able to achieve an enormous scientific and technological development during the past century. In the field of human resources development, however, we still have only to a small extent utilized this new science and we mostly continue to live and work as if the traditional Space+Time reality is the only one existing. In order to achieve sustainable development and true progress in our projects and find real solutions to our problems, we must increasingly make use of the untapped creative resources, which can be generated from the Space/Time reality.

Accordingly, we present here new tools and procedures for generating creative actions in engineering work as well as a basic Operating System for all human actions. We also make suggestions for how Creativity learning can be introduced in the CDIO syllabus and how it can be taught as a basic common subject in all engineering education and training.

INTRODUCTION

Creativity is considered to be one of the most important qualities of productive people in industry and business. The CDIO initiative has played a vital and outstanding role in promoting and enhancing engineering education in the world and creativity has a central part in all facets of the work in….

Graduating engineers who are able to
conceive-design-implement-operate
complex value-added engineering systems
in a modern team-based environment.

So far, creativity has not been introduced as a distinct subject in the CDIO syllabus and that is mainly due to the fact that the subject, up to now, has had no scientific definition and the result of creativity research has had little scientific relevance. In our research we have found that there are a great number (>50) of different definitions but none are science-based and universal, which is the prerequisite for determining the origin and nature of creativity.

From the science-based definition of creativity that we present, we can now establish a base for a Creativity Science and, in turn, develop tools and procedures for teaching and learning how all of us can be creative and generate creative actions. Creativity can now be introduced as a basic common subject in all education and training.

We propose that Creativity be introduced as a separate subject in the CDIO syllabus and presented as a basic common course for all students. This will have a profound positive effect on their learning and their future engineering profession.

UNDERSTANDING AND DEFINING CREATIVITY [1]

Our True Reality And Our Perceived Reality

Using the properties of the new world-view that Einstein's Theory of Relativity presented, we can now make a distinction between an external Space/Time reality, which is the true description of our reality and the Space+Time reality we can perceive with our five limited senses. In the same way we can describe our two corresponding inner realities as the original and true domain of Being and the one by us designed and developed domain of Knowing, graphically represented in figure 1 below.

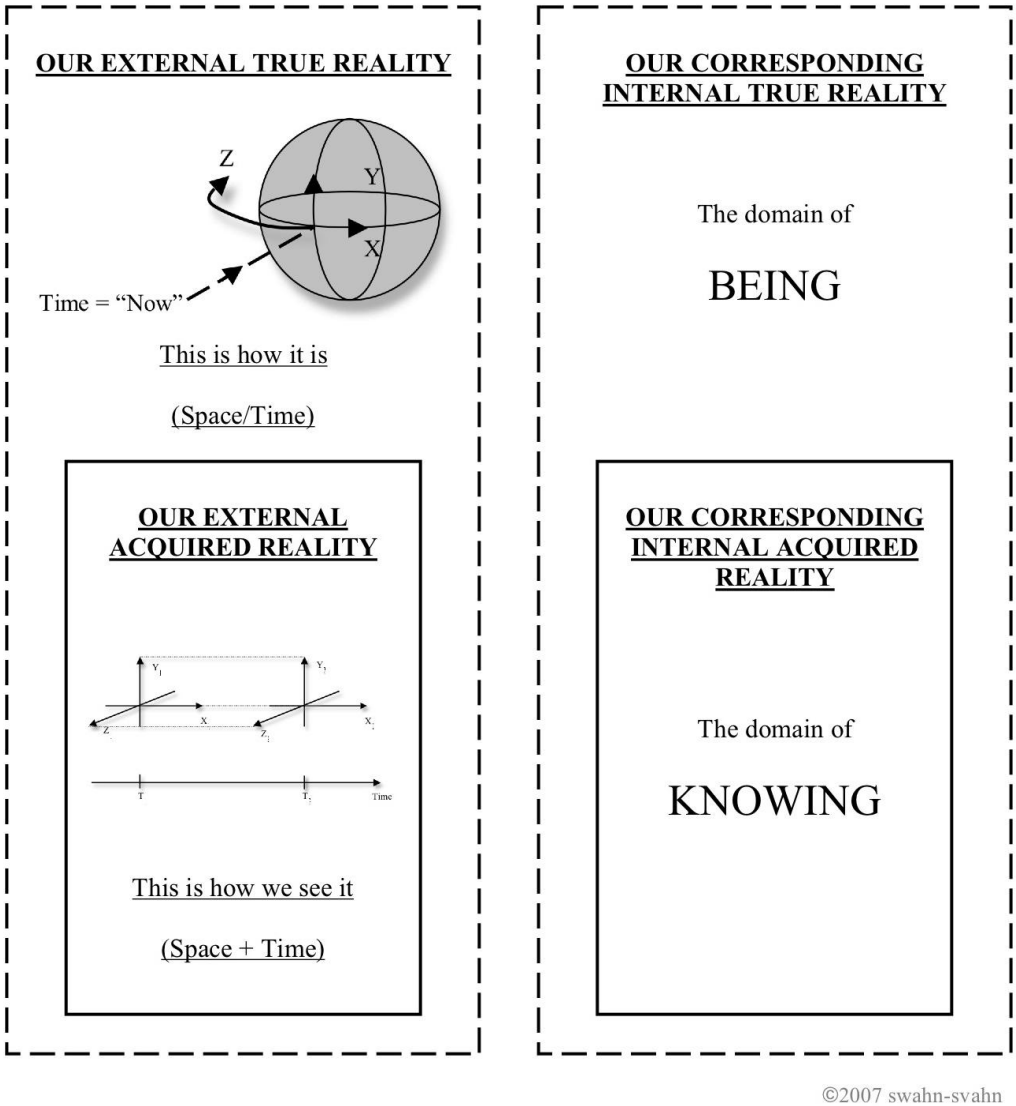

Figure 1: Our corresponding outer and inner realities

Knowing

The domain of Knowing is the part of our inner self that we have designed and constructed with the help of our limited five senses. Here we have stored all that we have learned since

birth; all our knowledge, skills, experiences, beliefs, opinions, thoughts, reasoning and emotions. The properties of its content are expressed in relative values (e.g. from warm to cold, from good to bad, etc., with the full scale in between), and information is processed in an analog way; it can be considered our analog inner domain. In Knowing, all information and all processing are related to the past. From Knowing we generate ”changing actions”, or actions that makes something that already exists into something else, often with bigger, better and /or different content. These types of actions we have defined as ReActions.

The domain of Knowing represents the summary of all we are, our personality or our EGO, and our ReActions are ultimately aimed at protecting and preserving its survival.

Being

An understanding of the content and workings of the domain of Being can only be reached by drawing parallels between our outer true reality, and its corresponding inner reality. In Being, the three space dimensions and the time dimension appear in a unified interdependent system eliminating time as a separate dimension. This means that “time does not exist” or as Einstein expressed it: “The distinction between the past, the present and the future is only an illusion”. This presents a possibility that information from Being can be related to the past, the present or the future.

In Knowing, our five senses are limited to obtaining and processing only a narrow spectrum of information and can therefore provide us with a limited or incomplete picture of our outer reality. In Being our senses can be assumed to be unlimited and they can provide us with a true and full picture of our reality.

The possible content of Being includes three important properties; Intuition, which informs us of our true reality received from the unlimited expansion of our five senses; Integrity, which expresses the absolute value and the truth about our reality; and Intention, which is the intrinsic life force and the driving force in using intuition and integrity to create something new. It is from the domain of Being that we generate creative actions that can bring into our reality something that did not exist before. We call these actions CreActions.

The result of our CreActions is sustainable development, progress and success for enterprises, organizations and societies, and flow, aliveness and well-being for the individual.

Defining Creativity

In reference to our previous reasoning we can now define creativity:

> *Creativity is the ability to bring something into existence that was not there before – from a possibility in the future. It is generated from our inner domain of Being*

Generating Actions

All actions are generated through a Communication for Action.
All our actions are a mixture of the two actions that we have defined - ReActions and CreActions. They are distinctly different because they are generated from different domains, and therefore we must analyze, investigate and deal with them as separate entities and in their most refined and extreme forms.

ReActions

ReActions are generated from a Communication for ReAction. The Source of the communication for ReActions is all that we have accumulated in the domain of Knowing in form of knowledge, skills and experience etc. and is verbally expressed through an order, accompanied by explanations and/or descriptions. A communication for ReAction is a one-way communication that changes something already exists into something else, often with better and/or different content or properties. The most refined ReAction process is automatic and repetitive symbolized by the light grey circle in figure 2 on the next page.

CreActions

CreActions are generated from a Communication for CreAction, which brings into existence something that has never existed before from the domain of Being.

The Communication for CreAction has to;

1. express a definite goal in the future;
2. have absolute, not relative values;
3. be guided by Intuition;
4. express the truth with Integrity and with Intention.

The future-based Communication for CreAction has three components;

Declaration – which defines the goal in exact qualitative and quantitative terms at a precise time in the future: I declare that X is true by Y

Promise – A Promise to reach the declared goal at the precise time, and

Request – A request for support at a precise time to reach the declared goal.

It is in this oral communication, in the speaking of declarations, promises and requests that creative actions are generated. A Communication for CreAction is always a two-way communication between at least two persons as there must always be somebody who is aligned with our declarations, listens to our promises and answers to our requests.
A CreAction is always generated with a committed intention and will never occur automatically, as often ReActions do.

It is important to know that we can always choose to be creative and generate CreActions, and that it is done through a deliberate communication.

The Operating System for all Human Actions

From these assumptions and deliberations we have developed and designed the following model that explains a basic Operating System for all human actions. It shows how communication for actions are transferred from our domains of Knowing and Being into our actual external world in forms of ReActions and CreActions, which we also call Doing, (Figure 2)

The basic Operating System for all human actions

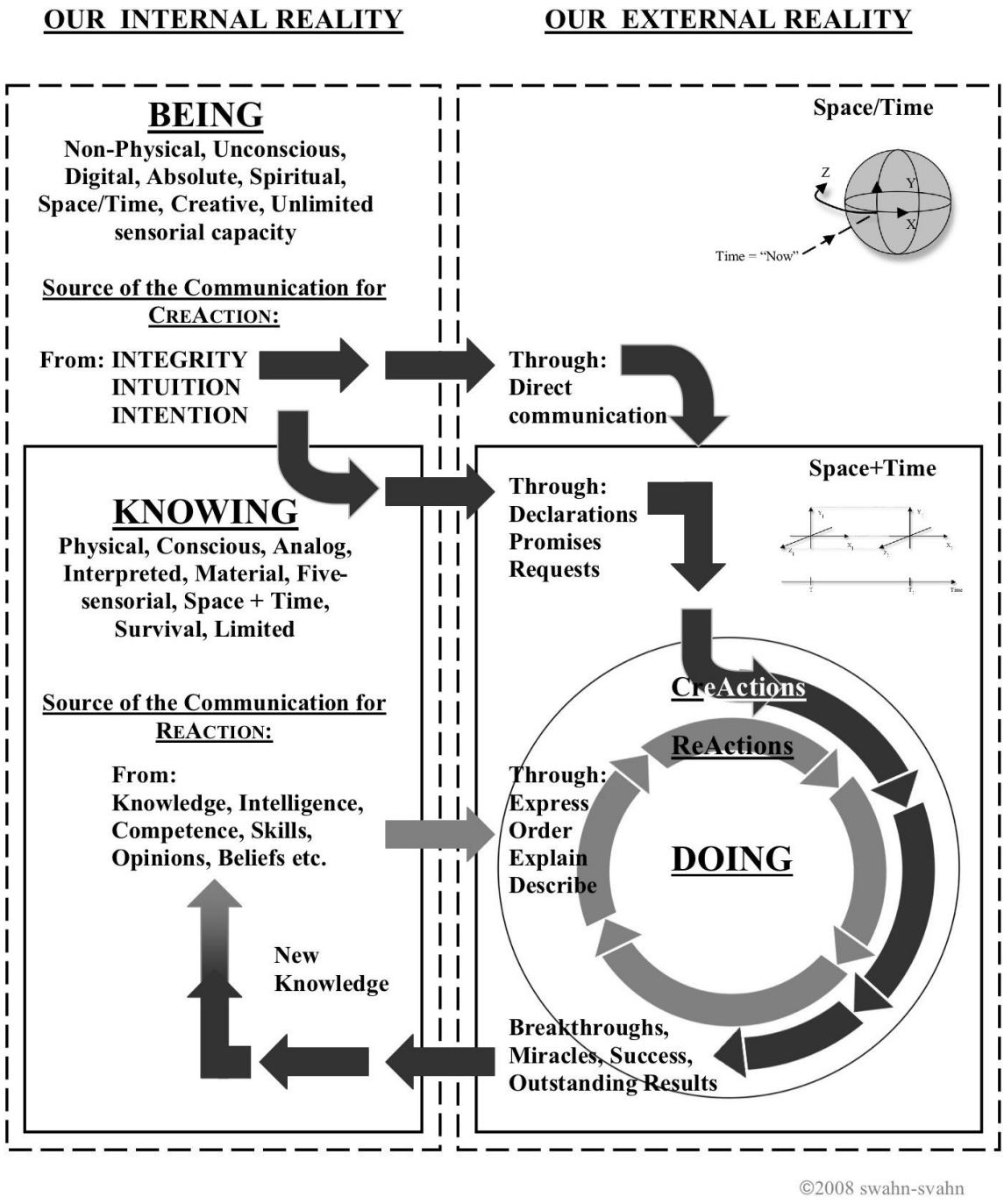

Figure 2: The basic Operating System of all Human Actions

Brief Comments On The Operating System

Two routes from Being to Doing.

CreActions can take two routes from Being (Space/Time) into our perceived reality (Space+Time). The first is direct. Artists and musicians use this route, for instance, when

they create and translate their art from Being directly onto a canvas or through an instrument. They have a special language that they use to communicate directly from Being

The second route is indirect. As we still have not invented a verbal language for a direct communication from Being the communication for CreAction must always be channeled through Knowing. This causes big problems, which we must realize and counteract.

The Importance of a Support Function

When the Communication for CreAction is channeled through Knowing it is strongly influenced by the survival forces inherent there. The Communication for CreAction (formulated through declarations, promises and requests) is such a strong intention to reach new bold ideas and possibilities, that our ego will perceive this as risky, uncertain and insecure. As our ego's primarily function is to secure our survival and to preserve and protect everything we have achieved and obtained so far, it will view our new project as a major threat to it's survival and will try to convince us that it was unwise to get involved, that it isn't going to succeed, that it will become problematic and risky for our career, etc. It will oppose everything that it sees as a threat to our physical, social, or mental survival.

To counteract this we need to establish a support function that assist us in going through with our projects, in keeping our word and in acting within our integrity. (The Communication for CreAction, which is formulated through a Declaration, Promises and Requests, establishes the prerequisites for this support function to work) A good support function is necessary in all creative projects and is essential for them to be successfully completed.

Creativity only shows up in cooperation between people supporting each other.

Cost and Benefits of the Different Actions

In figure 3 on the next page we present a Costs and Benefits analysis of the use of the two types of actions. The Costs and Benefits for using ReActions are shown to the left and for CreActions to the right. In the middle we show the two ultimate and extreme results of using solely one action.

The ultimate and extreme benefit and purpose of ReActions is the preservation, maintenance and "survival" of what already exists, both physically and mentally.

The ultimate benefits of CreActions are Progress, Development and Success for projects and aliveness, "flow" and wellbeing for individuals.

The benefit of utilizing the preserving ReActions is that they bring us security and material advantages at the cost of a decrease in feelings of well-being, aliveness and joy. The cost of CreActions is increased risk, insecurity, lack of material rewards etc. that is a threat to survival, and a loss of material possessions. The cost of CreActions is the same as the benefits of ReActions. With the same reasoning we can conclude that the Cost of Reaction is the same as the benefits of CreAction.

All our actions are a mixture of ReActions and CreActions. We can distinguish between them by analyzing the communications that generated them and the quality of the result they produce.

CreActions are normally a very small part of our actions and almost all our daily actions are ReActions. By increasing the CreActions in relation to the ReAction we can improve our progress and development and increase our aliveness, flow and well-being. This is always a choice that is open to us.

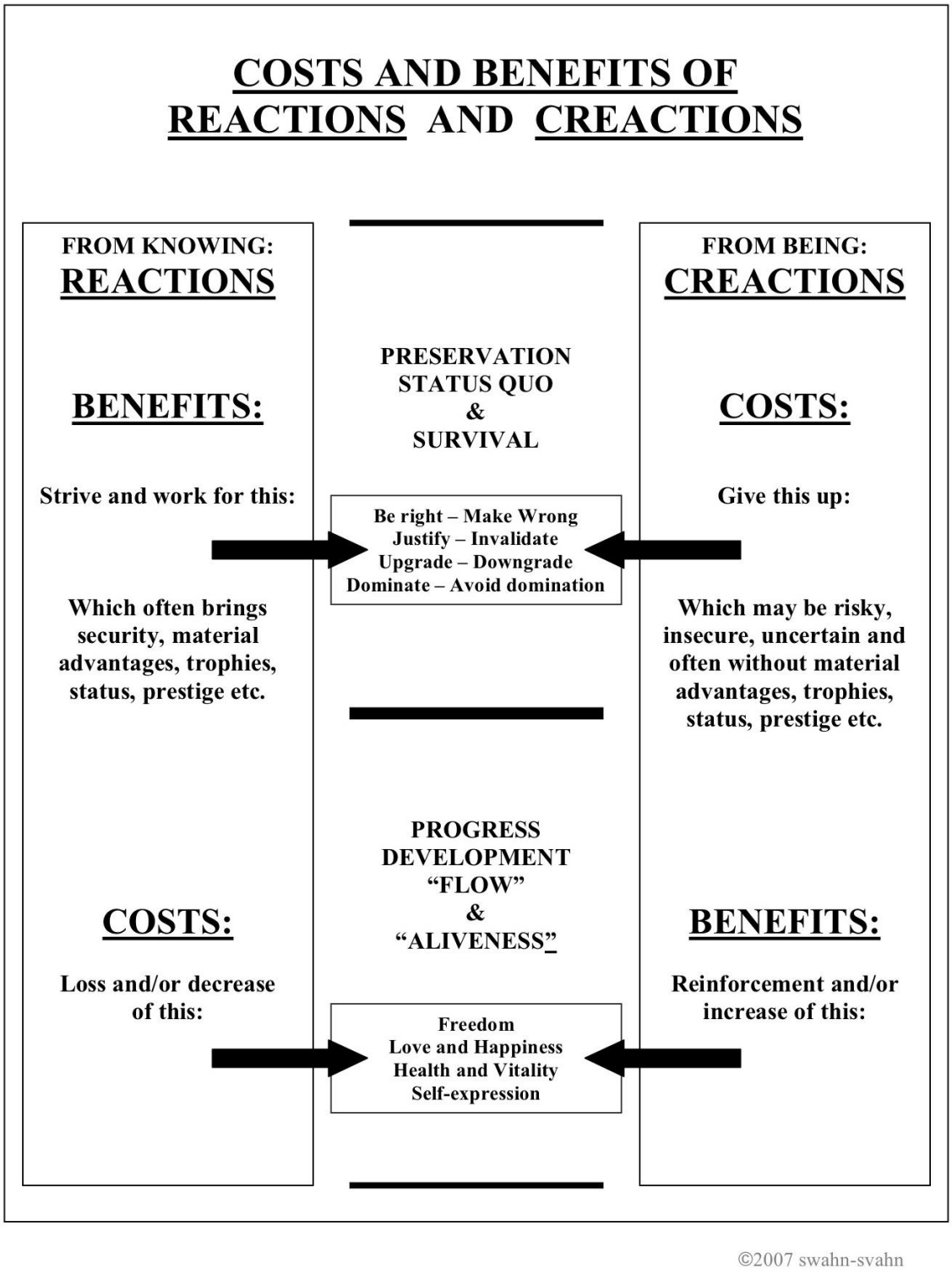

Figure 3: Cost and Benefit Analysis of Action

Why is it then so important to generate CreActions? In addition to the obvious advantages mentioned above, it is of utmost importance to find sustainable solutions to the problems of our time. One prominent statement by Albert Einstein about problem solving is worth remembering.

"The world we have made as a result of the level of thinking we have done thus far, creates problems we cannot solve at the same level at which we created them"

Translated into our vocabulary this can be expressed as follows:

Problems can be solved and situations improved by changing the communication for ReAction that caused them to a communication for CreAction.

When things go wrong and when results are unsatisfactory: *Change the communication for ReAction to a communication for CreAction.*

INTRODUCING CREATIVITY INTO ENGINEERING EDUCATION

General Considerations

Human resources development will in the future to be made up of three fundamental parts:

1. The Pedagogical part: the further development of the domain of Knowing, which consists of adding new, more, better and different knowledge, experience, skills etc.

2. The Psychological part: consists of unlearning and correcting the misinterpretations and/or the misunderstandings of our reality, which our five senses have stored in our domain of Knowing, and which distorts and prevents the learning process.

3. Creative part: explaining how to generate creative actions from the domain of Being. It is from the Creative part that development; progress, success, flow and aliveness will emerge.

Today's engineering education and training concentrates mainly on the pedagogical part with the objective to provide the job market with skilled, knowledgeable and competent engineers.

The psychological part is touched in varying degrees during the education when the students are introduced to training in personal, interpersonal and communication skills and when they are confronted with the complexities of teamwork.

The Creative part will introduce a new possibility of utilizing the great, untapped human ability to create from the domain of Being. The development of this part has just started, but within a few years it will, and must be introduced in all learning institutions from upper secondary school to university level.

The Consequences for the CDIO and Engineering Education

The understanding of the origin and nature of creativity and the application of the basic Operating System for all human actions will affect and augment all the building blocks of the CDIO syllabus. Creativity learning pervades all levels of the second and third building blocks. (as shown in figure 4).[2]

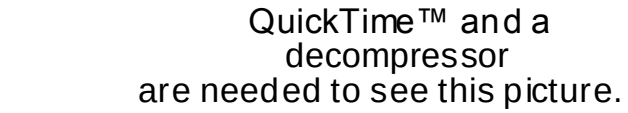

Figure 4: Building blocks of knowledge, skills, and attitudes necessary to Conceive, Design, Implement, and Operate Systems in the Enterprise and Societal Context (CDIO). [2]

Creativity is more then just a characteristic that can be attributed to a person, a team or a process. It is present and apparent throughout all human activities. It will therefore also have a strong positive impact on the Technical Knowledge and Reasoning building block. (Figure 4)

Creativity is accessible to all and can be consciously generated through a special, science-based and future-based communication, which everybody can learn and use. This will give students both an excellent tool and a new outlook on life and work, which will profoundly enhance and strengthen their professional, personal and interpersonal skills. (Figure 5) [2]

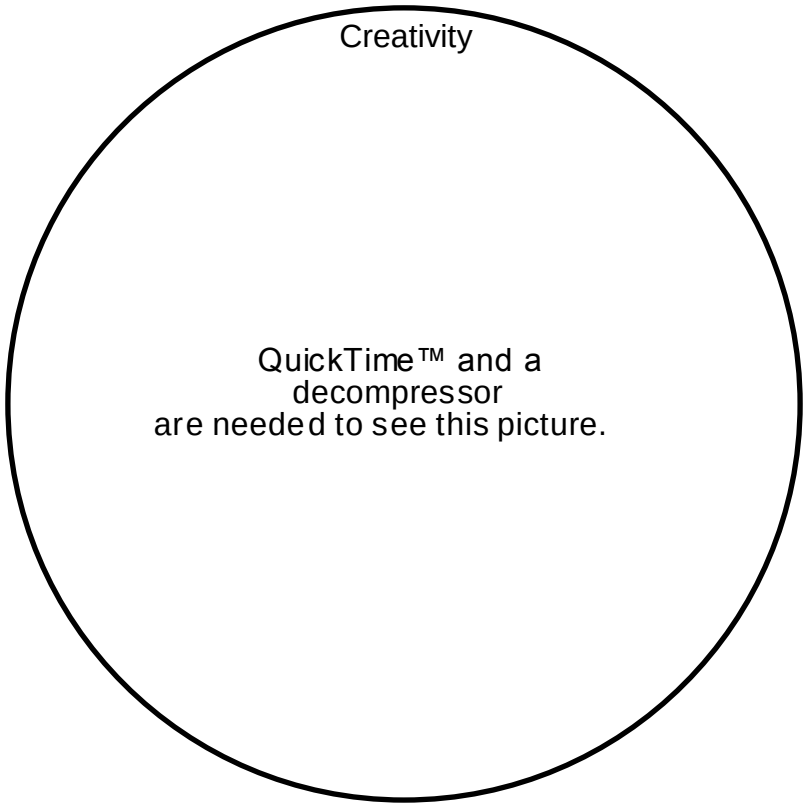

Figure 5: Venn diagram of Personal and Professional and Interpersonal skills. [2] (Modified)

Proposal for a Creativity course program

The introduction of a Creativity learning program in the CDIO syllabus could start immediately with test and pilot projects in one or more of the collaborating learning institutions.

Tentatively we suggest that a basic course in creativity should be offered to all students at the beginning of their first year of study. The first module of such a course would consist of a series of lectures in which the basic concepts are presented and explained leading up to the presentation of Operating System for all human actions. In conjunction with these lectures, lessons, exercises and workshops of both theoretical and practical nature will take place. For the general layout we refer to the textbook CREATIVITY – A Science-based Outlook on Life and Work. [1]

Creativity learning should also be open to students in the second year and above in form of refresher courses as well as lectures in special topics related to the development of a new Creativity Science.

The experiences gained from these pilot projects shall then be presented to all collaborating institutions and a new Creativity section of the CDIO syllabus will accordingly be developed and introduced.

CONCLUSIONS

The CDIO initiative of collaboration between leading engineering learning institutions in the world has provided for and achieved a great breakthrough within technical education.

We are now entering a new phase where Creativity will be offered as a basic subject to all students. This leading-edge initiative will be an even further breakthrough in engineering learning.

We provide here a science-based development program for Creativity learning as a part of presenting a basic Operating System for all human actions. We are confident that this will be the start of a new era, not only in engineering, but also in all human resources development.

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BIOGRAPHICAL INFORMATION

Anders Lennart Swahn (M.Sc. in Civil Engineering, CTH, Göteborg, Sweden, 1958) has a distinguished global career as engineer, technical education expert (UNESCO, ILO, World Bank), industrialist and creativity teacher and researcher.

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