Project Deliverable Report

Deliverable nr D1.1 – State of the Art on Pedagogical Strategies

Work Package	WP1
Task	T1.1
Date of delivery	**Contractual**: 01-10-2008 **Actual**: 28-11-1008
Code name	**Version**: 1.0 Draft ☐ Final X
Type of deliverable	report
Security (distribution level)	PU
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Abstract (for dissemination)	This deliverable focuses on support to enhance creativity via pedagogical strategies. It does so by influencing learning processes involved in the collaborative creation of new products. It presents an overview of the state of art regarding context factors that need to be taken into account when creating affording circumstances for creativity. And it surveys the development over time of perspectives on creativity and collaborative knowledge creation. Finally, it describes a selection of approaches to collaborative learning and working that are particularly relevant for the design of support strategies for *idSpace* and are based on existing pedagogical insight.
Keywords List	creativity, creativity support tools, CPS (creative problem solving), CSCL (computer supported collaborative learning), CSCW (computer supported collaborative work), ideas, innovation, invention, NPD (new product development), collaboration, learning. pedagogical strategy.

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Table of Contents

Summary

The ambition of the European Community to become one of the most prominent players in the world economy calls for excellence in the collaborative creation of new products and in the development of innovative solutions to existing and emergent problems. It is against this background that the *IdSpace* project aims to develop a set of web-based, context sensitive tools and techniques that may enhance a team's creativity in the creative phases of New Product Development (NPD).

Envisaged *idSpace* tools and techniques have to enhance the creativity of (distributed) teams by facilitating relevant learning processes. Learning to use one's own creative potential, learn from each other and use existing insights lay the foundation of a team's creative success. Therefore, this state-of-the-art report zooms in on available knowledge regarding the design of both active support strategies and enabling circumstances for the enhancement of those learning processes that positively influence co-creativity of product designers.

The purpose of this state of the art is to summarize existing insights on contexts of work based creativity, effective learning strategies and supportive tools for *idSpace.* Our attention is primarily focused on learning enhancement in function of inventiveness in new product development. We thereby restrict ourselves to the creative phases of the whole innovation process for NPD.

We explore the concepts of creativity, invention and innovation as important concepts in the context of NPD. Innovation can be defined as the process of putting new ideas into practice; it is about the implementation of new or significantly improved products (goods or services) and processes. Both invention and creativity are part of this innovation process. The concept of 'invention' is used for the act of discovery itself, as subpart of the innovation process. The concept of creativity is used for all activities related to the generation of new ideas. The *IdSpace* project focuses on the support of the latter. It aims to support the creative phases of idea generation, idea selection and construction.

The question then arises what is 'creativity'? This extensively researched concept is demarcated by two attributes: 'novelty' and 'recognition'. The 'novelty' dimension refers to acts of creativity as

creating something that is "new" to the individual person or group. 'Recognition' refers then to that the novelty is recognized by others as new.

For *idSpace's* design of creativity support, the "creative cognition" perspective is interesting. It approaches creativity from a cognitive (educational and psychological) perspective and suggests that creativity is a "learnable" human attribute. All important activities of creative problem solving - such as articulation and communication of ideas, sense making, structuring initial knowledge, divergent and convergent thinking, finding shared understanding between peers on problem and solution and developing new interpretations of knowledge - involve cognitive transformations i.e. learning. This implies that proven methods to enhance these cognitive processes of person and team provide insights transferable to the design of creativity support for *idSpace.*

Inspiration for learning support can also be found in componential models of creativity. These models acknowledge the multi-dimensionality and complexity of the creativity phenomenon. Creative thinking skills in these models are related to 'expertise', domain knowledge, motivation and social context all are crucial components of the act of creativity. Together these components influence new product creation by a team. Based on this perspective we propose that supportive action to enhance creativity has to take into account the characteristics of a specific design situation and should provide integrated support for learning. Integrated support takes all relevant dimensions into account on the one hand by suggesting actions that promote creativity, create affording circumstances, on the other hand remove barriers that inhibit a team's creativity.

Support recommendations have to acknowledge that the *idSpace* setting is one of work-based learning. In such a context a person's learning is embedded in that of the team, where learning aims at achievement of business performance. In the new product invention process, continuous learning is part embedded in daily work practices of professionals with various backgrounds working collaboratively towards a common goal.

For teams to be creative and successful in NPD certain conditions must be met. In this survey we explore how differences in context, expertise level, functional or cultural background, education and personality influence a team's creative output. This then should be translated into affording circumstances for *idSpace.*

It appears for example that in NPD, heterogeneous teams are preferred over homogeneous teams. Teams that set clear and specific goals, and stick to them are more successful than others. Miscommunication, as a result of differences in professional or cultural background, can hinder effective team performance. Successful teams develop open communication patterns, build mutual trust and share knowledge. Social awareness of the results of each others knowledge positively influences the collective result. Finally articulation of tacitly held, personal ideas triggers collaborative interactions with peers in which initial thoughts, sketches or wordings are discussed and enriched into evolving structures, more mature ideas, schemata and, finally, product design specifications.

The ability to support and enhance creativity and collaborative knowledge building in the non-formal learning context of *idSpace* not only requires creation of affording circumstances but also active interventions. These learning interventions are based on theoretical findings, including the assumption that knowledge creation in NPD is in essence a social process. To activate certain learning processes of collaborative creativity *idSpace* can draw from the following models.

(1)The *collaborative knowledge building* model states that ideas are developed via inquiry, questioning, interactive dialogue and systematic investigation. Starting from individual, initial ideas common ground evolves trough collaborative construction into collective problem and solution propositions and product ideas. Support-mechanisms for knowledge building consist of guidance (scaffolding) to optimize the collective inquiry process. Offering structure, giving suggestions to monitor and reflect, pose certain questions to generate new perspective, reflect and feedback are examples of support mechanisms. They are aimed at triggering creativity by achieving deeper understanding, discover yet another perspective and collaborate effectively towards the collective product.

(2) The method of *progressive inquiry* (PI) entails that knowledge needs to be constructed through systematic problem solving via question-driven investigation. This model relates creativity to the scientific problem solving method. Methods merging systematic

problem solving with systematic creativity investigation therefore are often referred to as CPS, creative problem solving.

(3) A third approach points to the *dynamics of the knowledge* that surfaces and the *communication* that is involved in collaborative creativity. Creative product design first requires articulation of tacit personal ideas and negotiation of shared meaning in the team. This process materializes in external artefacts which have to follow (evolve with) the dynamics of the creative collaboration process (as "evolving artefacts") This implies that *idSpace* tooling as described in WP2 has to provide the team with flexible expression modes across all stages of the process. Support consist of pedagogy-inspired recommendations for appropriate application of expression modes and tools.

(4)The fourth model relevant for *idSpace* learning support is ZPD, *zone of proximal development*. It states that there is a distance between the actual capacities of a person or team as determined by actual activity and the potential to reach further (into the next zone, the zone of proximal development) thanks to appropriate guidance, collaboration with capable peers, etc.

In the next chapters we survey existing guidelines proposed by researchers on creativity and collaborative working & learning and looked into concrete examples to support team creativity using a combination of a specific creativity technique and didactical inspired support.

1. Introduction

Recently the Commission declared 2009 the "European Year of Creativity and Innovation"[1]. The title of Prahalad & Krishnan (2008)'s new book "*The age of Innovation, driving Co- created Value through Global Networks*" underlines how the power to innovate becomes the key component of competitive advantage in the global economy. The EU's ambition to become a prominent player in the world economy calls for excellence in innovation. and states that "Europe needs a strategic approach aimed at creating an innovation-friendly environment where knowledge is converted into innovative products and services". This includes initiatives like the Lisbon declaration[2] aimed at stimulation of "co-innovation" between industries and universities. The "Education and Training 2010" and Community Action Programs aimed at competence development in the field of Lifelong Learning. Concurrently the EU works to raise the quality of the European workforce by upgrading the start qualifications of professionals to a level that at least 50% of the workforce is academically qualified.

In everyday practice professionals have to cope with continuous and rapid technological and market changes. Across their career professionals need to apply creativity to totally new problems in different team settings under different circumstances. For "creative productivity", so crucial to today's professional practice, the acquaintanceship with critical thinking from initial education is insufficient to meet the needs of workplace performance.

That the employees' inventive capabilities have become so crucial to a firm's performance, either large or small, is not that strange when we realize that the majority of our products today are structurally renewed after 2-5 years. There is an affluence of publications pointing to the economic importance of innovation. The innovation aspect has become even so prominent that Procter and Gamble[3] titles their Annual 2008 report "Designed to innovate". At the same time Arthur

1 http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/482coined 2009 to the Innovation Year.

Plan: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0159:FIN:EN:PDF
2 http://www.eua.be/fileadmin/user_upload/files/Lisbon_Convention/Lisbon_Declaration.pdf.

3 www.pg.com Procter & Gamble, Designed to innovate Annual Report 2008 http://www.annualreport.pg.com/PG_2008_AnnualReport.pdf

D. Little (2008)[4] emphasizes that the 25% most innovative companies realize 10 times more new products from their innovation budget than the 25% firms with the least innovative culture. At the same time, successful realization of innovation proves to be rather tough. Developing a new idea from concept design to market dissemination is a very intricate, complex process. There is ample evidence of breakdowns: ideas for new products that didn't even materialize or didn't make it to the market launch[5]. Indicating how difficult it is to achieve success. The causes of failure vary. However there are indications that problems often relate to learning breakdowns (Bitter-Rijpkema et al, 2002. Fischer, 2004; Ostwald, 1996).

Organizations are aware that they increasingly rely on the outcomes of creative collaboration of their design teams. To realize their innovation ambition multidisciplinary teams are composed with the sole objective to successfully create new products. In these teams professionals from various backgrounds have to learn from each other's expertise to collaboratively come up with new ideas. To stay co-creative over time and maximize the chance of success NPD professionals have to keep on learning. They have to acquire new competences during task execution and apply available knowledge of peers or external resources. It is this combination of concurrent learning while collaboratively creating new products that has to be supported by the *idSpace* environment.

In a situation of urgently felt needs and problematic practices the *idSpace* project aims to develop a web based collaborative environment to support multidisciplinary teams who work on innovative product design. In the end *idSpace* envisages providing distributed working team members with dedicated learning support for expanded and continued, collective, creative output.

The scope of this study is on *the team's creativity enhancement*. It is essential to notice that learning as part of new product design is part of work. It is embedded in the various work contexts of target user groups of the *idSpace* environment. The context can be one of a small enterprise (SME), a start-up network, a large multinational or yet other industrial alliances, in short, settings in which learning is performance driven.

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[4] Global Innovation Excellence Study 2005 Innovation as strategic lever to drive profitability and growth, Rotterdam April, 2005 www.vno-ncw.nl/web/servlet/nl.gx.vno.client.http.StreamDbContent?code=1244 -

[5] Take for example the Video 2000 product introduction failure http://en.wikipedia.org/wiki/Video_2000

This literature review will present an overview of the state of art as well as of issues under debate regarding knowledge on creativity support, on computer supported collaboration and on learning relevant for the design of *idSpace* support strategies. We will also indicate issues important for the project's type of team learning that have not yet been investigated. The review should in this way provide a solid basis for the design of appropriate pedagogical strategies to enhance co-creativity.

To provide an overview of the pedagogical strategy perspective on *idSpace*, this deliverable is structured as follows:

- This 1st chapter offers an introduction
- The 2nd chapter sketches the *context* characteristics of *idSpace* creativity enhancement via pedagogical support for new product development. It demarcates the focus of *idSpace* as learning support to enhance creativity and collaboration during the ideation phases. The phase of generating and evaluating ideas for new product development.
- The 3rd chapter presents creativity theories that characterize creativity as a unique human attribute and specific learning capability. It zooms in on available knowledge on creativity aspects to be support in new product design.
- The 4th chapter investigates creativity in practice at work. Defining specific requirements for teams of professionals collaborating on creative tasks, learning while performing.
- In the 5th chapter we present possible roads for creativity support in new product development inspired by existing educational theories from collaborative learning and working (CSCL and CSCW) fields. These suggestions are illustrated by concrete practices tested in educational settings.
- In chapter 6 we present examples of good educational practices for a number of creativity techniques.
- The final 7th chapter integrates findings relevance for *idSpace*.

2. Context and scope

New product Development: limitations on creativity

"Europe needs a strategic approach aimed at creating an innovation-friendly environment where knowledge is converted into innovative products and services" The modern economy, with its emphasis on adding value by means of better use of knowledge and rapid innovation, requires a broadening of the creative skills of the whole population.

For many European firms design of innovative products is crucial to the sustainability of their growth. The dynamics of today's global economy with its short cycles and continuous renewal requires timely invention of creative solutions to emergent problems and effective development and implementation of new products. At the same time it is well known that the potential to create inventive designs, effectively develop new products and finally introduce them successfully to the market are two different things. Known failures of successful product innovations illustrate this. The abundance of both innovation management methods and commercial innovation consultancies and tooling are indicators of the divide between innovation ambition and its effectuation. Causes of innovation breakdowns differ. Identified reasons for failure range from problems with generating new ideas, transformation from concept to product and further on technical, managerial and marketing problems. Two issues that cross-cut specific issues are the structural limitation of creative team performance due to (a) ineffective learning in the project team and (b) problems caused by the limitations of existing tools to support the collaborative creative (co-creation) processes.

Learning from each other is necessary to co-construct shared knowledge which is needed to co-construct and integrate new knowledge into a collective design. Apart from available domain expertise and creativity skills the accomplishment of the team's potential is inherently determined by the teams learning capability and its capacity to collaborate effectively across the entire design process. The inability of team members to effectively communicate their ideas and learn from each other during the collaborative invention process confines collective creative performance. Apart from this, a team's creativity is limited when the instrumentation doesn't support flexible articulation of initial ideas and their dynamic transformation to mature product functionalities.

Therefore we need to find methods for *idSpace* to remove factors that inhibit learning during collaboration and surface ideas to enhance learning for creative performance helping product designers.

Enhancement of co-creativity: learning to be creative.

The *idSpace* project aims to support effective and persistent learning between collaborating professionals designed for maximal use of their creative potential in new product design. Therefore the scope of this report is to review what we already know on productive learning and creativity of distributed teams in the context of new product development. Insight in the key factors that influence creative collaboration will help us to design appropriate creativity enhancing recommendations and create affording circumstances to positively stimulate team collaboration and creative productivity in NPD.

In this context our interest for the individual team member's learning is limited to individual learning in function of the collective endeavour. The team is seen as the locus of co-creation of collective learning embedded in a social and organizational context. This implies that creativity enhancement also has to pay attention to the social and organizational context in which that specific product design venture takes place.

To design support strategies for creativity it is necessary to define the playing field of learning that *idSpace* addresses. Creativity, inventiveness and innovation in product development settings are often used interchangeably. At the same time these terms are used in a variety of domains. Today for example innovation includes also development of new services, innovation in aesthetics, in housing, urban development, logistics etc. The *idSpace* project focuses its attention on learning enhancement in function of inventiveness for new product development. We will briefly deal with reviewing the relevance of terms of innovation, creativity and inventive thinking in relation to learning for new product development in *idSpace.*

NPD: Innovation and invention

In May 2008 the Dutch Scientific Council for Government Policy (WRR) presented its report to the government "Innovation Renewed. A Fourfold Opening". *Innovation* here is presented as a "system" of knowledge production, knowledge use, entrepreneurship, commercialization, organization and dissemination of new knowledge and expertise produced by combination of actors (people, organizations and governments) interacting to *create*, *invent*, innovate and diffuse. Again and again terms creativity, inventive thinking and collaborating are used interchangeably as container concepts. To design learning recommendations and instrument support for *idSpace* it is necessary to have some knowledge of the NPD, new product development context and examine the relevance of existing definitions of creativity, inventiveness and innovation in relation to *idSpace* support.

New product development is the broadest "umbrella" term. NPD refers to the complete process of bringing a new product or service into being from idea to market implementation.

Innovation is defined by the OECD as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations."(Olso manual 2005). The word innovation comes from the Latin verb innovare i.e novus = 'new' also referring to 'renew, alter'. Stanoevska-Slabeva & Hoegg (2007) defines innovation as "*the process by which new ideas are put into practice".* Central to innovation is that it involves the generation of novel ideas and the development of these ideas into a workable product, process or service. Notice that in recent times the term innovation broadens again to include more than product innovation alone. It nowadays includes also process, marketing and organizational innovations. For demarcation of the concept authors stress that innovation always is about *implementation of ideas*. *Innovation* might refer to completely new as well as significantly improved products, processes or methods. Note also that definitions of innovation by the Product Development and Management Association (PDMA) are not restricted to the outcome of innovation but include its processes. Innovation is described as an activity "the act of creating a new product or service". These activities include invention plus all work required to bring an idea or concept (for a new idea, method, or device) to its final form. Hence recommendations in i*dSpace* have to support critical learning and interaction processes involved.

Invention most often is used for *the act of discovery* itself, as a subpart of the innovation process.

A shared dimension across the definitions of creativity, invention and innovation is “novelty”. The novelty aspect might vary: a new idea might be based on pre-existing ideas, processes, materials and present an incremental innovation. In other cases a new product presents a major breakthrough, a radical innovation. Yet the impact of an innovation is another issue: breakthrough inventions might have a minor impact while some small novelties might sort large impact.

	1	2	2	4	5	6	7	8	9	10	11
Creativity project phases	Initial scan	Gather data /facts	Define problem	Generate solutions	Evaluate solutions	Plan action	Gain acceptance	Take action & develop	Implement	Disseminate	Evaluate & learn
				INVENTION							
	CREATIVITY										
	INNOVATION										

Figure 1. Innovation, creativity and invention scope within the creativity process.

Many efforts to support the process of successful new product development (NPD) concentrate on development of formalized methods which can be described in handbooks. Mostly they also take care of domain specific aspects. They support “learning” in the sense that they provide training to use specific invention methods, make relevant knowledge resources and procedures accessible and enable knowledge transfer. The various methods are described in handbooks such as for example the PDMA Handbook of New Product Development (Kahn, 2004) and the MOKA, methodology for knowledge based engineering (Stokes, 2001)[6]. The Six Sigma and Design For Six Sigma (DFSS) likewise provide knowledge support by presenting structures, methods and templates to define requirements, measure performance, analyze relationships, verify functionalities, describe design solutions (Pande, et al., 2001).

[6] Developed under the ESPRIT-IV program

It is good to be aware that these bodies of knowledge are available and more importantly might be part of the work repertoire of designers using *idSpace*. However their focus is not primarily on ideation but on product development and implementation (Eder & Hosnedl, 2008).

Creativity and learning in the early phases of new product design are less researched. Concerning the ideation phase the statement of Nootenboom (Nootenboom 28-May 2008) in his presentation speech of the WRR innovation report (WRR report, 2008) that innovation is "fundamentally an uncertain" process that "cannot be designed and programmed in advance" is important. It implies that we need to recognize that *idSpace* learning strategies have to cope with unpredictability. Contrary to existing conventional learning support, *idSpace* creativity support is not a matter of prescribing optimal paths towards a predictable goal, but presenting advice and support for situations without predefined outcomes, characterized by diversity of ideas and opportune learning paths. In the words of Nootenboom there is "room for surprise, idiosyncrasy and instructive failure".

From the perspective of the *idSpace* project we perceive NPD as the overall context in which *idSpace* creativity enhancement takes place. *IdSpace* concentrates on supporting teams to create new products, it supports people engaged in innovation but not the implementation part of the process (Cf. D1. 2). Thus the frameworks for new product development that offer formalized, domain specific templates and methods for product design are not directly relevant to *idSpace.* But awareness of the role they play in the work of *idSpace* users is advisable and refer to these frameworks, where appropriate, is useful.

3. Creativity: a unique quality

Creativity in the *idSpace* context concerns new product development. It starts with the creativity abilities of individuals to proceed via collaborative learning from each other to co-creation of new knowledge. In this process individual learning merges with the learning process of the group, in which individuals communicate their ideas, learn from the ideas of others and co-create new ideas.

The creativity of an individual person and group-creativity emerging from the team's interactions proves to be a very unique human capability. People are capable to produce something partly or wholly new. Connect new properties to existing objects, or see new possibilities not thought of before. Creativity presents itself in so many forms and contexts that it is difficult to capture its essence in one definition. That's why it has generated a plethora of, often very broad and generic, definitions.

Rhodes (1961) counted already more than 50 definitions. Mark Runco (2004) inspired by Rhodes, classified this large number of definitions around four dimensions, the four P's.

- the creative person, the individual involved in the creative act
- the creative product, product resulting from the creative act
- the creative process, the mental processes in creation
- the creative 'press' /environment, the social context of creative acts.

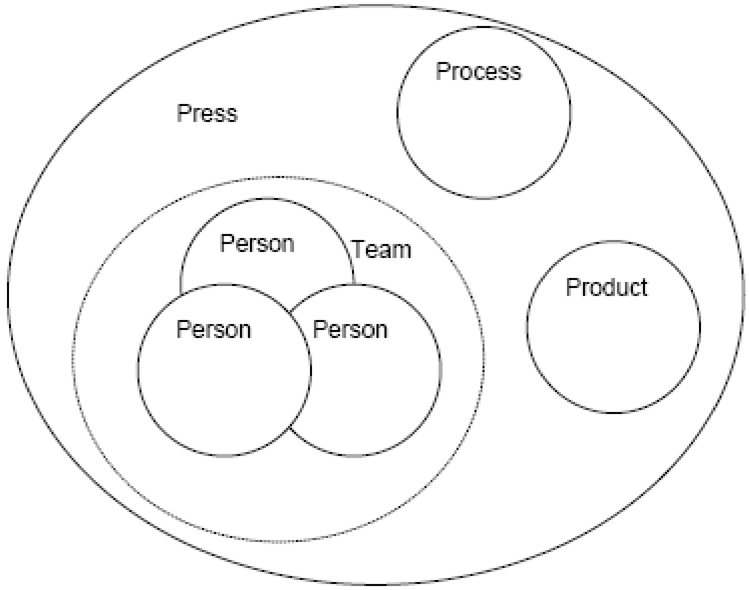


Figure 2. Rhodes four P's interpreted for *idSpace* .

Initially creativity research (mid 20th century) focused on the person. Scientists were primarily interested in a person's creative abilities and especially those of the creative genius, referred to as big C-creativity (versus common everyday small c-creativity) and clinical disorders (Amabile, 1996, Runco, 2006; Nickerson, 1999, Sternberg, 1999). These dimensions are not directly relevant for our project. Also the large amount of research in psychology focussing on the development of creative capabilities i.e. giftedness of children and adolescents in school settings, is not directly relevant to *idSpace*. Recent research (from the 1990's onwards) on cognitive processes behind creativity and social environments conducive to creativity however is highly relevant. Good overviews of these ideas are presented by Mark Runco in "Creativity" (2006) and "Creativity research handbook" (1997) and Robert Sternberg's (1999) "Handbook of Creativity". Their and other's (Amabile, 1998, Boden, 2003, Nickerson, 1999, Simonton, 2000, Ward 2007) most important findings relevant to the design of pedagogical support in *idSpace* will be reviewed in the next section.

"Novelty" linking creativity, inventiveness and innovation

In all definitions of creativity and innovation "*novelty*" something new or different is introduced. The novelty of the idea, concept or product is the discriminating concept. The discussion among scientists is how to define this novelty criterion. The problem is that an idea might be novel to the person (defined as P-creativity, P= personal by Boden, 2003 and Amabile, 1998) but not be recognized as new by the surrounding scientific community or the society in which it emerges (Boden's' so called H-creativity, H= historical, Boden, 2003, Amabile, 1996, 1998) and the other way around. For innovation, i.e. implemented creativity recognition of the newness of the product idea is even narrowed down more to the "usefulness" of the new idea.

Novelty is crucial for creative processes. This requires space for exploration, surprise, idiosyncrasy and "instructive" failure" (Nootenboom in WRR report, 2008). Thus *idSpace's* pedagogical recommendations have to take into account that the creative process and its outcomes are not predictable. Hence instead of procedures leading to a predefined outcome, recommendations to support creativity offer suggestions to use various forms of exploration, cope with risk and failure, take time for new iterations, and create space for surprise.

Support for collaboration and inventive thinking for creativity differ substantially from traditional learner support. Attempts to support inventiveness cannot rely on fixed predefined procedures and cannot target known outcomes. Instead it has to deal with opportunities to improve the intensive interaction of participants and instrument their expression through evolving artefacts during multiple iterations of exploration, discovery and new knowledge construction. The *idSpace environment* requires support along the whole process of effective articulation, exchange of new perspectives of sharing thoughts and decision making. Since the processes contributing to the new solution of a particular problem, are not linear (WRR report, 2008), support is needed for iterative learning loops, in which assumptions are tested and feedback is given; and also support for reflective discussions leading to new iterations and discovery of new insights.

Views on creativity

Runco, (2004) Finke (1992, 1996) Sternberg (1999, 2003) and Ward (2007) and many others have studied creativity from a variety of perspectives. Authors used different starting points and methods. Creativity has the problem of both an affluence of very broad definitions (Runco, 2004), lack of consensus on its foundations, and underlying processes and consequently a variety of research methods. Hence it is not surprising that the state of the art regarding the nature of creativity, on its cognitive processes and requirements for appropriate social and cognitive support across the phases of innovation is still inconclusive. Debates on the nature of creative cognitive processes and stages of the creative process still go on.

For our purpose an important view on creativity is represented by the *"creative cognition"* approach (Finke et al., 1992, Ward & Smith, 1996). Researchers working from this perspective, regard cognitive insight as the basis of creativity. Insight consists of *divergent and convergent thinking.* In *divergent thinking* new interpretations or uses are found for existing patterns or structures. While in convergent thinking a set of data is unified into a "pattern" or "structure". Especially the divergent thinking lies at the basis of creative endeavours to generate new ideas. Research based on the "creative cognition" model uses findings on cognition sciences, psychology, and pedagogy as well as brain research to discover mechanisms of creative discovery. According to them support for creativity will be successful if it addresses appropriately relevant mental structures, facilitates external representation and connection of new insight to existing structures.

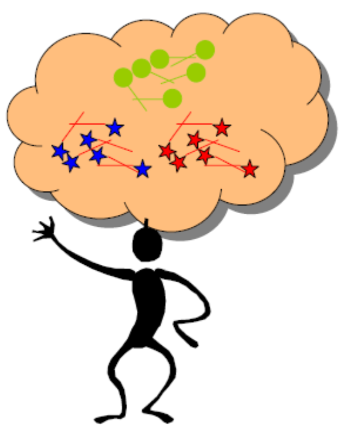


Figure 3. Connecting support to cognitive structures?

Based on this research, we will investigate how to design supportive recommendations that successfully connect to cognitive schemata and stimulate the team members' capability to generate new perspectives whilst applying divergent and convergent thinking.

One of the creativity researchers Finke states that stimulation of creative thinking is effective if it recognizes a person's associative structures. According to Finke's "*least effort theory*" persons will thereby first use familiar associations, before looking for further options, since familiar associations demand the least cognitive effort. Less common associations take more effort and therefore will be explored afterwards. By consequence recommendations in *idSpace* might explore triggers to move beyond the boundary of these first easy associations and explicitly suggest further (boundary crossing) inquiry to find these less common associations.

As already mentioned, the renowned creativity scientist Margaret Boden (2003) distinguishes between ideas that are novel to the individual (P-creativity) and ideas that are historically creative, novel to human history, to the community at large (H-creativity). The *idSpace* project aims to support a specific, restricted kind of H-creativity, namely ideas new to the "new product designers community" and *idSpace* 's user audience.

Notice that the definition of Boden (2003) goes beyond a pure cognitive scope. Boden defines psychologically creative ideas as those ideas that cannot be produced by the same set of generative rules as other, familiar ideas. Both Finke and Boden include psychological factors from the social context as critical to the creative process. Intrinsic motivation is emphasized as crucial to all creative activity. According to Boden, creativity in action consists in essence of three types of learning i.e. knowledge processing activities namely (1) exploration, (2) combination and (3) transformation. Together they lead to cognitive leaps and new creations or insights (see also D1.2).

The learning activities involved in creative productivity thus are:

- *Exploration:* inquiry learning leading to discovery of new relevant information or ideas about the problem and possible solutions. Openness to new perspectives is crucial for exploration.

- *Combination:* creativity requires constructive learning. The use of new possibilities or views on existing knowledge as basis for the construction of new combinations
- *Transformation:* creating new constructs re-constructs, creates and recreates new concepts. New ideas are generated by modifying existing ideas.

Learning activities to be discerned in relation Boden's ideas and findings from Schmid as articulated in D1.2 of the *idSpace*-project could then be:[7]

Table 1. Mapping Categories (Boden), Operators (IPC-Model) and learning categories (WP1)

Creativity Category (Boden)	Operators (IPC-Model) (Schmid)	Co- creativity learning activities in new product design (learning theories)
Exploration	Questions, Experiments, Association, Mental Simulation, inference / reformulation	Inquiry discovery learning Reflection in action, Open questions, New associations, new representations, Reformulation, Multiple structurations Surfacing fluently and flexibly new perspectives from different angles, articulation of new views.[8]
Combination	Association, Transfer/Induction, Concept Formation, Inference/reformulation	Co-constructions, reflection- in-action, combinatory clustering, re-structuration, associations, inferences, systematic questioning
Transformation	Concept Formation, Adaptation, Transfer/Induction, Inference/Reformulation, Reindexing	Reflection, problem solving, double-loop reflection, active knowledge construction.
	Evaluation, Mental Simulation, Experiments, Questions, Inference	Inquiry, questioning, evaluative inferencing. Drawing lessons learned from prior explorations

[7] Notice that the IPC model of Schmid add a fourth evaluation phase to the model.

[8] Boland & Tenkasi, 1995, Fischer, 2004

In recent years the creative nature of an act or product has been defined in relation to the social context. Studies investigate the role of the social environment on creativity. New componential models of creativity, as those by Sternberg (1999, 2002) and Amabile (1996) build on this and have enriched earlier cognitive models by including multiple dimensions that contribute to creativity: personal, process-related factors plus social and context variables. Support has to promote not only use of appropriate techniques, but also commitment and motivation. Findings from this stream of research accordingly point to the fact that pedagogical support has to focus on more than the cognitive dimension alone. Success according to Amabile, Boden and Sterberg requires foremost stimulation of motivation and commitment in combination with social context dimensions.

Yet other researchers such as Weisberg (1986) view creativity as cognitively speaking "nothing" special. Weisberg for example sees creativity as primarily dependent upon personal expertise (knowledge) and commitment. In his view creativity consists of ordinary cognitive processes that yield novel results. Enhancement of creativity thus becomes foremost a matter of creating affording circumstances for novel results.

In the meantime a certain consensus has been reached on the demarcation of creativity. This is relevant to *idSpace* for finding the right focus of creativity enhancement. According to most authors two properties (Ward, 2007; Amabile, 1996,et al., 1997; Sternberg, 1999) are crucial: "novelty" and "recognition". "Recognition" in a product development setting is defined as new (Nickerson, 1999) and useful (Tidd, Bessant & Pavitt, 2005, Shavinina, 2003) as judged by the relevant audience or community. For new product design in the *idSpace* project the distinctions of "novelty" to the community concerned and recognition of its value in terms of "usefulness" are necessary to demarcate creativity.

For the design of creativity support further specification is desirable. For this purpose we turn to Johnson-Laird (Haught & Johnson-Laird, 2003). He investigated creativity in music, researching creativity in verbal and musical expressions (Finke, Ward & Smith, 1992). Johnson-Laird postulates that the outcome of a creative process is NONCE, *Novel* for the person producing the result, *Optionally novel* for surrounding culture[9], the result of a *Nondeterministic process* guided by *Constraints* and based on existing *Elements.* Johnson-Laird thus presents creativity not as a process of complete freedom delivering radically new ideas, but on the contrary as a process in which constraints are at the core of the creative process. Constrained innovation and the role of existing elements are typical for new product design and thus add up to less specific definitions. Johnson-Laird's novelty dimensions are less easy to translate. Personal novel can be stretched to novel for the collective entity the team. The optional novelty gives broader boundaries for the degree of novelty perceived by the target community.

Expecially relevant to this definition is that certain constraints govern idea generation, providing verification and evaluation criteria to assess its value (Haught & Johnson-Laird, 2003). With the importance of constraints in design of new products and the need to verify and evaluate Johnson-Laird's definition of creativity criteria, while coming from a different domain, is very interesting and could be adopted for *idSpace* since it specifies the creativity integrating constraints as key element in the process of creative thinking.

The foundation provided by Margaret Boden's model of creativity has been elaborated by Amabile and Sternberg. Their views on the relation of creativity to creative thinking skills and domain knowledge are relevant for *idSpace.* According to Amabile (1996) creativity is indeed as Boden suggest driven by intrinsic motivation. It is also conditioned by domain specific competences and knowledge and techniques for task performance. In her c*omponential model* of creativity Amabile (2003) provides a rich view on the creativity process defining the following four components as crucial:

(1) d*omain knowledge*
(2) c*reative thinking skills* the flexibility and imagination with which people approach a problem and
(3) *motivation* especially intrinsic task motivation and
(4) the *situation*, the *social context* influences from the organizational environment in which the creative project takes place.

[9] In Johnson -Laird definition the surrounding culture is the society at large. For *idSpace* this could be the design or user community involved.

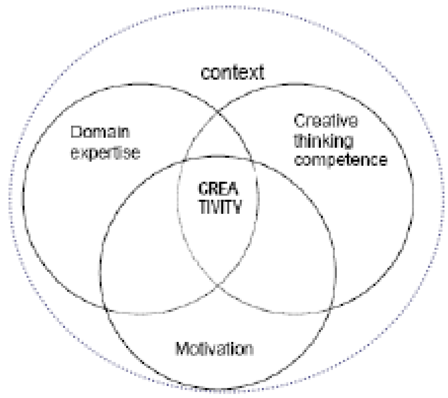


Figure 4. View on individual creativity functions according to Amibile (1998)

The componential models of Sternberg and Amabile offer a valuable elaboration of Boden's view on creativity in product development practices. Sternberg and Amabile's investigation points out that support has to offer more than a mere recommendation of which creativity technique is useful. Creative action acts upon knowledge. Knowledge (as stated by Schmid et al, WP2) of the domain, the problem and the solution, and also knowledge of effective inquiry i.e. learning strategies. (Hakairainnen, et al, 2002; Sarmiento & Stahl 2007) These authors articulate how creativity manifests itself. By its fluency to articulate ideas, flexibility to use different problem strategies, transformative capacity to reorganize facts, concepts and associations and by its elaborative abilities, to further develop ideas from their original source. The componential models of Amabile and Sternberg force us also to take into account the knowledge foundation of co-creativity as well as the influences of the surrounding environment. Taking this view as our starting point, we will elaborate context issues of work-based learning and team dynamics.

Stages of the creativity process

For the whole process of new product design, from idea to implementations, as well as for each of the sub processes, ranging from ideation via creative problem solving (CPS) to solution design, models abound that divide the process in stages and define these. NPD and managerial oriented models include project management and knowledge management aspects. These models pay attention to product implementation commitment of stakeholders, implementation and dissemination activities and eventually post-project evaluation.

Appendix 1 presents an overview of commonly used phase models for new product development, creative problem solving, creativity in general, etc. The number of phases range from two to ten. Not only the phases differ vastly, the type of knowledge processes, actors involved and stage names do so too. Some researchers look for the characteristic types of cognition involved, others look for the changes in collaboration process and yet others for the information and knowledge transformations involved. For *idSpace* it is relevant to note differences between the commonly used stage models. Figure 4 shows the different phases discerned in the major 6 stage models in use. (See also D1.2).

(1) *Wallas stage model*. The social scientist and educationalist *Graham Wallas* (Wallas & Smith, 1926) was the first to develop a generic stage model of creative process. It consists of four phases of (1) preparation, including problem exploration, followed by (2) a period of incubation where the problem is internalized only to surface in phase (3) illumination when the creative idea comes out in conscious awareness. (4) is the verification stage in which the idea is seriously evaluated, verified and elaborated for implementation. This Wallas model lies still at the basis of various models in use to day.

The most widely used stage models are elaborations based on the Wallas model (1926). For example Runco (2004, 2007).

(2) Schmid in his IPC model (Schmid,1996) proposes a 4 stage creativity model, consisting of an (1) orientation, (2) incubation, (3) illumination, and (4) verification phase.

(3) In *Finke's 'Geneplore' model* of creativity the creativity process is reduced to two stages. The first phase is a generative phase in which people construct a mental model of the problem space. Finke (Finke 1996; Ward & Smith, 1992) assumes that a specific class of mental structures exists which he calls "pre-inventive structures". Internal cognitive processes precede externalizations of open-ended exploration and consist of new mental examples of hypothetical categories, representations of conceptual systems etc. In the second phase people explore the possibilities of these mental "models" to arrive at externalizations of a new creative solution. For the design of

pedagogical strategies the two cognitive strategies are too simple to address all support needs. However the emphasis on exploration and externalization of mental states are important alerts against which to check *idSpace* support scenarios.

(4) Problem solving (PBL) stage models have been widely used in education since the 1960's. In these problem based learning (PBL) models learning is arranged around problems to be solved by student groups via a stepwise systematic inquiry process (Boud & Feletti, 1997; Schwartz, Mennin & Webb, 2001)

(5) *CPS, creative problem solving* stage model was developed by Alex Osborn (1963), creator of a brainstorming method and founder of the Creative Education Foundation (CEF). Sidney Parnes (Parnes, 1999) elaborated the model. The classical version is a five step model but sometimes a mess-finding is added. The stages then are: Mess-finding (Objective Finding), Fact-finding, Problem-Finding Idea-finding, Solution finding (Idea evaluation), Acceptance-finding (Idea implementation).

(6) The PI *Progressive inquiry* process presents a question based knowledge creation method using per stage a different inquiry focus.

(7) Finally we present the *management oriented stage model* of Tidd et al. (Tidd et al., 2005) to present a comparison with stages of innovation as used in business contexts.

Table 2. Stages of creativity processes: Stages of similarity

Wallas (4)	IPC Schmid (5)	Finke (2)	PBL learning (7)	CPS (6)	PI,progressive inquiry (6)	Tidd (2008) (5)
	Problem recognition		Explore/clarify problem	Mess finding	Context creation	Scan
Preparation	Preparation	Idea generation	Define problem	Problem finding	Definition of question	Strategy
Incubation	Incubation		Problem analysis	Idea finding	Articulation of theory	Resource/ Explore
		Explora-tion phase	Explain Problem	Solution finding	Externalization of thoughts	
Illumination	Illumination		Define Objectives		Searching for new evaluation	
Verification /elaboration	Verification/ elaboration		Explore investigate	Acceptance	Evaluation	Implement
			Synthesis conclude	Acceptance finding		Learn

Stage models inspired by problem solving, like the one for problem based learning (PBL) and creative problem solving (CPS), have the advantage that their stage definitions are already directly related to learning activity types like mess finding, data handling, problem analysis etc. This gives each phase a clear focus and characteristic activities, which present easy cues for the type of support needed. Stage models of Wallas and Schmid on the other hand have the benefit that they directly relate to the rhythm of the creativity process, with activities of active and systematic inquiry intertwined with incubation and followed by illumination.

The *idSpace* environment aims to support the creative part of the design process. It concentrates on the activities that the team members go through in order to arrive at new and creative design solutions. Thus the ideation process and solution selection activities prior to actual product development are the concern of the *idSpace* project.

For the design of pedagogical strategies further specification is needed. Specification of learning activities for problem recognition, activation of existing knowledge, inquiry and reflection in action (Argyris, 1991; Schön, 1983; Schön, 1992), schemata reconstruction and co-construction as well as evaluation of new knowledge can take inspiration from both types of stage models. The great advantage of the IPC model is that it offers a creativity-based stage model already enriched with connections to the type of information processes and knowledge types involved. Therefore for *idSpace* this model is most suitable.

Creativity: flow and incubation.

Mihály Csíkszentmihályi (1996) suggest that a person (or group) can get into a mental state which he calls "flow". In this state the person is fully immersed in the activity, feeling full involvement, an energized focus and success. This "flow" state is often referred to as getting in "the zone". To get there calls for a combination of affording conditions. Example conditions are to organize working in parallel, to keep the target and group focus sharply in mind, to use prototypes and visualizations to advance from the existing reality, and finally to address differences among participants as opportunities for creativity. All conditions constitute recommendations applicable to the implementation of *idSpace* support.

Reports of learners in CSCL and CSCW settings and those of creativity sessions (Santaanen & de Vreede, 2004) suggest that certain settings and supportive actions block the process while others just got things moving (Bitter-Rijpkema et al., 2002). Hence *idSpace* pedagogical support should observe how the combination of context awareness (D3.1) affords or hinders the team's "flow" followed by inserting enabling support actions based on these observations.

Within the creative process especially the period of *incubation* as a period in which the problem "rests " has been subject to recent investigation by Ward & Saunders (2002) and Dodds, Ward & Smith (2004). These authors found some empirical evidence consistent with the assumption that incubation aids creative problem-solving, enabling "creative worrying" (Weisberg, 1986; Schmid, 1996), "forgetting" of misleading clues, etc. Findings transferable into *idSpace* recommendations include suggesting a team to use a time out and letting ideas rest for a moment. In addition these observations suggest that support needs to trigger learning of new things but also should afford "*unlearning*" i.e., removing details or associations that block a change of perspective (Akgün, et al, 2006).

Creativity in engineering design

Nigel Cross (2002; 2008) a prominent author in the field of engineering design methods has investigated the creative process of highly successful designers. Engineering design includes articulation of ideas via text and visualizations of ideas and relations between concepts. It comprises transformations, redefining specifications and design solutions, and finally activities of convergence and prototyping for product development and recreation to make existing design sustainable over time. To create better design solutions he confirms the importance of critical and divergent thinking, during exploration investigating possibilities and constraints of problem and solution space.

Additionally Cross emphasizes the importance of intuition during the design process. Observation studies of excellent designers in action showed how engineering design thinking is intertwined with intuition. Successful designers frame the problem in a personal way (1). They define the problem in a rich, elaborative open way (2) and rely on 'first principles' (3). These designers explore the problem space from a particular perspective, since this helps them frame the problem in a way that stimulates pre-structuring (4). Finally Cross observes that creativity arises especially from conflict, for example between the designer's high-level problem goals and the clients acceptance criteria.

Awareness of Cross' findings regarding successful product designers offers input to present examples of the expert designers' type of problem definition and approach via a particular perspective. (cf. relevance of EU Trends project, Appendix 2 for *idSpace* project)

4. Creativity at work: context and constraints for creativity support

Social context of learning: learning in networks and professional communities.

New product design does not take place in isolation nor is it the work of an individual but co-creative work of a team of professionals, with various backgrounds and personalities, engaged in a new product design as part of their work. In this section we focus on those social context variables that should by supported by the *idSpace* environment.

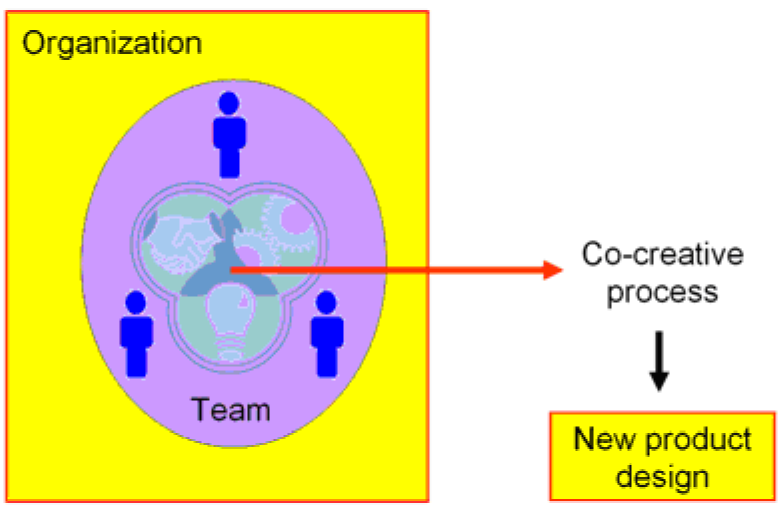


Figure 5. View on co-creativity for new product design

For invention of new products, continuous learning embedded in daily collaborative work practices is imperative. However, this does not apply to learning as a separate activity but as an ongoing activity, embedded in the collaborative work practice and geared towards performance. To accommodate these learning needs conventional methods of curricula class-based training fall short (Koper & Sloep, 2002). Course-based, post-initial training methods cannot cope with the learning needs of new product developers at work. Learning support for creative achievement in a business work context calls for advanced domain and context sensitive support which learners have to be able to acquire just-in-time. Fitting a person to predefined curriculum and standard training module doesn't work for this situation (cf. EU Collaboration4Innovation and KPLab project project, Appendix 2). Situations that *idSpace,* aims to accommodate pose constraints which are too tight for application of regular training formats. Learning support for new product designers has to fit the needs of the person(s) and their specific work context. Performance requirements of NPD teams will not leave team members time to take a learning "time out". This implies that the learning effort has to take place as part of the job.

Our literature scan for *idSpace* therefore singled out learning support methods and formats that match the specific needs of multidisciplinary teams, that is, matching the performance expectations and time constraints of specialists working collaboratively on the creation of new products in business practice.

Professionals at work: performance driven learning.

While learning at work is aimed at producing visible and desirable outcomes for the organization the process of work-based learning (Sacchanand, 2000, Marsick et al., 2006) itself often is invisible due to its complete incorporation in performance-oriented actions. Consequently, it is not perceived as learning but as "part of the job" or as mechanisms for "doing the job properly" (Boud & Middleton, 2003). In other words it concerns "learning", without explicitly labelling it as such.

Work-based learning is described as learning embedded in an organization taking place under normal operational conditions. It refers to learning immediately applicable to the professionals' job, including all means, processes and activities by which employees learn in the workplace. Investigations initially focused on on-the-job support (literally workplace learning). However, with the emergence of distributed work practices the emphasis moved to the exploration of models for support of work-based learning, taking into account the entire range of relevant learning activities. Included are activities of all possible kinds of professional task performance, whether taking place at a physical office location or at a person's or team's mobile workplaces or at virtual professional communities. The learning activity itself can vary from explicit and formal forms of learning to intentional non-formal learning activities and even to unintentional, informal learning as in dialogues with colleagues.

The scope of workplace studies is very broad, addresses issues in various domains and investigates processes ranging from individual competence development to team collaboration and organizational learning. Of special interest to *idSpace* is research that investigates the specific constraints of learner support for i) professional workers as well as for ii) the active CSCL and CSCW research communities, who zoom in on processes of learning support in respectively computer supported collaborative learning (CSCL) and work (CSCW) environments.

A very prominent characteristic of learning at work that affects learners is the learners' constant exposure to the opinions and practices of others who also work in the same context (Billet, 2000, 2001; Boud, 1994; Van der Klink & Streumer, 2006). The workplace provides natural opportunities for informal and unintentional (vicarious/incidental) learning. (Loewenstein & Spletzer, 1999). Research indicates that the greater part of learning by employees takes place during such informal encounters. There are statements that people learn about 70% or more informally. These types of informal, sometimes incidental learning are facts of workplace life. To support workplace learning in projects like *idSpace* requires affording circumstances for this kind of learning, i.e. setting up support for spontaneous learning while consulting peers or documentation, using one's network of colleagues. This isn't evident or easy. Learning as the term indicates isn't really manageable; one cannot predict when it takes place and what its outcomes will be. Sparks of creativity can happen at these informal peer encounters, a new perspective is triggered by some dialogue. Based on existing evidence regarding affording environments for informal learning *idSpace* might include an open social space, some kind of "coffee-corner" type space for informal encounters, affording informal knowledge exchanges which by chance might generate valuable input for ongoing *idSpace* teamwork.

Marsick (Marsick & Watkins, 2001) suggests that learning for work performance has to address multiple dimensions in parallel: the technical, interpretative and strategic dimension. First, the learners have to be supported in the acquisition of specific (bodies of) knowledge or domain specific competences to meet task requirements. Second, support has to help the learner with the interpretation of the current situation and make judgment about its consequences. This includes help to learn from past experience and judgments. Third, learning builds on a critical examination of underlying assumptions, values and beliefs of participants. Supportive action should support learning via discussion of ideas, articulation of underlying assumptions in open dialogue. In line with this advice, Mezirow presents learning as a transformative activity (Mezirow, 1997); additionally, he stresses the importance of dialogue support for learning at work since it is through dialogue that transformations take place in both person and collective.

5. Enhancing collaborative creativity for *IdSpace*

Creative collaboration does not emerge automatically. Innovation projects are well known for the high expectations that surround them. Well known are also multiple problems that these projects encounter in the process over the development stages. Future *idSpace* learning support aims to enhance creativity by making optimal use of available learning opportunities; addressing these by providing enabling tools and supportive circumstances, awareness of what is going on and the recommendation of useful strategies.

In this chapter we present key issues for creativity enhancement in the process of new product design. How can we enhance learning and collaboration processes in a way that the constrained creativity for new product design is triggered and nurtured?

Literature on use of explicit, dedicated pedagogical strategies to enhance creativity in industrial new product development settings is relatively scarce. However, as noticed, relevant insights have been found across disciplines involved: engineering design, new product development, innovation management, organizational and team learning and CTS, tool support for creativity techniques. Apart from these distributed sources across relevant domains, a prime source of inspiration comes from knowledge on learning support, more specifically from CSCL and CSCW, computer supported learning and work research.

In the next sections we will first investigate the state of knowledge in these communities dedicated to collaboration support for distributed work and learning. We start with a depiction of existing models for collaborative knowledge building and progressive inquiry. These models provide a framework for the support scenarios. We then address key issues in the design of collaborative learning environments and focus on barriers and supportive mechanisms of computer supported collaborative learning. Do note that theories, examples and evidence presented often were developed and tested in educational classroom contexts. For *idSpace* they provide a source of inspiration, but they need to be translated into guidelines and recommendations customized to the characteristics of the workplace settings of *idSpace* users.

Suggestions to support learning in order to find new ideas all build on the concept of Kolb's experiential learning cycle (Kolb & Kolb, 2001; Smith, 2001) and Dewey's and Schön's theories on reflection and action. Starting from concrete experiences, observation and reflection lead to conceptualizations and experimentation. This again generates new inputs, setting new goals, conceptualize, reflect, review, etc. Iteratively, through divergent and convergent thinking new ideas are explored via team members' contributions. The exploration proceeds until a satisfactory solution has been found (Miettinen, 2000). At the core of the theories presented is the assumption that knowledge creation is a social process. New ideas emerge most often among persons, rather than in the individual person.

Generating collaborative knowledge

Quite in general, four models for collaborative knowledge are relevant to the support of knowledge processes. First, Bereiter & Scardamalia (2003) present ideas about providing help for knowledge collaboration via scaffolding; second, Stahl (2005) does so for articulating methods and, third, Fischer for his suggestions on the role and evaluation of artefacts, externalizations as objects in the social process of creation. Vygotski (1978), finally, suggests how to release the learning potential within the zone of proximal development.

Scaffolding for collective knowledge building

Carl Bereiter and Marlene Scardamalia (2003, 2006) have been pioneers in bringing collaborative knowledge building into the classroom. Based on constructivist assumptions, they develop knowledge-building environments such as Knowledge Forum and Computer-Supported Intentional Learning Environment (CSILE) for education. Ideas are developed through processes of inquiry by questioning, dialogues and systematic search to improve the ideas. The CSILE environment was designed to facilitate students' and teachers' participation in knowledge development similar to scientific research. Pedagogical support comprises: a) systematic generation of research questions, b) construction of intuitive working theories, c) critical evaluation of generated intuitive concepts, d) search for new scientific information, e) generation of subordinate questions and engagement in further investigation, f) definition of new working theories as the investigation process proceeds (Hakkarainen et al, 2002)

Support offered by teachers, doesn't consist of presenting information or prescribing procedures but in assisting the collective inquiry to achieve deeper understanding. Support consists of providing guidance by offering scaffolds, temporary support guidance by offering structures and question. This approach of scaffolding, offering initial support when needed, fading away after time, has become an important method of support since then (Beers et al 2005; Bitter-Rijpkema et al 2005).

Derived from this line of research is a first generic heuristic for *idSpace*:

- Provide a scaffolding type of support, available as explicit recommendation or structure when needed but fading away once participants are self supporting, have internalized the advice.

Next, from the 12 guiding principles identified by Bereiter & Scardamalia (2003, 2006) the following aspects are worth taking into account in the design of *idSpace* guidance:

- *Ideas are improvable:* see the actual ideas as improvable objects.
- *Idea diversity:* the diversity of ideas raised is necessary for knowledge development
- *Sustained improvement effort*: higher levels of concepts and deeper understanding result from the sustained improvement effort.
- *Collective responsibility f*or community knowledge: active participation and responsibility of team members to the collective knowledge ambition.
- *Democratization of knowledg*e: all participants' contributions are needed for knowledge advancement.
- *Reciprocity of knowledge advancement*: advancement of personal knowledge in parallel to collective knowledge building effort.
- *Use of "authoritative" sources:* Inquiry builds on uses all kinds of expertise, known resources.
- *Knowledge building implies sharing and discourse*: knowledge building as a collective effort is based on dialogue and sharing ideas.

Systematic collaborative knowledge development using progressive inquiry (PI)

Later researchers from the Media Lab of Helsinki University, supported in the ICTOLE project by the EU Commission, developed the *future learning environment* (FLE) based on their model of progressive inquiry (Hakkarainen et al. 2002, Muukkonen et al., 1999). Support methods for progressive inquiry were developed and instrumented. The progressive inquiry method entails that new knowledge needs to be constructed through systematic problem solving via a question- and explanation-driven inquiry[10] (Mukkonen, 1999).

The stages of the progressive inquiry process relate to the scientific problem solving method. The stages include: 1) context creation 2) definition of research question 3) articulation of working theory 4) externalization of own thoughts 5) searching new information 5) critical evaluation. Progressive inquiry (abbreviated as PI) entails that new knowledge is not simply assimilated but explicitly constructed via systematic inquiry and problem solving strategies. Advancement towards new collective knowledge requires that students engage in a systematic effort to construct shared knowledge objects, i.e., hypotheses, theories, explanations and interpretations (Bereiter & Scardamalia, 2003; Scardamalia & Bereiter, 2006; Hakkarainen et al. 2002; Muukkonen et al., 1999).

The progressive inquiry approach provides relevant heuristics for *idSpace* :

- The need for participants each to generate and articulate their own working theories
- The necessity to critically evaluate knowledge advancement
- The importance of searching for new scientific information
- The continuous engagement in deepening inquiry
- The importance of sharing expertise

Support is instrumented in FLE3 among others by providing users with text structures relevant for making scientific statements offering text openers for assumptions etc. The free flow of ideas is supported by a mind mapping-like drawing tool for use in jam sessions, emphasizing the need to have tools for different ways of representing knowledge

[10] Fle3 was largely developed in the Innovative Technology for Collaborative Learning and Knowledge Building (ITCOLE) project, funded by the European Commission in the Information Society Technologies (IST) framework's 'School of Tomorrow' program

during the learning process. At the same time FLE3 provides tools for storing different versions of the object during its development.

Collaborative learning as shared meaning making: the role of evolving artefacts for externalization of group cognition.

Methods to support learning during collaborative design have been taken another step further by Gerry Stahl and Gerhard Fischer. They put extra emphasis on the articulation of personal tacit knowledge and the process of sense making, negotiation of meaning and development of shared understanding in the group.

Gerry Stahl (2005) stresses the importance of surfacing and integrating personal knowledge to the collective understanding. The collaboration process is seen as a process of articulating and negotiating perspectives, of mutual learning (Brown & Duguid, 1991) in order to construct shared understanding. This is a very dynamic transformation processes influenced by the context of the joint activity. Artefacts of emergent knowledge play a mediating role. Stahl refers to learning as shared meaning making, as an "essentially social activity that is conducted in joint activity of a group".

Heuristics relevant for *idSpace* inspired by Gerry Stahl (2005) include

- Facilitate articulation of ideas and provide option to preserve them in convenient forms (i.e. outline editors, and brainstorming tools).
- Provide representation of different perspectives, both personal and shared.
- Provide possibilities to aggregate to compare perspectives. Enable that artefacts can be related to each others that ideas from other people's perspectives can be adapted, adopted or contrasted (Ostwald, 1996).
- Support interactivity, ranging from straightforward dialogues to complex idea dialogues. Stahl based on (Donath et al., 1999) suggests that meta-level comprehension of the knowledge-building process is needed to point out where additional evidence is needed or alternatives have not been explored.
- Articulation of shared perspectives or negotiated conventions by building collective artefacts like a group glossary of the agreed upon definitions, terms.

Releasing learning potential in the zone of proximal development

Vygotsky (1978) defined a zone of proximal development (ZPD). He states that the ZPD of a person is the distance between the “actual developmental level as can be determined by independent problem solving and the level of potential development as determined through problem solving under guidance or in collaboration with capable peers". Vygotsky’s idea is that via appropriate assistance (scaffolding) the learner is capable of achieving the task in his zone of proximal development. After having mastered this type of task thanks to the support the learner will be able to work on similar problems on his own.

The importance of Vygotsky’s idea for *idSpace* support is that supportive action can help the expansion of the team’s capabilities for creative action further than its actual state by offering suggestions on which methods for knowledge development and collaboration with by capable peers to apply and which creativity technique and instruments to use.

Affordances for workplace learning

Skule (2004) discerns seven learning conditions at work conducive to learning. These seven conditions significantly affect the learning potential and intensity of the job, which is primarily determined by the type of task at hand. Skule’s conditions for learning refer to “learning intensive work”. The more employees are involved in development of new products and services as part of their job, the more learning opportunities are contained in their job. Key triggers for learning in knowledge demanding work environments are (1) a high degree of exposure to changes, i.e. frequent changes in technology (products and processes) and working methods, (2) a high degree of exposure to demands, for example from customers, managers, colleagues, group or (value) chain the company belongs to, (3) the inclusion of managerial responsibilities in the job (not only high or general management tasks but also allocated responsibilities for decision-making on a certain task, project management or work group management), (4) extensive professional contacts, in occupational networks, and contacts with customers or suppliers. (5) superior feedback, seeing direct results of work and getting feedback provides valuable opportunities for learning, (6) supportive attitude of management for learning, (7) rewarding of proficiency.

Evidence found by Skule on affording conditions for learning in knowledge demanding work environments provide fruitful directions for the *idSpace* environment. Take for example the idea to integrate suggestions for constructive feedback cycles or articulating positive side of change exposure and responsibility for task collaboration, risk taking, etc.

Affordances for (distributed) teamwork.

The *idSpace* project supports group creativity for new product development. Support thus entails more than just using methods for individual support and then multiplying these by the number of team members. It is well known that collective performance of teams has to take into account the dynamics of the team.

A team is defined as two or more persons with an interdependent task, a common goal and a shared responsibility. Every team-setting has its own advantages and limitations. Across their lifecycles, teams differ (Ward & Saunders, 2002; McGrath's, 1984) with respect to their input characteristics like team composition, culture, prior training and technical support. They also are literally localized (F2F) or distributed, or function in a distributed way across or within organizational boundaries (intra-/inter organizational). After Powell et al., we define virtual teams as "groups of geographically, organizationally and /or time dispersed workers, brought together by information and telecommunication technologies to accomplish one or more organizational tasks" (Powell, Piccoli & Blake, 2004, p.7). In short virtual teams are "working together apart" (Grundy, 1998).

Team composition and performance

The relation between group composition and performance is extensively researched. On the one hand evidence is found that differences in functional background, education or personality enhance creativity when the group process is supported. Hoffman et al (1961) for example found that in complex-decision making, heterogeneous groups produced better solutions than homogeneous groups. Kratzer et al. (2006) stated that team polarity and disagreement arising from differences in perspectives during conceptualization, positively influence creative performance of R&D teams. On the other hand in less complex situations team polarity negatively impacts the creative performance of teams.

Cultural differences can both negatively and positively influence group performance. Zakaria et al., (2004) found that cultural background influences the way knowledge is learned and communicated. Miscommunication inhibits creativity in cross-cultural settings "due to the sender's inability or refusal to shape the information in a culturally appropriate and understandable form for the receiver".

The same reasoning accounts for differences in coping with leadership, conflict handling and trust-formation. Thus Zakaria (2004) concludes "the ability to create a knowledge-sharing culture within a global virtual team rests on the existence of intra-team respect, mutual trust, reciprocity and positive individual and group relationships". For most users of the *idSpace* environment group composition will be a given. However when the system is "aware" of the team's composition, appropriate recommendations can be given to maximize trust formation, development of constructive relationships, and counter chance of misunderstanding by feedback loops etc.

Goal clarity and performance

Recent research findings are consistent with observations from everyday practice at SAS: agreement on the 'prime objective' is a necessary prerequisite for team result. In line with this Lyn, Skov &, 1999) state that the activity of setting goals itself facilitates team performance. Henttonen & Blomqvist, (2005) report that these 'shared goals' are critical to a team's success. Other authors (Larso and LaFasto, 1989; Lynn, et al 1997; Lynn, 1999) use the traveler metaphor stating that "in order to be a successful traveller you have to keep your destination in mind and follow the roadmap". Successful teams have clear and specific goals, with goal-stability throughout the entire NPD process and goal support of the organization. Hence a recommendation in *idSpace* could include triggers at certain points in time to formulate an agreement upon goal or set of goals for the phases to come.

Enhancement of coordination.

Working primarily virtually adds complexity to the combination of team processes leading to team performance, since the individuals have to coordinate their work on interdependent tasks, share responsibility for the collective outcome, work from different locations, rely on technology for all or most of their communication (Gibson & Cohen, 2003, Griffith & Neale 2001, de Guinea et al 2005), and in the meantime develop a shared understanding to proceed. The dominant vision on team performance, called the group deficit theories, postulate that group performance is hindered by process loss caused by coordination problems and reduced motivation of it's members. This in turn leads to diminished willingness of members to perform to the best of their capabilities. As a result the members of the group are unable to efficiently and effectively coordinate their actions. Another group of theories view team performance from the opposite side. The group bonus theories speculate that group performance benefits from assembly effects.

To counter 'process loss' triggering two methods were tried in an experiment: training in nominal group technique and stimulation of "social combination". The latter condition stimulates social interaction and collaboration of individual team members to learn from each other, collaborate and share resources and leads to learning enhancement of individual skills "critical to reduce coordination loss", while the first condition didn't sort any effect (Brodbeck & Greitemeyer, 2000). *IdSpace* should facilitate the enhancement of coordination.

The role of externalization of ideas.

During the evolution from idea to product, intangible ideas materialize in tangible artefacts. Representations of ideas are externalizations of the state of design at a specific moment in time. These externalizations will evolve to other states, via a number of transformations. Initial sketches or wordings evolve to structures, schemata and specifications. To support the evolution of ideas in *idSpace* , specific attention needs to be given to the role of these artefacts in the process of learning from each other and co-constructing shared knowledge.

Yet another area of interest from the *idSpace* perspective is what can be learned from the product design process as a whole and from earlier ideas in the project team and from elsewhere. Therefore we are interested in the role that artefacts can play in documenting earlier ideas or in strategies inspiring new ideas.

This interest, by the way, does not extend to other aspects of learning and creativity: like creativity training per se, the nature of the individual genius, domain specific or management methods for new product development (NPD), organizational creativity and dedicated computer supported collaborative learning (CSCL) and working (CSCW). Issues and methods not transferable to the *idSpace* context are out of the scope for this review.

Mutual trust and performance

A key factor for successful virtual team work that receives more and more research attention is trust formation. Trust formation develops "through actions and communicating individual roles and shared goals" (Henttonen & Blomqvist, 2005, p.117).

From Jarvenpaa et al (1998) we learn that successful teams show specific behaviour. In the early phases successful teams work enthusiastically and develop open communication patterns that facilitate trust building and initiative taking, thus developing coping strategies to tackle technical problems and task uncertainty. In the next phases Jarvenpaa perceives how the team's communication pattern becomes more predictable and substantive. These finding suggest that the focus shifts from a social oriented open communication pattern to more procedural patterns underlying trust building. Other accompanying factors include "management" of distant relationships which can be enhanced by a person showing leadership handling a conflict, identification of commonalities between team members, acting competently displaying integrity (Duarte & Snyder,1999) supporting inclusive conversations in a way that team members build a sense of community and trust (Kimble, Li, & Barlow 2004) in the community and the share task.

Implications for *idSpace*: like in team composition it starts with selecting the right people for the job. Participants should show a certain willingness to communicate through means of ICT, a certain openness towards other people and cultures, and a willingness to overcome the barriers that might be raised by the ICT tools. The

IdSpace environment itself should contain sufficient tools to communicate in a variety of ways.

Social knowledge awareness and performance

When people work together in a group, participants are generally uncertain about their relative expertise on, knowledge of, or contribution to a given task. This difficulty needs to be resolved because a group's ability to recognize the expertise of its members is known to be vital to the group's success in face-to-face environments. Consequently, information on the relative expertise of each group member should be provided especially in distributed teamwork. Michinov (Michinov & Primois, 2005) found that participants who received feedback via social comparison were more productive than those who did not receive this type of feedback. The two conditions differed on number of non-redundant ideas generated and the originality of the ideas. Thus Michinov assumes that creativity doesn't depend on the ideas generated in a newsgroup, but as a result of original efforts as to find original ideas relative to other team members. *IdSpace* should facilitate the 'awareness' of other team members' efforts.

To sum up our focus is on methods that improve the creative process and the inventive design outcomes. Methods that bear relevance to *idSpace* 's ambition to realize support and instrumentation for enhanced group creativity in distributed product design.

Note that this includes for example suggestions on how to improve the individual team members learning for idea generation of the team, specific creativity methods aimed at generation of more viable ideas, suggestions to improve effective communication of new ideas to peer team members and recommendations to combine ideas stemming from different sources into new product design.
In essence we are interested in existing methods to actively influence creativity via specific learning strategies and methods. As long as these ideas are relevant for our objective to develop recommendations for professional learners in teams or provide input to design affording circumstances in the i*dSpace* environment to enable the necessary creative actions.

Key Issues when designing computer supported collaborative learning/working environments

Computer supported collaborative learning (CSCL) is an emerging paradigm (Koschmann, 1996) for research in educational technology that focuses on the use of information and communications technology (ICT) as a mediational tool within collaborative methods (e.g. peer learning and tutoring, reciprocal teaching, project- or problem-based learning, simulations, games) of learning (Wasson, 2003). CSCL interest lies on 'how collaborative learning supported by technology can enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members.' (Lipponen, 2002).

Collaborative Learning can be characterized by a number of dimensions including the type of collaborative control, the type of collaborative tasks, the theory behind the type of collaboration, the context in which collaboration happens, the type of participants, the roles of the collaboration participants, the collaborative domain, and the type of tutoring that thrives in a collaborative environment (TELL, 2005).

In this section we present some of the key issues when designing CSCL environments derived from the extant literature such as (Kirschner et al., 2004; Jones et al., 2005) as well as from the findings of three European projects and networks, TELL (http://cosy.ted.unipi.gr/tell), E-QUEL (http://www.equel.net/), and Kaleidoscope Network of Excellence (http://www-kaleidoscope.imag.fr).

The first key issue is that the *success of an instructional/learning strategy heavily depends upon the expertise* of the teacher in structuring and developing the dynamics of the group as well as in encouraging and offering scaffolds to learners. Especially, in adult learning situations where adult learners typically have a set of methods for how they want to learn as well as are continuously seeking for evaluation metrics about their performance, teachers need to offer them to carry out authentic tasks that are close to their interests and competencies as well as give them prompt feedback about their learning progress.

The second key issue is related to *the design of integrated CSCL environment that incorporate computer-supported tools* that support collaborative learning tasks. There are many research questions that need to be answered for this technological implementation, among which:

- *Awareness*: Collaboration awareness is defined as "an understanding of the activities of the others which provides context for your own activity" (Dourish & Belloti 1992). It can be distinguished in the following types (Gutwin & Greenberg 2004):
    - social awareness which refers to awareness of the social connections within the group or team
    - task and concept awareness that concern awareness about how to complete the common task
    - workspace awareness which is an up-to-the-minute knowledge of the other learners' interactions with the workspace
- *Diagnosis*. There are situations where a moderator would want to know the status of progress of the learners. In that case, a CSCL environment is expected to diagnose learners' interactions and present concise and meaningful information with respect to the progress of the CSCL process as well as the performance of each learner. Applying such diagnosis as a filter to provide explanatory feedback customized depending on the learner and the context. Nowadays there is a set of methods and techniques for analyzing the interactions in CSCL environments (Martínez et al., 2003; ICALTS, 2005; Daradoumis et al., 2006; Petropoulou et al., 2007).

- Yet another aspect is that of *empirical usability evaluation of CSCL environments.*

Finally, the final key consideration when designing a computer supported collaborative learning/working environments is the acknowledgement that it is an iterative process in which continuous evaluation plays an important. The evaluation can be seen through two main distinct evaluation objectives (TELL, 2005):

- The first concentrates on the *usability of the distinct components* or combinations of components that offer the foreseen functionality to typical single users. This is related to key quality parameters like the expected functionality, reliability, efficiency, maintainability and portability of the components.

- The second focuses on evaluation of quality of collaboration functionality, like reliability and efficiency of the collaboration-support mechanisms.

Box 1: Example of a possible evaluation method. There are very few usability evaluation methods as well as heuristics which can be applied to this specific type of environments. These methods and heuristics are needed for unveiling problems in shared collaborative work surfaces for distance-separated groups. Gutwin & Greenberg (2000) introduced such a specific method, named Heuristic Evaluation of Groupware (HEG), which is based on the following groupware-specific heuristics: o Heuristic 1: Provide the means for intentional and appropriate communication. o Heuristic 2: Provide the means for intentional and appropriate gestural communication. o Heuristic 3: Provide consequential communication of an individual's embodiment. o Heuristic 4: Provide consequential communication of shared artifacts o Heuristic 5: Provide Protection o Heuristic 6: Provide management of tightly and loosely-coupled collaboration. o Heuristic 7: Allow people to coordinate and monitor their actions. o Heuristic 8: Facilitate finding collaborators and establishing contact.

Evaluation could be organized along the lines of Gutwin's framework for the mechanics of collaboration as the basis for this new set of heuristics (Baker et al, 2001). This framework describes the low level actions and interactions such as communication, coordination, planning, monitoring, assistance, and protection.

The research on the CSCL and computer supported creative design areas is still scarce, and the results are not conclusive. In the *idSpace* project, we should not try to achieve a set of universal truths applicable to any situation of training about and supporting collaborative development of innovative products, disregarding its context. Nevertheless, via systematic design, development and evaluation of the *idSpace* environment, we will be better able to distinguish which kind of issues affect learning in technology enhanced collaborative creative design processes for innovative products as well as to provide solutions to the typical problems that might be found in schools, universities, corporate research labs and other learn places.

Known barriers of computer supported collaborative creativity

The success envisaged for team collaboration often doesn't materialize. Mostly collaboration does not happen spontaneously. Problems with effective articulation and communication of participants knowledge is known to be a barrier to arrive at design success (Bitter-Rijpkema, 2005, Nonaka & Takeuchi, 1995, Fischer, 2005)

When investigating three groups that collaborated on a research tasks in a distributed settings (Farooq et al, 2007) Farooq identified yet other key breakdowns for creativity. He observed that (1) minority ideas were under-considered, (2) novel ideas were easily lost, (3) critical evaluation of perspectives was lacking, and (4) reflective action during convergence phases was weak. Loughran (2004) mentions the lack of shared goals, and communication problems due to cultural differences and lack of trust, which inhibits the emergence of creative ideas requiring an open exchange culture in which participants feel safe and confident and risk taking is appreciated.

Therefore it is important to take care that creativity support should not only focus on the creativity technique side itself but consider removing barriers and handling team dynamics as well.

Suggestions to enhance computer supported collaborative creativity

Current research on enhancement of learning in collaborative settings outside the aforementioned CSCL and CSCW communities is highly varied. Sometimes it zooms in on specific macro issues of organizational creativity (Runco,2004, 2007), sometimes it focuses on issues at micro level, like specific support to develop the creative abilities of individuals or specific applications of brainstorming to a specific design problem (Akgun, 2006 Chen, 2005). The same accounts for tooling.

Tool suites providing learner support across techniques and phases are scarce. Recent studies (Bitter-Rijpkema, 2005; Hipple, 2005; Paulus, & Brown, 2003) suggest that today's disjunctive support mechanisms are insufficient. Existing methods to accelerate learning from each other and existing artefacts mostly consist of dedicated, content-based procedures (i.e. systematic idea generation or evaluation via TRIZ), use of specific representation and argumentation formalisms or generic methods for systematic problem solving (Cho & Jonassen, 2002; Fischer & Mandl, 2001).

Development of support enabling collaborative learning and knowledge building at school and at work has attracted many investigators in recent decades. Models and instruments that support learning processes for collaborative creativity for creativity in product design are rather limitedly available. There are a number of studies at micro level investigating creative processes and outcomes in a specific domain or work setting. Syntheses are yet difficult to find. However, the recommendations for learner support in collaborative creativity by the investigations of Nickerson, (1999) Farooq (2005) and Akgun (2006) can be used in combination with the generic CSCL heuristics and recommendations from the CTS, creativity tool support communities as summarized by Sneidermann (2005).

Two authors present an overview of creativity support opportunities which can be translated to learning support for product design creativity. Nickerson presents his recommendations from a learning perspective while Shneidermann investigates creativity support tooling. In the next sections we describe their suggestions and integrate their main points.

Raymond Nickerson, experimental psychologist from Tufts University composed a set of support strategies for creativity enhancement (Nickerson, 1999):

(1) Establish purpose and intention during creative activities
(2) Build on the availability of creativity competences.
(3) Acts upon relevant domain knowledge..
(4) Stimulate curiosity and exploration..
(5) Provide opportunities for choice and discovery.

(6) Support intrinsic motivation
(7) Afford preparedness to take risks, encourage confidence and reward risk taking
(8) Support metacognitive skills of individual person and team
(9) Support self-management of person in relation to the group
(10) Support learning by "teaching" appropriate techniques and strategies to facilitate creative performance
(11) Provide balance**.**

Shneidermann (2007) addresses support for group creativity from an HCI designer of "creativity support tools"(abbreviated as CTS) perspective. He suggests to consider the following aspects when designing CST:

- Exploration
- Many path many styles
- Collaboration
- Open interchange
- Careful choice of "blackbox"
- Creating support "things" that you would want to use yourself.
- Iteration: "Iterate, iterate and iterate again"

6. Examples from educational settings showing possibilities for pedagogical support in *idSpace* .

The following paragraphs present examples of pedagogical support using educational strategies for collaboration for computer supported learning, use of specific creativity techniques and integrated pedagogical support for collaborative knowledge creation. Collaboration does not always happen spontaneously. In order to generate learning in an effective way instructional designers need to carefully design the tasks that teachers and learners will be called to perform as well as to choose the appropriate tools and resources that will support those tasks. There are several well-known learning or instructional strategies (other call them techniques) for structuring collaboration, that have repeatedly proven to generate effective learning.

Learning or instructional strategies determine the flow of activities that a teacher and learners may perform to achieve learning objectives. In the CSCL and creative design areas the most effective strategies are those which promote a high level of learner involvement in observing, investigating, drawing inferences from data, or forming hypotheses. They take advantage of learners' interest and curiosity, often encouraging them to generate alternatives or solve problems in a creative and innovative way.

Invariably, these strategies advocate that the role of the teacher shifts from lecturer/director to that of facilitator and supporter. They rely heavily on discussion and sharing among participants. Learners form virtual learning communities (or learning networks) which are supported by computer supported collaborative learning (CSCL) tools. In such communities, they can learn from peers and teachers to develop social skills, to organize their thoughts, and to develop their creative and innovative problem solving skills. The strategies that follow describe the flow of activities that should be performed. In a given learning situation and context, the instructional designer will make specific decisions about the amount of discussion time, the composition and size of the groups, the format of interim reports and final deliverables, the mechanisms for reporting or sharing information.

Examples of Computer Supported Collaborative Learning

A.1 Jigsaw strategy

The learners are split into small groups of 5-6 persons that are called "Jigsaw groups". (Hernadez, 2005; Katsamani, Retalis & Georgiakakis) The initial problem is assigned to each "jigsaw group" to solve it. The teacher defines a leader who is responsible to organize the group, to assign projects to the members of it and to solve the conflicts and the problems that are emerging from the collaboration of them. Each member of these groups studies a part of the problem and belongs to another group that is called "Expert group". The learner studies with the members of his "expert group" the same sub-problem and tries to collect as much information as possible from their interchange of ideas. Then he returns to his "jigsaw group" and shares with the members of it, the knowledge and the experience that has been acquired, so as to solve the initial problem. In this way each learner is responsible not only for his own learning but also for the learning of his group. At last all the "jigsaw groups" share the results of their collaboration in the classroom.

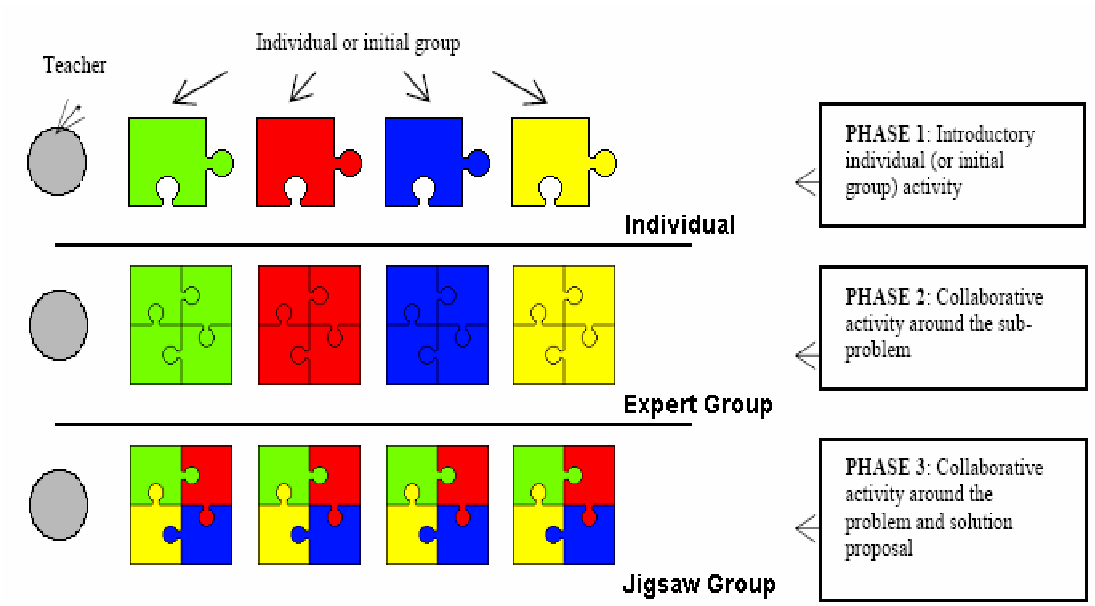


Figure 6. Graphic Representation of Jigsaw Flow of Activities (Hernandez, 2005)

A.2. The Pyramid (Hernadez, 2005 Katsamani, Retalis & & Georgiakakis)

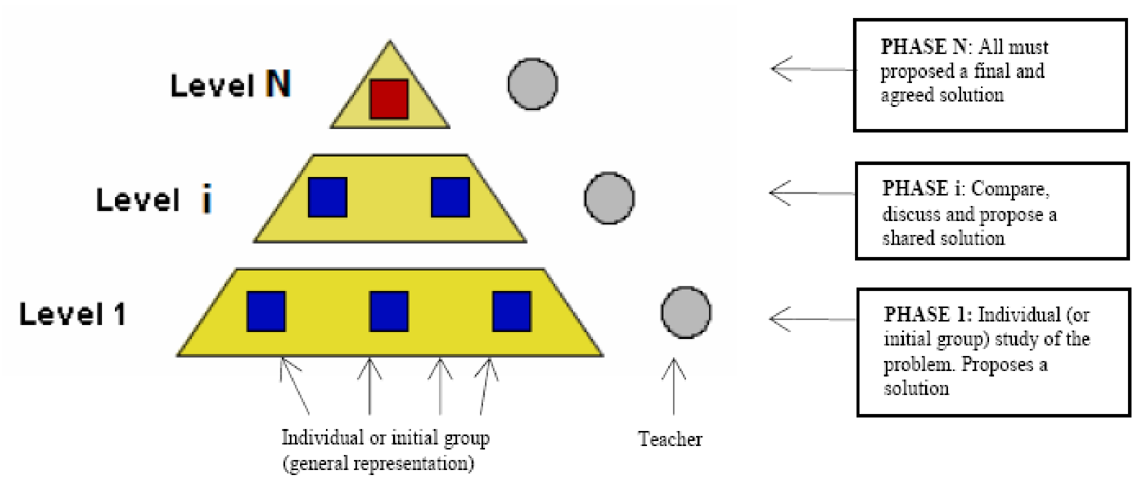


Figure 7. Graphic Representation of Pyramid Flow of Activities (Hernandez, 2005)

The Learning Strategy of "Pyramid", shown in Figure 7, is a collaborative learning strategy, the design of which has as a scope to find a common, accepted solution to a problem, through the collaboration of all the learners.

At first each learner studies the problem and finds a solution to it. Then groups of two (or more) persons are created and each member discusses with the others his initial proposition, then the group formulates a new solution to the problem. Next, groups of more members are created which in their turn create a new proposition and so on, until all the learners of the classroom eventualy find one solution. The conversation is the most important feature of this strategy because each learner through the interchange of ideas evaluates and re-formulates his own ideas and the ideas of his group, thus finding useful conclusions for the initial problem.

This strategy is applicable usually in the processing of difficult and complicated problems, that don't have one specific solution.

A.3 Simulation

The Learning Strategy of "Simulation", shown in Figure 8, is a collaborative learning strategy, the design of which has as a scope to put the learners in positive interdependence.

At first the teacher describes the problem and defines the scenario of the simulation that they are going to make. Then, the learners are split into small groups and to each one of them is assigned a role to study. The teacher gives all the necessary information needed through this process and the small groups present the simulation. Then the simulation is performed in the frame of the entire classroom and follows a conversation about the useful conclusions that emerge from this simulation.

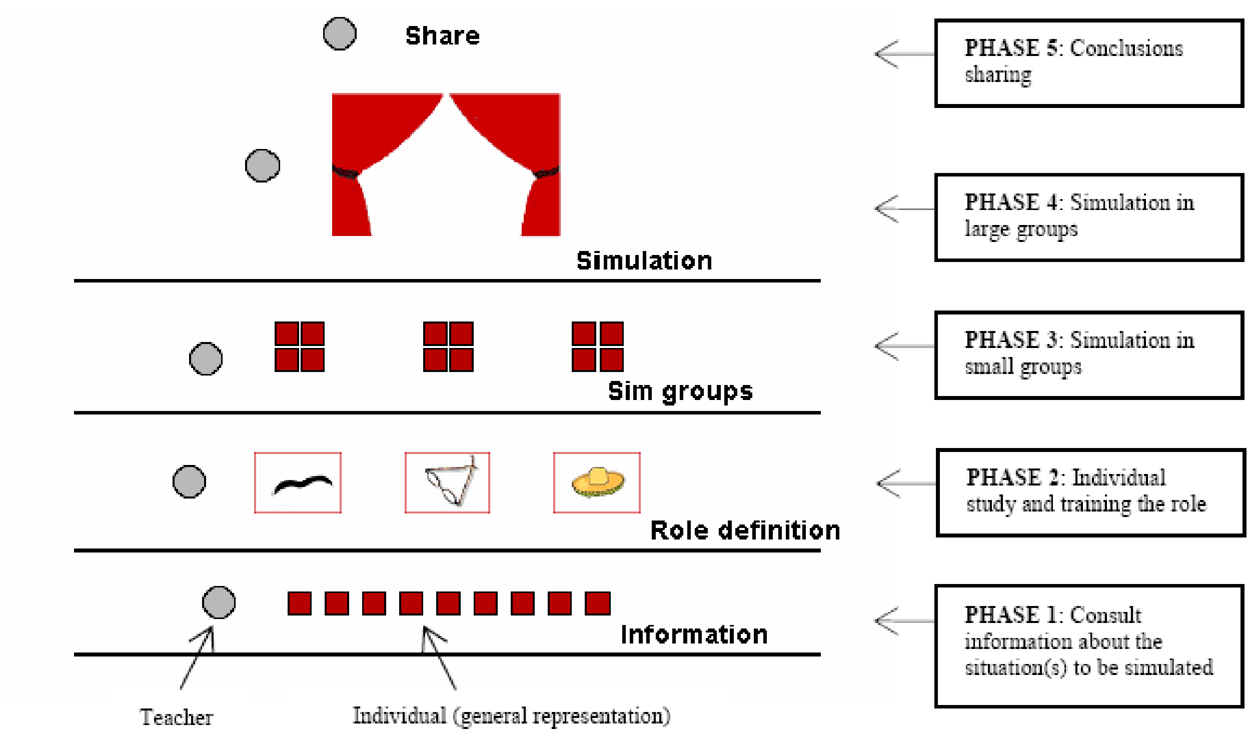


Figure 8. Graphic Representation of Simulation Flow of Activities (Hernandez, 2005)

Examples of strategies for computer supported collaborative creativity.

Examples of creativity strategies

B1. Attribute Listing
Attribute listing is a technique from the early 1930's which:

- takes an existing product or system,
- breaks it into parts,
- identifies various ways of achieving each part, and then
- recombines these to identify new forms of the product or system.

The basic steps are:
- Identify the product or process you are dissatisfied with or wish to improve.
- List its attributes. For a simple physical object like a pen, this might include: Material, Shape, Target market, Colours, Textures, etc.
- Choose, say, 7-8 of these attributes that seem particularly interesting or important.
- Identify alternative ways to achieve each attribute (e.g. different shapes: cylindrical cubic, multi-faceted….), either by conventional enquiry, or via any idea-generating technique.
- Combine one or more of these alternative ways of achieving the required attributes, and see if you can come up with a new approach to the product or process you were working on.

B.2 Name generation
Name generation rest on the idea that naming things is important, not only for understanding the project, but also for motivating the team working on the project. Many times it is very hard to find good names. Moreover, the process of looking for a name is, quite often, conceptually blocking: we cannot continue until a satisfactory name is found. Therefore it is suggested to provide a tool for generating names within certain context. The tool can use thesaurus, WordNet and other similar resources in order to suggest names that relates to key words the user provides.

B.3 Estimate-Discuss-Estimate technique

This technique is useful when a good quality united group judgement is required. A balance, to maintain constructive discussion and idea contribution whilst at the same time steering away from biasing or destructive group anxiety, is the key to success here.

Make the assumption that a general discussion has taken place regarding some issue, a point has been reached where the judgement or convergence is required, the estimate-discuss-estimate (Huber and Delbecq, 1972) method now comes into action via the following steps:

- *Estimate*, individuals vote privately in any way that feels appropriate to the task in hand and the judgement required, their votes are handed in via a round robin without discussion. Each individual has the opportunity to think through his or her preferences, avoiding the pressures to conform.
- *Discuss*, averages for the group are generated by the computer and displayed. The group then participates in an open discussion of these initial judgements.
- *Estimate*, following this discussion group individuals vote again, privately, without discussion. This final vote is average (as in step 2) and used to represent the consensus.

B.4 Productive Thinking Model (Thinkx)

The Productive Thinking Model has six steps. They are:

Step 1: "What's Going On?

Establishes a context for the problems or opportunities being addressed, exploring different ways of stating the so-called "itch", exploring what factors, circumstances, and entities are involved, and what a solution might look like.

There are actually five sub-steps to this phase:

- "What's the Itch?", generating a long list of perceived problems or opportunities, often re-stating similar ones in several different ways, and then looking for patterns and clusters with the mass in order to select one key "problem" to address.
- "What's the Impact?", digging deeper into the issue and identifying how it affects the world.
- "What's the Information?", describing various aspects of the problem in detail.
- "Who's Involved?", identifying other stakeholders in the issue

- "What's the Vision?", identifying what would be different if the issue were resolved, in the form of a "wish" statement (e.g., "If only my dog didn't run away when I let him outside.")

Step 2: "What's Success?"

The second step establishes a vision for a future with the problem solved or the opportunity exploited. In this stage often active imagination is used to imagine, explore, and describe how things would be if the issue were resolved. This vision then informs a process of creating a clearly articulated view of the future, using a tool called "DRIVE", short for:

Do - what do you want the solution to do?
Restrictions - what must the solution NOT do?
Investment - what resources can be invested?
Values - what values must you live by? (e.g. environmentally friendly, etc.)
Essential outcomes - what are the essential outcomes?

Step 3: "What's the Question?"

The third step frames the challenge by turning it into a question. This is accomplished through brainstorm-like techniques eliciting as many questions as possible, and then clustering, combining, and choosing the question or questions that seem most stimulating.

Step 4: "Generate Answers"

Through the use of brainstorming and other idea-generating techniques, the fourth step is designed to create a long list of possible solutions problem question. One of those solutions (or several, combined) is selected for further development.

Step 5: "Forge the Solution"

The fifth step uses a specific tool called "POWER" to develop the selected solution into something more robust. POWER is short for:

Positives - what's good about the idea?
Objections - what's bad about it?
What else? - what does it remind you of?
Enhancements - how can what's good about it be made better?
Remedies - how can the things that are bad about it be corrected?

Step 6: "Align Resources"

The final step translates the selected, developed solution into an action plan that may include, among other things:

- to do lists
- timelines and milestones
- lists of people who need to get involved
- lists of issues that need further work

B5. ARIZ (Algorithm of Inventive Problems Solving) TRIZ based inventive problem solving techniques

Algorithm of inventive problem solving (ARIZ) is a part of theory of inventive problem solving (TRIZ) developed by G. Altshuller. ARIZ consists of a program (sequence of actions) for the exposure and solution of contradictions, i.e., the solution of problems. It includes: the program itself, information support supplied by the knowledge base, and methods for the control of psychological factors, which are a component part of the methods for developing a creative imagination.

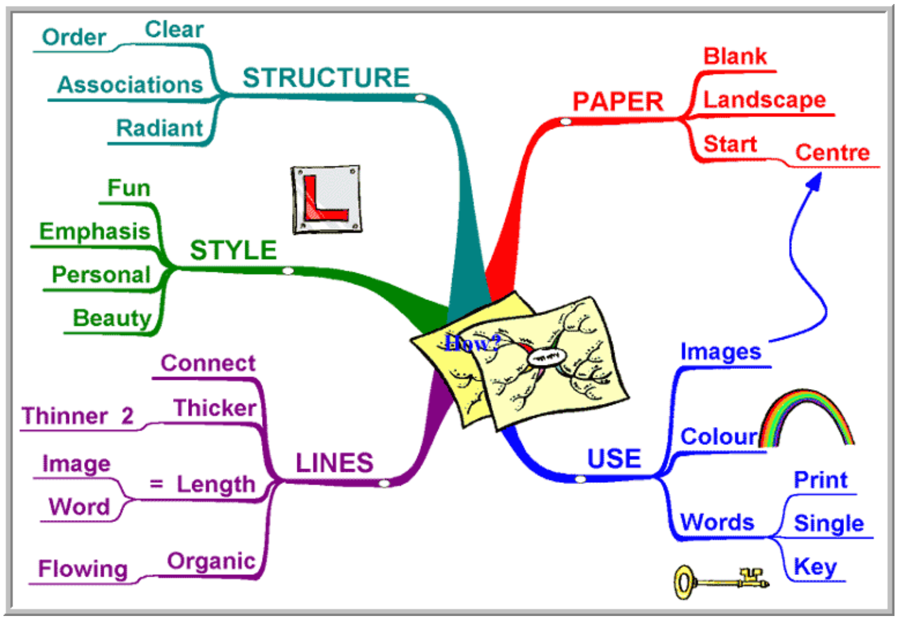
The ARIZ program consists of a sequence of operations for the following operations: exposure and solution of contradictions (see the basic sequence of ARIZ); analysis of the initial situation and selection of the problem to be solved; synthesis of the solution; analysis of the received solutions and selection of the best variant; development of received solutions; collection of the best solutions and summarization of this material for the improvement of methods for solving other problems. The structure of the program and the laws for its implementation are based on the laws and regularities of technological development.

Information support is supplied from the knowledge base, which includes a system of standards for the solution of inventive problems; engineering effects (physical, chemical, biological, mathematical, and particularly geometric – the most developed effect at the present day); techniques for the elimination of contradictions (inventive principles); methods for the application of resources of nature and technology.

Methods for the control of psychological factors are necessary as a result of the fact that the program ARIZ is not intended for computers and that problems are not solved automatically, but with the help of a human being. Therefore, the problem solver often exhibits psychological inertia, and it is necessary to control this. Furthermore, these methods allow one to develop the creative imagination necessary for the solution of complicated inventive problems.

Cf. with other TRIZ based techniques **Systematic Inventive Thinking (SIT)** derived from the original ARIZ Same underlying assumption innovative solutions share common patterns. These patterns can be translated into a set of mechanisms for which thinking tools help to generate new creative ideas. SIT is simpler uses a minimal set of (six basic) principles and (five) thinking tools

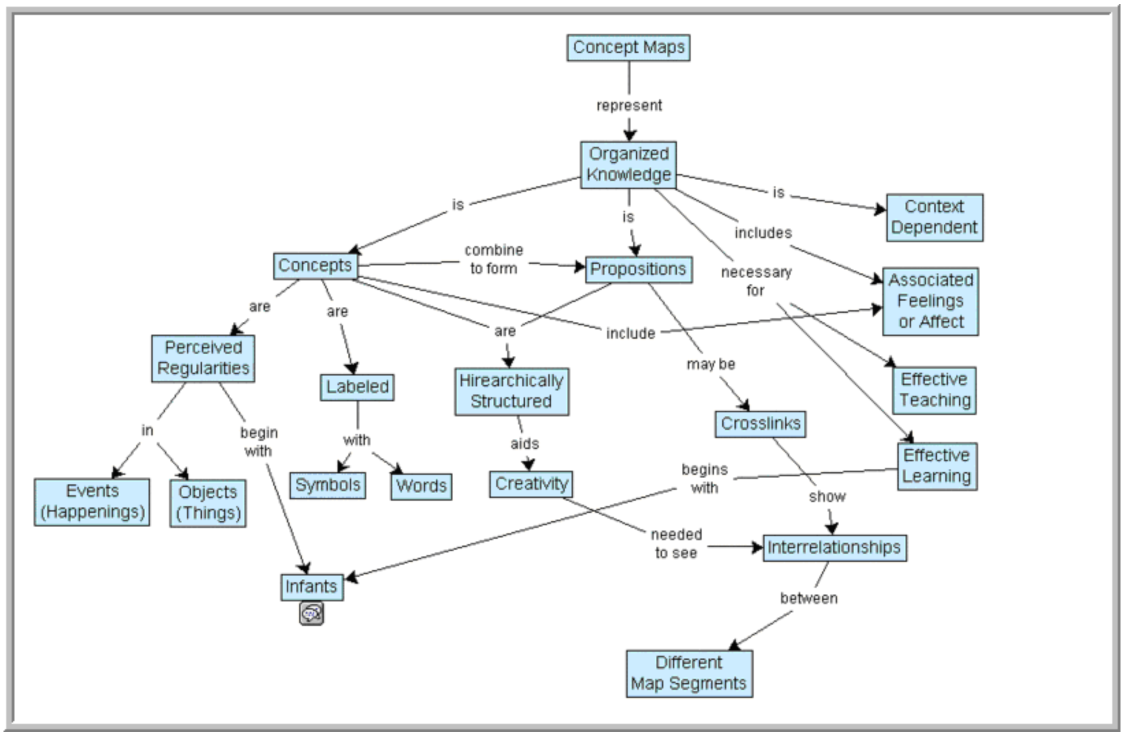
B.6 Concept & mindmapping



An example of a mind map

The concept map has as a scope to analyze a main concept and to describe the relation of it with other sub-concepts by plotting in a paper.
The components of a concept map are:
Main Concept: is the scope of the instruction around of which is going to be designed the concept map. This idea is written in a frame.
Sub-Concept: a concept that is in direct relation with the main idea.
Concept of Detail: it describes the concept
Connections: are the lines that connect the concepts
In the beginning of using this learning strategy, the teacher presents a concept map to the students and he describes its components. Then he may introduce a new subject to his class, by designing the corresponding map with the help of his students, on the board.
In general, this learning strategy may be used by the teacher during the teaching of a new entity, for finding out what are the knowledge that learners already have for a subject or for evaluating the learners and by the students for keeping notes during the lesson.
There are two kinds of map: the concept map and the mind map. The difference between them is that a mind map has only one concept while a concept map may have more. So usually a mind map takes the form of a star or a tree and a concept map looks like a network. The connections between the ideas are described with words that are

written over the connection lines, so a concept map is easily read. A mind map is more personal as the designer may use all his creativity and imagination but has the disadvantage that is hardly understood by the others.



An example of a concept map

B.7 Disney method.

A technique was developed by Robert Dilts, NLP pioneer inspired by the way Walt Disney successfully turned his fantasies into reality. The strategy separates the roles in the imagination process

1) The Dreamer: the visionary producing the big picture: no boundaries, limitations or restraints. The dreamer position typically uses the visual representation. Key question "What do I really want, in an ideal world"

2) The Realist: plans are organised, and evaluated to determine what is realistic. Process consists of constructive thinking, action planning. Establish time frame and milestones to measure progress. Estimating that actions can be initiated, maintained by appropriate persons/groups. Key question: "What will I do to make these plans a reality?"

3) The Critic: testing of the plan, looking for problems, difficulties and unintended consequences. In this role one thinks of what could go wrong, what is missing, of intended and unintended spins-offs. The critic evaluate i.e., something more than pointing at what goes wrong Key question; what will happen, what could go wrong, what might happen?

Example of collaboration and creativity strategies in a knowledge co- construction environment.

ACE forum, *environment for augmentation of collaborative knowledge elicitation and collaboration*

Example of an on line learning environment to support knowledge creation for multidisciplinary distributed teams. The environment was developed to offer flexible learner support by appropriate recommendations in combination with functionalities enabling articulation in open formats. These include a mind mapping tool to support initial associations, text notes with structure fields and meta-tagging options for incremental formalization, as well a synthesis messages to support overview and voting mechanisms to prioritize generated ideas.

Based on existing theoretical insight on knowledge creation tooling was designed to freely articulate ideas, enrich knowledge artefacts with tagging and options for incremental formalization of created artefacts. Tagging enables filtering and multiple views on artefacts. Per phase dedicated recommendations (i.e., hints) support learning, knowledge communication and problem solving. The suggestions include stimuli to a check comprehension of ideas after articulation. Suggestions to do so without criticizing asking first for clarification and methods to give each idea a fair change. A recommendation in this context includes the advice to "check and complete the ideas of peers by mirroring your interpretation" All suggestions are offered in combination with expression of the rationale of the recommendation and its added value one might expect.

The presentation of the recommendation depends on its nature. Options are among others a schema or checklist, like for example:

- Articulate your ideas as clearly as possible.
- Underpin your idea with arguments, data and evidence.
- Define what you know, you don't know yet, or need to know.
- Read all messages of your peers.
- Don't judge. Don't condemn ideas.
- Test your comprehension of each idea.

- Mirror your interpretation by asking open questions.
- Answer all questions on your contributions.
- Summarize the ideas of your discussion threads.
- Note and cluster shared perspectives. Also note: different perspectives.

Enablers affording these actions are: structure fields, meta-tagging options, synthesis messages, dialogues in the workspace and separate chat for social and coordinative actions.

7. Conclusions

It is well known that optimal use of the creative potential of multidisciplinary teams for the creation of new products has become crucial to today's enterprises. In a situation of the urgently felt need for creative productivity and problematic innovation practices the *idSpace* project aims to develop a web based collaborative environment to support multidisciplinary teams who work on innovative product design. *IdSpace* wants to help its users "to be (come) more creative" by learning "to be collaborative creative" in new product development. It supports effective collaboration and learns to integrate available knowledge into new product propositions.

The question addressed in this deliverable was to produce a review of available knowledge and strategies on how to stimulate creativity in collaborative product design as well as to identify inhibiting factors to creative performance. The investigation was guided by the notion that review and factors have to be taken into account for the design of pedagogical support strategies for the *idSpace* environment.

We started this state of art review by defining the objectives of *idSpace* pedagogical support. Its context, the field of NPD, new product development, the overarching innovation process and the moment of invention. In this context, the *idSpace* project focuses on the creative phases of the innovation process. The phase of ideation: of generation and evaluation of new ideas. The project envisages to provide distributed team members with dedicated learning support to facilitate and expand a team's creative capacity.

We noticed that learning in *IdSpace* context consist of a team's knowledge development via collaborative creation of new knowledge for new products. Product developers have to learn to act creatively using creativity techniques, learn from each other and collaborate to achieve the collective result. The outcome is a new product design, to be produced and brought to market.

The focus of supportive action is on the team's collaborative creativity in product design. Attention focuses on the product development stages where ideas are generated, evaluated and integrated in a new product proposition. Further development and implementation are out of the project's scope.

The learning that takes place in *idSpace* involves a particular form of problem solving and collaborative construction of new knowledge. Therefore we reviewed creativity theories in order to capture the essential features of creative knowledge development compared to regular, more "routine" oriented problem solving learning activities.

Inspired by the vision on creativity of scientists such as Boden, Amabile and Johnson-Laird, we see as essential characteristics of creativity in new product design, the "novelty" dimension in combination with "recognition", i.e. the recognition of usefulness of the "novelty" by the surrounding developers and target community. The novelty of the creative act in product development can be typified as in essence a non-deterministic process, aimed at a physical product and thus guided by constraints based on existing elements. Both its original, non-deterministic character and the fact that collaborative learning takes place as part of work put very specific requirements to the learning support to be offered by *idSpace.*

The fact that learning process and outcomes are not predictable and exploration of novelty requires risk taking and failure acceptance implies that *idSpace* learning is not helped by traditional prescriptives. Support that concentrates on collaboration support, articulation and knowledge communication, plus effective use of creativity techniques is required.

Guiding principles for composition of *idSpace* recommendations are derived from what we know of facilitation of knowledge processes in creative collaboration. The support strategy may be divided in two strands, one of active, guidance-providing, dedicated advice to NPD team suggesting which learning activities, creativity methods, ways of expression and collaboration will help in their situation at that moment in time; the other of supportive action consisting of advice on the creation of affording circumstances in which creativity will blossom.

Review of existing research indicates that diverse aspects of context, team and person have to be taken into account. Support of learning at work should recognize the constraints of the workplace and primacy of performance. Learning isn't perceived as "learning" but as "part of the job". Research on collaborative teamwork indicated the importance of heterogeneity in team composition, and of providing goal clarity across the co-creative process. Yet other theories showed how guidance might help a team to get in a positive “flow”, and how specific support helps (“scaffolds”) the team to move beyond their actual capability and expand it with the help of good recommendations.

Thus it became clear that support requires careful adaptation to the specific circumstances of the team. Customized support for *idSpace* will consists of “composed” recommendations. They will use available knowledge on creativity enhancement in combination with awareness information on the actual state of the team and design process. Based on results obtained by work package 3, *idSpace* will be able to compose recommendations tailored to time, task and team characteristics and based on awareness input gained from other components of *idSpace.* Thus recommendations might offer suggestions to use various forms of exploration, articulate ideas in free visual formats, take time for new iterations, create time and space for surprise. Support might also spots opportunities for creativity enhancement to its users suggesting the use of specific creativity methods which proved to be helpful in similar circumstances. The review presented some examples of this type of creativity support in educational settings.

Finally, we searched for concrete suggestions for creativity support based on existing theories of group creativity and of collaborative work and learning. The survey of research across the domains of creativity studies (Nickerson), computer supported collaborative learning and work (Bereiter & Scardamalia, 2003; 2006; Stahl, 2005), product design (N.Cross) and IT tools for creativity (Sneidermanm c.s.) provided specific suggestions relevant for the design of *idSpace* guidance:

- Build on the availability domain and creativity competences. (Amabile, Boden, Nickerson,)
- Support intrinsic motivation (Amabile, Boden,Nickerson)
- Stimulate engagement in deep inquiry (Bereiter & Scardamalia)
- Sustain “improvement” efforts. Guide the expansive inquiry to achieve higher levels of concepts and deeper understanding. Support the exploration of the Zone of proximal development (Bereiter & Scardamalia, Bitter-Rijpkema,)
- Take all relevant dimensions into account. The Four’ P’s of Rhodes: person, process, project and press. And the components of Amabile & Boden: domain knowledge, creativity thinking skills, motivation and social context

- Recognize the specific requirements of learning at work (Billett)
- Recognize the creative potential of heterogeneity in teams
- Establish and maintain purpose and intention during creative collaboration (Bereiter & Scardamalia)
- Support exploration (Boden, Sneidermann), combination and transformation learning (Boden) afford "many path many styles" (Sneidermann)
- Enable articulation of shared perspectives or negotiated conventions by building collective artefacts (Stahl)
- Provide support in a way that it connects to existing cognitive structures of the users. Trigger and help participants to move beyond the "least effort" associations to more remote associations (Finke, least effort theory)
- Facilitate interaction, open communication, interchange of ideas creative knowledge building, which implies sharing and discourse (Bereiter & Scardamalia, Sneidermann)
- Facilitate articulation of ideas and provide flexible tools to transform and preserve ideas as they evolve (Bitter-Rijpkema, Stahl)
- Support interactive collaboration, reciprocity and a collective responsibility for the team's emergent knowledge i.o. Include awareness functionalities on status, available knowledge resources, tools and peer activities (Bereiter & Scardamalia, Nickerson, Stahl)
- Provide explicit guidance or structure when needed but let it fade away once participants are self supporting and have internalized the advice (Stahl)
- Support the iterative nature of creative exploration (Nickerson, Sneidermann)
- Teach appropriate creativity techniques and strategies when needed (Nickerson)
- Encourage confidence and reward risk taking (Nickerson, Sneidermann)
- Creating support types that "you would want to use yourself" (Sneidermann).

It is this combination of insight into the theoretical foundations of creativity enhancement for new product development and rather specific guidelines derived from our state of art across various disciplines that provide us with input for a well-grounded design of adaptable scenarios for *idSpace* in the next deliverable.

Appendix 1 Stages of Creativity and New Product Design

Creativity project phases											
	1	2	2	4	5	6	7	8	9	10	11
Parnes	Initial scan	Gather data /facts	Define problem	Gene-rate solu-tions	Evaluate solutions	Plan action	Gain accep-tance	Take action & develop	Implem ent	Disse-minate	Evalu-ate & learn
Amabile	Prepara-tion	>	Problem +task identific ation	Res-ponse genera-tion	Res-ponse validated		commu nication	outcome	>>		
Basadur	Problem finding	Fact finding	Problem defining	Idea finding	Evalua-tion +selec-tion	Action plan-ning	Gaining accep-tance	Taking action			
CPS creative problem solving / Parnes Isaksen & Trefflinger	Mess finding	Data finding	Problem finding	Idea finding	Solution finding	Accept ance finding	>				
Value chain perspective, Hansen & Birkinshaw				Idea genera-tion in-house idea creation Cross-pollina-tion of ideas across units External collabo-ration on ideas with parties outside the firm	Conver-sion selection of ideas through scree-ning and provision of initial funding	Develo pment of ideas - moving from idea to result				Diffusion Disse-minate across organi-zations Measure success)	

Runco		Orientation data gathering	"incubation," consists of defining the problem and seeking a solution	Illumination," the third stage, is marked by divergent thinking, openness	, "verification," the individual evaluates his own work and compares it with what is known in the field.		Communication			validation	
Imagination, 7 step model of creative thinking Osborn	Orientation: pointing up the problem	Preparation: gathering pertinent data	Ideation: piling up alternatives	Incubation: letting up invite illumination	Synthesis: putting the pieces together Evaluation: judging the resulting ideas						
Schmid	Problem recognition/ problem identification	Search for knowledge Activation of knowledge		Restructuring of knowledge	Evaluation						
TRIZ			Solution generation	Solution evaluation							
Tidd	scan		strategy		resource			Implement	Learn		
Trompenaars	scoping					Development/ testing validation		Launch			
Wallas	Preparation	>	>	Incubation Illumination	Verification						

Appendix 2 Related EU-projects

COLLABORATION 4 INNOVATION A study on Collaborative Work: Productivity, Creativity and Innovation Impacts and Implications. The research analyzes emerging new working structures, focusing on the impact of eCollaboration on innovation processes, creativity and productivity. The main question is, What factors in eCollaborating teams, tools and the context explain a positive or a negative impact on innovation, creativity and productivity? While innovation has been a hot topic for some time, little research has gone towards explaining the role of eCollaboration in the innovation process. This study looked at the issues on a global scale, and brings the findings and the insights to the best practices to the European context. It yielded practical results and recommendations, applicable in organisations seeking to increase their rate of successful innovation. Adapted from: http://www.cdt.ltu.se/~zcivi

IMP³rove project, The European Platform for Innovation Management for Small and Medium Enterprises (SMEs). This project is to boost innovation management capabilities for SMEs within 27 countries. The project helps SMEs to improve the returns that they get from developing new services, products or work practices. It helps consultant firms to benefit from a good practice innovation management evaluation approach and to expand the range of services they offer clients. The project offers a benchmarking report on how the company performs against the best and average in its industry, region or across Europe. It gives personal feed-back via an interview with an expert with improvement suggestion, and offers Consultant advice. The website provides access to helpful information and resources on Innovation Management Training in use of the online tools.

- Website: http://www.improve-innovation.eu/

KP-Lab focuses on creating a learning system aimed at facilitating innovative practices of sharing, creating and working with knowledge in education and workplaces. The project promotes co-evolution of individual, collective and organizational learning with technology through developing the Knowledge-practices Laboratory (KP-Lab). Website: http://www.kp-lab.org/

CReATE aims to link European players from research, business and the public sector and to develop a joint research agenda. Partners from four European regions have joined forces in a strong network:. Special focus on small- and medium-sized companies the CReATE project consortium has been developing strategies to enhance the innovative capabilities of the creative sector and to improve cooperation on the regional and European level. Creating a Joint Research Agenda for promoting ICT-Innovations in Creative Industries across Europe
Website: http://www.lets-create.eu/2185.html?&L=5

The ECCE network provides business consultancy, financial advice, information and training for small businesses, entrepreneurs and individuals in the cultural and creative sector. These services are available via local resources centres operating in the cities of the ECCE network: Nantes, Rennes, Angers in France, Aachen in Germany, Eindhoven and Utrecht in Holland and CIDA in Huddersfield, UK. The ECCE network seeks to promote cultural and creative SMEs and encourage employment and economic growth in this sector. The name ECCE stands for developing *Economic Clusters of Cultural Enterprises.*

Website: http://www.connectedcreatives.eu/ecce/cEN18_ECCE.aspx

Trends project :
TRENDS integrates images from the web, let you retrieve images corresponding to a high-level expression of your need, provides tools to analyze these images and reveal visual trends for design and let the designers extract the essential information from the current product trends. Colours, texture, shape, can then be integrated into a design project. The TRENDS system is the output of a collaboration between research and industrial partners. This system answers several needs of the designers' pointed out by the project team :

- gathering information in order to find inspiration in visual content
- proposing up-to-date and targeted content
- following a both rational and creative methodology for expressing visual trends
- specific tools to extract trends from visual materials.

Website: http://www.trendsproject.org/

I-MAESTRO stands for Interactive Multimedia Environment for Technology Enhanced Music Education and Creative Collaborative Composition and Performance. The i-Maestro project is studying and exploring many aspects of music making in order to produce methods and tools for music education with innovative pedagogical paradigms, taking into account key factors such as expressivity, interactivity, gesture controllability and cooperative-work among participants.
Website: http://www.i-maestro.org/

The PIM project aims "facilitating the adaptation of industrial changes" through the development of a technological infrastructure enabling e collaboration among small and medium enterprises (SMEs).
Website: http://www.pim-project.com/

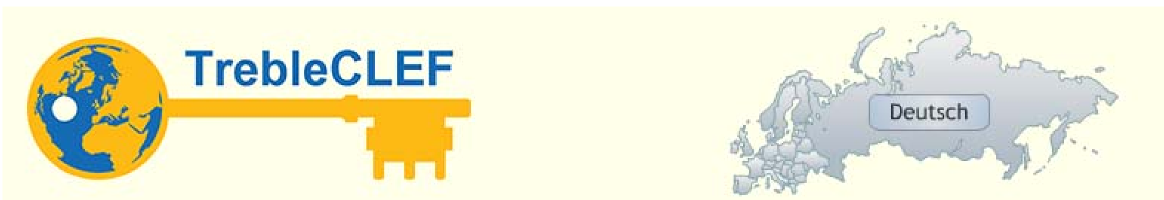
LTFLL The objective of the LTfLL(Language technology for lifelong learning) project is to create next-generation support services to enhance competence building and knowledge creation in educational and organizational settings. The services run (semi) automatically to avoid aggravating the workload of tutors.
Website: http://www.ltfll-project.org/

MATURE The agility of organizations has become the critical success factor for competitiveness and requires that companies and their employees together and mutually dependently learn and develop their competencies efficiently. Failures of organization-driven approaches to technology-enhanced learning and the success of community-driven approaches in the spirit of Web 2.0 have shown that for that agility we need to leverage the intrinsic motivation of employees to engage in collaborative learning activities, and combine it with a new form of organisational guidance. For that purpose, MATURE conceives individual learning processes to be interlinked (the output of one learning process is input to the other) in a knowledge-maturing process in which knowledge changes in nature. This knowledge can take the form of classical content in varying degrees of maturity, but also involves tasks and processes or semantic structures. The goal of

MATURE is to understand this maturing process better, and to build tools and services to reduce maturing barriers
Website: http://mature-ip.eu/en/start

GRAPPLE: Generic responsive adaptive personalized learning environment. The GRAPPLE project aims at delivering to learners a technology-enhanced learning (TEL) environment that guides them through a life-long learning experience, automatically adapting to personal preferences, prior knowledge, skills and competences, learning goals and the personal or social context in which the learning takes place. The same TEL environment can be used/accessed at home, school, work or on the move (using mobile/handheld devices). GRAPPLE will include authoring tools that enable educators to provide adaptive learning material to the learners, including adaptive interactive components (visualizations, simulations, virtual reality). Authoring includes creating or importing content, assigning or extracting meaning from that content, designing learning activities and defining pedagogical properties of and adaptation strategies for the content and activities. To ensure the wide adoption of adaptation in TEL GRAPPLE will work with Open Source and commercial learning management system (LMS) developers to incorporate the generic GRAPPLE functionality in LMSs. Evaluation experiments in higher education and in industry will be performed to verify the usability of the GRAPPLE environment (for authoring and delivery) and to verify the benefits of using adaptive TEL for the learning outcome.
Website: http://www.grapple-project.org/

SCY Science Created by You (SCY) will deliver a system for constructive and productive learning of science and technology. SCY uses a flexible and adaptive pedagogical approach to learning based on "emerging learning objects" (ELOs) that are created by learners. SCY-Lab (the SCY learning system) students work individually and collaboratively on "missions" which are guided by a general socio-scientific question (for example "how can we produce healthier milk?") and fulfilling the mission requires a combination of knowledge from different domains (e.g., physics and mathematics, or biology and engineering).
Website: http://www.scy-net.eu/



TREBLE-CLEF: TrebleCLEF supports the development and consolidation of expertise in the multidisciplinary research area of multilingual information access (MLIA) and disseminates this knowhow to the application communities through a set of complementary activities, with the following objectives:
To promote high standards of evaluation in MLIA systems using three approaches: test collections; user evaluation; and log file analysis.
To sustain a MLIA evaluation community by organizing annual evaluation campaigns and providing high quality access to past evaluation results
To disseminate knowhow, tools, resources and best practice guidelines, enabling system developers to make content and knowledge accessible, usable and exploitable over time, over media and over language boundaries.
Website: http://www.trebleclef.eu/

U-create, Creative Authoring Tools for Edutainment Applications, U-CREATE has been initiated by three SMEs which are primarily active in the field of edutainment, i.e. the joining of education and entertainment (customers are museums, cultural institutions, entertainment parks…) They share a common and important problem: efficient content creation.
Be it interactive setups, Mixed Reality experiences, location-based services, all these technologies are worthless without content: content is always to be tackled or delivered at the same time as technology. However, content creation is a long process that can hamper cost and time factors when implementing large-scale projects.
Website: http://www.u-create.org

EVaN - European Value Network EVAN

EVAN: European Value Network

The EVaN research project aims to improve the ability of European SMEs to compete internationally thanks to the development of value-intensive products. The basic concept is to focus on local networks of actors to preserve the concept of networks while providing them with the additional capabilities to broaden the scope of their actions. In other words, to transform these local networks into European Value Networks. More specifically, the project aims to:

1. Understand the best practices related to the development of value-intensive products of internationally successful European SMEs operating in the furniture industry;

2. Design methods and tools that support the development of value-intensive products. The aim is to create a set of tools and methods that aid the local network of actors to become European Value Networks;
3. Test the methodology in selected pilot cases;
4. Support the EU in developing a vision and a framework for actions at the European level based on the concept of value-intensive products and value- intensive international competition.

Website: http://www.evanonline.com/Default.htm

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