CREATIVE PROBLEM SOLVING:
AN APPLIED UNIVERSITY COURSE

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Abstract

This paper presents the principles of active learning and the contents of a creativity course entitled: Creativity and Problem Solving. The main purpose of this course is to create a space to discuss, reflect and experiment with creativity, creative processes and creative tools of relevance for students of any speciality (60% will end as operational researchers) working with problem solving approaches. This course has run with big success since 1998 at the Technical University of Denmark. It started with very few students, now is a very popular course attracting many students from abroad. The selected themes, the methods and techniques, the structure of this course, the learning processes and the achieved results are presented. The results of student's and teacher's evaluations are also outlined. Finally some reflections, recommendations and conclusions are discussed.

Keywords: creativity; problem solving; learning; creative methods.

1. Introduction

In the last several decades many industrialised countries are shifting from an industrial economy to a knowledge economy, an economy based on the production and distribution of knowledge and information, rather than production and distribution of goods. In these economies, knowledge workers are "symbolic analysts" who manipulates symbols rather than machines, and who create conceptual artefacts rather than physical objects. Then the importance of creativity, innovation, and ingenuity is central to the knowledge economy. If the core of the knowledge society is creativity, then the key task for educators is to prepare learners to be capable of participating creatively in an innovation economy (OECD, 2000). Today's educational centres often fail to meet this need. These centres teach students that knowledge is static and complete; the students then become experts at consuming knowledge rather than to create knowledge.

The above-mentioned development means that professionals 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, it is important to teach students of any specialisation (including Operational Research) methods and techniques to support and facilitate creative and participative problem solving processes. These creative approaches will complement the traditional understanding of problem solving as a highly rational and programmed process.

In addition, problem solvers 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, and 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.

The main purpose of this paper is to present our experiences from teaching a creativity course for problem solvers entitled: Creativity and Problem Solving. This course has been running since 1998. It begun with 8 Danish students and it has evolved to a very popular course. Last semester (Spring 2008), around 60 students applied to follow this course where there was only place for 30 students. It is important to mention that 75% of the students are coming from abroad, usually students that are visiting the Technical University of Denmark for a semester or two. Most of these foreign students are coming from European countries, but we have also had some students from the USA, China, Hong Kong, Singapore and New Zealand. The course has evolved every year, and after five years it has taken its final shape, this is the one presented in this paper.

Our objective with this course is to create a space to discuss, reflect and experiment with creativity, creative processes and creative methods of relevance for students facing problems to be solved in an innovative way. We assume that this reflective, active and experimental approach will indirectly influence the development of students own creativity. In this respect, the focus will be centred on the role of the problem solver as supporter or facilitator of problem solving groups. This paper is founded on two previous papers: Vidal (2006b) where the view of Operational Research as a field based on natural, social and/ or humanistic sciences is grounded and the central role of the operational researcher as a facilitator is enhanced and Vidal (2009) where creative methods suitable for hard, soft and critical Operational Research are presented.

The course has been grounded on learning experiences and praxes from three related areas: Action Learning, Action Research and Experiential Learning.

Action Learning (Revans, 1983) can be defined as a process in which a group of people come together more or less regularly to help each other to learn from their experiences. The participants typically come from different situations, where each of them was involved in different activities and faced individual problems. The current practice more often now is to set up an action learning program within one organisation. It is not unusual for a team to consist of people with a common task or problem. In action learning, each participant draws different learning experiences. Action learning is more often used in organisational settings.

Action Research (Reason & Rowan, 1981) is a process by which change and understanding can be pursued at the one time. It is usually described as cyclic, with action and critical reflection taking place in turn. The reflection is used to review the previous action and plan the next one. It is commonly done by a group of people. In action research a team of people draws collective learning from a collective experience. Action research is more common in community and educational settings.

Experiential Learning (Kolb, 1984) is a process for drawing learning from experience. The experience can be something which is taking place, or more often is set up for the occasion by a trainer or facilitator. Clearly, both action research and action learning are about learning from experience. The experience is usually drawn from some task assumed by a person or a team.

All these learning experiences are cyclic. All involve action and reflection on that action. All have learning as one of their goals. You might say that experiential learning is the basis for the learning component of both action learning and action research. You could also say that both action learning and action research are intended to improve practice. Action research intends to introduce some change; action learning uses some intended change as a vehicle for learning through reflection. In action research, the learners draw their learning from the same change activity. All are stakeholders in this activity.

The experiential learning cycle appears to capture the main features of experiential learning, action research, and action learning. It consists of the following stages:

Action → Review → Planning → Action …

You could say, then, that experiential learning functions by a dual alternation: between action and reflection; between unconscious and conscious principles. By engaging with both of these in a cyclic procedure, we integrate them. There are many methods and techniques that can support the team work at each stage. An essential element in the learning process is the motivation of the students. They should be free to find the problems to be solved and the methods to be used. The teacher will facilitate the students in these problem finding and problem solving processes. Training of students creativity needs training concepts to be developed which tend to incentive responsibility with an emphasis on "freedom" rather than "order". Thus, it needs to deal not only with technical problem-solving, but also with more holistic creative processes, taking into consideration the most complex problems of reality today. These problems to be solved by the students have to adhere to such complex reality.

Summarizing, it can be formulated that our course is based on the belief that learning occurs at the following levels:

- Learning to deal with real-life problems,
- Learning about creative methods,
- Learning to work in groups,
- Learning about oneself,
- Learning to facilitate groups, and
- Learning to learn.

The next section will present shortly our interdisciplinary and holistic conceptualization of creativity and creative processes to be applied in problem solving. This interdisciplinary approach is one of the main principles of the course. Section 3 will present in detail how the course is carried out in practice. The different stages and corresponding learning styles of the course are described. Then, Section 4 will present some evaluations of this teaching experience both from the student's and the teacher's viewpoints. The teacher's reflections about this teaching experience are outlined in Section 5. One central question to be discussed is "Which competences did the students achieve?". Finally, Section 6 presents the final remarks.

2. What is creativity?

Our main point of departure is the work of E. Paul Torrance (Millar, 1997). He was a pioneer in creativity research and education for more than 50 years. Torrance saw creativity as a process and has developed a battery of tests of creative thinking abilities. He believed that all individuals are creative and that creativity can be enhanced or blocked in many ways. He considers creativity *developmentally,* opposite to those who believe that a person's creativity was established at an early age, however his research has shown that creativity does not develop linearly and that it is possible to use activities, teaching methods, motivation and procedures to produce growth, even in ageing. Torrance asserts that creativity is an infinite phenomenon; you can be creative in an endless manner and that a central element in developing a person's creativity is practice.

You find creativity in many apparently different areas: humour (ha-ha), science (aha) and art (ah). Koestler (1976) presents the theory that all creative activities – the conscious and unconscious processes underlying artistic originality, scientific discovery, and comic inspiration have a basic pattern in common, he calls it "*bisociative thinking*" – a concept he coined to distinguish the various routines of associative thinking from the creative jump which connects previously unconnected frames of references and makes us experience reality on several planes at once. Koestler introduced the concept of a "*matrix*" to refer to any skill or ability, to any pattern of activity governed by a set of rules – its "*code*". All ordered behaviour, from embryonic development to verbal thinking is controlled by the rules of the game, which lend it coherence and stability, but leave it sufficient degrees of freedom for flexible "strategies" adapted to environmental conditions. The term code is deliberately ambiguous, and reflects a characteristic property of the nervous system: to control all bodily activities by means of coded signals.

It is difficult to give a simple and general definition of creativity. It is easier if we restrain to study creativity in relation to problem solving tasks. Herrmann (1996) gives a short definition that encapsulates many other definitions presented in the literature: *"What is creativity? Among other things, it is the ability to challenge assumptions, recognize patterns, see in new ways, make connections, take risks, and seize upon chance."*

Let us elaborate a little more on this definition: Challenge assumptions means questioning the basis of the problem formulation with the purpose of problem reformulation; recognise patterns because usually chaos and complexity are caused by simple patterns which, when recognised, lead us to the solution to the problem; see in new ways means looking for patterns from different perspectives: a rational or logical, an organisational or procedural, an interpersonal or emotional, an intuitive or imaginative, and an experimental or holistic; make connections, or bisociate, because many creative ideas are the result of synergy occurring between two thoughts or perceptions of usually very different areas (metaphors); take risks because there always exists the probability that your ideas will lead to failure due to many factors out of your control; and seize upon a chance (serendipity) means to take a calculated risk in order to take advantage of an opening that will allow to move forward toward a creative solution.

The creative person

We can identify at least three types of creative persons. First, the problem solver where the person (subject) is trying to solve a problem (object) in a creative way, this is the case of doctors, managers, scientists, advisers, etc. Secondly, the artistic person (subject) who creates a new piece of art (object) will usually be in close interaction with the object. The "soul of the artist" will be in the object, which can be a product (painting, music, film) or a process (dance, theatre, performance). And thirdly, the persons that adopt creativity as a life-style being creative at work, at home and everywhere, both in an extrovert and introvert way (inventors, artists, mode designers, etc).

Maslow (1987) distinguishes between "special talent creativeness" and "self-actualising creativeness" and he found that creativity is a universal characteristic of self-actualising people. Self-actualisation may be described as the full use and exploitation of talents, capacities, potentialities and the like. Such people seem to be fulfilling themselves and doing the best that they are capable of doing. He identified the following characteristics of self-actualising creativeness:

- Perception or fresh appreciation and wonder of the basic good of life,
- Expression or ability to express ideas and impulses spontaneously and without fear of ridicule from others,
- Childlike or innocence of perception and expressiveness, natural, spontaneous, simple, true, pure and uncritical,
- Affinity for the unknown,
- Resolution of dichotomies or the ability to synthesise, unify, integrate, and
- Peak experiences or fearless, wonderful, ecstatic experiences which change the person and his/her perception of life.

Their codes of ethics tend to be relatively autonomous and individual rather than conventional. They regard upon the world with wide, uncritical, undemanding, innocent eyes, simply noting and observing: what is the case? without either arguing the matter or demanding that it is otherwise. Self-actualising creativeness is "emitted", like radioactivity, and it hits all of life, regardless of the problems.

Individuals exhibit various degrees of creativity throughout their lifetime. Usually, we have settled into a pattern or style of creative thinking. Just as it is valuable to understand your

locks to creativity, it is important to understand your own style of creativity. Each of us has different personalities, although we all have the ability to be creative, personal differences and preferences cause us to approach creative problem solving in different ways. This is very central especially while working in groups, because each person has a contribution to make due to his or her unique profile. Creative groups are very effective if different styles of creativity are combined, to stimulate our thinking in different directions and to cause us to re-think our usual approaches.

Miller (1989) has developed a questionnaire that helps persons to identify their style of creativity. It is founded in three assumptions:

- Each person has the ability to think creatively in different ways, the main issue is: How is he or she creative?

- Each person has equal potential for creativity, but persons have different approaches to making change when they work, and

- There is not a single style, but a combination of styles, yet still each person has a favourite style.

A person's creativity style is founded in how he uses information to stimulate his creativity. Each creativity style prefers a different method for generating and evaluating ideas. Miller's research shows that preferences for style can be classified in four categories:

- *The modifying style* likes to ask: What can we adapt to improve upon what has worked before? These people are more comfortable working with facts and making decisions. They seek solutions using methods that have worked before. They are precise, reliable, efficient and disciplined.

- *The visioning style* likes to ask: What can we realistically image as the ideal solution over the long term? These people trust in their intuition and like to make decisions. They seek solutions that focus on maximising potential. They are persistent, determined, hard working and visionary.

- *The experimenting style* likes to ask: What ideas can we combine and test? These people emphasise fact-finding and information gathering. They seek solutions by applying pre-established processes and experimental trial and error. They are curious, practical, and good team players.

- *The exploring style* likes to ask: What metaphors can we use to challenge our assumptions? These people like using their insights to guide them. They collect lots of information hoping that it will help to approach problems from different angles. They are adventurous, dislike routine, and like to be challenged.

Amabile (1983) has documented that creativity in each individual has three components:

- Expertise,
- Creative-thinking skills, and
- Motivation.

Expertise is in a few words knowledge in its many forms: technical, procedural and intellectual. Knowledge can be acquired both theoretically and practically. Learning to learn is an important tool for becoming an expert in modern Society. Creative-thinking skills determine how flexibly and imaginatively people approach problems and tasks. It demands

courage to be creative because you will be changing the status quo. According to Amabile, individuals can learn to be more creative and can learn to use creative tools in problem solving. Motivation is the last component. An inner passion and desire to solve the problem at hand will lead to solutions far more creative than external rewards, such as money. This component, usually called intrinsic motivation, is the one that can most immediately be influenced by the work environment. Amabile's research has identified six general categories that support creativity: challenge, freedom, resources, work-group features, supervisory encouragement, and organisational support.

Amabile (1998), after many years of research focusing on creativity within organisations has also concluded that individual creativity gets killed much more often that it gets supported. Mostly, it is not because management has a vendetta against creativity, it is undermined unintentionally because of the optimisation of short business imperatives: co-ordination, productivity, efficiency and control. Her research has shown that it is possible to develop organisations where both profit and creativity flourish, but you need a conscious strategy.

Torrance's research has also shown that children's creativity gets killed in the primary schools and it is possible to design schools and education systems where both rational and creative work flourishes. Amabile has drawn attention to the crucial importance of intrinsic motivation in creative endeavour. Business has traditionally rewarded people extrinsically with pay and promotion but creative actions often arise out of a long-standing commitment to and interest in a particular area. She appreciates this is only one part of the equation, and that expertise in the domain concerned, and sufficient mental flexibility to question assumptions and play ideas, are also important. In addition, she points out the critical importance of challenge, for instance, matching people to tasks they are interested in and have expertise in, permitting people freedom as to how they achieve innovation, setting a sufficiently diverse team the task of innovation, along with sufficient resources, encouragement and support.

The systems view of creativity

Creativity is usually seen as a mental process but creativity is also a cultural and social activity. Csikszentmihalyi (2001) asserts that any definition of creativity will have to recognise the fact that the audience and social environment is as important to its constitution as the individual or group who is producing novelty. This environment has two main aspects:

- The *domain*, a cultural or symbolic aspect, and
- The *field*, a social aspect.

For creativity to occur, a set of rules and practices must be transmitted from the domain to the individual. The individual (or a group) must then produce a novelty in the content of the domain. The field for inclusion in the domain then must select the novelty.

Creativity occurs when a person (or a group) makes a change in a domain, a change that will be transmitted through time. But most novel ideas will be forgotten if some group does not accept them entitled to make decisions as to what should or should not be included in the domain. These gatekeepers are the field. The field is the social organisation of the domain, those who decide what belongs to a domain and what does not. Therefore the occurrence of creativity is not just a function of how many gifted individuals there are, but also of how accessible the various symbolic systems are and how responsive the social system is to novel ideas.

Csikszentmihalyi has outlined a systems theory of creativity, relating creative effort by individuals to the state of the domain they are working in and the characteristics of those who assess the worth of the creative endeavour in the field concerned. This offers a penetrating analysis of how creative endeavour emerges within a social field. Drawing on years of research in the field, he hypothesises about the interplay between knowledge about the domain, gatekeepers in the field and creative individuals. In addition, many of the points made by him in relation to other domains apply equally well to creativity and innovation in organisational settings. Csikszentmihalyi has drawn attention to the social context out of which creativity and innovation emerge. For example he has demonstrated the beneficial role of working at a place and time in which other individuals are engaged in related creative activities.

The creative process

Some conceptualisation of creativity are closely related to the process of sensing problems or gaps of information, forming ideas or hypotheses, testing and modifying these assumptions and communicating the results. In this respect creativity is the ability to see a situation in many ways (*divergent thinking*) and continue to question until satisfaction is reached (*convergent thinking*). In creative work, it is a good idea to separate these in processes, first diverging and then converging. The creative process can involve tiny creative leaps or giant breakthroughs. Both require that an individual or a group go beyond where they have gone before, embracing the unknown, the mysterious, the change, and the puzzling without fear.

The creative process may be considered as a new way of seeing, a different point of view, an original idea or a new relationship between ideas. It is the way or manner in which a problem is solved. It is the process of bringing something new into being. It is the process of combining previously unrelated ideas or perceiving a new relationship from previously unrelated ideas. Whether solving problems alone or in a group, you really must have a guided process i.e. a plan or a map of the steps to be followed. This is especially so in a group due to the need to align the capabilities of the members in a positive way. This map is usually called the creative problem solving process and under this denotation there exist a huge number of methods, tools and techniques to support the creative process.

Group creativity has not been researched as much as individual creativity. Leonard & Swap (1999) presents their process for group creativity as five linear steps for discussion, while acknowledging that in practice it would look more like a "plate of spaghetti." The five steps are (1) preparation, (2) innovation opportunity (3) divergence: generating options (4) incubation and (5) convergence: selecting options. This process parallels creative problem solving techniques which involve cycling repeatedly through a process of divergent and convergent thinking.

Focusing first on group composition, the concept of "*creative abrasion*" is important. Creative abrasion is descriptive of the friction that is caused when a heterogeneous group works together to develop creative ideas. It is usually hypothesised that the relationship between creative abrasion and performance has an inverted-U shape. That is to say, at low or high levels of abrasion the group is less creative while at moderate levels of abrasion performance is maximized. Creative abrasion is caused by the diversity of the team members along dimensions such as individual professional expertise, cultural heritage, dominant thinking styles, etc. To have creative abrasion groups must have diversity along those same dimensions.

3. How does the course run in practice?

The course has been designed for a maximum of 30 students. From the beginning, each student will be member of a group that will work as a team during the whole course. Each group will usually be composed of 5 students. The course runs for 13 weeks. We meet one morning every week from 8 a.m. to 12 o'clock. Lectures always start at 9.00 am. Table 1 shows the first description of the course with some factual information and a short outline of the activities to be carried out, while Table 2 presents the schedule of the course where we can see that the course schedule is divided in four parts.

First Part

This part runs for four weeks. It has been designed as a traditional course with seminal lectures and group exercises. The main purpose of the lectures is to give a holistic and multidisciplinary view of the field: Creativity and Problem Solving; focusing on theories, methods and applications. The bases for these lectures are three papers:

- *Creativity and Problem Solving* (Vidal, 2004a): This paper presents some modern and interdisciplinary concepts about creativity and creative processes of special relevance for problem solvers and groups. Central publications in the area of Creativity and Problem Solving are briefly reviewed. Some creative tools (brainstorming, mind map, SWOT-analysis, etc) and the Creative Problem Solving (CPS) approach are also discussed. Finally, some applications of these concepts and tools are outlined. Some central references are presented for further study of themes related to creativity or creative tools.

- *Creativity and Strategy Development* (Sørensen & Vidal, 2006): This paper focus on how creative thinking, processes and methods can support the strategy development and planning process in organisations. First, several fundamental concepts related to both strategy development and planning are stipulated. In addition, the concept of living organisation will be discussed as well as the interaction between strategy and creativity. Then, methodological ideas to support the strategy making process are presented enhancing the use of creative methods and tools. Finally, a case study related to the development of a strategy for organisational development using creativity tools is discussed.

- *The Vision Conference* (Vidal, 2004): This paper presents the principles behind the design and management of the Vision Conference: a one-day workshop in which a large group of participants meet to create ideas, projects and visions for the future activities of a local community or an organisation. A case study from a local community in Denmark is also presented to illustrate the organisation, planning and management of a Vision Conference. The paper focuses on the three central social processes of the conference: group work, problem solving and facilitation. The paper ends with a discussion of creativity and creativity techniques suitable for Vision Conferences.

02733 CREATIVITY AND PROBLEM SOLVING   Spring 2008

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Exam's form: Delivery of folder including:
- Project report
- Notes from exercises
- Transparencies from oral presentations.

Grade: 13-point grade
Course form and delivery
The course is based on a number of lectures, group exercises, oral presentations and more freely chosen mini-project to be made in the last part of the course. The first day you will get a course overview and you will be presented for the overall themes and fundamental ideas of the course. Already the first course day, groups will be established as well as a method that they should be presented orally to the other groups. *To follow this course you have to be a member of a group!*
In the first part of the course introductory lectures will be given and the groups will work with obligatory exercises. Then the groups will present some creative tools and methods. In the last part of the course the groups will work with their mini-project. In this mini-project, all groups work with a problem related to the join theme: *Design of products, systems or organizations using creative methods.*
The delivery folder must include:
- Report of the mini-project (around 20 pages)
- Report from exercises 1, 2, 3 and 4 (around 3 pages per exercise)
- Transparencies from presentation of the group's method
- Transparencies from the presentation of the mini-project.

You must hand over your delivery folder to the lecturer at latest 05.05.06 at 14.00 pm.
Course literature
The lecturer will provide notes, papers and other references. All groups are urged to search for extra references at the Internet and libraries.
Oral presentations and report
The lecturer will give information about the form and content of both the oral presentations and the final report.

Table 1 – Presentation of the course.

The main goal of the group exercises is to form, prepare and develop the group to be able to work as a creative and purposeful team during the rest of the course. These four obligatory exercises are focusing on the following themes:

1. Exercise where the groups are supposed to solve four creative puzzles.

2. Exercise where the groups are supposed to solve a task in a creative way using two creative tools: brainstorming and mind mapping. The task is to design a logo for an international creativity conference.

3. Exercise where the groups work in a divergent manner suggesting proposals for possible mini-projects using brainstorming to diverge. Finally, they will select from 3 to 5 projects for a final selection. These projects are usually related to the design of products, processes or organizations.

4. Exercise where the groups work in a convergent manner to find a final mini-project. Two creative tools will be used for project evaluation: SWOT-matrix and mind mapping.

Each exercise takes around 1 hour. The rest of the time, around 1 hour, the groups work with the creative methods that they have adopted. These methods will be presented in the second part of the course.

First Part: Introduction
1. (03.02) Course overview and plan
At 9.00-12.00: First lecture about the purpose of the course. Groups are formed and methods are allocated.
Exercise 1: Solve 4 puzzles. What is common to all of them?
2. (10.02) Creativity and Problem Solving
At 9.00-12.00: Lecturer: Professor Victor Vidal.
Exercise 2: Design of a logo for a creativity conference. Use brainstorming and mind mapping.
3. (17.02) Strategy and Creativity
At 9.00-12.00: Guest lecturer: Associated Professor Lene Sørensen, CICT, DTU.
Exercise 3: Design of a mini-project (Diverge)
4. (24.02) The Vision Conference
At 9.00-12.00: Lecture: Professor Victor Vidal.
Exercise 4: Design of a mini-project II (Converge). Each group delivers to the lecturer one page with the problem formulation of their mini-project.

Second Part: Presentation of Methods
5. (03.03) Method's presentation of the first three groups.
6. (10.03) Method's presentation of the last three groups

Third Part: Work with the mini-projects
7. (17.03) Group work with mini project
9.00-10.00: Guest lecture
8. (24.03) Group work with mini project.
9. (31.03) Group work with mini project.
9.00-10.00: Guest lecture: Creativity in Practice
10. (07.04) Group work with mini project.
11. (21.04) Group work with mini project.

Fourth Part: Presentations of the mini-projects
12. (28.04) Group presentations I (3 groups)
At 9.00-12.00: Transparencies must be included in the delivery folder.
13. (05.05) Group presentations II (3 groups)
At 9.00-12.00: Transparencies must be included in the delivery folder.
Hand over the deliver folder to the lecturer.

Table 2 – The schedule of the course.

Second Part

This part runs for two weeks. In the first part of the course each group has already adopted a creative method. They have been studying and working with them and in this part each group will give an oral presentation of their method. The methods to be presented are:

- *Future Workshops:* The purpose of this method is to formulate innovative solutions and action proposals based on the participants' own experiences so that they can put these into practice. These proposals will usually be in relation to a local issue or challenge or in connection with the planning of local action concerning a particular development. A Future Workshop works best with 15-25 participants who are selected among those directly affected by the problem and who are in a position to remedy it. The Future Workshop is a local initiative, arranged at local level with local participation. This workshop incorporates a 3-phase work process beginning with a critical analysis of the current situation (the critical analysis phase). This analysis is then used to focus on future visions (the visionary phase) which are subjected to a reality check and then finally transformed into action proposals (the implementation phase). A Future Workshop can last a few hours or take place over several days. The most common model, however, is the 1-day workshop, where the morning is devoted to the critical analysis phase, the first part of the afternoon to the visionary phase and the last part of the afternoon to the implementation phase. Prior to the actual work of the Future Workshop, an oral presentation can be held outlining the workshop's problems for participants. See further Vidal (2005).

- *Synectics:* This is an approach to creative thinking that depends on understanding together that which is apparently different. Its main tool is analogy or metaphor. The approach, which is often used by groups, can help to develop creative responses to problem solving, to retain new information, to assist in generating writing, and to explore different aspects of the problem. It helps users break existing minds sets and internalize abstract concepts. Synectics can be used with all ages and works well with those who withdraw from traditional methods. Facilitators can use Synectics by leading the group to: Describe the Topic, Create Direct Analogies, Describe Personal Analogies, Identify Compressed Conflicts, Create a New Direct Analogy, and Re-examine the Original Topic. See further Gordon (1961).

- *Sociodrama:* Sociodrama is a way of simulating what happens in life in order to: explore social issues; develop greater understanding between groups and individuals; problem-solve and make decisions; experiment and try out new options; rehearse new roles and strategies and predict outcomes. Sociodrama is concerned with social learning in a group. A sociodramatist will base their work around an understanding of the roles people play, the systems within which they work and the social forces which impinge on the situation being examined. By using role reversal, doubling, sculpting and role playing within a number of different scenes, sociodrama is based on many of the principles of adult learning: it draws on people's experiences; is relevant to their concerns; it engages people in the learning process and follows the learning cycle of people being involved in a learning experience, which they have time to reflect and theorise upon afterwards before planning new actions. Sociodramatists are always concerned about the wider social, political and economic influences operating in any particular situation. The real world doesn't always work according to text book formulae. People make decisions from a combination of external and internal factors and sociodrama gives people the opportunity to explore these different facets. In the

context of education, sociodrama can be used in teaching to enable students to explore situations from a variety of viewpoints and gain a better understanding of why decisions were taken and what other options were on offer. See further Sternberg & Garcia (2000).

- *Storytelling*: The purpose of this workshop is to use stories to build common understanding of a problem. When people participate in a common experience, many assume that there is shared meaning about that experience. The participants will be invited to explore a situation from individual points-of-view with the intention of gathering collective information. Through personal stories a group story about a problem will be constructed. Then the collective story can be revealed to identify the underlying strands that define the problem. The session will uncover about the problem: Shared history, Myths that exist, Assumptions held by individuals, Unique points-of-view, Archaeological foundations that are the underpinnings, and Existing/ pre-existing roles. The intended results of the session will be: Mindset focused on hidden problems, Patient listening to others' stories, Deepened learning/thinking, Talking in the "and" mode, Expanded examination of what a problem contains, Option-oriented thinking, Involved parties at one "table", Suspension of judgment, and Creating a container for the problem and problem solvers. The session will create a space to learn, inquire, and reflect to enable the problem definition to emerge from the stories told. The purpose of this workshop is to use stories to build common understanding of a problem. See further Allan *et al.* (2002).

- *TRIZ:* TRIZ is a Russian acronym for "Teoriya Resheniya Izobretatelskikh Zadatch" a Theory of solving inventive problems or Theory of inventive problems solving (TIPS) developed by Genrich Altshuller and his colleagues since 1946. This is a methodology, tool set, knowledge base, and model-based technology for generating innovative ideas and solutions for problem solving. TRIZ provides tools and methods for use in problem formulation, system analysis, failure analysis, and patterns of system evolution (both 'as-is' and 'could be'). TRIZ, in contrast to techniques such as brainstorming (which is based on random idea generation), aims to create an algorithmic approach to the invention of new systems, and the refinement of old systems. See further Clarke (1997).

- *Morphological Analysis*: This is a method for exploring all the possible solutions to a multi-dimensional, non-quantified problem complex. In linguistics it refers to identification of a word stem from a full word form (see morpheme). As a problem-structuring and problem-solving technique, morphological analysis was designed for multi-dimensional, non-quantifiable problems where causal modelling and simulation do not function well or at all. This approach was developed to address seemingly non-reducible complexity. Using the technique of cross consistency assessment (CCA) the system however does allow for reduction, not by reducing the number of variables involved, but by reducing the number of possible solutions through the elimination of the illogical solution combinations in a grid box. A detailed introduction to morphological modelling is given in Ritchey (1998).

These oral presentations should follow the guidelines shown in Table 3. Creative presentations are enhanced. The group presenting a method should plan a discussion of the advantages and disadvantages of a method where all the students should participate. This activity is training in critical thinking.

Each group has approximately 40 minutes for presentation and discussion/questions (a suggestion could be to spend around 25-30 minutes for the actual presentation and leave around 10 minutes for comments and questions). All group members must participate and present parts of the presentation.

Each presentation must include the following aspects:

Historical background
- What is the background for the development of this methodology?
- What types of problems does this methodology address?

The methodology
- What are the purpose and steps within the methodology?
- Special techniques?
- What are the phases and involvement in the methodology?
- Who should participate as part of the methodology?
- What is the role of the facilitator?

An example (or more)
- Show the usage of the methodology in a practical example. Illustrate the different steps, techniques and the process. Discuss which contribution of the method in this specific situation.

Conclusions
- Discuss critically the method. Do you see any limitation in usage? What are the difficulties in using the method?

References
- At least 2 recognized papers or books (published from universities or in journal papers) must be given for covering the understanding of the methodology and the application example.

Table 3 – Presentation of methods.

Third Part

The following 6 weeks the students will work in groups with a practical project selected by them, approved and supported by the professor. Every Friday the professor will discuss with each group the different problems and task, the selection of methods, the design of the most suitable approach, etc. Some examples of projects are the following: Design of a Master Thesis, Application of the creative process to a real-life problem in an innovative way, Solve creatively a problem that has been solved before using a rational method, Combination of rational and creative approaches to a real-life problem, Creative design of a web page, From an idea to business or how to start your own firm, Strategy development in organizations, Dealing with complex social problems, Design of computerised systems, Design of a product or a process, Design of a new board game, Design of a firm that uses depleted tires as main raw material, Design of an organization for foreign students, Design of a new canteen at the University, Design of an action plan for an eventual landing of aliens, To find applications of a new technology: Intelligent glasses, Design the school of tomorrow, etc.

The students will search for information, apply the creative methods and tools, 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 CPS approach (Table 4) (Vidal, 2006a) will be the main guideline for the problem solving process, supplemented by methods and techniques used in a designed approach for the problem in question. 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, originating 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.

Table 5 shows the suggested disposition of the final report to be written as a paper for an international journal.

The five steps of the CPS approach are:

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?

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.

Table 4 – The Creative Problem Solving approach.

Concerning the final report to be delivered by each group.
Size: Around 5 pages/student (max) about your mini-project.

The contents of the report (mini-report)
1. **Introduction**
   - general about the report
   - background for choosing the problem
   - structure of the rest of the report

2. **Problem formulation**
   - general problem
   - sub-problems and their relation to the general problem

3. **Potential/Actual users**
   - Who?   Short about their background

4. **Choose of methods**
   - which methods?
   - why?

5. **The problem solving process**
   - the problem, the boundaries
   - selection of methods and approaches
   - introduction and communication in the group
   - the analysis phase
   - Milestones

6. **Results**
   - Knowledge and experiences
   - Recommendations

7. **Evaluation**
   - work in the group
   - use of methods
   - criticisms

8. **List of references**
   - books
   - articles
   - web pages

Appendices: Exercises 1, 2, 3 and 4; + Transparencies

Table 5 – Disposition of the report.

4. Evaluations

At the very first day the students will be presented with the purpose of the course and the program to be followed. The students might suggest changes and modifications. Then, groups will be formed. Some few students (from 4-6) will drop out of the course already this same day or they will not show up the next week. Usually students will book for more courses that they can cope in a semester and the very first week they make a final decision about which courses they will follow the semester. The main reason for dropping out of this

course is the demand that the students should be members of a group. This demands some social competences and commitment to a group of people that some students find rather difficult to satisfy.

At the Campus net of the University the students can evaluate the course replying to a standard evaluation scheme. Around 65% of the students will reply to this evaluation. Those students no replying are usually foreigners that are only coming for a semester. Summarizing, the students in these replies express:

- A high satisfaction with the course
- A high satisfaction with this learning experience, and
- A high satisfaction with the teacher.

For most students this course is the first time that they will confront with the principles of Active Learning. Most of them have been from 3 to 4 years at the University. The students are overwhelmed about the possibility of take responsibility for their own learning in team work. This course is not a burden, students are happy to participate in all the activities in a cooperative and collaborative way

The students also praise the engagement, wisdom, enthusiasm, and charisma of the teacher. At the beginning of the course the teacher will use a hierarchical teaching style as a traditional teacher. In the second part the groups will takeover the lecturing activities and the teacher will be an adviser to the groups. Finally, at the last part of the course the teacher will function as a facilitator.

Seen from the teacher's chair, the objective of the course has been fully fulfilled. This will be reflected in the marks obtained by the students. These are normally distributed from more than satisfactory to excellent. Main weight will be given to the final report, while variations in the individual marks can occur due to the oral presentations and the personal engagement.

In this course all the students have experienced to:

- Work in groups,
- Have some fun,
- Feel free enough to be creative (learn to fly!),
- Not get too embroiled in technicalities,
- Practise their communication skills,
- Practise some creative methodology,
- Practice some facilitation skills,
- Deal with real-life problems, and
- Learning from other groups.

That is all the students obtain a grounded basis in creative tools and methods that can be used in their future work with other courses, work with their final thesis, and for their future professional life. Some students will be highly motivated to continue working with the teacher towards the design of a project that can be the subject for a Master Thesis. Some of these projects have been: The establishment of a consulting firm selling creativity, Strategy development for a consulting firm, Creativity tools for small firms, and the application of a multi-methodological approach to software design for optimization. All these five students,

after the finishing of their theses, have continue working with creativity either establishing their own firms or getting jobs in consulting firms where it is expected to work with innovative projects.

5. Reflections

Many students find the demands of a creative role based in the principles of action learning, both unfamiliar and uncomfortable. It is, therefore, important that they learn methods that will help them to develop a creative attitude to problem solving work. They need to be able to recognize when a creative approach is required and to be able to engage in a creative mode. In order to do this they need to have an appropriate toolkit which will enable selection of the right tool for the task in hand. The informing part of these needs can be fulfilled through traditional teaching methods, but in order to gain experience it is essential that projects are used. It has long been recognized that projects are the best methods for achieving this and developing recognition of creative ability, which is vital to the overall education of problem solvers.

One essential element in this course is what has been called collaborative learning. This means that students learn best when they are actively involved in the learning process and that they learn best when they work in small groups. They will be motivated for learning when parallel with the subject to be learned, they learn to learn in a study team. Study teams are long term groups existing over the course of a semester with stable membership whose primarily responsibility is to provide members with support, encouragement, and assistance in completing course requirements and assignments when someone has missed a session. Collaborative learning is an effective way to deal with complex problems and at the same time to learn to learn in practice.

Another theme of interest is that our course is based on what is known as Project-Based Learning (Kolb, 1984) 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. They learn via contextualized problem situations. Because of that, and all that goes with that, namely the dynamics of group work and independent investigation, they achieve higher levels of comprehension, develop more learning and knowledge-forming skills and more social skills as well.

My reflections about my teachings are usually supported by the Critical Theory of Habermas (McCarthy, 1979). He is widely considered as the most influential thinker in Germany over

the past years. As a philosopher and sociologist he has mastered and creatively articulated an extraordinary range of specialized literature in the social sciences, social theory and the history of ideas in the provocative critical theory of knowledge and human interests.

Habermas differentiates three primary generic cognitive areas in which human interest generates knowledge. These areas determine categories relevant to what we interpret as knowledge. That is, they are termed *knowledge constitutive* – they determine the mode of discovering knowledge and whether knowledge claims can be warranted. These areas define cognitive interests or learning domains, and are grounded in three different aspects of social existence – work, interaction and power.

Work Knowledge broadly refers to the way one controls and manipulates one's environment. This is commonly known as *instrumental action* – knowledge is based upon empirical investigation and governed by technical rules. The criterion of effective control of reality direct what is or is not appropriate action. The empirical-analytic sciences using hypothetical-deductive theories characterize this domain. Much of what we consider 'scientific' research domains – e.g. Physics, Chemistry and Biology and methods for problem solving are classified by Habermas as belonging to the domain of Work Knowledge.

The Practical domain identifies human social interaction or *communicative action*. Social knowledge is governed by binding consensual norms, which define reciprocal expectations about behaviour between individuals. Social norms can be related to empirical or analytical propositions, but their validity is grounded only in the intersubjectivity of the mutual understanding of intentions. The criterion of clarification of conditions for communication and intersubjectivity (the understanding of meaning rather than causality) is used to determine what appropriate action is. Much of the historical-hermeneutic disciplines – social sciences, history, aesthetics, legal, ethnographic literary and so forth are classified by Habermas as belonging to the domain of the Practical Knowledge.

The Emancipatory domain identifies *self-knowledge* or self-reflection. This involves interest in the way one's history and biography has expressed itself in the way one sees oneself, one's roles and social expectations. Emancipation is from libidinal, institutional or environmental forces which limit our options and rational control over our lives but have been taken for granted as beyond human control. Insights gained through critical self-awareness are emancipatory in the sense that at least one can recognize the correct reasons for his or her problems. Knowledge is gained by self-emancipation through reflection leading to a transformed consciousness or *perspective transformation*. Examples of critical sciences include feminist theory, psychoanalysis and the critique of ideology, according to Habermas.

Now we can ask the following question: What are the competences achieved by the students of this course? The concept of competence consists of three dimensions: The know-what, the know-how and the know-why. It is inspired by Habermas' type of knowledge: instrumental knowledge, practical knowledge and emancipatory knowledge (Cranton, 1996). Know-why when evaluating students has been described as potentially painful for the learner as he/she will have his/her conception of the world disturbed and though it is not the goal, emancipatory learning probably occurs. Learning to learn and creativity as a way to get liberated from routines can have some emancipating aspects. The two first dimensions are of relevance for our purpose. The know-what and the know-how are the most important types of knowledge for the problem solving students. It is necessary really to understand both know-what and know-how to achieved satisfying work in creative problem solving. All students achieve this competence in the course.

6. Final remarks

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 enthusism, although they have very different backgrounds and specialities. Motivation is the key factor for learning.

It demands courage to run such a course as outlined above in a competitive academic environment where students have most often been rewarded for individual effort; collaboration may not come naturally or easily for everyone. The success of this experience is very much conditioned by student's participation and motivation. You cannot force students to be more creative in a collaborative way but at least you can make them reflect about the importance of creativity. It is my experience that student learn best when they are actively involved in the learning processes. 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. The teacher has to be:

- Generous, given knowledge as presents,
- Supportive, seeking that each group seeks for excellence in its work,
- Reflective, about the evolution of each student and the groups,
- Creative, suggesting new ways to solve problems,
- Emphatic, feeling the best way to learn for each student and group, and
- "Radioactive", emitting all the time a good atmosphere for work.

Our experiences have shown that it is possible to design a course for 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 problem solvers 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.

Finally, I refer to my e-book: Creative and Participative Problem Solving – The Art and the Science (Vidal, 2006a), where further discussions about the facilitation of creative problem solving processes can be found.

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