MIKKO AHONEN

Designing an Information System for Open Innovation

Bridging the Gap between Individual and Organisational Creativity

ACADEMIC DISSERTATION
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"Discovery consists of seeing what everybody has seen
and thinking what nobody has thought."
Albert Szent-Györgyi (1893 - 1986)

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Abstract

History shows that those companies that continue to invest in their innovative capabilities during tough economic times are often those that prosper when growth returns. Recently, information systems (IS) have been harnessed to support innovation. Even with IS support, innovation campaigns and suggestion management systems often end up in failure. Employees and customers are reluctant to share their best ideas. Individuals' interests, motivation, creativity and life-long learning are seldom adequately supported by companies. In the information systems research area there is very little research on creativity and creativity has traditionally been studied mainly within the decision support systems (DSS) research area. This DSS area has focused on rather mechanistic idea-generation processes lacking a focus on individuals and their creativity. Even in the emerging open innovation paradigm, individual and group levels have come in for little research. From these starting points, we became interested in ways to improve existing information systems and innovation practices.

The research question here is: How to design an artefact to support learning and creativity within the open innovation paradigm. Since we are interested in building new artefacts, we will utilise design research methods, particularly the Design Science Research Methodology (DSRM) process model.

Our three artefacts are the results of our work. The first artefact, the Mobile Personal Development Plan, is focused on extending development talks between an employer and employees within human resource management to support innovation. Curiosity and emerging interests are seen here as idea seeds and future competences. The second artefact, the iPortfolio, extends this with a life-long learning and problem-solving focus. The third artefact, the Brokering Platform for Open Innovation, finally focuses on collaboration with customers and crowds. The software development was time consuming in our work and only the first artefact is demonstrated as a functional software prototype. Our pilot in an SME company illustrates practical requirements and usability issues related to the software. Additionally, a Delphi study with international open innovation experts served to identify future related requirements. Given the lack of creativity research in the IS field, we claim that our work makes an appropriate contribution. To the design research literature our input is new usage cases of the previously mentioned DSRM process model. Our results apply to organisations, where the employees work in dispersed teams and need an information system to communicate their emerging ideas and interests for more systematic problem-solving. The managers in our study reported that there are plenty of ideas available, but the challenge is to ensure the commitment of external resources to the actual innovation building. The integration of learning into the innovation and problem-solving activity should be motivational. We therefore discuss human resource management in relation to creativity and innovation. Surprisingly, in our pilots we noticed difficulties in time management in mobile settings and the current health risk debate gradually changed our artefact design, so this work also provides a critical view on mobility and on the access anytime, anywhere phenomenon. Finally, we suggest improvements to existing innovation practices in organisations.

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1. INTRODUCTION

An information system can be a competitive factor for companies when they are pursuing innovation and creativity. In the early 90's Couger, Higgins and McIntyre (1993) made a literature review of creativity in information systems (IS) organisations and found less than 10 research papers on this topic. Currently, in 2010, the number of research papers of this topic has not radically changed, in their literature reviews (Dean, Hender, Rodgers and Santanen, 2006; Farooq, Carrol and Ganoe, 2006) indicate that creativity in information systems research is still an unknown topic and worth investigating.

Creativity within information systems research has been discussed in connection with creative problem solving techniques (Couger, 1996); brainstorming efficiency (Dennis, Aronson, Heninger and Walker, 1999); suggestion management (Stenmark, 2002) and idea evaluation (Dean *et al.*, 2006). Within the information systems (IS) research field, creativity has been mostly studied in connection to Decision Support Systems (DSS). The integration of creativity support within DSS, theoretically, can enhance the quality and efficiency of the decision-making support, create synergistic effects, and augment decision-making performance and value (Forgionne and Newman, 2007; Marakas, 2003; Nunamaker, 1997).

According to Gartner (2002) tools and information systems can only support the innovation process and do not themselves create or drive creativity. Innovation processes are highly dependent on human activity and are low on repeatability, structure and predictable outcomes. Thus, innovation and human resource processes are less adaptable to automation than other business processes (Kossek, Young, Gash and Nichol, 1994). In daily practice, information systems are often used for idea competitions and suggestion management. Although research has shown that suggestion management systems can be a useful way to obtain and utilise employees' creative ideas, effective suggestion management systems must also motivate employees to think creatively and to participate in the suggestion process (Fairbank, Spangler and Williams, 2003, 305). Noteworthy here is that an information system itself cannot motivate employees. Laursen and Foss (2003) claim that new human resource practices can impact the innovation performance of companies. Quite surprisingly, the information systems literature involves a very limited number of research papers (Stenmark, 2002; Leede and Looise, 2005) linking creativity to human resource development, especially to development talks and performance review.

Research has also indicated conflicts and discontinuities. Hargadon and Bechky (2006) address the discontinuity between innovation literature and creativity literature, the former being focused on the processes while the latter being focused on people. Information systems literature has actively focused on processes (see for example Dennis *et al.*, 1999). Regarding creativity, McAdam (2004, 697) points out: the idea generation literature and practice must address the underlying sources of knowledge creation before methods and techniques are devised. Li and Kettinger (2006) see that the whole IS field has had difficulties understanding the evolutionary nature of knowledge. There is very little research on using IS on systematic development of ideas to the level of innovation.

Additionally, Iivari (2007) has criticised the overemphasis on business requirements in information systems research, with limited focus on individuals and their requirements. For these reasons, we will illustrate how our artefacts could support creativity on individual, group and organisational levels. Beckman and Barry (2007) have demonstrated that there is a limited amount of literature about both learning and innovation processes. In the practice, too, these rarely intertwined elements are valued. When Maula (2001) studied the transformation process in a global company, she noticed the aims to develop the following *four abilities* among leaders and employees: 1. Self-awareness, self-esteem, 2. Self-regulation, self-management, 3. Creativity and innovation, 4. Social competence, the capability to relate to other people, to get contact with people, to solve problems, and to contribute to the environment. These findings illustrate that innovation activity in a company requires intrinsic motivation, learning, human resource management and social networking emphasis, which will be addressed in our artefact building.

Since a human being has only limited capacity to recognise and memorise, we see that collaboration and the use of IT is becoming essential. The challenge for IT artefacts is to support multi-contextuality (Henfridsson and Lindgren, 2005) and different levels of mobility (Luff and Heath, 1998; Perry, O'Hara, Sellen, Brown and Harper, 2001). Our approach will provide a complementary view on innovation since the open innovation related research has mostly focused on the organisational levels of analysis, lacking individual and group level analysis (West, Vanhaverbeke and Chesbrough, 2006, 149). Open innovation is a way for firms to access sources of knowledge outside the firm, and to develop and diffuse knowledge produced within the firm (Chesbrough, 2003). Additionally, the absorptive capacity, the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends is becoming critical to its innovative capabilities (Cohen and Levinthal, 1990). Often this absorptive capacity is associated with brokering and brokers (Hargadon and Sutton, 1997). This brokering activity needs special kind of tools which will be illustrated.

Work with our pilot company demonstrates that individuals and groups request problem-finding and note taking tools to enable continuous learning and capture of external ideas. In our previous research projects we have studied blogs, wikis and the Web 2.0 phenomenon. These tools are often personal in nature and utilised in a bottom-up manner (Tapscott and Williams, 2006). These tools can also be mobile and ubiquitous, seedling ideas to be collected and recorded in various formats (text, image, audio, video) in various context (work, home, travel, online, offline). Our artefact design work demonstrates the challenges in implementing these elements within an information system. The current health risk debate (The INTERPHONE Study Group, 2010) also influenced the design of our mobile components.

Our research is design-oriented: "Whereas natural sciences and social sciences try to understand reality, design science attempts to create things that serve human purposes" (Simon, 1981, 55). Within information systems research the design research is called design science (Nunamaker, Chen and Purdin, 1991; Walls, Widmeyer and El Sawy, 1992; March and Smith, 1995; Hevner, March, Park and Ram, 2004). Lately, Kuechler and Vaishnavi (2008) have pointed out differences in design research and design science, preferring a more neutral name: Information Systems Design Research.

When Arnott and Pervan (2008) made a comprehensive literature review of current DSS literature, they saw that most DSS research is disconnected from practice. Additionally they pointed out: "design science research, when is properly grounded in relevant high-quality theory, has the potential to achieve the deeper concept of relevance associated with reshaping professionals ideas." (Arnott and Pervan, 2008, 668). In addition to theories, design science research may include social innovations or new properties of technical, social, or informational resources (Järvinen, 2007a).

Since we have interest in designing and building, we decide to utilise a design research methodology. Our research question is: How to design an artefact to support learning and creativity within the open innovation paradigm. We choose to start building our own artefact, since the existing artefacts (like the MindPool from Stenmark (2002) and the Creativity enhancing Decision Making Support System (CDMSS) from Forgionne and Newman (2006)) are lacking a clear connection between individual creativity and organisational human resource development. All our artefacts are described using the Design Science Research Methodology (DSRM) of Peffers, Tuunanen, Rotherberger and Chatterjee (2008). The following phases are covered in this design work: 1) Identify problems and motivate, 2) Define the objectives for a solution, 3) Design and development, 4) Demonstration, 5) Evaluation, 6) Communication (Peffers *et al*., 2008).

The outcomes of our design work manifest as artefacts. Eventually, we built altogether three artefacts. Our first artefact is the Mobile Personal Development Plan (PDP) which is related to the human resource management (HRM) process and practically to development talks. As one motivator for our design work, Lindgren, Henfridsson and Schulze (2004) point out that competence management systems often fail to support creativity, evolving interests and motivations of employees. This was the starting point for our design work. This artefact integrates ideating, problem-finding, learning in the experiential learning cycle of Kolb (1984). The intention is to create a close connection between the innovation and HRM practices in a company. The artefact was functional and was piloted as software in a case company.

The second artefact is the iPortfolio which supports observing, learning, problem-finding and reflecting during a longer time period. Unlike financial and patent portfolios, the focus here is on supporting time and task management between several, long-lasting idea projects. This artefact is related to ePortfolios from educational world. Therefore, our second artefact is built to support intrinsic motivation (Amabile, 1983; Amabile *et al*., 1996) and informal learning (Marsick and Watkins, 1997) in the innovation process.

The innovation process as a learning model suggests that teams should be composed of individuals who are polar opposites in how they take in and transform information. Some take in information through symbolic representation or abstract conceptualization, while others take it in through direct sensation. (Beckman and Barry, 2007). Supporting different learning styles is a challenge and it is not extensively discussed in our work. The second artefact, the iPortfolio, was not fully functional; it was only demonstrated in the case company.

Our third artefact, the Brokering Platform for Open Innovation, is intended to support the scanning of ideas, absorbing them and collaborating. Lately the focus in the innovation discussion has turned from employees to customers and lead users (von Hippel, 2005) and their collective input in the innovation process. Research and development (R&D) activity is extended to utilise the knowledge and design skills of customers, even competitors. Brokers are those companies and individuals who act as mediators between different organisations and groups. Ideas are transmitted and nurtured by brokers (Hargadon and Sutton, 1997; Allen and Cohen, 1969). Within Open Innovation (Chesbrough, 2003) brokers are called intermediaries. There are even companies which act as innovation intermediaries like InnoCentive (http://www.innocentive.com) which utilises the wisdom of crowds and brokers to solve problems for companies all over the world (Tapscott and Williams, 2006). However, these intermediaries do not necessarily help individuals in companies to develop their expertise in innovating or help in recognising external ideas for innovation purposes. Thus, companies still need their research and development (R&D) activity although its role is changing towards brokering and learning (Chesbrough, 2006a). This scanning and recognising of external ideas is the ultimate goal for our third artefact, the Brokering Platform for Open Innovation. We were fortunate to have a group of international open innovation experts to participate in our study, using the Delphi method (Dalkey, 1969). The third artefact remained as a concept and was not implemented as a functional software prototype.

In addition to artefacts, our results will contain improved models and design rules (van Aken, 2004). According to Hevner *et al.* (2004, 82) the result of design-science research in IS is, by definition, a purposeful IT artefact created to address an important organisational problem. For this reason, we also collected organisational problems from our case company as well as from open innovation experts through the Delphi study.

Origin of our research idea: This PhD research work has started from our observations of shortcomings in the innovation and knowledge management processes in our earlier research contracts in a Finnish and in an American company. We have been interested in motives and interests of employees who participate in the official innovation process of a company. When conducting knowledge management research in Dallas, USA (Ahonen, 2002), our finding was that employees, teams and managers could not support each others' interests and related creativity, because they did not know enough about each others' interests and the interest (curiosity) expression was difficult within the formal innovation process. Similarly, those information systems intended to facilitate innovation were inflexible at that time and provided hardly any personal incentive to use them. During the period 2001-2005 we worked on two projects focused on mobility and learning (EU IST MOBIlearn and Tekes Digital Learning).

This work led to a better understanding of ubiquitous information systems, but at the same we realised the limitations and risks in access anyplace, anytime computing. Our pedagogical background (MSc. in Education) has made aware of the gap between innovation literature and creativity literature. Similarly, our rather unusual inclusion of ePortfolios in the information systems thesis originates from our previous work with motivational factors in learning. Recently we have worked with intermediaries, innovation marketplaces and open innovation in the Tekes Parteco research project (from 2006 to 2008). This experience has changed our perception of participation and collaboration in the innovation process.

In the following Section 2 we will describe the basic concepts and theories behind our artefacts. The design science in the information systems and the DSRM process model (Peffers *et al.*, 2008) will be described in Section 3. In Section 4 we will illustrate our artefacts with the help of the DSRM process model. Finally, Sections 5 and 6 will will include discussion and conclusions.

2. BASIC CONCEPTS

Before designing and implementing our artefacts, we will describe the theories and concepts on which they are based. By and large, we are interested how individual motivation and curiosity are associated with innovation. Therefore, we will next provide a description, how learning is associated with creativity and further on, with innovation.

2.1. Learning

According to Illeris (2002) all learning comprises three different dimensions – learning is stretched out between three poles and accordingly may be looked at and analysed from three different approaches.

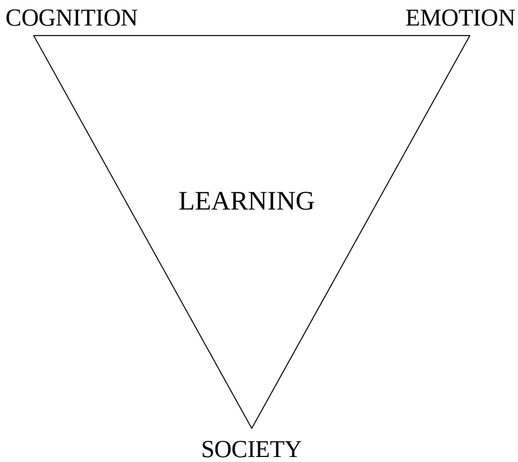

Figure 2.1. The tension field of learning (Illeris, 2002)

Firstly, *cognitive process* includes both knowledge and motor learning which traditional learning psychology has concentrated on. Secondly, learning includes the *emotional process* with psychological energy, transmitted by feelings, emotions, attitudes, and motivations. Thirdly, learning is a *social process*, taking place in the interaction between the individual and his/her surroundings. (Illeris, 2002) The following picture describes some of those thinkers and positions on this field.

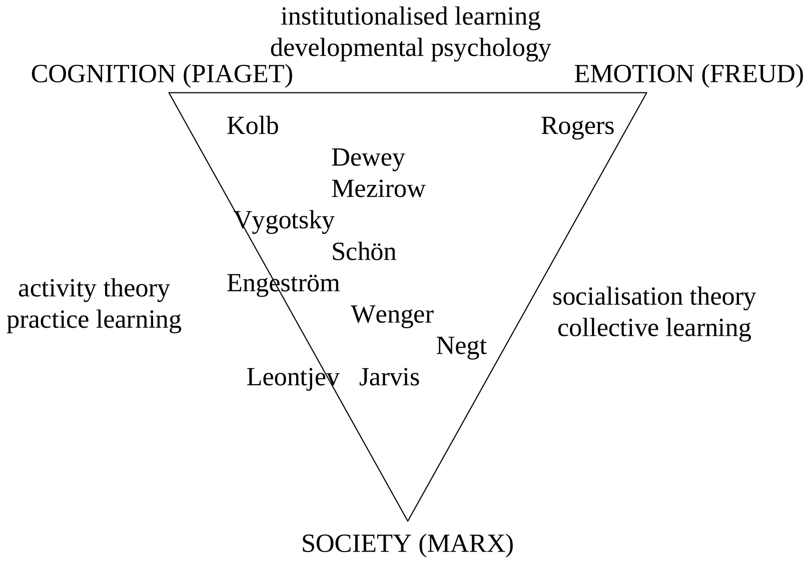

Figure 2.2. Some positions in the learning theoretical tension field (Illeris, 2002)

In learning philosophies the tension between these three dimensions of learning exists, and the representatives emphasising one of the dimensions (cognition, emotion, and society), are respectively Piaget, Freud, and Marx (Figure 2.2). Koponen (2009) sees that in Illeris' partial tension field (Figure 2.1) the institutionalised learning, between cognition and emotion corners, seems to have limitations compared with the e-learning. He sees that the e-learning may have ability to extent the learning sphere to direction of society.

Learning involves also problem-finding and problem-solving, especially in the innovation process (Cohen and Levinthal, 1990). In order to understand different stakeholders' view on learning, we will next focus on various theories of learning. According to Boud and Garrick (1999) the goal of learning is an improvement to the performance of the employee, the team and the whole organisation, the development of the sense of community in the work organisation and support for the employee's personal development, and mastery of her or his own life. Generally, behind learning theories there are at least four different orientations of learning. These orientations are introduced in the following Table 2.1 with explanations about the origin.

Aspect	Behaviourist	Cognitivist	Humanist	Social and situational
Learning theorists	Thorndike, Pavlov, Watson, Guthrie, Hull, Tolman, Skinner	Kohler, Lewin, Piaget, Ausubel, Bruner, Gagne	Maslow, Rogers	Bandura, Rotter, Lave and Wenger, Salomon
View of the learning process	Change in behaviour	Internal mental process (including insight, information processing, memory, perception	A personal act to fulfil potential.	Interaction /observation in social contexts. Movement from the periphery to the centre of a community of practice
Locus of learning	Stimuli in external environment	Internal cognitive structuring	Affective and cognitive needs	Learning is in relationship between people and environment
Purpose in education	Produce behavioural change in desired direction	Develop capacity and skills to learn better	Become self-actualized, autonomous	Full participation in communities of practice and utilisation of resources
Educator's role	Arranges environment to elicit desired response	Structures content of learning activity	Facilitates development of the whole person	Works to establish communities of practice in which conversation and participation can occur.
Manifestations in adult learning	- Behavioural objectives - Competency -based education - Skill development and training	- Cognitive development - Intelligence, learning and memory as function of age - Learning how to learn	- Andragogy - Self-directed learning	- Socialization - Social roles - Mentoring - Locus of control

Table 2.1. Learning orientations and explanations (Merriam and Caffarella, 1991, 138)

Merriam and Caffarella explain Table 2.1: “Behaviorist define learning as a change in behaviour. The focus of their research is overt behaviour, which is a measurable response to stimuli in the environment. The role of the teacher is to arrange the contingencies of reinforcement in the learning environment so that the desired behaviour will occur. … In contrast to behaviorists, researchers working from a cognitivist perspective focus not on external behaviour but on internal mental processes. Cognitivists are interested in how the mind makes sense out of stimuli in the environment – how information is processed, stored and retrieved. … Also in contrast to behaviourism is the humanistic orientation to learning. Here the emphasis is on human nature, human potential, human emotions and affect. Theorists in this tradition believe that learning involves more than cognitive processes and over behaviour. It is a function of motivation and involves choice and responsibility. … The fourth and final orientation discussed is social learning. This perspective differs from the other three in its focus on the social setting in which learning occurs. From this perspective learning occurs through the observation of people in one’s immediate environment. Furthermore, learning is a function of the interaction of the person, the environment, and behaviour.” (Merriam and Caffarella, 1991, 137-139) We see this classification of Merriam and Caffarella (in Table 2.1) as an important addition to earlier presented The tension field of learning by Illeris (in Figure 2.1).

We do not systematically present all learning theorists mentioned in Table 2.1. The limitation of Table 2.1 is the focus on adult learning, while the organisational learning view is missing. Therefore we start with the social and situational orientation and focus on organisational learning theory in Sub section 2.1.1. Within organisational learning we go through human resource management (HRM) and competences in Sub sections 2.1.2 and 2.1.3, since they are not often discussed in connection to innovation and creativity (Lindgren *et al.*, 2004; Stenmark, 2002). Although the informal learning is not a learning theory, we will discuss about it as part of situational learning orientation in Sub section 2.1.4. The collaborative learning is introduced in Sub section 2.1.5. The cognitive and behavioural orientations are covered within the experiential learning model in Sub section 2.1.6. In summary, our learning section covers a short discussion about adult learning while main focus is targeted on organisational learning.

2.1.1. Organisational learning

Several disciplines have shaped thinking about organisational learning over the past decades. The founding fathers most frequently cited are Argyris and Schön (1978), Cyert and March (1963) and March and Olsen (1963). All these authors have been engaged with research in management, but they have different backgrounds in psychology, sociology, economics and political science.

The information technology (IT) in organisational learning is seen able to transform resources into capabilities and eventually into core capabilities (Andreu and Ciborra, 1996). Robey, Boudreau and Rose (2000, 125) see that future research on information technology and organisational learning proceeds in a more integrated fashion, recognizes the situated nature of organisational learning, focuses on distributed organisational memory, demonstrates the effectiveness of artefacts in practice, and looks for relevant research findings in related fields.

This notion about distributed organisational memory and emphasis in effectiveness of artefacts serves also as a motivator for our design work.

Learning capabilities in organisations are seen by some authors to be linked to problem-solving capabilities. “We argue that problem solving and learning capabilities are so similar that there is little reason to differentiate their modes of development, although exactly what is learned may differ. Learning capabilities involve the development of the capacity to assimilate existing knowledge, while problem-solving skills represent a capacity to create new knowledge.” (Cohen and Levinthal, 1990, 130)

“Organisations in hyper-competitive environments face an increasing gap between their learning opportunities and needs, and actual learning performance. In order to survive they must improve their absorptive capacity so that they can simultaneously learn broad, deep and fast.” (Lyytinen, Rose and Yoo, 2002) Cohen and Levinthal (1990) propose a question: How to improve absorptive capacity when earlier investments in knowledge can be inhibiting or not helpful? To our mind absorptive capacity can be developed through learning in the Open Innovation (Chesbrough, 2003) environment. Similar connection is seen by Cohen and Levinthal (1990, 128): “Ability to exploit external knowledge is thus a critical component of innovative capabilities”. The same authors continue: “The firm’s absorptive capacity depends on the individuals who stand at the interface of either the firm and the external environment or at the interface between subunits within the firm. That interface function may be diffused across individuals or be quite centralised.” (Cohen and Levinthal, 1990, 132) This importance of prior knowledge is similarly emphasised by Amabile (1983) in her Componential Model of Creativity, which we will illustrate in Sub section 2.2.3. Prior knowledge is just one type of knowledge; there are several other types that are important for an organisation. According to Cook and Brown (1999) organisations are better understood if explicit, tacit, individual and group knowledge are treated as four distinct and coequal forms of knowledge (each doing work the others cannot).

Organisational learning can take place in several levels in an organisation. According to Hargadon (2002) learning describes the set of activities and groups in organisation engage in to extend their ability to comprehend and act within their environment. He describes these four distinct activities: (1) learning about the existing resources of each new domain; (2) learning the related problems in that domain; (3) learning what others in their own firm know and (4) learning how to learn (Hargadon, 2002, 58). Learning of existing resources and their existing combinations is the traditional focus of much of the literature on organisational learning (Walsh and Ungson, 1991; Weick, 1991; Hargadon, 2002). For these reasons we need to focus on organisational boundaries and combining various information resources.

Situated nature of organisational learning is another noteworthy element. Situated learning theory originates from the work of Jean Lave and Etienne Wenger (Lave and Wenger, 1991). They argue that learning as it normally occurs is a function of the activity, context and culture in which it occurs (i.e., it is situated). This contrasts with traditional, organised learning activities which involve knowledge which is abstract and out of context. Social interaction is a critical component of situated learning – learners become involved in or apprenticed to a "community of practice" which embodies certain beliefs and behaviours to be acquired. As novices moves from the periphery of this community to its centre, they become more active and engaged within the culture and hence assume the role of expert. Furthermore, situated learning is usually unintentional rather than deliberate. Lave and Wenger (1991) call this process "legitimate peripheral participation." For our artefact design this means that the tools and the user interface should be adaptable to the expertise development of the user. The tools of the novice would be different from the expert.

Other researchers have also developed the theory of situated learning. Brown, Collins and Duguid (1989) introduced the idea of cognitive apprenticeship: "Cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge." Brown *et al*. (1989) also emphasize the need for a new epistemology for learning - one that emphasizes active perception over concepts and representation.
Some organisational learning theorists are critical about Lave and Wenger’s view of learning. Contu and Willmott (2003, 283) argue that “Lave and Wenger’s embryonic appreciation of power relations as media of learning is displaced by a managerial preoccupation with harnessing (reified) “communities of practice” to the fulfilment of (reified) corporate objectives”. In other words, they implicate those challenges in managing communities of practice.

Contu and Willmott (2003) further in Table 2.2 compare the established view on learning involving a selective transmission of comparatively abstract, codified bodies of knowledge with Lave and Wenger’s (1991) situated learning theory emphasising communities of practice.

Conceptualization	**Established**	**Situated**
Learning	Cognitive – passive – selective	Interactive – participative – pervasive
Form of knowledge	Canonical/codified/ theoretical Distilled in texts and manuals	Tacit/embedded/practical Embedded in community and identity
Understanding developed	Abstract/universal	Embodied/context-sensitive
Outcome of learning	Acquisition of information and skill	Trans(formation) of identity
Transmission	Vertical: Instruction by authorities	Horizontal: Collaboration with peers

Table 2.2. Established and situated conceptualisations of learning compared, Contu and Willmott (2003)

Situated learning occupies an ambivalent position. On the one hand, it espouses radical analysis of learning practices, where concepts of contradiction, ideology, conflict, and power are central. Yet, on the other hand, Lave and Wenger select functionalist or interactionist illustrations of their thinking, in which consensus and continuity are assumed (cf. Burrell and Morgan, 1979). The reality in companies is often different from this consensus view. This inconsistency in Situated learning has made it easier for proponents of mainstream organisational learning to regard situated learning theory as, at best, a somewhat innovative approach that may be utilized to extend or enrich, but not fundamentally challenge, its theoretical and normative orientations (Contu and Willmott, 2003, 292). When we build our artefacts, the Situated learning theory informs us how difficult it is to support communities of practice.

Our non-traditional view on organisations deserves a comment. In our second artefact, iPortfolio, our focus is on lifelong learning and ideation even outside corporate boundaries. A possible user of that artefact is seen as a self-employed person having perhaps several employers. For this reason, the garbage can model of organisational choice (Cohen, March and Olsen, 1972) fits quite well for our non-traditional organisation view. This model describes organised anarchies which are characterized by problematic preferences, unclear technology and fluid participation. Actually, this model originally illustrates universities and it includes decision making and rules structure. In the garbage can model a decision is an outcome or interpretation of several relatively independent streams within an organisation (Cohen *et al.,* 1972, 2-3). The garbage can model has four streams and these are listed in Table 2.3.

Stream	**Description**
A stream of choices	Some fixed number, m, of choices is assumed. Each choice is characterized by (a) an entry time, the calendar time at which that choice is activated for decision, and (b) a decision structure, a list of participants eligible to participate in making that choice.
A stream of problems	Some number, w, of problems is assumed. Each problem is characterized by (a) an entry time, the calendar time at which the problem becomes visible, (b) an energy requirement, the energy required to resolve a choice to which the problem is attached (if the solution stream is as high as possible), and (c) an access structure, a list of choices to which the problem has access.
A rate of flow of solutions	The verbal theory assumes a stream of solutions and a matching of specific solutions with specific problems and choices. A simpler set of assumptions is made and focus is on the rate at which solutions are flowing into the system.
A stream of energy from participants	It is assumed that there is some number, v, of participants. Each participant is characterized by a time series of energy available for organisational decision making. Thus, in each time period, each participant can provide some specified amount of potential energy to the organisation

Table 2.3. The four streams of the garbage can model (Cohen et al., 1972)

The value of the garbage can model is in its realism. When an innovation system to support creativity and learning is constructed, the energy and sometimes limited motivation of participants need to be understood, even measured. Similarly, time pressure (the ‘stream of choices’ in Table 2.3) need to be considered and ideas need to be prioritised. Humans seem to be more unpredictable than organisational learning theories often assume. Even in the organisational learning the individuals are those who actually learn. An organisation can only provide support and a motivating environment for individuals. Therefore, we will next introduce human resource management (HRM) with learning, creativity and innovation related viewpoints.

2.1.2. Human resource management (HRM)

Human resource management is often defined by job description and activities associated with employees like recruiting, training, promoting, terminating, record keeping and meeting various legal requirements (Targowski and Deshpande, 2001). This definition mainly describes the old role of HRM, without focusing on the creativity and innovation aspect. Therefore, the definition of Beer, Spector, Lawrence, Mill and Walton (1984) is more general: HRM is defined as all management decisions and activities that affect the nature of the relationship between the organisation and its employees – the human resources. This Harvard Analytical Framework (Beer *et al.*, 1984) does not, however, refer to innovation management and we need to look further for other frameworks.

According to Leede and Looise (2005, 108): “Except for the early recognition within ‘strategic’ HRM of the need for an HR policy related to innovation as a company strategy … there was not that much interest in translating this policy into specific HR practices or in the ‘innovation-related’ outcomes of these policies.”

To improve this situation Leede and Looise systematically build a framework to combine innovation management and HRM (Figure 2.3.).

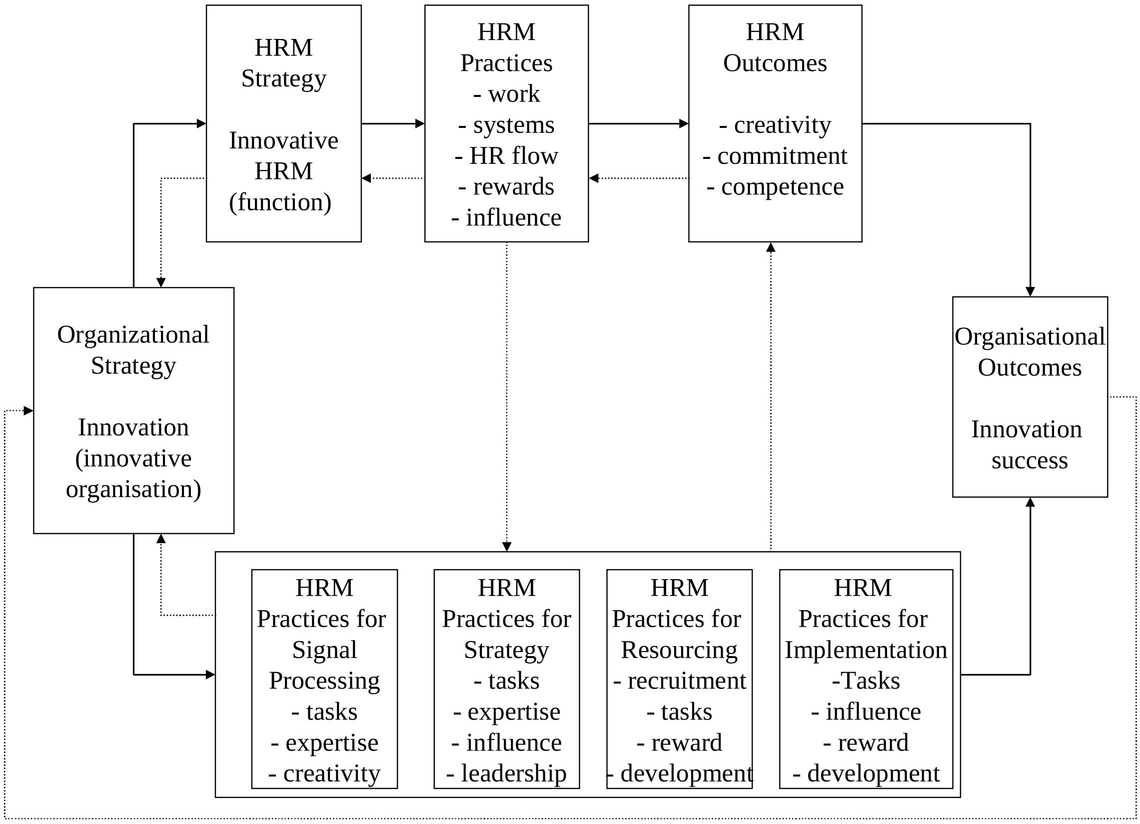

Figure 2.3. An Integrated Model for Innovation and HRM (Leede and Looise, 2005)

Leede and Looise explain their model in Figure 2.3:

"From the innovation side, HRM should be viewed as a strategic and integrated field contributing to the organisation as a whole, and not just as fragmented practices supporting specific innovation activities, types or even phases. From the HRM side, innovation must not be seen, in a rather static way, as only a one-time strategic choice for the organisation as a whole, but related to all kinds of dynamics inside and outside the organisation. Furthermore, we propose focusing on the two levels mentioned before: the level of the organisation and the level of the innovation activities. This leads us to the … integrated model for innovation and HRM." (Leede and Looise, 2005, 114)

This description of Leede and Looise informs us that an information system based on integrated model for innovation and HRM is complicated to construct. Additionally, their model describes a closed system where all activities take place inside the company. This is perhaps the weakness of Leede and Looise model, especially when we are interested in open innovation (Chesbrough, 2003). Still, we will focus on a certain part of this model, namely 'HRM Practices for Signal Processing' and 'HRM practices for Strategy'. This is linked to the frontend of the innovation process.

Interestingly, Leede and Looise (2005) utilise the following innovation management process model of Tidd, Bessant and Pavitt (1997) as basis of their model (An Integrated Model for Innovation and HRM) and its frontend. This model of Tidd *et al.* (1997) is presented in the following Figure 2.4.

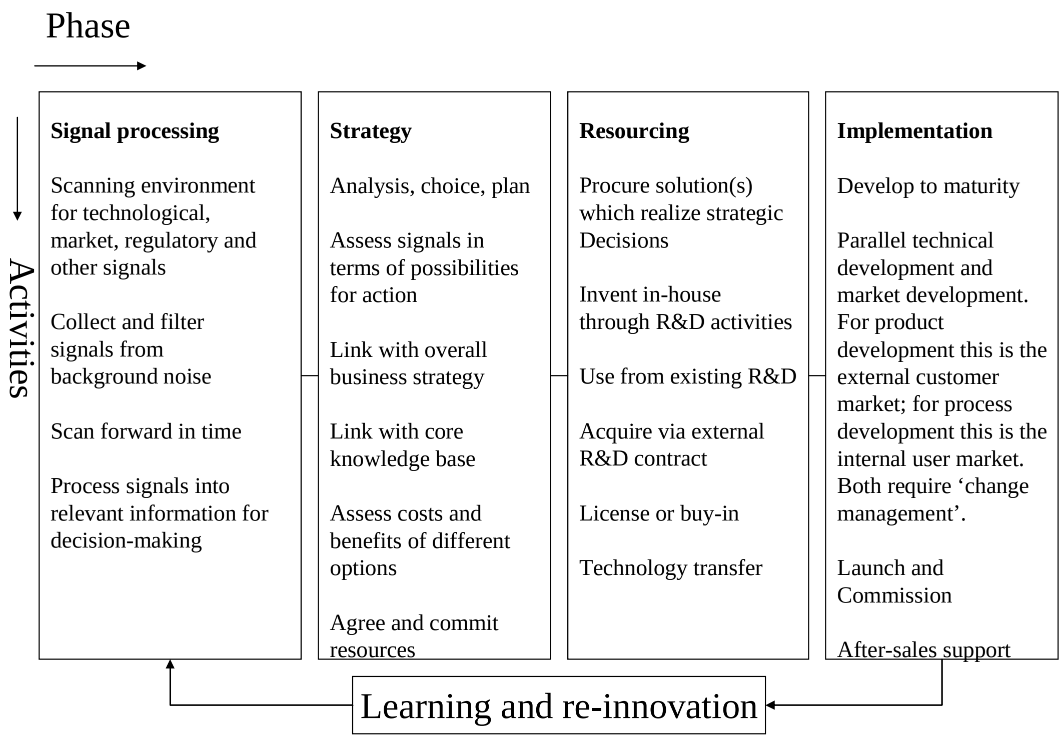

Figure 2.4. Routines underlying the process of innovation management (Tidd, Bessant and Pavitt, 1997, 41).

This model in Figure 2.4 nicely explains the signal processing concept which is also elementary in our first artefact which is focused on gathering information and weak signals. Word ‘signal’ means here business related signals and is not used to describe typical input-output signals often used in the computer science and technical literature. Scanning in the figure emphasises the role of brokers (Hargadon and Sutton, 1997) and is an elementary activity in our third artefact, Brokering Platform for Open Innovation. The model of Leede and Looise (2005) and the process model of Tidd *et al.* (1997) are useful to us to understand the linkage between human resource development, innovation and learning. Still, the level of analysis is not sufficient to us to understand tasks and practical steps.

Therefore, we will next look at the Investors in People standard (IiP, 2009). This standard provides a practical framework for improving business performance and competitiveness through good practice in human resource development. The Investors in People, IiP (2009) includes (among others) four elements. These elements are listed in Figure 2.5.

OBJECTIVES AND OUTCOME REVIEW	**COMPETENCE ASSESSMENT**
PERSONAL DEVELOPMENT PLAN	**PERFORMANCE ASSESSMENT**

Figure 2.5. The areas of IiP (Investment in People) standard (IiP, 2009).

The Objectives and outcome review of IiP (2009) will in our interest when we will design our artefacts in Chapter 4. The Personal Development Plan (PDP) provides an opportunity for the manager and individual staff member to identify - and then to monitor progress towards - appropriate and legitimate development goals required for the individual’s personal and professional development. It forms the basis of the informal agreement that will shape the career- and professional progress and aspirations of both parties for the period ahead. (IiP, 2009). Next we will focus on competences, since they are closely related to the HRM.

2.1.3. Competence and competence management systems

In the information systems research, there are not many competence management systems related studies. The work of Lindgren *et al.* (2004) and Stenmark (2002) are rare exceptions. HRM literature focuses on the micro or individual level of analysis of competence. A competence itself is an underlying characteristic of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or situation (Spencer & Spencer, 1993, 9). Here we may ask: is characteristic ever causal? Spencer & Spencer thereafter present the following picture of various competencies.

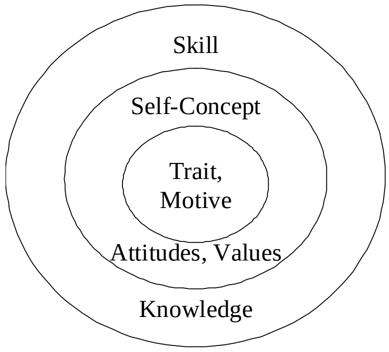

Figure 2.6. Central and surface competencies (Spencer and Spencer, 1993, 11).

In the centre of Figure 2.6 are motives and traits. Spence and Spencer define motive as the things person consistently thinks about or wants that cause action. Traits are physical characteristics and consistent responses to situations or information. In the middle circle there is self-concept which includes a person's attitudes values or self-image. In the outer circle skill means the ability to perform a certain physical or mental work.

Spencer and Spencer see that surface knowledge and skills in Figure 2.6 are relatively easy to develop. Training is the most cost-effective way to secure these employee abilities. Core motive and trait competencies at the base of the personality iceberg are more difficult to develop and assess. Motive, trait and self-concept competencies predict skill behaviour actions, which in turn help to understand job performance outcomes. (Spencer and Spencer, 1993)

Marton and Säljö (1976) do not focus on competencies, they talk about deep and surface learning. Learners may be classified as "deep" or "surface", however, one person may use both approaches at different times. These learning styles are related to motivation: "deep" with intrinsic motivation and "surface" with extrinsic motivation (Marton and Säljö (1976), see also Amabile (1983)).

The individual-focused competence view of Spencer and Spencer (1993) is different from organisation-focused competence view of Prahalad and Hamel (1990, 81): Core competencies are defined as the collective knowledge and capabilities that are embedded in the organisation; they are central determinants of the organisation's competitiveness due to their centrality to customer value, their resistance to imitation and their ability to extend to new business applications.

So, Prahalad and Hamel discuss about the competitive factors of an organisation. According to Prahalad and Hamel (1990) core competencies are the collective learning in the organisation, especially how to coordinate diverse production skills and integrate multiple streams of technologies. Similarly, to Lado and Wilson (1994, 702) core competencies include all firm-specific assets, knowledge, skills, and capabilities embedded in the organisation's structure, technology, processes and interpersonal and intergroup relationships. The strategy literature focuses on the macro or organisational level of analysis and concerns itself with the notion of core competence as a means of generating competitive advantage (Lindgren *et al*., 2004).

Competences can be listed and categorised into databases and competence management systems. According to Lindgren and Stenmark (2002, 20) a typical competence management system (CMS) is designed to support organisations in their competence management processes by providing information about competence status and competence development needs. "CMS form part of the mediating structure that facilitates the smooth interaction between competencies at the macro and micro levels of the organisation. In order to support organisational competence management in day-to-day action, the design of CMS must appreciate the reciprocal relationship of the three competence types (competence-in-stock, competence-in-use, competence-in-the-making) and the organisation's core competencies." (Lindgren *et al.*, 2004, 440) These competence types are in our interest while we build our first artefact, The Mobile Development Plan.

Interestingly, Sandberg (2000, 9) sees the meaning of competence differently: "Findings suggest that the meaning work takes on for workers in their experience of it, rather than a specific set of attributes, constitutes competence. More specifically, the results demonstrate that the particular way of conceiving of work delimits certain attributes as essential and organizes them into a distinctive structure of competence at work. This view emphasises that conceptions, rather than attributes, should be the point of departure both for efforts to identify and describe competence and for efforts to develop competence in various jobs and professions." Stenmark (2002) earlier emphasised interests as a starting point for competence, while Sandberg (2000) emphasises experiences as starting point of competences.

To summarise, competence management systems and IT tools should support both individual and organisational competencies. The understanding of evolving interests and purpose of work is a challenge for competence management. Since the context, where competences are developed, is even outside firm boundaries and outside traditional education, we will next focus on informal learning.

2.1.4. Informal learning

Not all learning is planned, organised and easy to integrate to human resource development. As part of situational and social learning orientation, the informal learning will be next described. According to a corporate culture survey made among Top-100 US companies (Dobbs, 2000), 70 % of job-related learning occurs informally. As a challenge for research concerning informal learning has been recognised incidentally-initiated learning and irregularly timed learning (Livingstone, 2000, 54). Formal and informal learning nourish one another and finding the right balance between the two is important in maintaining a productive learning environment (Cofer, 2000).

Marsick and Watkins (1997) point out that informal learning can be planned, and overall learning is enhanced by planning, either before the fact or in retrospect to learn from past experience. This theme is echoed by Bell (1977), when he encourages taking advantage of the career development process to build in planned opportunities for informal learning on behalf of the employee. In our research we are focusing on these planned opportunities and how technology can facilitate them. Marsick and Watkins suggest three personal characteristics which, if present, make work-based learning more likely, or may enhance it. These are: (1) Proactivity - a readiness to take the initiative in situations. (2) Critical reflection - a tendency to reflect, not just on events, but on underlying assumptions. (3) Creativity - to enable a persons to think beyond their normal point of view. (Marsick and Watkins, 1990)

As noted above, Marsick and Watkins see informal learning as a subset of workplace learning. They also emphasise that certain personal characteristics are pre-requisites of informal learning. Hager (1998) provides the following comparison between informal workplace learning and on-the-job training.

Informal workplace learning	On-the-job training
learners in control	trainers in control
often unplanned	planned
no formal curriculum	formal curriculum
non-prescribed outcomes	prescribed outcomes
unpredictable	predictable
learning often implicit or tacit	learning largely explicit
emphasis on learning and the content of training	emphasis on training and the learner
learning often collaborative and /or collegial	focus on individual learning
learning as highly contextualised	training is partly contextualised
learning as seamless know how	learning as knowledge to be applied
learning as development of competence or capability with no knowledge/skills distinctions	learning knowledge seen as more difficult than learning skills

Table 2.4. Comparison between informal workplace learning and on the job training (Hager, 1998)

According this table, on-the-job training is more controlled and instructor-led. Instead, informal workplace learning is seen more contextual and collaborative. According to Vavoula (2000) people may or may not plan their learning, and this depends on what they are learning about: formal work-related projects are more likely to be planned, whereas non-formal projects are more likely to be largely unplanned. Planning may be high level (roughly specifying what they are going to do) or low level (translating objectives into tasks and scheduling). Tough (1971) reported that adults perform an average of eight informal learning projects per year, and spend an average of 500 hours per year on informal learning. A learning project is a series of clearly related episodes, usually spread over a period of time, adding up to at least seven hours (Vavoula, 2004; Tough, 1971). To our understanding, the support for informal learning can be built in the learning environment, also in the IT artefact. However, mentoring and managerial support is perhaps necessary and informal learning skills need to be systematically developed.

Eraut (2000) has criticised the name informal learning. Word informal creates easily an association with a dress code or discourse. Eraut therefore divides non-formal learning to implicit, reactive and deliberative. Informal learning or non-formal learning are not learning theories, more like they are ways to describe learning that takes place suddenly and in a certain context. Since informal learning is often individual activity, we will next discuss about collaboration and collaborative learning.

2.1.5. Collaborative learning

When thinking about groups, within collaborative learning individuals often learn better by co-operating with others than they would on their own (Cheetham and Chivers, 2001). Eraut (2000) suggest that this results from a combination of observation, consultation, mutual exchange of information and a process of osmosis. We chose to include the collaborative learning as a sub section, because this learning orientation has a long history related to information systems.

Computer-Supported Collaborative Learning (CSCL) is a research area concerned with the theory and the design of collaboration tools. Examples of such tools include 'Knowledge Forum' (http://www.knowledgeforum.com/), an electronic group workspace; 'Belvedere' (http://lilt.ics.hawaii.edu/lilt/software/belvedere/index.html), a software to support problem-based collaborative learning and CSILE (Computer-Supported Intentional Learning Environment), Scardamalia, Bereiter and Lamon (1994).

These tools need specific instructions, curriculum or process to utilise them. Similarly, tasks and objectives can be systematically shared. Distribution of cognitive efforts allows the community to be more flexible and achieve better results than otherwise would be possible (Hakkarainen, 2000). That is perhaps the biggest strength of collaborative learning. The limitation of collaborative learning is its vagueness: it can contain almost any learning that involves collaboration. Collaborative learning and all previously mentioned learning orientations have not yet focused on experience and it's role in the learning process.

2.1.6. Experiential learning

Not only individuals but also companies go through different processes in their learning. The experiential learning processes in R&D and new business development are illustrated by Buijs (2003) and Carlsson, Keane and Bruce Martin (1976). The Experiential learning model provides a holistic model of the learning process and a multilinear model of adult development, both of which are consistent with what we know about how people learn, grow, and develop (Kolb, Boyatzis and Mainemelis, 2001). The theory behind the model is called "Experiential learning" to emphasize the central role that experience plays in the learning process, an emphasis that distinguishes experiential learning from other learning theories. The model of experiential learning is originally developed by David Kolb. The term "experiential" is used therefore to differentiate experiential learning both from cognitive learning theories, which tend to emphasize cognition over affect, and behavioural learning theories that deny any role for subjective experience in the learning process (Kolb *et al.*, 2001).

Another reason the theory is called "experiential" is its intellectual origins in the works of Dewey, Lewin, and Piaget. Taken together, Dewey's philosophical pragmatism, Lewin's social psychology, and Piaget's cognitive-developmental genetic epistemology form a unique perspective on learning and development. (Kolb, 1984).

Kolb's experiential learning model consists of four elements: concrete experience, observation and reflection, the formation of abstract concepts and testing in new situations. These elements are described in Figure 2.7.

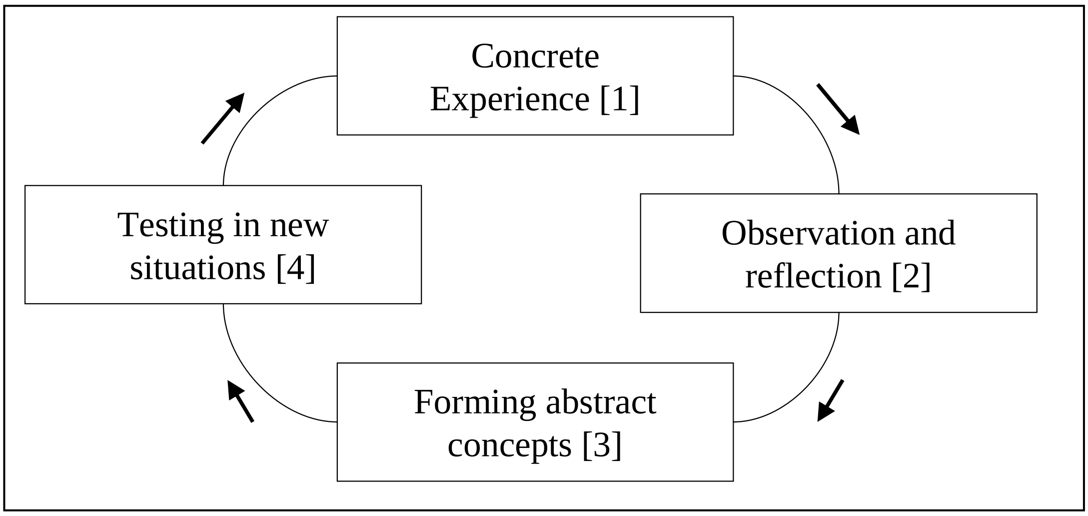

Figure 2.7. Experiential learning cycle (Kolb and Fry, 1975)

Kolb and Fry (1975, 35-36) see that effective learning entails the possession of four different abilities (as indicated on each pole of their model): concrete experience abilities, reflective observation abilities, abstract conceptualization abilities and active experimentation (testing) abilities. These abilities are visible in the following four basic learning styles (Table 2.5).

Learning style	Learning characteristic	Description
Diverger	Concrete experience + reflective observation	- Strong in imaginative ability - Good at generating ideas and seeing things from different perspectives - Interested in people - Broad cultural interests
Assimilator	Abstract conceptualization + reflective observation	- Strong ability to create theoretical models - Excels in inductive reasoning - Concerned with abstract connects than people
Converger	Abstract conceptualisation + active experimentation	- Strong in practical application of ideas - Can focus on hypo-deductive reasoning on specific problems - Unemotional - Has narrow interests
Accomodator	Concrete experience + active experimentation	- Greatest strength in doing things - More of a risk taker - Performs well when required to react to immediate circumstances - Solves problems intuitively

Table 2.5. Learning styles within the experiential learning (Kolb and Fry 1975, Tennant 1997)

Each of these learning styles mentioned in Table 2.5 have practical consequences. For example, a diverger will tend to prefer observing something concrete; perhaps from different perspectives, an assimilator will learn by developing hypotheses based on what he/she observes, a converger will learn best through putting ideas into practice, and an accommodator will prefer ``hands-on’’ approaches and ``learning by doing’’. (Cheetham and Chivers, 2001)

According to Swanson and Holton (2001) human resource development practitioners are increasingly emphasising experiential learning as means to improve performance. The learning style test of Kolb is one way of motivating employees and informing them about their learning opportunities. Similarly, the test results make it possible to modify the exercises and learning tools for employees based on their learning style. In our artefact development in Chapter 4 we will discuss about this personalisation challenge.

How is the learning style test of Kolb related to knowledge creation? Kolb has later defined a process called conversational learning describing knowledge creation (Baker, Jensen and Kolb, 2002). So, there are connections from experiential learning to organisational knowledge creation and organisational learning. Within new product development (NPD) literature, the experiential learning cycle by Kolb and Fry (1975) has even been utilised to facilitate discussion between production and NPD departments (Smulders, 2004).

The experiential learning of Kolb has also received criticism. According to Cheetham and Chivers (2001, 257): "While the various theories of experiential learning have their limitations in terms of explaining how the process works, they may point to ways in which individuals can better exploit naturally occurring learning experiences. Similarly, the main utility of learning cycles may be the enhancement of individual or group learning, rather than providing accurate models of how people actually learn."

In summary, we presented several learning orientations with examples. Noteworthy here is that within a learning project, as described by Vavoula (2004), there can be several phases with different learning orientations and learning styles as demonstrated in the table below.

Phase	**Initiated by learner**	**Initiated by others**
Identify needs	Intrinsic necessity learning	Extrinsic necessity learning
Identify opportunities	Intrinsic opportunistic learning	Extrinsic opportunistic learning
Formulate objectives and plot plans	Self-managed goal-driven learning	Institution-managed goal-driven learning
Learning action	Self-initiated experiential learning	Externally-initiated experiential learning
Evaluation of, and reflection on experience	Self-managed reflection-driven learning	Externally-managed reflection driven learning

Table 2.6: Typology of Learning Projects (Vavoula, 2004)

When we look at Table 2.6, we notice how many different ways to learn there are. Depending on the phase and who is the initiator, the proper learning project and learning style will be chosen. For this reason, in previous sub sections we focused only on organisational, informal, collaborative and experiential learning. Since we are interested in ideas and innovation, we will next look at creativity. Grundy (1993) comments that organisations are notoriously bad at learning when it comes to change and creativity. To understand that comment we need start with various views on creativity.

2.2. Creativity

Creativity has become a buzzword that means different things in different contexts. Our focus is first on individual research and therefore we focus on journals like ‘The Journal of Creative Behavior’ and ‘Creativity Research Journal’. Additionally, we are of course interested how creativity is referenced in the organisational and information systems literature. The field of research on creativity began as the study of an individual cognitive and personality trait (Guilford, 1950; Sternberg and Lubart, 1999). The research area has slowly expanded to include more dynamic, interconnected social systems such as workgroups (Kurtzberg and Amabile, 2001) and entire organisations (Woodman, Sawyer and Griffin, 1993). Creativity can be important in all aspects of IT development, from requirements definition through program design (Couger, 1996). We start by defining and characterising creativity in Sub section 2.2.1. Thereafter we will look at creative problem-solving (CPS) and motivation. In the last sub section we will focus on systems models of creativity and organisational creativity.

2.2.1. Different views on creativity

Creativity as a concept means different things in different contexts. For this reason we present the following table that summarises two opposing approaches to creativity. The first major view (called "origin-oriented") asserts that creativity originates from characteristics of the individual and/or his or her environment. Some researchers describe creativity as the natural ability of the individual, while others see it as the presence or absence of conflict in the individual's external environment, mental environment, or both. The second major view (called "process-oriented") characterises creativity less as a natural characteristic or response and more as a process. Proponents of this view assume individuals have the ability to invoke, explore, and direct cognitive processes toward specific creative goals. (Ackoff and Vegara, 1981; Couger, Higgins and McIntyre, 1993). All these views are summarised in Table 2.7.

Origin-Oriented Approaches	Process-Oriented Approaches
Psychoanalysts Creativity arises from conflicts within an individual. The creative process involves externalizing the internal products of imagination through the interaction of primitive and more mature types of thinking (Freud, 1970).	**The Associationists** An individual's creativity is a function of his or her ability to invoke and explore remote associations in selecting a response to a problem (Mednick, 1962).
Humanistic Psychologists Creativity arises when there is no conflict within an individual. The creative process involves the release of natural creative potential through the removal of inhibitions from the individual and obstructions from his or her environment (Fromm, 1959).	**Gestalt Psychologists** Creative thinking proceeds neither by piecemeal logical operations nor by disconnected associations but by more determinate restructuring of the whole situation (Wertheimer, 1959). Creativity lies in the ability to redirect a line of thought taken in solving a problem (Maier, 1970).
Psychometricians Each individual's natural creative potential is limited by his or her genetic endowment and can be measured by standard tests. The creative process involves the interaction of two contrasting types of thinking: "divergent," which converts information into a variety of unconventional alternatives, and "convergent," which aims at unique or conventional outcomes (Guilford, 1977).	**Cognitive Science Theorists** The human thinking process can be simulated as the process of information processing in computer programs. Creative activity is a special class of problem-solving activity characterized by novelty, unconventionality, persistence, and difficulty in formulation (Newell and Shaw, 1972).

Table 2.7. Summary of views on the Nature of Creativity (Ackoff and Vergara, 1981; Couger et al., 1993)

Like learning orientations, all views of creativity complement each other and no one is more correct than the other one. Couger *et al.* (1993) assumed that IS-associated individuals and teams can improve their creative process by using of specific techniques and methodologies.

Another useful distinction has been made by Rhodes (1961) in his 4-Ps model between the creative person, the creative product, the creative process, and the creative 'press' (environment). According to Couger *et al*. (1993) the 4-Ps model provides a better structure for understanding creativity and its application in IS. Within the First P: The Creative Person, IS management can stimulate creativity in employees by reinforcing the fact that all individuals are innately creative. In the Second P: The Creative Process, creative abilities can be developed by deliberate corporate programs and creative enhancement techniques. Within the Third P: The Creative Product, by adopting metrics for creative products and services, management can make explicit a goal that is implicit in most IS organisations. Finally, in the Fourth P: The Press, managers can induce new styles of thinking by introducing a climate that encourages creativity. (Couger *et al.*, 1993) We here emphasise that Couger talks about IT organisations and IT departments and their management. The fourth P – The Press – does not mean that a manager can necessarily change the way employees think.

Sternberg and Lubart (1999) define creativity as the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning task constraints). Creativity is thinking outside the box, coming up with novel ideas through divergent, tangential thinking. Conversely, innovation is turning ideas into products, services and processes. (Couger, 1995). The following figure illustrates creativity as an integral element in every step of the innovation process.

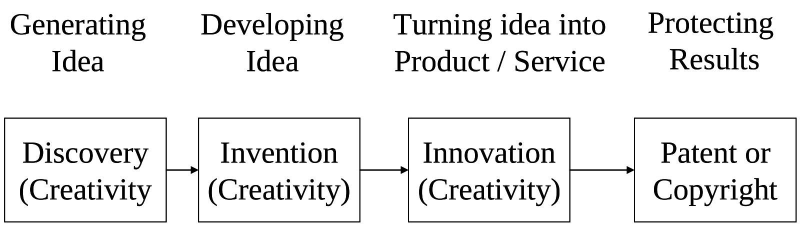

Figure 2.8. Creativity in the innovation process (Couger, 1995)

In Figure 2.8 the process starts with discovery. This view is shared with Schank (1988) who points out that creativity consists of two subprocesses: (1) Search process, looking among previously experienced explanation patterns; (2) Alteration process, modifying an explanation derived from one situation to be used in another.

Creativity is often seen as the generation and emergence of new ideas. The quality, novelty and creativity of ideas is however difficult to evaluate. It has been chronically problematic to compare findings across studies because these evaluation constructs have been variously defined and the constructs have been sampled in different ways (Dean *et al.*, 2006, 646). They illustrate the purpose of idea metrics below, in Table 2.8.

Dimension	Definition
Novelty	The degree to which an idea is original and modifies a paradigm.
Workability	An idea is workable (feasible) if it can be easily implemented and does not violate known constraints.
Relevance	The idea applies to the stated problem and will be effective at solving the problem.
Specificity	An idea is specific if it is clear (worked out in detail).

Table 2.8. Definitions of the quality dimensions of ideas (Dean et al. 2006)

There are rarely ideas that fulfil all those four dimensions mentioned by Dean *et al*. For this reason, a group of people are needed to elaborate and improve individual ideas. We may also ask which elements are needed for creativity? Sternberg and Lubart's (1995) investment theory of creativity is based on research in cognitive psychology. The theory postulates that six elements must coincide for creative production: intellectual processes, knowledge, intellectual style, personality, motivation, and environmental context. This theory asserts that creative thinkers, like good investors, buy low and sell high – not in the world of finance, but in the world of ideas. Specifically, creative people generate ideas that are like undervalued stocks. Initially, others often view these ideas bizarre, useless, and foolish, and the ideas are rejected. The authors believe that the ideas are rejected because the creative innovator defies the crowd and makes people uncomfortable by standing up to vested interests. The majority do not maliciously or even wilfully reject creative notion: Rather, they do not realise or admit that the ideas represent valid and often superior alternatives. (Sternberg and Lubart, 1995). From the information systems view we see the theory of Sternberg and Lubart confusing, since it mixes processes and products. Järvinen (2007a) points out that new innovation can be based on new properties of technical, social and/or informational resources or their combination. A more systematic view is often requested for creativity, therefore we will next look at creative problem solving.

2.2.2. Creative problem solving (CPS)

The above mentioned (Figure 2.6) macro-level phases by Couger (1995) can be broken down to even smaller micro-level phases. Creative problem solving (CPS) is originally based on work of Osborn (1963) who discusses about applied imagination. CPS means a step-based approach to define a problem and find solutions to it. Treffinger and Isaksen (1992) have, for example, defined six phases, which is illustrated in Table 2.9.

CPS phase	Process examples
1. Mess-finding	Identifying and selecting a broad goal.
2. Data-finding	Many general goals or starting points for problem solving are considered.
3. Problem-finding	An effort to identify all the possible problem statements and then to isolate the most important or underlying problem.
4. Idea-finding	An effort to identify as many solutions to the problem statement as possible.
5. Solution-finding	Ideas are selected, analyzed, or developed through the use of possible criteria and application tools.
6. Acceptance-finding	Making every effort to gain acceptance for the solution, determine a plan of action, and implement the solution.

Table 2.9. Creative problem solving (CPS) phases (Treffinger and Isaksen, 1992)

The whole Creative problem solving (CPS) is a continuous search process. When we look at suggestion management systems (described in the next sub section 2.2.3), only the Phase 5 (solution-finding) is covered. Therefore, we see that tools and information systems supporting creativity should support also Phases 1-4 and 6.

Couger *et al.* (1993) demonstrate how analytical techniques (progressive abstraction, interrogatories and force field analysis) and intuitive techniques (associations/images, wishful thinking, and analogy/metaphor) were used in several industries to solve a variety of problems and/or opportunities. These techniques were typical CPS techniques and we see the difficulty in selecting a proper technique for our artefact building. Like we mentioned in the previous section, the learning style of an employee should be perhaps first tested and recognised before selecting a specific CPS technique.

The Creative problem solving (CPS) phases have also met critique. Sternberg and Lubart (1999, 6) saw that CPS or pragmatic approaches “lack any basis in serious psychological theory, as well as serious empirical attempts to validate them”. Therefore, we will next look at motivational factors in creativity.

2.2.3. Motivation and creativity

Decision support systems literature discusses about motivational support in information systems (Marakas, 2003; Nunamaker, 1997). A sub class of DSS, namely suggestion management systems are specialised in handling ideas and initiatives. Fairbank *et al.* (2003, 305) write: Although research has found that suggestion management systems can be a useful way to obtain and utilize employees’ creative ideas, effective suggestion management systems must also motivate employees to think creatively and to participate in the suggestion process. Since our first artefact, the Mobile Personal Development Plan, is focused on handling ideas, interests and initiatives, the work of Fairbank *et al.* (2003) are interesting to us. Their artefact is based on expectancy theory.

According to expectancy theory, employees are most strongly motivated to attempt a task (a) when they believe that they have the ability to successfully complete it, (b) when they believe that successful performance of that task will be instrumental in achieving an outcome, and (c) when they expect the outcome to be rewarding to them (Vroom, 1964). Fairbank *et al.* (2003, 307) also list limitations concerning suggestion management systems: They fail to motivate employees to participate because (1) they often do not offer compensation or rewards of any type for participation, (2) submitters do not understand the process through which their suggestions are evaluated, and (3) there are long delays in getting the suggestions processed. In our artefact design we need to be aware of these limitations. In this point we need to identify how motivation is linked to creativity; therefore we will look at the work of Amabile.

Amabile’s (1983) componential theory of creativity proposes that anyone of normal capability can be creative, and that the work environment influences the level and frequency of this creativity.
“The componential framework of creativity includes three major components: ... *Domain-relevant skills* can be considered as the basis of for any performance in a given domain... *Creativity-relevant skills* include cognitive style, application of heuristics for the exploration of new cognitive pathways, and working style. ... *Task motivation* includes motivational variables that determine an individual's approach to a given task.” (Amabile, 1983, 67)

These three major components are illustrated in the figure below:

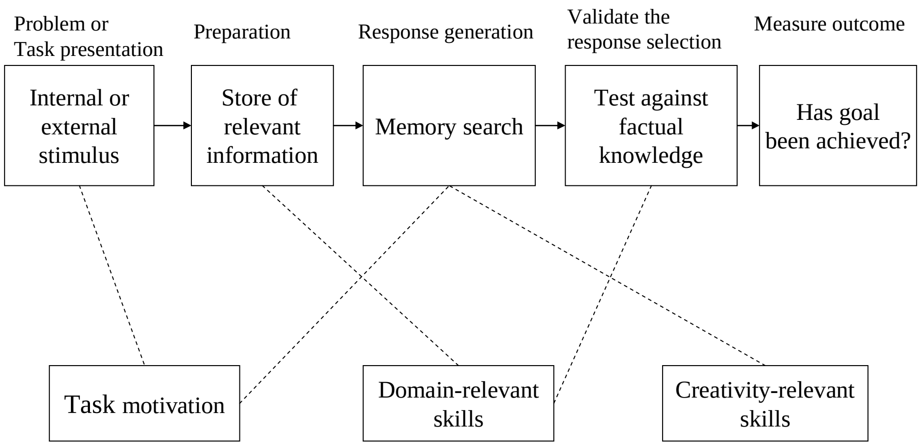

Figure 2.9. Componential theory of individual creativity (Amabile, 1983)

There are three components that affect individual creativity: Domain relevant skills (expertise), creativity relevant skills and task motivation. Task motivation means both intrinsic and extrinsic motivations. Figure 2.9. includes also a problem-solving cycle in the upper row. In our artefact design work, domain-relevant skills are connected to earlier mentioned competences and their development. Creativity relevant skills mean that the artefact should support several, alternative creative problem solving methods and the artefact should help the user improve their skills in problem-solving.

The componential model of creativity (Amabile, 1983) suggests that creativity will be highest in that area where the three components share their greatest overlap with the individual's strongest intrinsic interests and creative-thinking processes: "Identifying this intersection can, in itself, be an important step toward enhancing creativity. This can be particularly important for gifted individuals who are likely to have strong skills in many different domains and who may also have high levels of creative-thinking skills. These individuals should strive and should be helped by their mentors, to discover where their strongest interests lie. It is in those areas of greatest passion that their greatest creativity is likely to emerge." (Amabile, 1995, 397)

There is also the extrinsic motivation element. Toubia (2006) encourages to maximise the contribution of the participants by rewarding them for a weighted average between their individual contribution and their impact on the group. This way, both individual and group effort would be rewarded. Kurtzberg (2005, 51) emphasises that cognitive diversity may be beneficial for objective functioning but may damage team satisfaction, affect, and members' impressions of their creative performance. Often diverse teams are emphasised in organisations but this may also diminish individual creative performance as mentioned by Kurtzberg. Based on these findings, we need to balance between personal and group rewards in our artefact construction.

2.2.4. Systems model of creativity

Instead of focusing only on creativity of individuals and groups, business-oriented artefact development like ours need to also consider societal, organisational and systemic views of creativity.

The systems model of creativity by Csikszentmihalyi (1996) emphasises interaction: "Whether an idea or product is creative or not does not depend on its own qualities, but on the effect it is able to produce in other who are exposed to it. Therefore it follows that what we call creativity is a phenomenon that is constructed through an interaction between producer and audience." (Csikszentmihalyi, 1999, 314). According to Csikszentmihalyi, creativity encompasses the environment in which the *Individual* operates. This environment has two salient aspects: a cultural, or symbolic, aspect which here is called the *Domain*; and a social aspect called the *Field*. Creativity is a process that can be observed only at the intersection where *Individuals*, *Domains* and *Fields* interact.

The following Figure 2.10 describes these aspects within the Systems model of creativity.

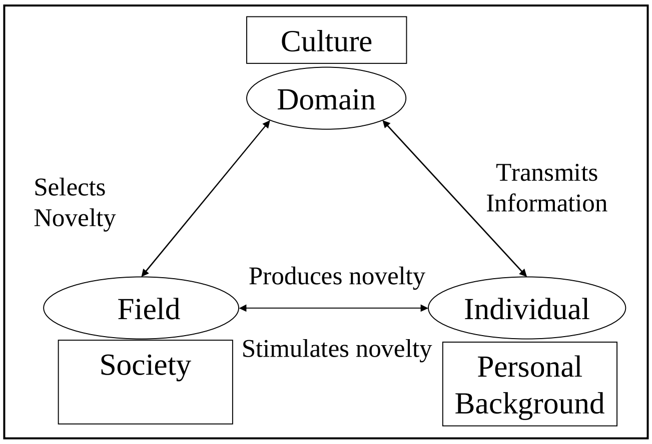

Figure 2.10. Systems model of creativity (Csikszentmihalyi, 1996)

The *Domain* in Figure 2.10 consists of a set of symbolic rules and procedures. The second component of creativity is the *Field*, which includes all the individuals who act as gatekeepers to the domain. It is their job to decide whether a new idea or product should be included in the domain. The third component of the system is the *Individual*. Creativity occurs when a person, using the symbols of a given *Domain* such as music, engineering, business or mathematics, has a new idea or sees a new pattern and when this novelty is selected by the appropriate *Field* for inclusion into the relevant domain. (Csikszentmihalyi, 2003, 28)

Earlier Csikszentmihalyi and Sawyer (1995) have explained differences in presented and discovered problems.

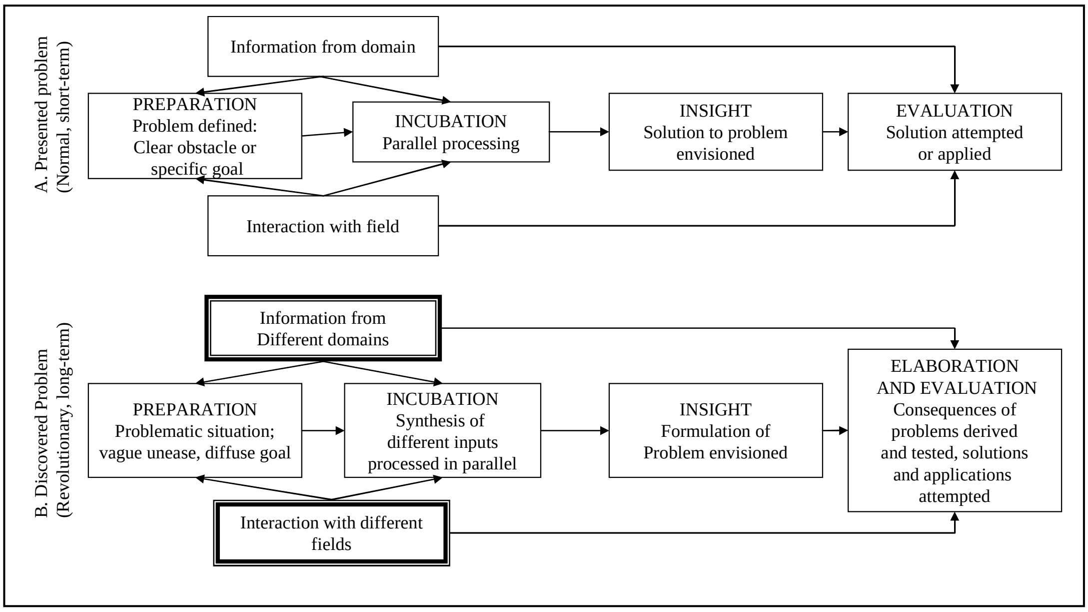

Figure 2.11. Proposed models of presented and discovered problem solving (Csikszentmihalyi and Sawyer, 1995)

Like Couger (1995) also Csikszentmihalyi and Sawyer (1995) in Figure 2.11 emphasise front-end, namely preparation and incubation processes before insight and elaboration. When we are developing artefacts, Model B, discovered problem solving is more relevant, since the problem is ill-defined and the problem-finding phase is important. Noteworthy is the emphasis on "Information from different domains" and "Interaction with different fields". So, an individual can operate on several fields and collect information from several domains. In summary, Csikszentmihalyi (1999, 332) recommends: In order to function well within the creative system, one must internalize the rules of domain and the opinions of the field, so that one can choose the most promising ideas to work on, and do so in a way that will be acceptable to one's peer. When an information system is built to support the systems model of creativity (Csikszentmihalyi, 1996), the idea needs to get accepted through collaboration, argumentation and even selling. The challenge of collaboration with peers will be next discussed.

2.2.5. Problem solving in groups and collective creativity

All our artefacts are designed to be used in collaboration. Collaboration takes place in teams, groups or in communities of practice. We will next exemplify the group problem-solving in general level and then introduce some techniques.

Hoffman (1988) sees organisation problem-solving groups as having two principal objectives: (1) the maximum utilisation of the resources brought by each individual member, including any added group potential; and (2) the generation of a high level of motivation for carrying out the group's decision in each and every member.

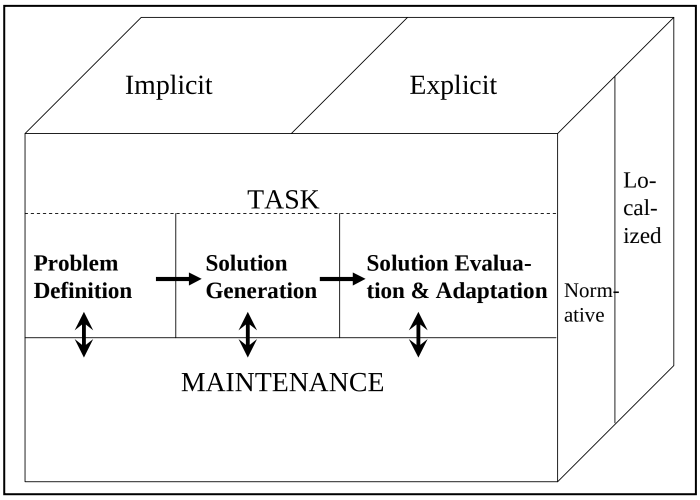

Figure 2.12. Hierarchical model of group problem solving (Hoffman, 1988)

As described in Figure 2.12, Hoffman's hierarchical model of group problem solving has three dimensions. Task-Maintenance, Normative-Localized and Explicit-Implicit are assumed to be activated simultaneously whenever a group solves a problem. The phases of problem solving are considered to be the implicit procedures of most problem-solving tasks (Hoffman, 1988). Problem solving takes place in a certain order: Problem definition, solution generation and solution evaluation & maintenance.

King and Anderson (1995) explored the literature related to 'innovation in working groups'. They identified that the following factors promote innovation in a group environment:
- A democratic, collaborative leadership style that encourages and motivates group members.
- Cohesiveness between team members – a heterogeneous team is an advantage for idea generation to avoid ''group think'' and a homogeneous team for smooth implementation.
- Group longevity – short-lived groups have been found to be more creative.
- Group structure – an organic structure is preferred to adapt to new problems

King and Anderson (1995) also highlight that groups are more willing to take risks than individuals, which can be advantageous if innovation is being inhibited by too much caution.

West (1990) describes the innovation process at the group level. He lists the following facilitators of group innovation:

Facilitator	**Explanation**
Vision	The group should have a clear focus or goal that is negotiated and shared by the group, valued within the group, and is accepted as attainable
Participative safety	The group works in non-threatening environment that allows motivated involvement in decision making by the group participants.
Climate for excellence in task performance	Group members expect and welcome critical evaluation and appraisal of quality.
Support	The company provides practical support for innovation.

Table 2.10. Facilitators of group innovation (West, 1990)

All those four facilitators mentioned in Table 2.10 share one common element: managerial commitment. We feel that this should be emphasised here. Especially, because the following, original brainstorming technique (Osborn, 1953) does not emphasise this specifically.

Separating Solution Generation and Evaluation

The main idea behind Osborn's (1953) brainstorming is that the generation of ideas and their evaluation are antithetical processes encouraged the invention of new solutions by delaying their evaluation. Groups may therefore benefit if the members brainstorm individually before they solve the problem together (Bouchard, 1972). Dennis, Aronson, Heninger and Walker (1999) wrote about the use of GSS (Group Support System) in brainstorming. Dennis *et al.* (1999) noticed that when there were three short (10 minutes) sessions, the result was better than in having just one (30 minutes) session. Groups in the partitioned task treatment generated 40% more ideas, but there were no time effects. These differences are attributed to the ability of the partitioned task to refocus members' attention more evenly across the entire solution space. (Dennis *et al.*, 1999, 95)

Solution Evaluation and Choice

The separation of idea production and evaluation benefits the idea-production phase, but has little effect on improving evaluation. The Nominal Group Technique (Delbecq, Van de Ven, and Gustafson, 1975), in which each group member contributes in turn, serves two functions. It concentrates the group's activities in the solution-generation phase and it assures that each member has a chance to be heard. In this way the implicit maintenance norm that regulates member's participation does not intrude on the task. Formal decision rules, like rules of majority or unanimous vote, perform a similar dual function. By having members make judgements anonymously, the Delphi Method (Dalkey, 1969) prevents status differences from affecting the quality of group outcomes. Delphi Method is utilised in designing our third artefact, the Brokering System for Open Innovation.

Collective creativity

Hargadon and Bechky (2006) have studied the time perspective in problem-solving and collaboration: "Organisations may therefore benefit when people come together to collectively work on defining and solving problems, and we need to deepen our understanding of how such collective problem solving happens. Collective creativity reflects a qualitative shift in the nature of the creative process, as the comprehension of a problematic situation and the generation of creative solutions draw from—and reframe—the past experiences of participants in ways that lead to new and valuable insights." (Hargadon & Bechky, 2006, 487) Here we see that collective creativity differs greatly from individual creativity. What we find interesting, is the focus on past experiences and their recollection. When Hargadon and Bechky (2006) analysed their field data it revealed four sets of interrelating activities that play a role in triggering moments of collective creativity, as presented in the following table.

Activity	Description
Help seeking	activities that occur when an individual who either recognizes or is assigned a problematic situation actively seeks the assistance of others
Help giving	represents the willing devotion of time and attention to assisting with the work of others.
Reflective reframing	represents the mindful behaviors of all participants in an interaction, where each respectfully attends to and builds upon the comments and actions of others.
Reinforcing	reflects those activities that subtly (and sometimes not so subtly) reinforce the organisational values that support individuals as they engage in help seeking, help giving, and reflective reframing.

Table 2.11. Activities of collective creativity (Hargadon and Bechky, 2006)

These activities described in Table 2.11. are not necessarily natural in organisations. In certain expert-organisations help seeking may be seen as a weakness, if the management of that company has not emphasised its importance. Hargadon and Sutton (1997) as well as Hargadon and Bechky (2006) provide examples how, for example, an expert organisation like IDEO is utilising collective creativity. Our challenge is to support all those activities mentioned in Table 2.13 in our artefacts. That might prove us difficult, since those activities should be taught by someone and creativity is difficult to foster.

The following figure describes how the above mentioned activities are interrelated.

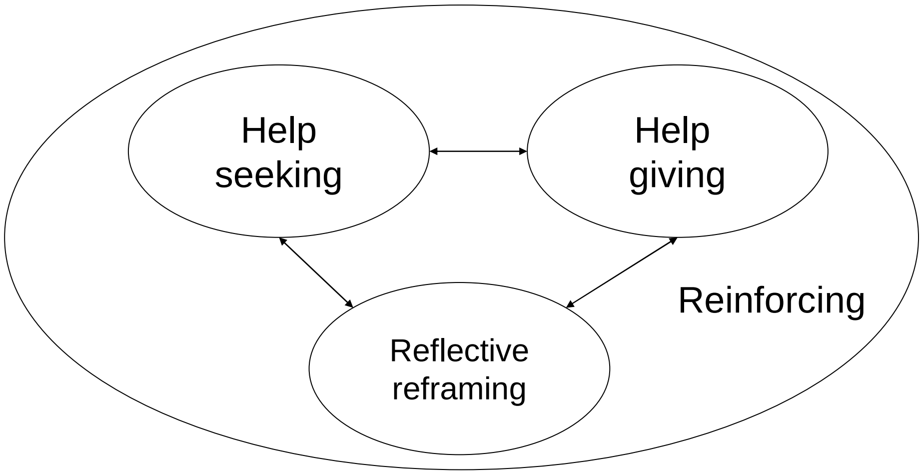

Figure 2.13. Collective creativity – elements (Hargadon and Bechky, 2006)

As a summary of the figure above, Hargadon and Bechky (2006, 494) explain: Rather than thinking of supraindividual creativity as a persistent organisational phenomenon with varying degrees of collectiveness, our research suggests that it is a rare and fleeting phenomenon even in the most creative of organisations.

This research of Hargadon and Bechky extends our understanding of organisational creativity by highlighting the collective and transient nature of those interactions that generate creative insights.

Similarly, Farooq *et al*. (2006) provide a review of findings in the creativity, group interaction and CSCW (Computer Supported Collaborative Work) literature. Based on the review, they define 3 requirements for supporting creativity: (a) Support for divergent and convergent thinking, (b) Development of shared objectives and (c) Reflexivity. Within the first item, the creative process involves the interaction of two contrasting types of thinking: "divergent," which converts information into a variety of unconventional alternatives, and "convergent," which aims at unique or conventional outcomes (Guilford, 1977). These thinking skills could be perhaps measured *before* using the system and tools/views could be tailored based on those test results. The second item, shared objectives, is not recognised in many creativity research papers and artifacts, like Hargadon and Becky (2006) demonstrated. Farooq *et al.* (2006, 226) point out "strong goal commitment is necessary to maintain group member persistence for implementation in the face of resistance among other organisational members". The third item, reflexivity, is similar to (critical) reflection. Centrality of experience, critical reflection, and rational discourse are all common themes in Mezirow's Transformational Learning theory (Mezirow, 1994). Reflection is a thinking skill and note-taking skill that can be trained, but it requires an extra effort.

When we summarise the above mentioned elements, problem solving in groups can be enhanced with many techniques. Solution generation and evaluation should be separated. The information system should help the user to recognise the best thinking and problem-solving style for them. After the initial individual problem-finding phase, the actual problem-solving should be collaborative. For these reasons the experiential learning model and various learning styles earlier presented by Kolb and Fry (1975) are worth noting in our artefact design phase. Nevertheless, when group cohesivity is increased, individual motivation may drop. Therefore we need to understand what is specific in organisational creativity.

2.2.6. Organisational creativity

Organisational creativity means creation of a valuable, useful new product, service, idea, procedure, or process by individuals working together in a complex social system (Woodman, Sawyer and Griffin, 1993).

Within information systems research area, Cooper (2000) has applied the organisational creativity model of Woodman *et al.* (1993) to create an organisational change within IT. Cooper also uses a concept ‘IT development creativity’ and points out that managing this kind of creativity is a complex process.

Why is organisational creativity needed? Williams and Yang provide the following explanation:

> *Established formulas for decision making have become less applicable, because these formulas were based on principles promoting and reflecting the stability of a prior era. Traditional procedures for routinising problem-solving processes through the use of hierarchical and bureaucratic systems are being challenged and shown to be inefficient. As a result, the limitations of policies based on traditional conceptions of organisations are being exposed. … To remain competitive, businesses can no longer follow time-tested formulas of precedent; they must be able to produce and be receptive to innovation, which is synonymous here with creativity in an organisational context.* (Williams and Yang, 1999, 374)

Earlier in Sub section 2.2.1. we introduced the investment theory of creativity (Sternberg and Lubart, 1995). The implications of the investment theory for organisational creativity are also broad. First, this theory suggests that organisations should actively encourage employees to buy low and sell high in the world of ideas, and reward employees who do so. Second, organisations should create environments in which employees feel secure in offering their new ideas. Third, organisations should not seek to stifle their outspoken and adversarial members, but rather should work to harness these individuals' ideas for the organisation's benefit. Fourth, organisations should recognise that creative performance sometimes has more to do with employees having the right attitude than with employees having been born with the right profile of abilities. And finally, organisations should be mindful of the fact that many creative individuals never attempt to share their creative insights with others, let alone try to persuade others of the merit of these insights. An organisational climate that offers incentives for creative production (e.g., "creative idea of the month" contexts) may prod such individuals. (Williams and Yang, 1999, 382)

To us this means that creative individuals in an organisation need a lot of freedom and creativity-supporting tools should measure creative potential and input in a right way. Therefore, we will present one more evaluation framework.

WEI Work Environment Inventory (Amabile and Gryskiewicz, 1989; Amabile, 1995; Amabile, Conti, Coon, Lazenby and Herron, 1996; Amabile, 1998)

We have interest in the WEI because rather than a measurement of general organisational climate, it concentrates on the climate for creativity. The WEI instrument has been validated since the late 1980's and the developers accumulated a database on business/industry organisations that serves as comparison basis for any organisation (Amabile *et al.*, 1996).

The WEI has following practices.

Challenge	involves matching people and assignment so that the stretch of the employee ability is “not so little that they feel bored but not so much that they feel overwhelmed and threatened by a loss of control”.
Freedom	involves giving employees autonomy around process, but only to the extent that there are clear and consistent goals.
Resources	involves the decision on the allocation of time and money to a project or a team.
Work-group features	involves creating teams that are comprised of people with “diversity of perspectives and backgrounds”.
Supervisory Encouragement	involves management recognition and acknowledgement of creative work before its impact is known.
Organisational Support	involves support from the organisation’s leadership and acknowledgement of the top priority set on creative efforts.

Table 2.12. Six practices that support creativity in organisation (Amabile, 1998)

The WEI focuses on these six practices that should support the expression and development of creative ideas. According to developers, the instrument is based on the assumption that large percentages of employees are capable of generating and developing creative ideas, given a conducive organisational environment. They believe that in reality most of this creative potential goes untapped, that it should be possible to increase the rate of creativity by improving the work environment. (Amabile and Gryskiewicz, 1989)

To us the WEI instrument is interesting, but it is difficult to implement it so that it would support our artefact building in Chapter 4. The WEI instrument is not originally focused on information systems, but its scale and question sets could be utilised as a check-list. The 78 items in the WEI survey are written as simple descriptive statements of the work environment, such as “I have sufficient time to do my projects,”, “There is a good blend of skills in my work group,” or “My supervisor has poor interpersonal skills.”

The WEI instrument is not functional without managerial support. In fact, the support of management is essential for organisational creativity. Amabile, Conti, Coon, Lazenby and Herron (1996) see that management-instituted mechanism for creativity (such as developing mechanisms for new ideas) differentiates between high and low performance organisations. We looked at WEI because we were interested in ways to support creativity in organisations. Next we will describe how innovation is related to creativity.

2.3. Innovation

Innovation literature is extensive and multi-disciplinary. For this reason we will first illustrate connections between creativity and innovation in Sub section 2.3.1. Thereafter in Sub section 2.3.2 a view on some frameworks of innovation (Henderson and Clark, 1990; Kim, 2005) is provided. Diffusion of innovations is addressed in Sub section 2.3.3. In Sub section 2.3.4 we will discuss about open innovation (Chesbrough, 2003) and how it changes innovation practices. Finally, in Sub section 2.3.5 we will discuss about intermediaries and brokering in the innovation process.

2.3.1. From creativity to innovation

Couger (1995) sees creativity central in all phases of the innovation process: in generating idea, in developing idea, in turning idea to product/service and finally, in protecting results. Establishing a systematic process to capitalize on creativity is an essential capability for enterprises operating in an accelerated business environment. A seeming paradox of innovation is that the most useful ideas originate from a structured process rather than random occurrences of creativity. (Gartner, 2002).
Innovation process in organisations has been described as an entity where ideas are evaluated and accepted ideas are developed to products and marketed (Majaro, 1988).

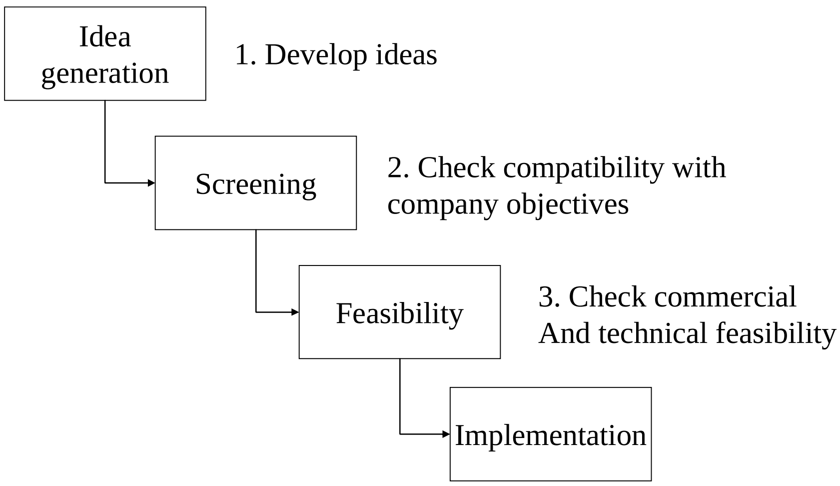

Figure 2.14. The innovation process (Majaro, 1988)

Many current suggestion management systems and idea competitions in organisations utilise the approach described in Figure 2.14. The screening and feasibility phases in the picture above are sensitive, both from evaluation and time management perspective. As Hargadon and Sutton (1997, 717) state: “Valuable solutions seldom arrive at the same time as the problems they solve, they seldom arrive to the people working on those problems, and they seldom arrive in forms that are readily recognizable or easily adaptable.”

We may also ask how functional the innovation process described by Majaro (1988) is, when for example, social innovations or scientific work are considered? If the screening phase takes place too early, will it kill a promising idea seed? Additionally, how does that kind of process support the expertise development of individuals who participate in it? The innovation process of Majaro (1988) does not refer to competences or human resource development.

Idea competitions and suggestion management systems have existed for decades. Employers have had interest in harnessing suggestions and ideas of employees in a structured manner. However, the results have not always been successful. Motivating employees to participate is a common weakness of suggestion management systems (Fairbank & Williams, 2001). The whole evaluation procedure is problematic since there is limited focus on internal motivation (Amabile 1983, 1989) and as Dean *et al.* (2006) indicated in their literature review on idea evaluations, some people evaluate ideas based on their novelty while others are more concerned if the idea is applicable, effective and implementable. Also competition and even jealousy exist in the innovation process (Shalley and Oldham, 1997). McAdam and McClelland (2002, 95) made a survey of innovation management literature and their finding was “Overall, there is a need for systematic integrated research to investigate how organisations develop philosophies of knowledge, create knowledge and generate ideas, thus enhancing creativity and innovation.” When thinking about of level of analysis, the groups are in focus: “Groups often create novel and unexpected combinations an organisation’s past knowledge in ways that individual or more formal organisational structures do not” (Hargadon, 1999, 137). Novelty in innovation is often associated with radical innovation. We will next show that architectural innovation requires novelty as well.

2.3.2. From incremental to architectural innovation

There have been several definitions for incremental versus radical innovation since the Schumpeter’s (1942) creative destruction, an economic theory of innovation and progress. Henderson and Clark (1990) present that “incremental innovation introduces relatively minor changes to the existing product, exploits the potential of the established design, and often reinforces the dominance of established firms”. They continue: “Radical innovation, in contrast, is based on a different set of engineering and scientific principles and often opens up whole new markets and potential applications and can be the basis for the successful entry of new firms or even the redefinition of an industry” (Henderson and Clark, 1990, 11).

Thereafter Henderson and Clark demonstrate that the earlier classification of innovation into two classes: incremental and radical, is insufficient. In addition to the earlier dividing dimension (reinforced, overturned) another dimension (unchanged, changed) was needed. The architectural innovation could then be classified, and a new class (modular) was also generated.

Core components

Linkage between Core Concepts and Components	Reinforced	Overturned
Unchanged	Incremental Innovation	Modular Innovation
Changed	Architectural Innovation	Radical Innovation

Figure 2.15. A framework for defining innovation (Henderson and Clark, 1990)

The figure above classifies innovations along two dimensions. The horizontal dimension captures an innovation's impact on components, while the vertical captures its impact on the linkages between components. The distinctions between radical, incremental, modular and architectural innovations are matters of degree. Architectural innovations stand out as creative acts of adapting and applying latent technologies or potential to previously unarticulated user needs (Abernathy and Clark, 1985).

Henderson and Clarke (1990) provide a practical example, a room fan:

> "*a room fan's major components include the blade, the motor that drives it, the blade guard, the control system, and the mechanical housing. The overall architecture of the products lays out how the components will work together. Taken together, a fan's architecture and its components create a system for moving air in a room. A component is defined here as a physically distinct portion of the product that embodies a core design concept and performs a well-defined function. In the fan, a particular motor is a component of the design that delivers power to turn the fan. There are several design concepts one could use to deliver power. The choice of one of them – the decision to use an electric motor, for example, establishes a core concept of the design. The actual component – the electric motor – is then a physical implementation of this design concept. (Henderson and Clark, 1990, 11)*

After this practical room fan example, authors shows the link to knowledge: “The distinction between the product as a system and the product as a set of components underscores the idea that successful product development requires two types of knowledge. First, it requires component knowledge, or knowledge about each of the core design concept and the way in which they are implemented in a particular component. Second, it requires architectural knowledge or knowledge about the ways in which the components are integrated or linked together into a coherent whole. The distinction between architectural and component knowledge, or between the components themselves and the links between them, is a source of insight into the ways in which innovations differ for each other.” (Henderson and Clark, 1990, 11)

We would like to add a complementary concept and a framework. The new concept is “break away innovation” which means that real growth comes both from new markets and new products (Kim and Mauborgne, 2005). The next ‘Blue ocean strategy’ framework describes how break away innovation is a mixture of marketing and technologies.

Applied marketing		Applied technologies: existing	Applied technologies: new
	new	Market Innovation	Break Away Innovation
	existing	Cost Innovation	Feature Innovation

Figure 2.16. Blue Ocean Strategy (Kim & Mauborgne, 2005)

In Figure 2.16 Kim and Mauborgne begin with an elementary differentiation between the “red ocean” and the “blue ocean”. The former comprises all the industries in existence today while the latter represents all the industries not in existence today. The new unit of analysis that Kim and Mauborgne propose is a strategic move. A strategic move is defined as a “set of managerial actions and decisions involved in making a major market-creating business offering” (Kim and Mauborgne, 2005, 10). In Figure 2.16 this strategic move is the same as break away innovation. The empirical base Kim and Mauborgne (2005) is drawn from more than one hundred fifty strategic moves made from 1880 to 2000 in more than thirty industries. Kim and Mauborgne (2005) includes analyses of both the winners and the losers in their attempts to create blue oceans.

When we compare Figure 2.16 to the previous Figure 2.15, we notice that the architectural innovation by Henderson and Clark (1990) does not consider marketing as a way of innovating. Occasionally the discussion about radical versus architectural innovation should perhaps focus on the ways innovation gets adopted by the users or by the community. Therefore, the next sub-section will be about diffusion.

2.3.3. Diffusion of innovations

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. Diffusion is a special type of communication concerned with the spread of messages that are perceived as new ideas (Rogers, 2003, 35). Empirical research shows that users often do achieve widespread diffusion by an unexpected means: they often “freely reveal” what they have developed. When we say that an innovator freely reveals information about a product or service she has developed, we mean that all intellectual property rights to that information are voluntarily given up by the innovator, and all interested parties are given access to it—the information becomes a public good (von Hippel, 2005, 9). Since IPR (intellectual property rights) is not the topic of this thesis, we may only conclude that companies can speed up diffusion by providing some elements of the innovation or product for free.

There may also exist diffusion networks that consist of opinion leaders who purposefully or unknowingly spread the word about new innovation. Opinion leadership is the degree to which an individual is able to informally influence other individuals’ attitudes or over behaviour in a desired way with relative frequency. Opinion leaders play an important role in diffusion networks, and are often identified and utilised in diffusion programs. (Rogers, 2003, 362) Once again, we find an interesting connection to brokers (Hargadon and Sutton, 1997) and gatekeepers (Allen and Cohen, 1969), which will be described from Section 2.4 onwards. Often those opinion leaders are called as gatekeepers or brokers who spread the word about a new innovation in a diffusion network. This diffusion network is next described.

Rogers (2003) sees the following network elements important:

Communication network	Consists of interconnected individuals who are linked by patterned flows of information. An individual's network links are important determinants of his or her adoption of innovations.
Communication structure	Differentiated elements that can be recognised in the patterned communication flows in a system. This structure consists of the cliques within a system and the network interconnections among them that provided bridges and liaisons.
Communication proximity	The degree to which two linked individuals in a network have personal communications that overlap.
Personal network	Consists of those interconnected individuals who are linked by patterned communication flows to a given individual. Personal networks that are radial (rather than interlocking) are more open to an individual's environment; and hence play an important role in the diffusion of innovations.

Table 2.13. Elements of diffusion networks (Rogers, 2003)

As Table 2.13 indicates, diffusion means systematically utilising networks of people to market or promote an innovation. Table 2.13 contains similar elements as the earlier mentioned Systems Model of Creativity (in Sub section 2.2.5). One of the most serious shortcomings of diffusion research is its pro-innovation bias. The pro-innovation bias is the implication in diffusion research that an innovation should be diffused and adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should be neither re-invented nor rejected (Rogers, 2003, 106).

Rogers' (2003) innovation-development process has five steps passing from recognition of a need, through R&D, commercialization, diffusions and adoption, to consequences. From a managerial perspective, this theory of Rogers illustrates the activities needed to coordinate organisational resources in knowledge creation and diffusion.

Nevertheless, the theory emphasizes the diffusion of new knowledge after its creation, which limits its value in completely and accurately describing knowledge creation prior to the diffusion (Li and Kettinger, 2006). We may also ask: is innovation always a positive thing? Many innovations have turned to risks (like asbestosis and DDT). Rogers talks about these risks in his book but he does not seem to recognise a risk. In that sense, the innovation process should also include a risk management phase. This topic is not extensively covered in this thesis but will be discussed in Chapter 4 where artefacts are designed. Those elements of diffusion networks mentioned by Rogers (2003) originate from company and organisation specific settings, but they are relevant also with the emerging open innovation paradigm.

2.3.4. Open Innovation

Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology (Chesbrough, 2006a, 16). West and Gallagher (2006) define open innovation as systematically encouraging and exploring a wide range of internal and external sources for innovation opportunities, consciously integrating that exploration with firm capabilities and resources, and broadly exploiting those opportunities through multiple channels. “Firms practicing open innovation face three inherent management challenges, which are 1) *maximization* (including outbound licencing of IP, patent pooling and even giving away technology to stimulate demand for other products), 2) *incorporation* (firms need to identify relevant knowledge through scanning, recognitions, absorption and political willingness to incorporate external innovation) and 3) *motivation* (firms must cultivate ways to assure continued supply of relevant external technologies and IP)”. (West and Gallagher, 2006, 82)

When setting a research agenda for the future of open innovation, West, Vanhaverbeke and Chesbrough (2006) point out needs to support individual innovators: “… the commonly cited examples of shared creativity lie within a broad class of information goods, for which the Internet and relevant software tools enable collaborative production across time and space. If such collaboration were to generalize beyond information goods, what sorts of identification, coordination and distribution mechanism would be required? Will the necessary tools (or skills) be available to individual innovator, or only under the umbrella of firms, universities and other organisations?” (West *et al.*, 2006, 149)

This discussion about tools, skills and ownership is relevant to information systems research area. Our first and second artefacts provide these missing tools for individual innovators. Our third artefact, the Brokering System for Open Innovation is already focused on communities and company networks.

Von Hippel (2005) encourages companies to integrate into open source communities and even freely reveal innovations to speed up their diffusion. Fitzgerald (2006) discusses about open source 2.0, where companies systematically build, support and utilise open source communities. “The open source phenomenon is market-driven … places a great deal of emphasis on services. It adopts a professional approach to achieving value by establishing a profitable business venture for which customers are willing to pay the going rate” (Fitzgerald, 2006, 593). The open innovation paradigm of Chesbrough (2003, 2006a) encourages companies to co-operate with open source communities and bring ideas from R&D as basis of this co-operation. According to Chesbrough (2006a) open innovation processes combine internal and external ideas into architectures and systems. Torkkeli, Koch and Salmi (2009) have demonstrated that sharing and openness may also have adverse consequences and therefore closed innovation may be a better option for certain companies. So, we try to avoid saying that open innovation is better than or a substitute of closed innovation. Nevertheless, customers are essential in open innovation.

Customer co-design describes a process that allows customers to express their product requirements and carry out product realization processes by mapping the requirements into the physical domain of the product (Khalid & Helander, 2003; von Hippel, 1998). The customer can choose from an infinite set of options an individualized combination or even extent the options and even invent new ones. During this process of elicitation, the customer is being integrated into the value creation of the supplier (Piller, Schubert, Koch and Möslein, 2005). Chesbrough (2003) therefore encourages companies to change the role of R&D (from earlier creating new knowledge), to focusing on knowledge brokering. Our artefact design in Chapter 4 provides us an opportunity to integrate a customer into co-design and brokering. Next sub-section will describe brokers and brokering in detail.

2.3.5. Brokering, gatekeepers and intermediaries

The term, broker, comes originally from financial world. Brokers act like mediators between people and organisations. Open Innovation communities utilise brokers (Chesbrough, 2006b). Open innovation communities represent a new and powerful social context in which to generate knowledge and advance technology (von Hippel and von Krogh, 2003). Technology brokering (Hargadon & Sutton, 1997) and knowledge brokering (Hargadon and Sutton, 2000) are specific subtypes of brokering and they will be described below. Brokers often belong to many communities, inside and outside of the company. Wenger (1998) uses the term broker in context of communities of practice (CoP). Since his term use is different from Hargadon and Sutton's (1998, 2000), brokering within CoPs is illustrated. Brokers can be individuals, groups or even organisations. Intermediaries are organisational brokers and their specialities will be illustrated.

Technology brokering

Technology brokering as defined by Hargadon and Sutton (1997) means a strategy for exploiting the networked nature of the innovation process and building new communities around innovative recombinations. The technology brokering process model (Hargadon and Sutton, 1997) was originally based on observations how a certain company (IDEO, http://www.ideo.com) and its designers develop innovative products. This firm exploits its network position, working for clients in at least 40 industries, to gain knowledge of existing technological solutions in various industries. IDEO acts as a technology broker by introducing these solutions where they are not known and, in the process, creates new products that are original combinations of existing knowledge from disparate industries.

The findings of Hargadon and Sutton (1997) suggest that IDEO's ability to generate innovative products that are new combinations of existing technologies can be understood by considering both organisation's network position and the behaviours of its designers in exploiting that position. (Hargadon and Sutton, 1997, 723) The following figure summarises the steps in working with the organisational memory and behaviours of its designers in accessing this memory.

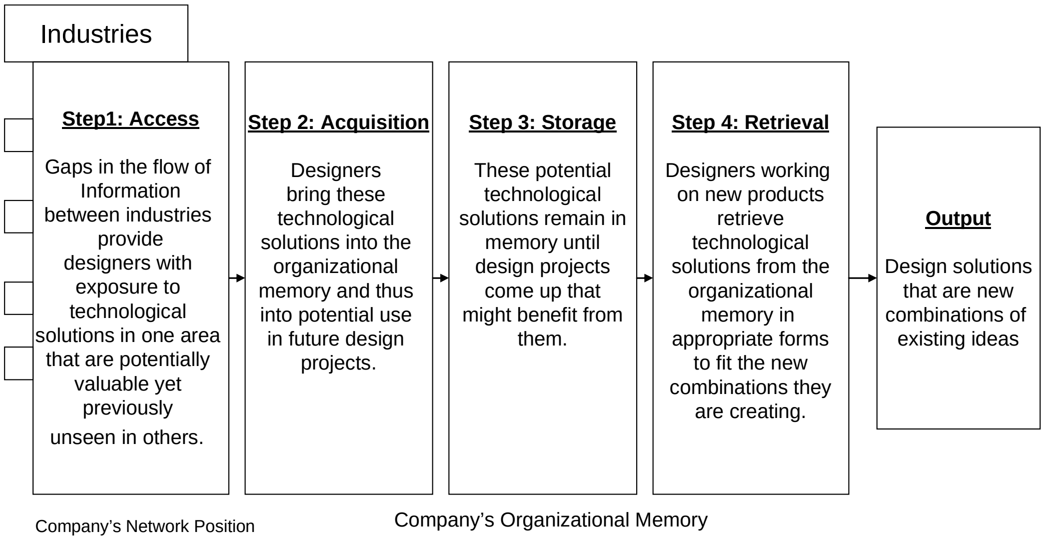

Figure 2.17. A process model of how innovation occurs through technology brokering (Hargadon and Sutton, 1997)

Designers exploit their access to a broad range of technological solutions with organisational routines for acquiring and storing this knowledge in the organisation's memory and, by making analogies between current design problems and the past solutions they have seen, retrieving that knowledge to generate new solutions to design problems in other industries. (Hargadon and Sutton, 1997, 716)

When we define requirements for our our artefacts in Chapter 4, we are interested to support this exchange of information from one area (industry) to another. Hargadon and Sutton (1997) have utilised the work of Walsh and Ungson (1991) and IDEO case observations when naming their steps (access, acquisition, storage, retrieval) in Figure 2.17. Walsh and Ungson (1991) describe three processes of organisational memory: acquisition, retention and retrieval. Additionally, they discuss about five storage bins and identify them in the following table.

Storage bin	Description
1. *Individuals*	Individuals have their own recollections of what has transpired in and about organisations. As many researchers have recognized, individuals in an organisation retain information based on their own direct experiences and observations. This information can be retained in their own memory stores or more subtly in their belief structures, cause maps, assumptions, values, and articulated beliefs. Briefly, individuals store their organisation's memory in their own capacity to remember and articulate experience and in the cognitive orientations they employ to facilitate information processing. Moreover, individuals and organisations keep records and files as a memory aid. As researchers observed, such information technologies help to constitute an organisation's memory."
2. *Culture*.	Organisational culture has been the subject of increasing interest. It has been defined as a learned way of perceiving, thinking, and feeling about problems that is transmitted to members in the organisation. The words learned and transmitted are central to this definition and our purpose. Culture embodies part experience that can be useful for dealing with the future. It is therefore, one of organisational memory's retention facilities. This learned cultural information is stored in language, shared frameworks, symbols, stories, sagas, and the grapevine. Because this information is transmitted over and over again, some of the detail and context of the various decisions are likely to be dropped or even altered to suit the telling."
3. *Transformations*.	Information is embedded in the many transformations that occur in organisations. That is, the logic that guides the transformation of an input (whether it is a raw material, a new recruit, or an insurance claim) into an output (be it a finished product, a company veteran, or an insurance payment) is embodied in these transformations. It is argued that the analyzability of search behaviour in the transformation process characterizes the nature of technology. This search behaviour varies from analyzable (where there are known ways of solving a problem) to unanalysable (where the residue of experience, judgment, knack, wisdom, and intuition directs problem solving). In either case, the retrieval of past information from past transformations guides current transformation processes. … Transformations occur throughout the organisation. Practices from the design of work itself, to selection and socialization, to budgeting and market planning inhabit transformations and build on past experience."
4. Structures	Organisational structure must be considered in light of its implications for individual role behaviour and its link with the environment. Individual roles provide a repository in which organisational information can be stored. … It is noted that social interaction between persons is conditioned by mutual expectations attendant to their particular roles. … It is postulated that individual enactments are guided by collectively recognized and publicly available rules. These rules represent formal and informal codifications of 'correct' behaviour that is conditioned by consensual agreement among the participants. … It is also hypothesized that structure reflects and stores information about the organisation's perception of the environment."
5. *Ecology*	The actual physical structure or workplace ecology of an organisation encodes and thus reveals a good deal of information about the organisation. … The physical setting often reflects the status hierarchy in an organisation. As a consequence, the workplace ecology helps shape and reinforce behaviour prescriptions within an organisation."

Table 2.14. Storage bins of organisational memory (Walls and Ungson, 1991)

What we learn from Walls and Ungson in Table 2.12 is that storage bins are often non-technical. The bins (Individuals, Culture, Transformations, Structures, Ecology) should be understood before knowledge processes are modelled for an information system. Additionally, Hargadon and Sutton (1997) showed how products and prototypes carry information. So, these can also be new types of storage bins, mentioned in the previous table by Walls and Ungson (1991). In their review article of knowledge management systems, Alavi and Leidner (2001) point out: "…knowledge may be tacit or explicit; it can refer to an object, a cognitive state, or a capability; it may reside in individuals, groups (i.e., social systems), documents, processes, policies, physical settings, or computer repositories. Thus, no single or optimum approach to organisational knowledge management and knowledge management systems can be developed. A variety of knowledge management approaches and systems needs to be employed in organisations to effectively deal with the diversity of knowledge types and attributes." (Alavi and Leidner, 2001, 131)

This variety mentioned by Alavi and Leidner can be achieved by utilising several information sources. The structural holes theory by Burt (1992) has been utilised by Hargadon and Sutton (1997) as the basis of technology brokering process model. This process model suggests that innovators can innovate routinely because they occupy a "structural hole", a gap in the flow of information between subgroups in a larger network. For innovators, these gaps exist between industries where there was and was not knowledge about the new emerging technologies. Actors filling these gaps are brokers who benefit by transferring resources from groups where they are plentiful to groups where they are dear. (Hargadon & Sutton, 1997, 717)

Lately, these brokers have been discussed in connection to social networks. According to Granovetter (2005) social structure, especially in the form of social networks, affects economic outcomes for three main reasons. "First, social networks affect the flow and the quality of information. Much information is subtle, nuance and difficult to verify, so actors do not believe impersonal sources and instead rely on people they know. Second, social networks are an important source of reward and punishment, since these are often magnified in their impact when coming from others personally known. Third, trust--the confidence that others will do the right thing despite a clear balance of incentives to the contrary--emerges, if it does, in the context of a social network." (Granovetter, 2005, 33) This informs us that in our artefact design in Chapter 4 we need to support social networks, and generally, brokering.

After discussing about technology brokering, Hargadon and Sutton (2000) have also written about knowledge brokering and knowledge brokers. They have taken wider perspective, so that knowledge brokering process does not describe only IDEO's way of brokering. In this context they have defined following general processes:

Brokering process	Description
1. Capture good ideas	Knowledge brokers constantly scavenge for promising ideas, sometimes in the likeliest places. They see old ideas as their primary raw material.
2. Keep ideas alive	To remain useful ideas must be passed around and toyed with. Effective brokers also keep ideas alive by spreading information on who knows what within the organisation.
3. Imagine new uses for old ideas	This is where the innovations arise, where old ideas that have been captured and remembered are plugged into new contexts.
4. Put promising concepts to the test	Testing shows whether an innovation has commercial potential. It also teaches brokers valuable lessons, even when an idea is a complete flop.

Table 2.15. Knowledge brokering (Hargadon and Sutton, 2000)

Our artefacts are meant to *capture good ideas* (Process 1 in the table). *Keep ideas alive* (process 2) means that people are 'tagged' with ideas, so, that each idea is linked to a person. *Imagine new uses for old ideas* (process 3) means that an information system needs a knowledge base where old ideas are available for further use and remixing. *Put promising concepts to the test (*process 4*)* is perhaps the most difficult phase to support, since our artefacts are (mostly) intended to support the fuzzy front end of the innovation process.

Gatekeepers

Earlier we described brokering as a process. Since gatekeepers as individuals practice brokering, we will provide a description of gatekeepers' roles and activities. This way we can provide a highly personalised description of brokering.

Technological gatekeepers are defined as those key individual technologists who are strongly connected to both internal colleagues and external sources of information (Allen and Cohen, 1969; Allen, 1977; Tushman, 1977; Katz and Tushman, 1981; Tushman and Scanlan, 1981). Gatekeepers are capable of translating technical developments and ideas across contrasting coding systems. They keep up-to-date with new technical developments outside the organisation by reading the technically more sophisticated literature and by communicating with external technical experts. Like mentioned here by Allen and Tushman, technological gatekeepers are technical experts mostly in engineering companies

The gatekeeper is frequently consulted by local colleagues because they have demonstrated their technical competence in a particular field. Allen and Cohen (1969) noted when studying gatekeepers in a large aerospace firm that "..if one were to sit down and attempt to design an optimal system for bringing in new technological information and disseminating it within the organisation, it would be difficult to produce a better one than that which exists".

Though not essentially innovators themselves, gatekeeper conversion is the key to launching an idea or an innovation (Barabási, Jeong, Néda, Ravasz, Schubert and Vissek, 2003). Allen (1977) has made seminal contributions to the research of gatekeepers. His research has focused on the intra-organisational aspects of knowledge flows and he has made some interesting findings. While direct communication by all project members may be effective for internal communications, the particular method for effectively keeping up-to-date with technical advances outside the organisation is very different. Similar studies have found that when the work involves locally-defined tasks which require the integration of external knowledge, then it is more effective to have only a small number of gatekeepers (Allen and Cohen 1969; Katz and Tushman 1981). In fact, the presence of a high number of gatekeepers in these types of projects has a detrimental effect on performance. In explaining these findings, Allen and Cohen (1969) concluded that most engineers are unable to effectively communicate with external information sources. Thus, only a few key actors should have external links. Widespread direct contact by all project members is not an effective method for transferring technical knowledge into a project from external sources (Whelan and Ahonen, 2008).

Given their ability to scan and interpret information from external areas and to transfer this information to the innovating unit, persons filling these boundary spanning roles can be seen as an important information processing mechanism in the innovation process. In fact, Brown and Duguid (2001) conclude that the key to competitive advantage is a firm's ability to coordinate autonomous communities of practice internally and leverage the knowledge that flows into these communities from network connections. Figure 2.18 illustrates the two-step process through which gatekeepers mediate the transfer of information from external information areas into the organisations internal communication network.

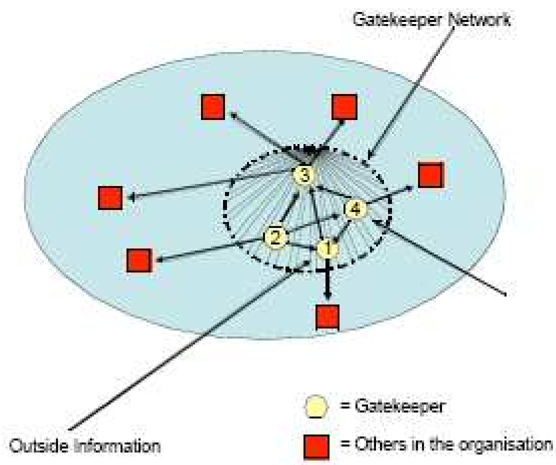

Figure 2.18. The function of the gatekeeper network (Whelan and Ahonen (2008), adapted from Allen and Cohen (1969)

In the figure new information is brought into the organisation by the gatekeeper 1. It can be transmitted to gatekeepers 2, 3 and 4 via the gatekeeper network. It reaches its eventual users (squares) through their contacts with gatekeepers).

Gatekeepers are different from organisational champions. These champions often have more limited role than gatekeepers. The following description by Heng, Traut and Fischer (1999) illustrates how an individual champion operates: “The results of this study show that these organisational champions fall somewhere in between the classic IT champion and the project manager. While personal leadership characteristics are not as much in evidence, organisational characteristics are emphasised more. They use their political skills to obtain resources and organisational acceptance of the IT innovations as they are shepherding the innovation through the organisational bureaucracy. However, these champions seem to place as much emphasis on creativity as classic IT champions. When necessary, they break rules, give veiled threats and find ways to get around the organisational bureaucracy. They seek creative outlets for themselves and those they manage.” (Heng *et al*., 1999, 193)

Since this IT champion activity of Heng *et al*. (1999) is collaborative, we will next illustrate the CoP (Communities of Practice) approach.

Brokers and communities of practice

There is one more definition of brokering and brokers by Wenger. Brokering has been discussed in connection to Communities of Practice (Wenger, 1998). “Brokers are able to make new connections across communities of practice, enable coordination, and – if they are good brokers – open new possibilities for meaning. Although we all do some brokering, my experience is that certain individuals seem to thrive on being brokers: they love to create connections and engage in ”import-export” and so would rather stay at the boundaries of many practices than move to the core of any one practice. The job of brokering is complex. It involves processes of translation, coordination, and alignment between perspectives. It requires enough legitimacy to influence the development of a practice, mobilize attention, and address conflicting interests. It also requires the ability to link by facilitating transactions between them, and to cause learning by introducing into a practice elements of another. Toward this end, brokering provides a participative connection – not because reification is not involved, but because what brokers press into service to connect practices is their experience of multimembership and the possibilities for negotiation inherent in participation.” (Wenger, 1998, 109)

This view of Wenger informs that brokering is a skill but also that some people have personal characteristics more suitable for this activity than others. The challenge in our artefact design is to support those brokering skills and perhaps recognise brokers through social network analysis (SNA). The writings of Wenger have later received some criticism for too much emphasis of community and individual characteristics.

The following criticism of Wenger comes from Brown and Duguid (2001): Taking the community of practice as a unifying unit of analysis for understanding knowledge in the firm … often too much attention is paid to the idea of community, too little to the implications of practice. Practice, we suggest, creates epistemic differences among the communities within a firm, and the firm's advantage over the market lies in dynamically coordinating the knowledge produced by these communities despite such differences. (Brown and Duguid, 2001, 198) This raises a question: can a company act as a broker?

Intermediaries

Intermediary is defined as "Acting or of the nature of action between two persons, parties, etc; serving as a means of interaction; mediatory." (Concise Oxford English Dictionary, 2009). Intermediaries and intermediate markets are also terms used by Chesbrough (2003, 2006a, 2006b) in connection to Open innovation paradigm: "Intermediate markets are markets in which an upstream supplier licenses its know-how and intellectual property to downstream developers and producers. In intermediate market situations, different ingredients for business success (the idea itself, the critical development, manufacturing and distribution assets, the intellectual property [IP] may all lie in different hands." (Chesbrough, 2006a, 4)

Intermediate markets alter the incentives for innovation, and also condition the mode of entry of new technologies and new firms into an industry. "Being an innovation intermediary is not an easy business", writes Chesbrough (2006b). Chesbrough (2006b, 139-140) introduces 5 challenges for intermediaries:

1. *How can the intermediary help its clients define the problem that needs to be solved*. This definition must be sufficiently clear to outsiders that they can recognise whether they know enough to answer the problem, without being so clear as to reveal sensitive client information.

2. *How to manage the problem of identity*: whether and when to disclose the identity of one party to the other party.

3. *How to demonstrate the value of their service to their clients*. Other processes, beyond the control of the intermediary, must occur in order for an idea or technology to become valuable, so how can one measure the contribution for the intermediary to whatever value was subsequently created?

4. *How to create or access a two-sided market, with lots of buyers and lots of sellers*.

5. *How to establish a strong, positive reputation early on in the company's operation*

In our artefact design in Chapter 4 we need to address these intermediary challenges. However, the challenges Chesbrough illustrates above are related to management and marketing practices of a company that is working as an intermediary.

So far, the best known and most successful intermediary is a company called InnoCentive (http://www.innocentive.com). The InnoCentive service is based on Challenges (questions submitted by companies) which Solvers (researchers, research groups and interested individuals around the world) try to solve. The best Solvers get a monetary reward from the company for succeeding in solving the Challenge. InnoCentive has managed to change the face of R&D for many corporations, government agencies, and non-profits by employing their price-based method to engage innovators in many industries from around the world (Tapscott and Williams, 2006). The InnoCentive information system is already quite advanced with several levels of privacy and highly-developed data security levels. In that sense, it provides design ideas for our artefact design.

In this section we demonstrated how brokers, gatekeepers and intermediaries operate. Next we will illustrate the challenge in building a decision support system (DSS) with creativity support.

2.4. Decision support systems (DSS)

As decision support systems are one main area of information systems research, creativity-support have been occasionally discussed within it (Forgionne and Newman, 2007; Marakas, 2003; Couger, 1995; Nunamaker *et al*., 1997; Fairbank *et al.* (2003).

There are many definitions of a Decision Support Systems (DSS), but all have three themes: (1) applied to structured problems, (2) supports but does not replace the decision process, and (3) is under the user's control (Marakas, 2003).

DSS Domain

Stable context	←→	Volatile context
Commonplace	←→	Atypical, unique
Recurrent	←→	Discrete
Programmable	←→	Intuitive, creative
Easily accessible information	←→	Problematic access to information
Decision criterion understood	←→	Decision criterion unknown
Focused decision strategy	←→	Multiple decision strategies

Structured ←――――――――→ Unstructured

Structured	Semistructured	Unstructured

Figure 2.19. Decision systems – from structured to unstructured (Marakas, 2003)

Figure 2.19 above presents the characterictics of decision support systems. When explaining the figure, *Programmable* is seen by Marakas contradictory to *Intuitive*, *Creative*. "DSS have successfully supported only the problem solving tasks associated with decision making. However, problem finding; including the tasks of uncovering the underlying decision problem, gathering relevant information about it, and diagnosing it is fuzzy, difficult, and not amenable to technical support." (Todd and Benbasat, 2000, 4) Marakas (2003) sees that ″In the realm of DSS design, mechanisms must be developed to allow the decision maker to impart intuition to the decision process as a supplement to other problem-solving resources, including creativity″. When talking about the future, Marakas points out: ″The integration of components of expert systems and other AI approaches with organisational DSSs presents a major focus". To us those are new requirements for creativity support in information systems.

Forgionne and Newman (2007) compared two groups: the first one using a traditional decision support system and the second one using the same DSS with an additional creativity enhancement tool (Creativity enhancing Decision Making Support System, CDMSS). They found out that: (a) CDMSS users generated more ideas in the same amount of time as DSS users; (b) CDMSS users had more net profit than DSS users; and (c) the variation in net profit was largely accounted for by the variation in the number of ideas and the time needed to make decisions. Their CDMSS has the following architecture.

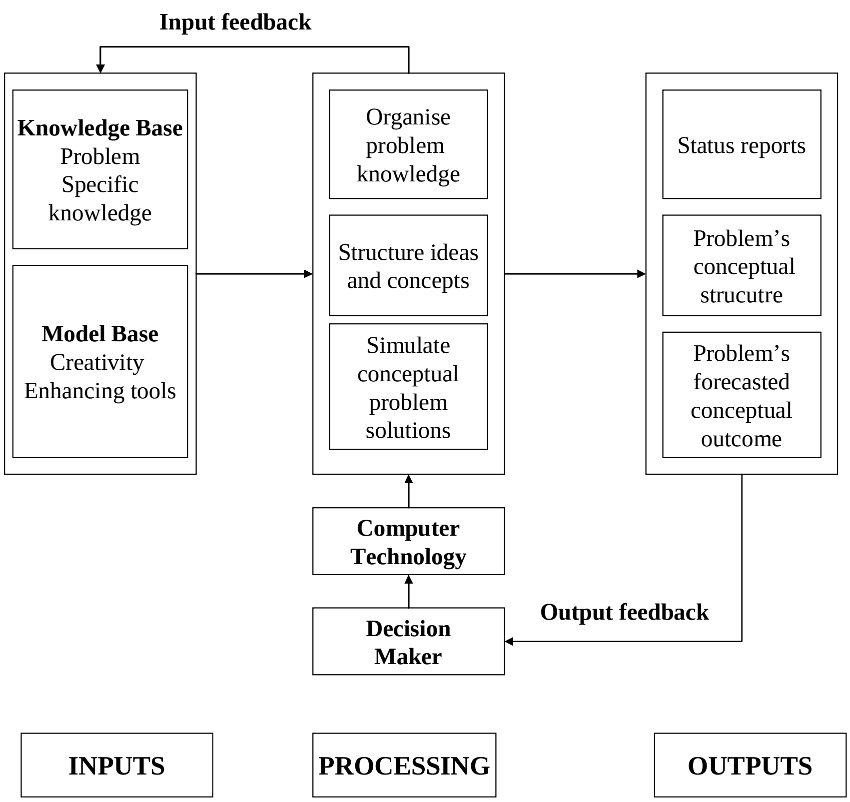

Figure 2.20. Creativity enhancing decision making support system, CDMSS (Forgionne and Newman, 2007).

Authors describe the system’s functions in Figure 2.20: “CDMSS captures and stores as inputs problem specific knowledge (ideas and concepts) and creativity enhancing tools. Ideas and concepts may come from conventional wisdom, documents detailing standard operating procedures, case studies or other sources, while creativity enhancing tools include morphological analysis, metaphors, convergent and divergent thinking mechanisms, brainstorming, calculus and other methodologies.” (Forgionne and Newman, 2007, 2127)

We may ask that where are those creativity-related elements in this CDMSS artefact? Forgionne and Newman explain: “The decision-maker utilises computer technology to: (a) organize (chiefly categorize and classify) the problem knowledge, (b) structure ideas and concepts into problem elements and relationships, and (c) simulate conceptual problem solutions. Results are reported as problem elements (status reports), the problem's conceptual structure (criteria, alternatives, events and relationships) and/or forecasted outcomes from the conceptual analyses. Feedback from the user-controlled processing guides the decision-maker through the design stages of the decision-making process and identifies the parties affected by the conceptual analyses. This identification helps the decision-maker to develop an implementation plan and put the plan into action. Created problem elements and structures are stored as additional inputs for future or additional processing.“ (Forgionne and Newman, 2007, 2127). We see that creativity-support here means assisting in problem design by helping the decision-maker to define problems from ill-defined data. In that sense the CDMSS of Forgionne and Newman (2007) is not a typical Decision Support System (DSS).

Lately DSS literature has been criticised for providing poor identification of the clients and users of the various DSS applications that are the focus of investigation (Arnott and Pervan, 2005). Several existing information systems with DSS functionalities will be introduced in Chapter 4: IdeaFisher (Marakas, 2003), Mindpool (Stenmark 2002, 2005) and BRIDGE (Farooq, Carroll and Ganoe (2005). Before we start our artefact building exercise, we will present our research method.

3. RESEARCH METHOD

In the previous Chapter 2 we indicated that our interest is on artefact development and related ideas and design principles. Originally, the starting question for our research was: how to build an information system. Therefore, our research is design-oriented. We are interested in building an artefact, but our strengths are not in programming or system modelling, more like our strengths may lie in work system descriptions. In the next section (3.1) we will first discuss about basics of design research and in particularly design science (Simon, 1981). IT artefact is compared to IT-reliant work system (Alter, 2003). Thereafter in Section 3.2 we will look at the process and steps. Since design science is also rigorous and practice oriented, we will focus on design rules (van Aken, 2004) in Section 3.3. Of course we need to understand the theory of design science and we will similarly introduce the selected Peffers *et al*. (2008) methodology in Section 3.4 That chapter works as a prologue before our artefact building in Chapter 4.

3.1. Design research and design science

Design research is an old research tradition stemming from architecture and engineering sciences. Simon (1981, 113) in his seminal work, The Sciences of the Artificial, argues that we need a science of design that is “tough, analytic, partly formalisable, partly empirical, teachable doctrine.” Simon believes that design theory is concerned with how things ought to be in order to attain goals, although the final goals of design activity might not be explicitly realised, and the designer could well proceed with a search guided by “interestingness”.

Iivari (2007) has criticised the information systems research mainstream for lacking design orientation: “The dominant research philosophy has been to develop cumulative, theory-based research to be able to make prescriptions. It seems that this “theorywithpracticalimplications” research strategy has seriously failed to produce results that are of real interest in practice”. (Iivari, 2007, 40) Similar concerns have been expressed by other authors: “Our focus should be on how to best design IT artifacts and IS systems to increase their compatibility, usefulness, and ease of use or on how to best manage and support IT or IT-enabled business initiatives” (Benbasat and Zmud, 2003, 191). Van Aken (2004) sees that mainstream research tends to be description-driven, while relevance problem can be mitigated with prescription-driven research. The problem of the practitioner, however, is always unique and specific. Therefore, general knowledge must be translated to the unique and specific case at hand.

Van Aken (2004, 224) distinguishes three categories of scientific disciplines:
1) The *formal* sciences, such as philosophy and mathematics.
2) The *explanatory* sciences, such as the natural sciences and major sections of the social sciences.
3) The *design* sciences, such as the engineering sciences, medical science and modern psychotherapy.

Design science and information systems design research are terms used also in the information systems research area. “Information Systems Design Research (ISDR) is a new design research tradition that has grown up, through historical accidents, largely isolated from other design communities. Thus, ISDR’s defining discussions have not been able to benefit from the 50+ years of design discipline reflection from other communities.” (Kuechler and Vaishnavi, 2007) This comment of Kuechler and Vaishnavi points out that the design science within information systems research has rather unique roots.

Referring to Simon (1981) van Aken (2004) describes that “the mission of a design science is to develop knowledge for the design and realization of, i.e. to solve *construction* problems, or to be used in the improvement of the performance of existing entities, i.e. to solve *improvement problems*”, in other words, to implement some innovation. Van Aken (2004) in a design-science study emphasizes both construction and improvement with an integrated outcome, called a technological rule, and one research approach. According to March & Smith (1995) progress is achieved in development research like design science when existing technologies are replaced by ones that are more effective: "Rather than posing theories, design scientists strive to create models, methods, and implementations that are innovative and valuable".

Word ‘artefact’ has received also criticism. Alter (2003) presents 18 reasons why IT-reliant work systems should replace “the IT artifact” as the core of the IS field. The specific reasons involve important topics including IS success, IS costs, IS risks, IS life cycles, methods for analysing systems, communication with business professionals, organizing and codifying knowledge about systems in organisations, and maximizing the value of IS research (Alter, 2003, 366). To Alter a work system is a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and/or services for internal or external customers. Typical business organisations contain work systems that procure materials from suppliers, produce products, deliver products to customers, find customers, create financial reports, hire employees, coordinate work across departments, and perform many other functions (pp. 368). Treating IT-reliant work systems as the core of the IS field will insure that both people and technology are present in the analysis, and will also avoid the commonly mentioned but unnecessary socio-technical split between the social system and the technical system (Alter, 2003, 374). Later, Alter has emphasised the importance of customers: “The elements of a work system can be used as a basis for evaluating the customer-centricity of any work system (or IS) and adjusting the system to attain the right degree of customer-centricity. … The classification of an IS as customer-centric or not is far less important than the use of dimensions of customer-centricity to respond to customer needs” (Alter, 2008, 461)

The challenge of this thesis is similar what Järvinen (2004) sees in design science: “building an innovation and proving that it is useful for the community and measurable”. Therefore, the building process is next illustrated.

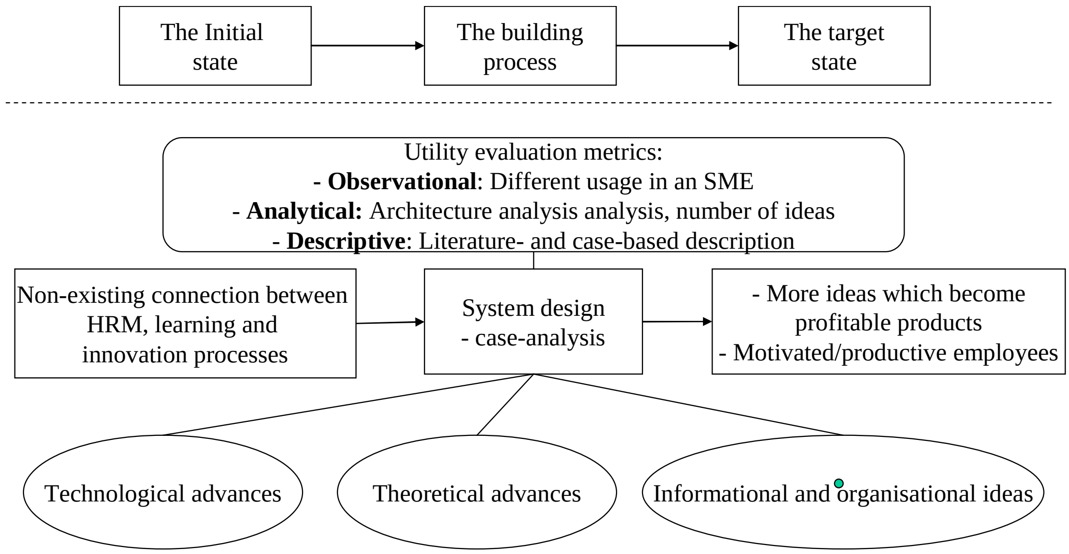

Figure 3.1. The building process (applied from Järvinen, 2004, 102)

As stated in the picture above, evaluation takes place in multiple levels. The created artefact itself is observed and evaluated in case organisations and differences in use and usability issues are reported and categorised. According to Järvinen (2004) technological advances (like software architectures), theoretical advances (like improved models) and informational/organisational ideas (like our insights) need to be brought to the building process. March and Smith (1995) see that if the artefact (i.e. construct, model, method or instantiation) is really novel, actual performance evaluation is not required at this stage. According to Järvinen (2004) both building and use processes, actually the whole 'life' of an innovation, from an idea to the first realisation and then use, and finally to its demolition must be evaluated. The final stage (demolition) of an artefact may mean either a transition from use of the old artefact to use of the new one or the finish of its use. The utility is evaluated and this evaluation is focused on the artifact's lifecycle.

3.2. The phases of artefact design

According to March and Smith (1995) design science consists of two basic activities, build and evaluate. Building is the process of constructing an artefact for specific purposes; evaluation is the process of determining how well the artefact performs. In design science, computational and mathematical methods are primarily used to evaluate the quality and effectiveness of artefacts; however, empirical techniques may also be employed (Hevner *et al*., 2004, 80-81).

Järvinen (2004) sees that there exists an additional process, namely demolition.

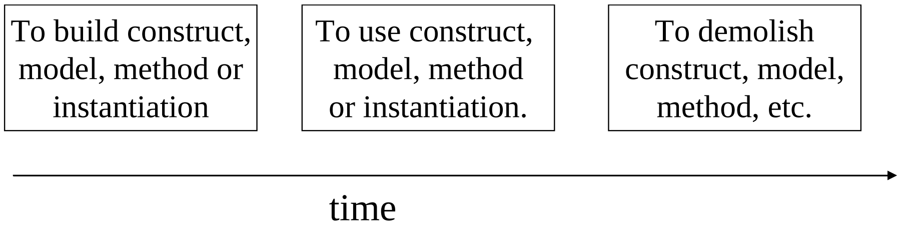

Figure 3.2. The sequential processes (build, use and demolish) of an artefact (applied from Järvinen, 2004)

This view of Järvinen is different from Hevner *et al*. (2004) who do not have the demolish process. According to Hevner *et al*. (2004, 80) relevance and rigor both guide building and evaluation phases. Rigor is achieved by appropriately applying existing foundations and methodologies. The environment defines the problem space in which reside the phenomena of interest. Lee and Hubona (2009, 238) have emphasised that rigor follows relevance in design science: “The primary contribution of this essay is to demonstrate that the MPMT framework provides a scientific basis for the rigor of research, where the bulk of our examination focuses on rigor in positivist research and interpretive research. A corollary to this examination will be that the MPMT framework can also provide a scientific basis for the rigor of research which focuses on relevance, such as action research and design research.” (Lee and Hubona, 2009, 238) To Hevner *et al*. (2004, 79) there are goals, tasks, problems and opportunities that define business needs as they are perceived by people within the organisation. To us this concept ‘business needs’ of Hevner *et al.* is a limiting factor, because it should also include ‘individual needs’ especially, if human-centered, creativity and learning -focused technologies are designed. If the business needs are in line with individual needs, that would be an optimal situation. These topics are discussed in the area of participatory design and are outside the scope of this thesis. What is relevant for this thesis, however, is design knowledge and possible rules that guide design.

3.3. Design knowledge and design rules

Design-repertoires contain three types of design knowledge, according to van Aken (2004): “The repertoire of a professional typically contains predominantly object knowledge, i.e. knowledge on the settings and properties of the artefacts or interventions to be designed. For a mechanical engineer this may be the properties of different types of bearings and for a medical doctor the effects of alternative therapies for a given disease. It may also contain realisation knowledge, e.g. knowledge on manufacturing technologies for a mechanical engineer and knowledge on various types of surgery for a surgeon. Finally, a design repertoire typically contains only a fairly limited amount of explicit process knowledge, i.e. knowledge on how to tackle the actual design process itself. Most professionals obtain their process knowledge in a craftsman-like manner, i.e. by their own experience and by imitating their teachers and peers. Process-knowledge tends to remain largely tacit; professionals often find it difficult to express their approach to design problems. Within each of the three types of design knowledge discussed above, prescriptions are an important category. The logic of a prescription is ‘if you want to achieve Y in situation Z, then perform action X’”. (van Aken, 2004, 227) To our mind, supporting all these three types of design knowledge in an information system is challenging. Van Aken continues: “The logic of a prescription is 'if you want to achieve Y in situation Z, then perform action X'. There are algorithmic prescriptions, which operate like a recipe. However, many prescriptions in a design science are of a heuristic nature” (p. 227).
They can rather be described as ‘if you want to achieve Y in situation Z, then something like action X will help’. ‘Something like action X’ means that the prescription is to be used as a *design exemplar*. A design exemplar is a general prescription which has to be translated to the specific problem at hand; in solving that problem, one has to design a specific variant of that design exemplar.” (van Aken, 2004, 227) These design rules and design exemplars are already more useful for our artefact design in Chapter 4.

“In the design sciences the research object is a ‘*mutandum*’; these sciences are not too much interested in what *is*, but more in what *can be*. The typical research product is the prescription discussed above or in terms of Bunge (1967, p. 132) a technological rule: ‘an instruction to perform a finite number of acts in a given order and with a given aim’. A *technological rule* is defined as *a chunk of general knowledge, linking an intervention or artifact with a desired outcome or performance in a certain field of application*. The *tested* technological rule is one whose effectiveness has been systematically tested within the context of its intended use. The real breakthrough came when tested technological rules could be *grounded* on scientific knowledge (Bunge 1967, p. 132), including law-like relationships from natural sciences. The typical research design to study and test technological rules is the multiple case: a series of problems of the same class is solved, each by applying the problem solving cycle. By borrowing concepts from software development one can say research on technological rules typically goes through a stage of *α-testing*, i.e. testing and further development by the originator of the rule, to be followed by a stage of *β-testing*, i.e. the testing of the rule by third parties. (Bunge, 1967; van Aken, 2004). Later in Chapter 4 we will illustrate technological rules applied to our artefacts.

3.4. The theory of design research

The preliminary work of Walls, Widmeyer and El Sawy (1992) focused on information systems design theories (ISDT). "We contend that the underlying theoretical basis of EIS (Enterprise Information System) can be addressed through a design theory of vigilant information systems. Vigilance denotes the ability of an information system to help an executive remain alertly watchful for weak signals and discontinuities in the organisational environment relevant to emerging strategic threats and opportunities." (Walls *et al.*, 1992, 36)

Interestingly, to Walls *et al.* (1992) vigilance meant adaptability and alertness, so, for them an information system is also a scanning and brokering system (similar to Hargadon and Sutton's (1997) technology brokering process). Walls *et al.* (1992, 37) summarise: "A design theory is a prescriptive theory based on theoretical underpinnings which says how a design process can be carried out in a way which is both effective and feasible".

The components of an information system design theory (ISDT) are summarized in Table 3.1.

Design Product		
1.	Meta-requirements	Describes the class of goals to which the theory applies
2.	Meta-design	Describes a class of artifacts hypothesized to meet the meta-requirements
3.	Kernel theories	Theories from natural or social sciences governing design requirements
4.	Testable design product hypotheses	Used to test whether the meta-design hypotheses satisfy the meta-requirements
Design process		
1.	Design method	A description of procedure(s) for artifact construction
2.	Kernel theories	Theories from natural or social sciences governing design process itself
3.	Testable design process hypotheses	Used to verify whether the design hypotheses method results in an artifact which is consistent with the meta-design

Table 3.1. Components of an Information System Design Theory (ISDT), Walls, Widmeyer and El Sawy (2004, 46)

Noteworthy in Table 3.1 is that Walls *et al.* separate clearly product and process. There are also other definitions for a design theory. The following one comes from Gregor and Jones: “A design theory is something in an abstract world of man-made things, which also includes other abstract ideas such as algorithms and models. A design theory instantiated would have a physical existence in the real world.” (Gregor and Jones, 2007, 320)

After this description Gregor and Jones illustrate in Table 3.2 the following components of an Information Systems Design Theory:

Component	Description
Core components	
1) Purpose and scope	“What the system is for”, the set of meta-requirements or goals that specifies the type of artifact to which the theory applies and in conjunction also defines the scope, or boundaries, of the theory.
2) Constructs	A definition of the entities of interest in the theory
3) Principle of form and function	The abstract “blueprint” or architecture that describes an IS artifact, either product or method/intervention.
4) Artifact mutability	The changes in state of the artifact anticipated in the theory, that is, what degree of artifact change is encompassed by the theory.
5) Testable propositions	Truth statements about the design theory.
6) Justificatory knowledge	The underlying knowledge or theory from the natural or social or design sciences that gives a basis for the design (kernel theories).
Additional components	
7) Principles of implementation	A description of processes for implementing the theory (either product or method) in specific contexts.
8) Expository instantiation	A physical implementation of the artifact that can assist in representing the theory both as an expository device and for purposes of testing.

Table 3.2. Eight components of an Information Systems Design Theory (Gregor and Jones, 2007)

Originally, we tried to use this framework in Table 3.2 to build and evaluate our artefacts. We even modelled all our three artefacts inside these eight components of Gregor and Jones (2007). What we liked was the number four, artefact mutability, that is not often mentioned in design theories. The component number 5, Testable propositions, by Gregor and Jones, however, proved difficult. Additionally, there is no utility-related elements in Table 3.2. So, we were forced to reject this framework of Gregor and Jones. More suitable for our purposes was the Design Science Research Methodology (DSRM) process model (Peffers, Tuunanen, Rothenberger and Chatterjee, 2008).

We needed a very clear, practical framework where different stages are simple to describe. Peffers *et al.* introduce their approach with following words: “We propose and develop a design science research methodology (DSRM) for the production and presentation of DS research in IS. This effort contributes to IS research by providing a commonly accepted framework for successfully carrying out DS research and a mental model for its presentation. It may also help with the recognition and legitimisation of DS research and its objectives, processes, and outputs and it should help researchers to present research with reference to a commonly understood framework, rather than justifying the research paradigm on an ad hoc basis with each new paper. (Peffers *et al.*, 2008, 48).

Like Peffers *et al.* point out, the challenge in design research has been the lack of proper methodology and this has resulted recognition and legitimisation problems. They continue: “Such a process could accomplish two things for DS research in IS. It would help provide a roadmap for researchers who want to use design as a research mechanism for IS research. Such a process would not be the only way that DS research could be done, but it would suggest a good way to do it. It could also help researchers by legitimatizing such research, just as researchers understand the essential elements of empirical IS research and accept research that is well done using understood and accepted processes.” (Peffers *et al.*, 2008, 50) After that, Peffers *et al.* evaluate multiple design and design science process elements. They illustrate the processes of Archer (1984), Takeda *et al*. (1990), Eekels and Roozenburg (1991), Nunamaker *et al.* (1991), Walls *et al.* (1992), Cole *et al.* (2005), Rossi and Sein (2003) as well as Hevner *et al*. (2004). So, they consider both traditional (engineering) design literature as well as information systems design literature.

As a result of their review, they illustrate their own meta-model. This meta-model is presented in Figure 3.3.

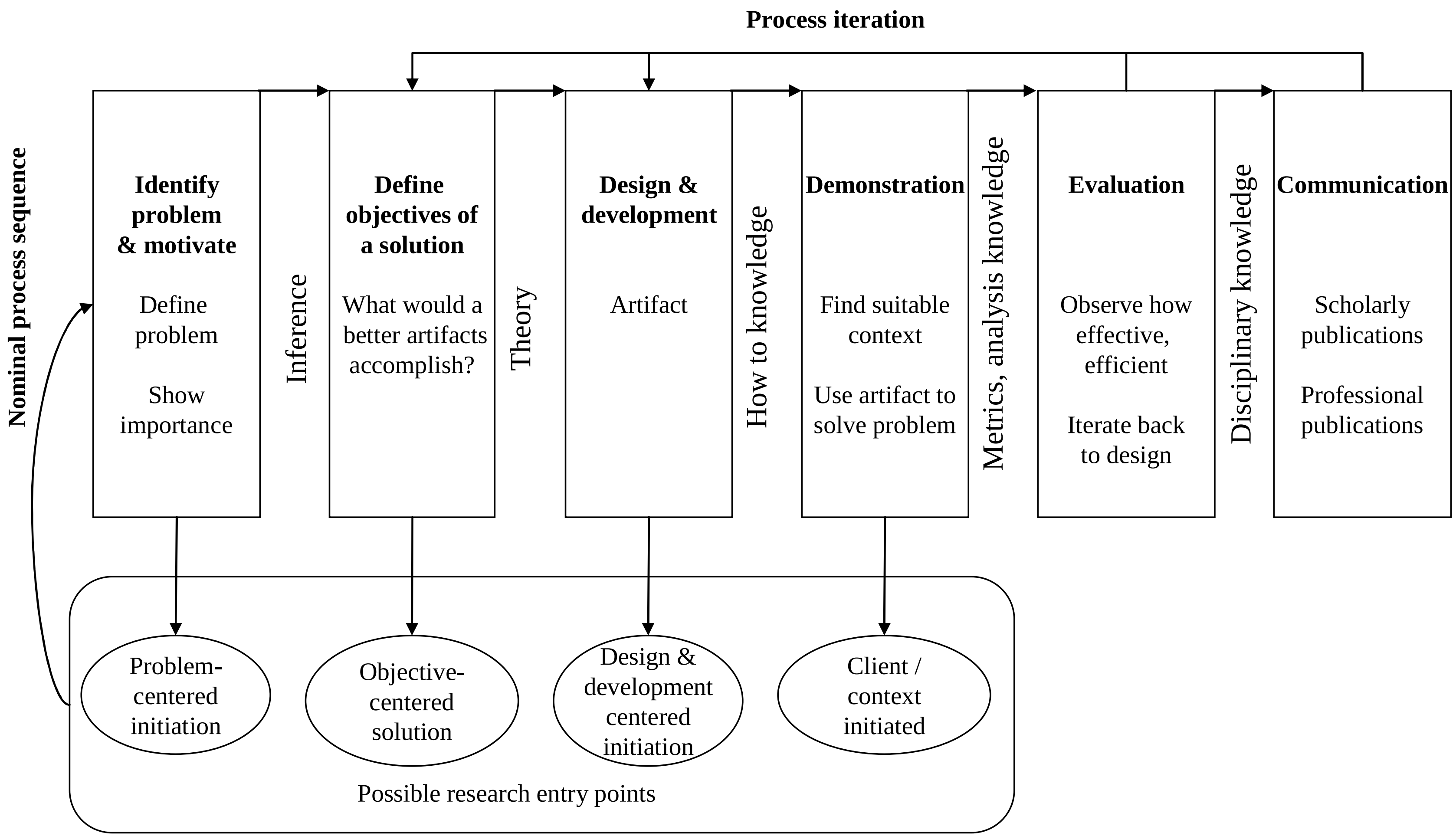

Figure 3.3. Design Science Research Methodology (DSRM) process model (Peffers *et al.*, 2008, 53)

Since Peffers *et al.* (2008) developed a methodology; they needed to design the DSRM process. According to them, the process can be entered in a certain point ("possible research entry point" in Figure 3.3), depending on the case and who is the initiator. The result of their synthesis is the process model above consisting of *six activities* in a nominal sequence. These activities are described below with explanations.

Activity	**Description**
1. *Problem identification and motivation*	"Define the specific research problem and justify the value of a solution. Since the problem definition will be used to develop an artifact that can effectively provide a solution, it may be useful to atomise the problem conceptually so that the solution can capture its complexity. … Resources required for this activity include knowledge of the state of the problem and the importance of its solution."
2. *Define the objectives for a solution*	"Infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible. … Resources required for this include knowledge of the state of problems and current solutions, if any, and their efficacy."
3. *Design and development*	"Create the artifact. Such artifacts are potentially constructs, models, methods, or instantiations …Resources required moving from objectives to design and development include knowledge of theory that can be brought to bear in a solution.
4. *Demonstration*	"Demonstrate the use of the artifact to solve one or more instances of the problem. This could involve its use in experimentation, simulation, case study, proof, or other appropriate activity. Resources required for the demonstration include effective knowledge of how to use the artifact to solve the problem."
5. Evaluation	"Observe and measure how well the artifact supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from use of the artifact in the demonstration. It requires knowledge of relevant metrics and analysis techniques. Depending on the nature of the problem venue and the artifact, evaluation could take many forms."
6. *Communication*	"Communicate the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences, such as practicing professionals, when appropriate. … Communication requires knowledge of the disciplinary culture."

Table 3.3. Six activities of DSRM process model (Peffers et al., 2008, 52-56)

The DSRM process model and its activities defined in Table 3.3 are similar to action research cycles (Susman and Evered, 1978). Peffers *et al.* (2008) also noticed this while constructing their DSRM process model. Cole, Purao, Rossi, and Sein (2005) and Järvinen (2007) concluded that the similarities between these research approaches are substantial. Cole *et al*. (2005) argued that the approaches share important assumptions regarding ontology, epistemology, and axiology. Järvinen (2007) points to many similarities, and suggests that: “after comparison of the seven aspects: concrete results of the study, knowledge produced, activities, the intent and the nature of a study, the division of labour in a study and generation, use and test of knowledge, the concordance between the characteristics of action research on the one hand and of design science on the other hand is very good (Järvinen, 2007, 37).

According to Peffers *et al.* (2008) the clearest distinction between action research and design science is found in their conceptual origins. Design science research comes from a history of design as a component of engineering and computer science research, while action research originates from the concept of the researcher as an “active participant” in solving practical problems in the course of studying them in organisational contexts. (Peffers *et al*., 2008, 72).

To Sein, Henfridsson, Purao, Rossi and Lindgren (2011) dominant DR (design research) thinking takes a technological view of the IT artefact, paying scant attention to its shaping by the organisational context. Consequently, we should perhaps avoid this technological view in our artefact design. Sein *et al.* (2011) advice to use the ADR (Action Design Research) research method to create prescriptive design knowledge through building and evaluation ensemble IT artifacts in an organisational context. We try to accomplish this but we can not fully follow the ADR cycle since Sein *et al.* (2011) see that evaluation efforts cannot follow building in a sequence suggested in prior, stage-gate models of DR. Since we chose the DSRM process model from Peffers *et al.* (2008), in our artefacts evaluation activity will follow building activity.

3.5. Outputs of design research

As a conclusion, the design research framework used in this research is fundamentally a problem-solving paradigm. We will implement an innovation which according to Hevner *et al.* (2004) defines the ideas, practices, technical capabilities and products through which the analysis, design, implementation, management, and use of IT artefact can be effectively and efficiently accomplished. This we need to construct with relevance in mind to create a functional architecture and a tool to support earlier described creativity, learning and innovation theories.

Iivari (2007) illustrates end-results as archetypes of IT applications based on the function of the artefact. He lists seven different roles, their metaphors and examples in Table 3.4.

Role / function	Metaphors	Examples
To automate	Processor	Many embedded systems Many transaction processing systems
To augment	Tool (proper)	Many personal productivity systems; Computer aided design
To mediate	Medium	E-mail, instant messaging, chat rooms, blogs Electronic storage systems (e.g. CDs and DVDs)
To informate	Information source	Information systems proper
To entertain	Game	Computer games
To artisticize	Piece of art	Computer art
To accompany	Pet	Digital (virtual and robotic) pets

Table 3.4. Archetypes of IT applications (Iivari, 2007)

Ideally, all those roles of Iivari (2007) could be present in our artefacts. However, due to technical and time limitations the following three artefacts will focus to augment, informate and mediate daily tasks. Jarvinen (2006) proposes that we should use a goal function for measuring the goodness of a new artifact. The goal function could cover both intended and unintended consequences of the developed artefact.

In this chapter we described what design science is and what is a design theory. Next we will start building our artefacts and will utilise the previously mentioned Design Science Research Methodology (DSRM) process model (Peffers *et al.*, 2008). This DSRM process model will be extended with the design rules described by van Aken (2004).

4. THREE ARTEFACTS, THREE DESIGNS

Three designs will be next illustrated. The first and second designs are focused inward the organisation while emphasising individual and group-based problem-solving and learning. The third design is focused outward the organisation and communities of practice, emphasising open innovation paradigm (Chesbrough, 2003) with brokering and the use of organisational memory (Hargadon and Sutton, 1997). All the following designs are processed through the Design Science Research Methodology (DSRM) process model (Peffers *et al.*, 2008) which was described in Section 3.4.

4.1. First design: Mobile Personal Development Plan

Like mentioned earlier in Chapter 1, the idea for our first artefact originates from our observations of short-comings in the innovation process and in the human resource management (HRM) process in large companies. In Dallas, USA, while we were conducting research on knowledge management of a retail company, we noticed that in the innovation process of that company the ideas (suggestions) were requested in a very formal format (Ahonen, 2002). There were no tools or instructions which could have helped the employee to recognise the problem (problem finding tools), nor there were tools to support the employee to understand their intrinsic motivation (Amabile, 1983) or interests generally (curiosity etc.). Collaboration in the innovation process lacked almost totally. In that retail company this deficit led to low participation percentage in innovation campaigns. (Ahonen, 2002) We also used to work in several ubiquitous computing research projects (EU IST MOBIlearn and Tekes Digital Learning, from 2001 to 2005), so mobility of the artefact was first seen as an advantage and as a starting point. So, interestingness and awareness of new technological resources were the initiators of our design work. Later Järvinen (2007b) has commented that the design science paradigm should be extended with an opportunity, i.e. advances in technical, human (organisational) and informational resources offer an opportunity to build a new innovative artefact. So, our artefact ideation started in 2001 and related software prototype was tested in 2004. However, as late as 2008 we chose the DSRM process model from Peffers *et al.* (2008) after trying out unsuccessfully several other process models for design. Next we will describe the design process of the Mobile Personal Development Plan.

4.1.1. Problem identification and motivation

Peffers *et al.* (2008, 52) advice: “Define the specific research problem and justify the value of a solution”.

According to Orlikowski (1992) people’s mental models and organisations’ structure and culture significantly influence how groupware is implemented and used. A suggestion management system is one type of groupware. Many organisations have a suggestion management system in place to encourage their members to submit improvement proposals. Often, these proposals are submitted to local Proposal-Handling Committees (PHC) that review the ideas (Stenmark, 2002). Good suggestions are usually rewarded in some way, while other proposals are often rejected (see for example closed innovation process model by Chesbrough (2003)).

However, a few serious shortcomings with this traditional way of handling suggestions have been noticed (see for example: Fairbank *et al.*, 2003). Firstly, the suggestions are seldom communicated sufficiently within the organisation: good ideas may be implemented locally but remain unheard of in other parts of the organisation. Other ideas may be prematurely rejected due to the PHC's limited cognitive capacity, the proposer's poor communication skills, bad timing, or being proposed in the wrong context (Stenmark, 2000).

Stenmark (2002) has pointed out a problem both in existing competence management systems and in innovation management systems:

> "Since personal interests highlight things for which individuals have a passion, competence systems should support expressions of interests so that they become visible and valued. Competence is also related to professional interest. Interests provide motivation and hence an incentive for actions. Pursuing a professional interest in a corporate setting eventually leads to competence within that area. … I therefore argue that it seems plausible that interests can be a means for identifying applied knowledge." Stenmark (2002, 15)

Like Stenmark comments, interests and their facilitation have not been traditionally integrated into the competence management systems. Similarly, the suggestion management systems often have no link to competence management systems. When Lindgren and Stenmark (2002, 20) investigated new types of competence management systems, they pointed out: "such systems should have the potential to detect, visualise, and leverage interests of organisational members".

Based on these comments, we started to investigate: What is the growth path from interests to ideas and finally to innovations? Can interests be managed as part of human resource management (HRM) with connection to R&D and innovation management? Traditionally these areas have not been interlinked. Innovation systems in organisations are often separate ones, for example, the employee participation in suggestion management systems is not automatically linked to competence management or human resource management. In other words, innovativeness and creativity have not traditionally been recognised as competences. Therefore, we started to view the Personal Development Plans of the HRM process as a starting point for our artefact design. Hardless, Lundin and Nulden (2001) talk about mobile competences and emphasise competence development for nomads, mobile workers. There is a need to support ideation, interest identification and competence development in variable, ubiquitous settings. We crystallised our research problem related to the first artefact: how to build a ubiquitous Personal Development Plan which is at the same time a problem-finding and problem-solving tool for the organisational innovation process.

4.1.2. Define the objectives for a solution

In this step, Peffers *et al.* (2008, 56) provide the following instruction: "Infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible. The objectives can be quantitative, such as terms in which a desirable solution would be better than current ones, or qualitative, such as a description of how a new artefact is expected to support solutions to problems not hitherto addressed".

Earlier, in Chapter 2 we introduced both the HRM process and the IiP standard. The personal development plan (PDP) is a central part of IiP (Investment in People, 2008) human resource development framework. Objectives and outcome review, competence assessment and performance assessment are stages where PDPs are evaluated. The PDP has traditionally been a document in paper or electronic format, as an outcome of development talks. PDPs are important objects in the HRM process. PDPs have been traditionally very static in nature and reviewed formally once in 6 months. (IiP, 2008) In this point we realised the limitations of the PDP. In order to be a learning and problem finding tool, this PDP should be available and accessible continuously. We must comment here that when we started ideating our first artefact, we did not consider the IIP standard. Only later on we have noticed that it supports our artefact building.

Next we will define the objectives mentioned by Peffers *et al.* (2008). However, we will use the concept 'design principles' because it describes our design work and aims better.

Design principle: Develop a Mobile Personal Development Plan (MPDP).

The MPDP should be a notebook like tool for problem-finding, learning and problem-solving. This MPDP integrates human resource development, learning and innovating activities. Our MPDP artefact is designed to be accessible independent of place and, partly, independent of time. This makes our PDP artefact portable and ubiquitous. Learning with this MPDP should be as real and practical as possible.

We also need to understand the setting for this continuous problem-finding and problem-solving. The context is not stabile; it changes from work to leisure time, from desk to car. For this reason we had interest in ubiquitous computing design. Perry *et al.* (2001) discovered four key findings about the way in which mobile technologies (both "high tech" devices such as mobile phones and "low tech" artefacts such as paper) were used by mobile workers to maximize flexibility and access to information while on the move. Their findings can be summarized as follows: A) preparation for a trip and planning for the unpredictable ("planful opportunism"); B) effective use of "dead time" by mobile workers; C) use of the mobile phone as a "device proxy"; and D) use of technologies for remote awareness monitoring. (Perry *et al*., 334, 2001). From these four examples we can extract following design principles:

Design principle: Support context switching.

Design principle: Make the information system adaptive and provide recommendations of actions, do not automatically run processes.

These design principles are later supported by Henfridsson and Lindgren (2005). Next they will list various principles, outcomes and socio-technical implications.

Design principles	Design outcomes	Socio-technical implications
Context-sensitive service synchronisation (Use problem addressed: *Hands-free problems*)	• Increased convenience • Enhanced hands-free use	• The persistence of various individual use patterns (e.g. recent number access for call initiation) over contexts complicates service synchronisation
Contextually adapted manipulation (Use problems addressed: *Call taking, mobile device manipulation*)	• Improved call taking abilities • Facilitated mobile device manipulation	• Integration of services relying on different interaction models makes contextually adapted manipulation difficult in ubiquitous computing environments
Context-switching support (Use problem addressed: *Problems of context change*)	• Generally convenient context switches	• Insufficient mode awareness undermines trustful context-switches

Table 4.1. Design principles and socio-technical implications (Henfridsson and Lindgren, 2005)

When we look at this table, we notice that these design principles are constructed with a car in mind. However, the socio-technical implications are more general: IS systems should be able to recognise and memorise individual usage patterns. At the same time, full automation is not possible because of rapid context-switching.

In addition to context, we are interested in what kind of learning and problem-finding support is needed.

The experiential learning theory of Kolb (in Kolb and Fry, 1975), explained in Sub section 2.1.6, is also related to Human Resource Management (HRM). Our interest was on learning support, but also on ideation support. Vavoula (2004) demonstrated that depending on the phase and who is the initiator, the proper learning project and learning style will be chosen. The CPS, Creative problem-solving cycle (Treffinger and Isaksen, 1992) informs us that idea seeds need to be recognised and captured.

From these models and processes (Kolb and Fry, 1975; Vavoula, 2004; Treffinger and Isaksen, 1992) come the following design principles:

Design principle: Support the capture and storing of ideas and concepts.

Design principle: Support different learning styles.

Kilpinen (2004, 50) sees that learning support environments need to support the learner not only for a variety of tasks, but also by providing flexibility so they can determine their own navigation or learning strategy with which to accomplish these tasks.

However, already in 2004 we realised that the selected design principles needed more grounding on innovation. The following process model of Beckman and Barry (2007) is useful for us since it is based on the Kolb's experiential learning model. Once again we must emphasise that we found this model rather late, in 2007, after being familiar with earlier Kolb's model.

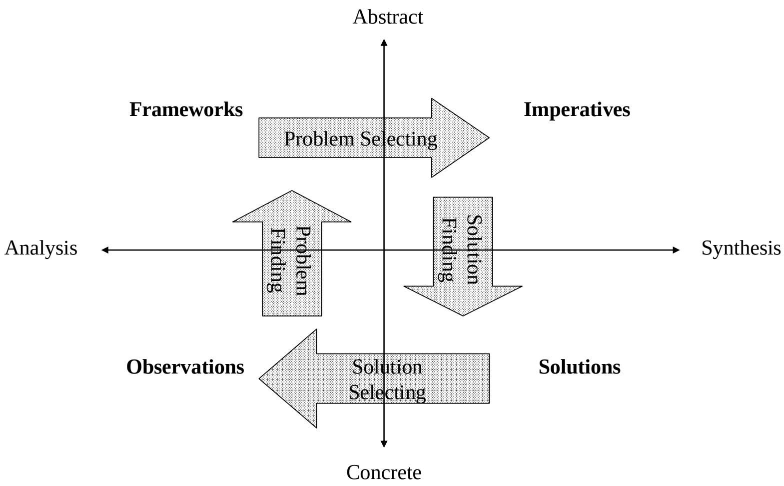

Figure 4.1. The Innovation Process as Problem and Solution Finding and Selecting (Beckman and Barry, 2007; Owen, 1993, based on Kolb and Fry, 1975).

Beckman and Barry explain Figure 4.1: ”… this process moves its participants between the concrete and the abstract worlds, and it alternately uses analysis and synthesis to generate new products, services, business models, and other designs. In moving among those extremes, it in essence requires participants to engage in concrete experience and abstract conceptualisation, reflective observation and active experimentation, thus exercising all four learning styles. Although the process is far from linear, we introduce it as if one steps through the four stages of generating observations, frameworks, imperatives, and solutions in sequence.” (Beckman and Barry, 2007, 29) Interestingly, the problem-finding and problem-selecting by Beckman and Barry are similar to Creative problem solving (CPS), described earlier in Sub Section 2.2.2. Accommodator, Diverger, Converger and Assimilator are those learning styles which address how the information is 'absorbed'.

This combined learning and innovation process above can not yet be implemented as an information system or IT-reliant work system. Therefore we sought solutions from the decision support systems (DSS) literature. Fairbank *et al.* (2003) provided us information how suggestion management systems can motivate employees to think creatively and how to participate in the innovation process with changing roles.

Kilpinen (2004) has demonstrated how to test a learning style and how many different learning styles are listed in the literature. In our design work this kind of support of various learning styles might prove demanding. Therefore, we looked at various roles in problem-finding and problem-solving.

Design principle: Support various roles. Make it possible to change role.

When we later found out the work of Forgionne and Newman (2007) it emphasises the role of decision-maker. This reminds us about management information systems (MIS) tradition of information systems research. Definitely, creativity enhancing decision support system needs a systematic approach, the possibility to check the status, the alternatives and predicted outcomes. Often these functions are reserved for a manager or for a CEO. We may ask: Should everybody involved in the use of the system have similar rights? A decision maker is needed, but it may be a turn-based role.

Hargadon and Sutton (1997) originally discussed about knowledge brokering and they included a process called: *Imagine new uses for old ideas*. It means that an information system needs a knowledge base where old ideas are available for further use and remixing. This requirement was reflected in our design.

Design principle: Integrate a knowledge base.

The later published model of Forgionne and Newman (2007) is useful especially because it contains the Knowledge Base. This has an implication to our IS artefact: it should contain problem specific knowledge and this kind of knowledge should be accumulated when the IS is used regularly.

Fairbank *et al.* (2003) introduce their design of an IS-based Electronic Suggestion Management System (ESMS), built on the conceptual foundation provided by expectancy theory and the GDSS framework. In consideration of the objectives discussed earlier, the general functionality of the system should include the following features:
- an accessible interface for submitting suggestions
- a dynamic routing capability, which would (a) direct a suggestion to the person(s) best qualified to comment on it, and (b) direct comments to the other stakeholders, including the initiator of the suggestion and the ESMS administrator
- a central knowledge repository wherein suggestions and feedback could be deposited and discussed in an open, interactive forum
- information about stakeholders and originator knowledge and preferences
- a mechanism for monitoring the progress of suggestions through the system
- support for an ESMS administrator

(Fairbank *et al.*, 2003, 311)

These requirements are useful for the later phases of the innovation process, but do not actually support the problem-finding part. In the literature there are examples of these kinds of artefacts which include both interest management and connection to human resource practices. We were particularly interested in the pioneer work of Stenmark (2002) and Stenmark (2005).

CASE: THE MINDPOOL PROTOTYPE

Mindpool is an intranet electronic brainstorming system (EBS) prototype, available to the entire organisation. The idea is to mimic the creative atmosphere found in brainstorm sessions, where no suggestions are turned down but instead are used to spawn new and possibly even better ideas (Osborn, 1953). Mindpool is based on three fundamental design principles; asynchronicity, anonymity, and accessibility. Unlike ordinary EBS, Mindpool supports asynchronous brainstorming, which means that users do not have to be active simultaneously. This removes the temporal restriction present in other media, e.g. chat forums. The system further allows the proposer to be anonymous whilst yet providing a mechanism for letting people contact them. Accessibility is achieved by the web interface allowing access to all organisational members from their ordinary work places, thereby inviting the entire organisation to be part of the process, rather than just a group of a selected few.
Suggestions are submitted as emails and automatically added to a web page. The web is accessible from all platforms and the persistent nature allows the idea to linger long enough for it to be found by many different people in different locations and contexts, thereby allowing ideas to develop long after the point of introduction. The possibility to add comments directly to the proposal, as is the case in news groups, is absent in Mindpool. This helps shielding the new idea from public negative critique. Still, a mechanism that made it possible to contact the proposer either to ask for or to provide more information was provided. Though the latter may contain criticism, the original idea remains publicly available and can serve as a seed for others, whilst the critique is not displayed. The fact that each contributor can be traced also enables individual recognition, which is otherwise a problem in anonymous EBS.

(Stenmark, 2005, 87)

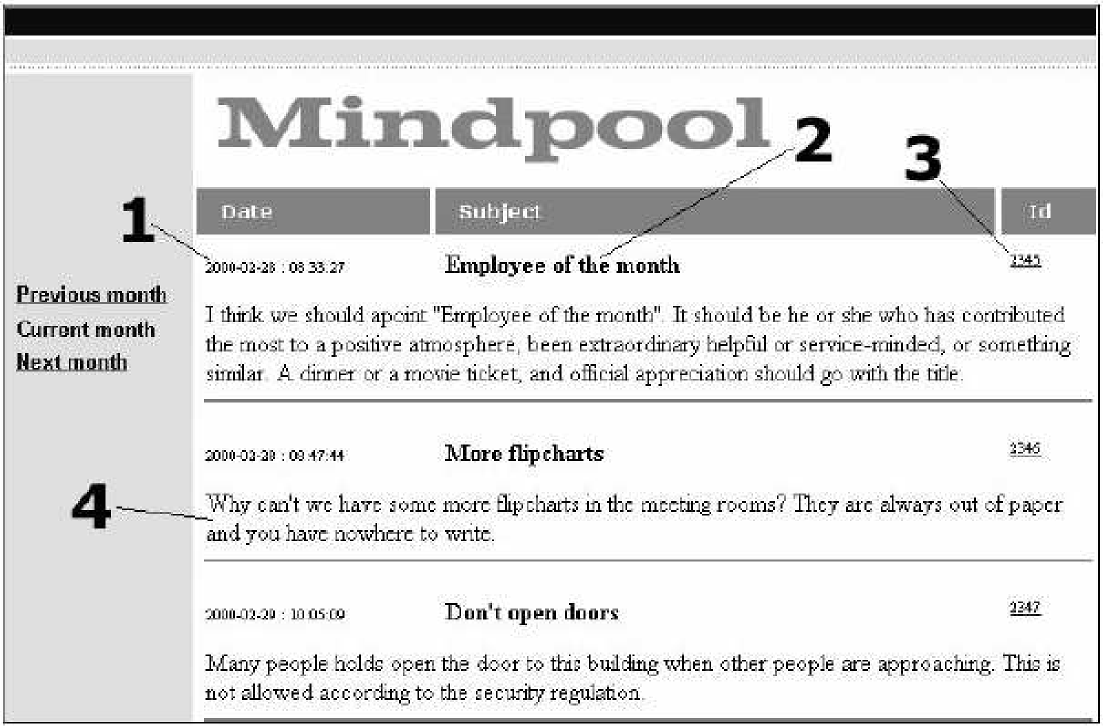

Figure 4.2. The visualisation of ideas in Mindpool, which shows the date and time (1) of the submission, the subject (2) of the submission, the identification number (3) of the submitter, and the actual content (4) of the suggestion. (Stenmark, 2002 & 2005)

What is noteworthy in the Mindpool protype, is openness. Ideas aimed to improve work environment are submitted as well as product improvement suggestions. Ideas are submitted as semi-anonymous so that the original submitter can be contacted. There is no support for private problem-finding phase in Mindpool, all ideas are immediately submitted and made public. In that sense, the problem-finding phases are missing. For this reason we looked at the CPS-cycle and problem-finding in it (Treffinger and Isaksen, 1992).

Design principle: Support problem-finding.

Brennan and Dooley (2005) later constructed an artefact called the Framework for Networked Creativity (FNC). This software had both private and public workspaces. It was meant to feed the organisational innovation process with personal and group-based ”seedlings of innovation”. These seedlings acted like problem-finding tools.

Problem-finding does not take place without motivation. That is why we were interested in the origin of motivation. Motivation that stems from the individual’s personal involvement in the work is crucial for high levels of creativity in any domain (Amabile, 1999, 297). Csikszentmihalyi (1996, 53) remarks: Without a good dose of curiosity, wonder, and interest in what things are like and in how they work, it is difficult to recognise an interesting problem. The mentor or the employer should help the employee to pursue the interests he or she is most competent. To our understanding, this provides a new angle for development talks, the focus is on interest identification. Problem-finding is also related to interest identification.

The PDP artefact can be used by the user for personal and for community purposes. However, since the PDP is also an elementary part of development talks, a mentor or a superior is needed to facilitate more advanced use of the artefact.

When discussing user involvement in the innovation process, the motives and traits should be understood. In this respect, communicating to each other Personal foundational practices of innovation (Denning 2004) would enable users and developers to understand each others’ views and perspectives (Boland and Tenkasi, 1995). It would also help managers to develop the right competences to improve user involvement in the innovation process.

Design principle: Make the development talk form accessible in various formats.

The following check-list from Denning (2004) can be converted to questions and used in forms to guide problem-finding process, even in the context of the development talks, human resource development and problem-finding. The purpose of this check-list is to communicate the original idea in a more understandable form to colleagues.

Awareness	Ability to perceive opportunities and concerns, distinguishing them from your own agenda and concerns; ability to overcome cognitive blindness.
Focus and Persistence	Ability to maintain attention on the mission and avoid distractions; holding to the mission amidst chaos, challenge, or opposition; refusal to give up in the face of obstacles and challenges to the mission.
Listening and Blending	Listening for deeply held concerns and interests and adapting actions to fit ("finding the win-win")
Declarations	Ability to make simple, powerful, moving, eloquent declarations that create possibilities and open attractive new worlds for others.
Destiny	Operating from a sense of a larger purpose than yourself; the purpose drives you.
Offers	Making and fulfilling offers that bring services, practices, or artefacts of value to your customers; organising groups and managing their commitments toward delivery of the results; maintaining a deep commitment to doing whatever is needed to obtain the results.
Networks and Institutions	Gathering allies, defending against objectors, and creating institutions to further the innovation, develop common standards, and widen its acceptance.
Learning	Making time to learn new skills, acquire new knowledge; making well-grounded assessments in preparation for new learning and action.

Table 4.2. Personal foundational practices of innovation (Denning, 2004).

Denning's (2004) Personal foundational practices of innovation is one possible structure to advance dialog and a framework for making individual's ideas and interests more accessible to other employees. When user fills in an interest (or an idea), the user is simultaneously responding to a set of questions. For problem-finding we used therefore question lists (by Kainulainen *et al.* (2004), more about this in Table 4.7) and those Personal foundational practices of innovation (Denning, 2004) were transformed to question lists.

With these question lists we tried to narrow the gap between individual interests and organisation's competence requirements. Similarly, Lindgren *et al.* (2004) emphasised this gap within competence management systems:

> *An infrastructure reflective of the job-based paradigm present problems for competence management in contemporary, knowledge-intensive organisations. … Our findings highlight the interdependence between organisational needs for competence and individuals' competence interests. Organisations adopting a skill-based approach will find that they have to market their competence needs to their workers in order to stimulate individuals' interests in a particular competence.* (Lindgren *et al.*, 2004, 468)

We see that this interdependence mentioned by Lindgren *et al*. (2004) should be notified.

4.1.3. Design and development

According to Peffers *et al*. (2008, 55) a design research artefact can be any designed object in which a research contribution is embedded in the design. This activity includes determining the artefact's desired functionality and its architecture and then creating the actual artefact. Our MPDP artefact consists of following elements: HRM process and development talks, personal development plan in a paper format, a development plan in an electronic format, idea submissions and a database in the Internet-server. The following figure describes how different elements are connected to each other.

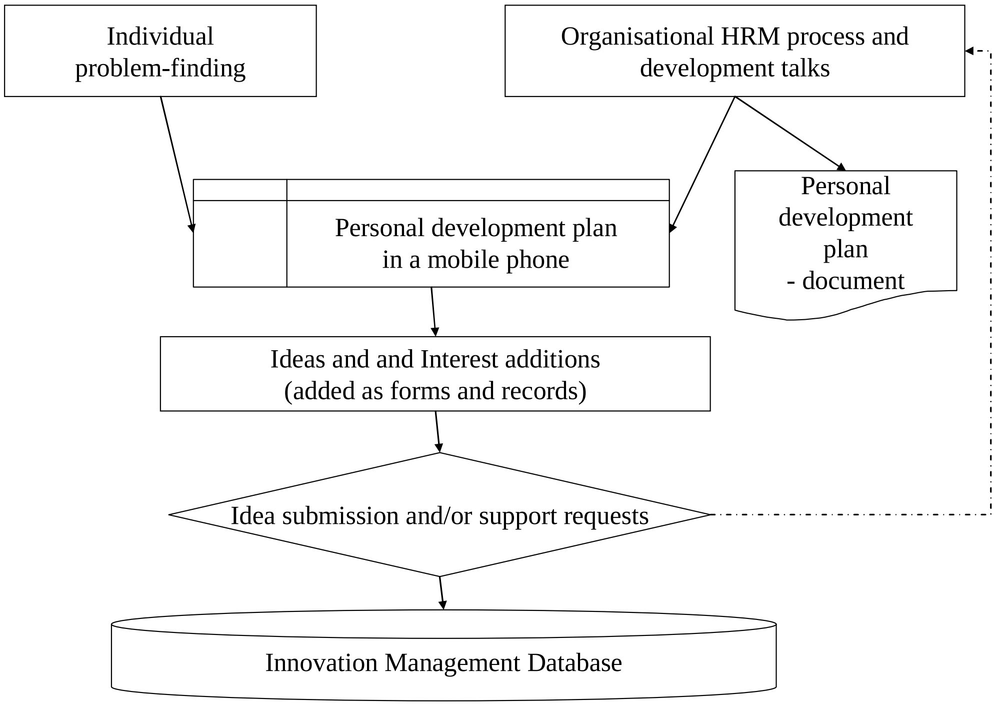

Figure 4.3. A mobile, personal development plan as part of innovation and HRM processes.

The challenge within the MPDP artefact is to integrate individual and corporate goals into one plan in a digital (mobile) format. So, these goals are continuously accessible and they can be checked and updated. If there are ideas that are submitted from the MPDP-artefact, these ideas will become visible both in the future development talks (in the HRM process) and corporate innovation management process.

To summarise objectives (design principles) and related design actions:

Below is a list of design principles and design actions for the 1st artefact: Mobile Personal Development Plan. The previously mentioned design principles are listed as Y and design actions are listed as X. Table 4.3 has on purpose similarities with the design rules of van Aken (2004) and Bunge (1967).

If you want to achieve Y	In situation Z	Then do X
Maintain a Mobile Personal Development Plan (MPDP)	Before, after and during development talks in the HRM framework.	Construct a Personal Development Plan accessible in various situations and in various devices.
Support context switching	In various situations (at work, at home, in the car)	Make it possible to use client even in the off-line mode, without network connection.
The information system should be adaptive and provide recommendations of actions, not automatically run processes.	When changing from one context to another	Gather information about use and usage patterns. Make recommendations based on collected information.
Support the capture and storing of ideas and concepts.	When an idea or need emerges	Make note-taking as simple and quick as possible. Enable note-taking, photo addition, voice recording. Use related APIs (Application Programming Interfaces).
Support various roles. Make it possible to change role.	Since MPDP is a tool within HR process, development talks can be also group-based.	Make several user interfaces that can be selected based on role (employee/employer, ideator/commentator, company X/company Y).
Integrate a knowledge base.	When the individual and group's ideas should be in line with corporate objectives.	Insert company specific challenges and problem-scenarios to the client software. Store solutions for later use and gradual improvement.
Support problem-finding (skill in innovating)	Everywhere (always)	Integrate multiple problem-finding tools in the artefact. Make the tool to support various learning styles (Kolb and Fry, 1975).

Table 4.3. Objectives and design actions, the first prototype, summarised.

In Table 4.3. there is listed desired functionality of an artefact; mentioned by Peffers *et al.* (2008). Next we will need to understand which functions are done by humans manually and which are supported by software. Definitely, the corporate part (the official development plan) needs to be somehow separated from individual part (personal interests and ideas). Therefore, we decided to separate these functions in the first software prototype. However, we still wanted to keep both parts modifiable.

The following illustration will provide a more structured view of this artefact to enable programming of the first prototype.

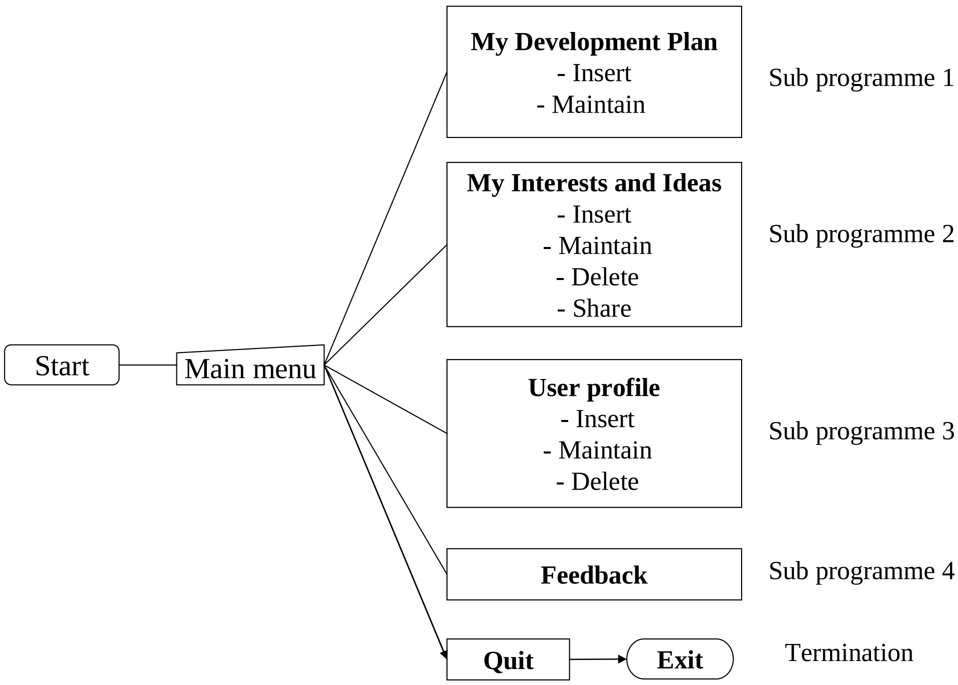

Figure 4.4. An illustration describing different elements and selection points in software

In this first prototype, the official, agreed development plan was still a separate entity ('My Development Plan'). Working with personal ideas and interests took place in a different menu, in a different function ('My Interests and Ideas').

The functionality of the first software prototype was simple: maintaining 'My Development Plan' and 'My Interests and Ideas'. When the user was comfortable with the added ideas, he/she submitted them to the server for others to comment.

From individual's point of view, the MPDP is a collection of interests, even insights. The PDP is not solely related to work, it should enable also hobbies related notes taking. (See the "My Interest and Ideas"-sub programme).

From the company's point of view, the PDP is a list of competencies in which employees should become better at. For this reason the menu structure includes the item "My Development Plan" which is actually a copy of the official PDP document. The PDP artefact is part of company's information system and human resource management.

Our PDP allows both individual and collaborative use. The PDP can be used online or offline, without connection to the Internet and to an information system. The forms utilised by the artefact can be reconfigured, updated, even changed. The organisational part can be configured to support multi-organisations (e.g. when the employee has many employers).

The initial purpose of the portable PDP is to integrate individual goals with organisational HRM development goals. We may righteously ask, can IT really help in this process or does it make it even more difficult? Anyhow, the personal development plan with both organisational and personal goals would be first updated and installed in the mobile phone. This way both the official development targets (agreed with the superior) and individual learning targets would be available to the employee, independent on time and place. To make this Personal Development Plan to support learning, these personal goals and interests are visible as a learning project and other colleagues may join these learning projects.

The software platform selection was difficult. We had a need to find a platform that would support off-line use. After several alternatives (Lotus Notes, Windows Mobile, Java 2) we decided to build our first prototype with Java 2 Platform, Micro Edition (J2ME) with Mobile Information Device Profile 2.0 (http://www.oracle.com/technetwork/java/javame/overview/index.html). This J2ME allows independent, fast notetaking and storing that data to the memory of the smart phone's Record Management Storage (RMS) without using wireless connection to the server. The interests, the official development plan and user profiles were stored in the RMS. This enables to use the software in off-line mode. That functionality provides user more ownership of their data and faster access. The use and installation of software should be as easy as possible. Luff and Heath (1998) separated micro, local and distant mobility. This first prototype of ours supported both micro and local mobility. It included tools to maintain the personal development plan, share employee's plan to group and comment others' plans. Similarly, the ideas of others can be retrieved from an external database and can be commented. The following figure describes the technical architecture in detail.

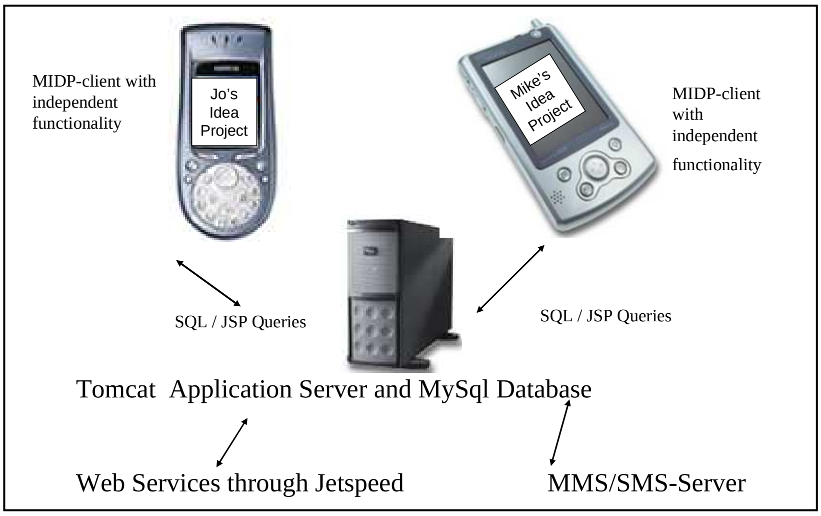

Figure 4.5. The first version of the prototype's technical architecture.

As mentioned in Figure 4.5. we planned to utilise a typical LAMP (Linux-Apache-MySQL-PHP) architecture, except that some components were replaced by mobile java software components and related application server (Tomcat). The interoperability with other information systems was modelled through Web Services. The MMS/SMS-server was an option for alerts and notification services.

After asking about the needs and requirements in the company, we used a WYSIWYG (What You See Is What You Get) development tool (Midlogic Studio for Mobile Java) by a company called Geniem Ltd to create the first software prototype. We had selected this WYSIWYG-editor, because it first seemed as a proper tool for quick, visual prototyping and modifying both the client- and server-components.

We chose the J2ME client-server architecture with MIDP-based client-software. However, the second best alternative was a server-based HTML architecture, without specific mobile clients or installing software to mobile phones. We rejected this second alternative, because we estimated that accessibility and speed of use would be better in the J2ME client-server architecture.

4.1.4. Demonstration

Peffers *et al*. (2008) instructed us that we should demonstrate the use of the artefact to solve one or more instances of the problem. This could involve its use in experimentation, simulation, case study, proof, or other appropriate activity. We will next describe how we used experimentation in a company to integrate problem-finding and problem-solving tool to their HRM and innovation processes.

Originally, we intended to use three separate groups to test the artefact: an SME (small and medium-sized company), a global telecommunications company and a global metal company. The testing plan was too ambiguous; therefore we will next describe the pilot with the SME (a small and medium-sized enterprise). This SME-company had 30 employees at the time of the pilot (September-October 2004). The company was working in the elearning and human resource management (HRM) business area, so, this artefact was interesting even from their business perspective. We were also historically friends with the CEO and the middle manager of that company.

When we discussed with the CEO about the human resource development in the company, he pointed out:

"The challenge is to integrate daily business and strategic management of the company with human resource development. Development talks (as part of the HRM process) take place actually in connection to meetings and work. Our business and business areas change so rapidly, that once a year development talks have limited value". (CEO in the pilot company)

Then we discussed with him about the individual and privacy issues, namely seeing each others' development plans and informal interest expressions:

The CEO responded to us:

”That might be interesting. Why should it be confidential information?”
“Those plans and interests related to the professional expertise could be open to everyone. I feel that this ‘level of openness’ question should be discussed with our staff and agreed together. Of course, there should be privacy control and private ownership of data.” (CEO in the pilot company)

So, the CEO was very open to the pilot. Thereafter, we decided to test the prototype among the executives of that company. When we had our first meeting with the CEO and executives, the surprise to us was the place where the ideas (problems) were found. We had thought that ideas are more like individually found ideas that need to be supported and motivated so that they will be shared and restructured. In this SME the hierarchy was low, so every internal meeting was like a brain-storming session and they needed a tool to support those sessions. So, our original idea to support private problem-finding was not seen primary by the CEO and the executives of this SME.

“Lot’s of ideas are born daily. The problem is to make them activity, development and products. We have had difficulties in making sure that somebody in our staff takes the responsibility of the idea and systematically works on it. Additionally, the documentation process could be more efficient.” (Executive in the pilot company)

After these meeting we were ready to start. So, we created client-software with the WYSIWYG-tool (mentioned in the previous sub section) and helped users to install the following Java-MIDP-based client-software to their mobile phones.

Figure 4.6. The first prototype of the IT artefact.

The pilot with five users (the CEO and four executives) took place between September-November 2004. We provided them examples of ideas related to the use of the prototype. Additionally, we mentored the use and encouraged their use by providing summaries by e-mail of ideas which had been submitted to the server. All participants filled their personal development plan (PDP). Additionally, they added interests (as ideas) to the client software in their mobile phone and submitted some of those more mature ideas to the server. Altogether, 12 ideas were submitted by users to the server during the test period. Two users had difficulties in using the software prototype because not all buttons and menus worked properly in their mobile phones. Therefore, we made a second, corrected prototype version during the test period and installed it to those two users' mobile phones.

4.1.5. Evaluation

Within the Design Science Research Methodology (DSRM) Peffers *et al*. (2008) emphasise that within the evaluation phase we should observe and measure how well the artefact supports a solution to the problem.

Therefore we will next describe, how to those objectives described in the sub-section 4.1.2. were eventually realised. The Table 4.4 will list objectives, actions and evaluation.

Design principle	**Action**	**Evaluation**
Maintain a Mobile Personal Development Plan (MPDP)	Construct a Personal Development Plan accessible in various situations and in various devices.	Only thin client for the mobile phone was implemented with server-support. The users in the case company saw the prototype useful and functional for their work.
Support context switching	Make it possible to use client even in the off-line mode	Off-line use was possible and test users utilised it. This functionality proved useful while travelling in trains, buses etc.
The information system should be adaptive and provide recommendations of actions, not automatically run processes.	Gather information about use and usage patterns. Make recommendations based on collected information.	Information was gathered, but the software did not provide any recommendations. The users did not expect this functionality, so the relevance was questionable.
Support the capture and storing of ideas and concepts.	Make note taking as simple and quick as possible. Enable note taking, photo addition, voice recording. Use related APIs (Application Programming Interfaces).	Making a simple text note took only 30 seconds if the software was running in the mobile phone. If not, it took 90 seconds to start the software and make a note. No photo or voice notetaking was supported, yet. Users requested quicker notetaking for meetings.
Support various roles. Make it possible to change role.	Make several user interfaces that can be selected based on role (employee/employer, ideator/commentator).	The software supported different roles, since the CEO used different components (and different user interface) than executives.
Integrate a knowledge base.	Insert company specific challenges and problem-scenarios to the client software. Store solutions for later use and gradual improvement.	A simple knowledge base (business challenges) was implemented based on elements of Denning (2004). The CEO and executives saw this knowledge base relevant.
Support problem-finding (skill in innovating)	Integrate multiple problem-finding tools in the artefact. Test individual learning styles (Kolb and Fry, 1975) to select a proper problem-finding tool.	No learning style tests were included. No sophisticated problem-finding tools were available. Definitely, training for CPS techniques and implementation of various CPS instruments would have been useful.

Table 4.4. Objectives and actions, how these were realised in the MPDP design.

After the pilot period, users (executives and the CEO) provided us feedback in a meeting in December 2004. The functioning of buttons and menus was not actually the biggest problem. Users were quite pleased with the fast off-line functionality of the prototype, only the starting and multitasking of the prototype program with other programs in the mobile phone caused difficulties. The biggest problem was encountered when users tried to submit their ideas to the server. The network-components of Mobile Java were slow that time and also the initiation of the GPRS (Global Packet Radio System) -connection took sometimes many minutes to establish. Mainly for this reason the number of ideas submitted to the server remained minimal. The quality of those submitted ideas was not very high, if we compare them to the evaluation framework of Dean *et al.* (2006): novelty, workability, relevance and specificity were not fulfilled. This is understandable since users had difficulties in using the system and they just wanted to test with "scratch data" how the artefact works. Users provided also several wishes for extra-functionality, like ability to store digital images, videos and sounds first in the mobile phone and then transfer them to the server. Since the SME-company had their own intranet and e-mail application server, they also wished to have connectivity to those platforms.

According to Orlikowski (1992, 362): "… where the premises underlying the groupware technology (shared effort, cooperation, collaboration) are counter-cultural to an organisation's structural properties (competitive and individualistic culture, rigid hierarchy, etc.), the technology will be unlikely to facilitate collective use and value." In our SME case organisation these tensions were not strong, or at least we did not notice them. With originally planned two other pilots, we were forced to give up this PDP and competence system related approach, because our focus to integrate human resource development, learning and innovation processes was too radical and perhaps too complex for those big companies we contacted. Both a global telecommunications company and a global metal company rejected our research request because it was not possible to get their chief of HR and chief of R&D manager to the same table and they said that "they do not have resources for a pilot". Additionally, in our SME case the need for personal development plans, PDPs, was minor compared to the need to have an idea-process support tool. Generally, the users saw that the tool supported inadequately both informal learning and organisational learning. The WYSIWYG-development tool that we had used by Geniem Ltd for system development was not any more applicable, since the company had discontinued maintenance and support for this product. So, we needed additional (human) resources and new insights to start the coding the next artefact (iPortfolio) from scratch.

4.1.6. Communication

We described our artefact design experiences in a conference paper. Ahonen and Ketola (2005) wrote a paper for the 12th Product Development Management Conference. This paper discussed the linkages of product development and competence development within one particular product lifecycle. This paper also introduced fourth ingredient to earlier mentioned Lindgren *et al*. (2004) competence classification, namely *competence-in-co-creation*. This ingredient was inspired by our first artefact and our observations on collaboration on interest and ideas within our pilot in the SME. This first artefact we created had that time (Autumn 2004) no resemblance in scientific literature.

4.2. Second design: iPortfolio, ePortfolio with idea management

Our previous design, the Mobile Personal Development Plan (MPDP), lacked long-term planning and learning focus. These deficits were pointed by our case company. Therefore, we focused on tools and practices that would support long-term development of ideas to the level of innovation. ePortfolios are used in educational settings to support lifelong learning (Wiedmer, 1998; EIfEL, 2007). To support lifelong learning adequately, it is possible to maintain a record of an individual's learning in a persistent and standard way to ensure that learners can search for new learning facilities that fit and extend their current knowledge. Quite untraditionally, we brought these ePortfolios to the world of innovation management and will next describe our second artefact, the iPortfolio.

4.2.1. Problem identification and motivation

In this step the problem should be defined and shown its importance (Peffers *et al.*, 2008).

Portfolios exist in the world of ideas and innovation. Often, these portfolios are made for intellectual capital management and to support the management of surplus of ideas (Chesbrough, 2003). Lately Viskari (2006) has described an artefact called RSP (Research Surplus Portfolio), which includes results and outcomes of R&D projects, even patents. These portfolios mostly focus on the end phase of the innovation process. According to Stenmark (2002, 40) the problem at hand is not that of recurrence and redundancy, but to create a surplus of innovative ideas that can guide knowledge workers when developing new solutions. Therefore, our iPortfolio is focused on daily ideating and also long-term personal development. Nowadays, people change jobs, units and employers in increasing speed. Quite often people have even many employers or they employ themselves by working for many clients. Educational institutes have started to emphasise ePortfolios as means of reflection and transfer (EIfEL, 2007; Marsick and Watkins, 1997). However, there is little transferability in learning between various phases of human life, like from vocational education to working life. Quite often only the CV (Curriculum Vitae) will be maintained and updated, not the original ePortfolio.

The word ePortfolio is the abbreviation of the concept 'electronic portfolio'. The ePortfolio displays an exhibition of individual work: efforts, projects and achievements in certain areas (Wiedmer, 1998). An ePortfolio is not owned by one organisation, more like an ePortfolio is meant to support lifelong-learning, creative-thinking skills and work experiences from various organisations.

These needs are also emphasised by Isaksen: “The assumption that creativity is a natural, human resource leads to the educational practice of dealing with the concept in three basic ways. The applications include weaving creativity into the existing curriculum, teaching creative thinking and problem solving skills directly, and using creativity in the process of planning for learning.” (Isaksen, 1989, 173)
What model could help in integrating creativity within an ePortolio? Earlier in Sub-section 2.2.3 we introduced the componential model of creativity (Amabile, 1983; Amabile, 1996) with three components that affect individual creativity: *Domain relevant skills* (expertise), *Creativity relevant skills* and *Task motivation*. According to Amabile (1983, 115): The intrinsically motivated state is conducive to creativity, whereas the extrinsically motivated state is detrimental. For these reasons, we have been interested in extended, work-related ePortfolios which could support creativity.

The idea of an extended ePortfolio is not new. An idea of Memex was developed originally by Vannevar Bush.

> “Consider a future device for individual use, which is a sort of mechanised private file and library. It needs a name, and, to coin one at random, “memex” will do. A memex is a device in which an individual stores all his books, records, and communications, and which is mechanised so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory.” (Bush, 1945)

Interestingly, this view of Bush from 1945 shares some common architectural and functional elements of current ePortfolios. Our iPortfolio artefact extends the earlier described artefact, Personal Development Plan. The focus in the iPortfolio is more on supporting learning, memorising and reflecting than on competence development. The i-letter emphasises focus on idea projects and continuous and life-long problem-finding and problem-solving phases. The research problem within our second design is defined: How to design an ePortfolio that is also a long-term problem-finding and problem-solving tool for the innovation process?

4.2.2. Define the objectives for a solution

According to Peffers *et al.* (2008) after the problem is identified, there remains the step of determining the performance objectives for a solution. These performance objectives are somewhat similar to design principles, utilised with our previous artefact.

We see like Kankaanranta and Linnakylä (2002) learning organisers and ePortfolios as vehicles of reflecting and communicating the knowledge of individual to the group and to the organisation. As Dewey (1939) already put it: “We do not learn from experience. We learn from reflecting on experience.” Therefore we have had interest in the latest portfolio and learning organiser research (Vavoula 2004; Vavoula and Sharples, 2002) and utilised these research results while defining objectives.

We must emphasise here that our artefact design work started in 2005 before we were aware of all theories, frameworks and existing artefacts (like Zhang *et al.*, 2007 or EIfEL, 2007)). In fact, we were originally inspired by the work of Vavoula and Sharples (2002) after working with them in the MOBIlearn-project from 2002 to 2005.

Vavoula and Sharples (2002) introduce criteria for a lifelong learning organiser (LLO). Their criteria can be seen as one sort of usability criteria for an ePortfolio artefact: 1) A LLO should be easily transferable between places: it should be either implemented on a device that is easy to carry and use around, or it should be designed so as to run on a single computer system and be accessed remotely, via any system. 2) LLOs should be available and functional anytime, during any day of the week. 3) LLOs should provide a smooth transition between learning topic areas and support the user to construct meaningful, integrated knowledge. (Vavoula and Sharples, 2002) Furthermore, Vavoula (2004) has demonstrated these LLO criteria in connection to organising learning from activities to episodes and finally to projects. A learning project is a series of clearly related episodes, usually spread over a period of time adding up to at least seven hours (Tough, 1971; cited by Vavoula, 2004). This view of Vavoula is similar to our learning project approach in our first design, Mobile Personal Development Plan. According to Jafari (2004) a successful ePortfolio system must include an advanced user interface, a robust integrated technology architecture, lifelong learning support, standards, and transportability.

Design principle: Make iPortfolio easily transferable between places.

Design principle: Focus on long-lasting, lifelong learning support.

This life-long learning support was emphasised by Vavoula and Sharples (2002) in their life-long learning organizer (LLO). Later EIfEL has defined ePortfolios more in detail (2007): “An ePortfolio is a personal digital collection of information describing and illustrating a person’s learning, career, experience and achievements. ePortfolios are privately owned and the owner has complete control over who has access to what and when.“ Earlier in Sub Section 2.2.5. we looked at problem solving in groups and collective creativity. Individual and group-based rewards were both seen important ( ).

Design principle: Make evaluation focus on collaboration but also on individual effort.

Later this is emphasised by Zhang *et al.* (2007, 211): “One of the challenges of implementing a collaborative ePortfolio system is how faculty and institutions reengineer their assessment and grading methods to deal with the situations where part of a student’s portfolio is collaborative work by multiple people, and how the freeloader or dominator issue … can be addressed in collaborative work.” This comment is referring to faculty, but similar challenges will be faced in organisations were portfolios are used and modified by several people. Therefore, the evaluation and grading with ePortfolios are sensitive issues; perhaps more effort should be put in collaboration and equal commenting. The evaluation should therefore support both individual and collaborative achievement.

EIfEL is an organisation in the EU that develops ePortfolios. EIfEL listed the following interoperability framework already in 2005 to support life-long learning, employment and social integration.

Component	Description
Identity management	Consciously or not, individuals have a digital identity. The objective of identity management is to empower individuals with the ability to control their digital identity and the services exploiting the information contained in their identity (biographical data, competencies, publications, social networks, etc.). This includes security and privacy management as well as authentication.
Social network management	This is an extension of the identity management (individuals exist in relation to others), e.g. to grow circles of trust, communities etc.
Content management	Beyond basic biographical data, the digital identity of an individual comprises learning artefacts and outcomes, such as documents, reports reflections, work experience, feedbacks, etc. It is likely that the contents will be heterogeneous and distributed over many different information systems. Intellectual property right management (IPR) is part of it.
Publication	Can be static (e.g. a PDF file or a content package) or dynamic (e.g. a website or an Atom stream in XML format).
Physical architecture	The implementation P2P (Peer to Peer) / Client-Server: ePortfolio contents can be accessed through different modalities, in particular in a peer-to-peer environment to facilitate the development of social networking.
Services	Job search, learning, assessment, community networking etc.

Table 4.5. Interoperability framework (EIfEL, 2005)

In that EIfEL framework, it is interesting to notice that social network management is emphasised. The EIfEL framework has been developed since early 2000. The acceptance-finding of ideas (Treffinger & Isaksen, 1992) is important and the social network may help this process. Following objectives can be extracted:

Design principle: Support identity management.

Design principle: Support social network management.

Design principle: Support content management.

Design principle: Support static and dynamic publishing.

After defining the above mentioned design principles in 2005, we have found standards and new practices for content management. The full (e)Portfolio may contain paper documents, notes in a computer, an official CV in the Europass-format (Europass, 2008), even a blog.

Similarly, after defining in 2005 the above mentioned design principles for publishing and content management we realised that dynamic publishing is getting more and more important. Wilson (2005) suggests that an ePortfolio consists of various data elements (feeds), which can be integrated into larger portfolios. These feeds are produced by various information systems and blogs (Figure 4.7). Interestingly, one of these information systems is the HRMS (Human Resource Management System) that reminds us about our artefact number one, Mobile Personal Development Plan (MPDP).

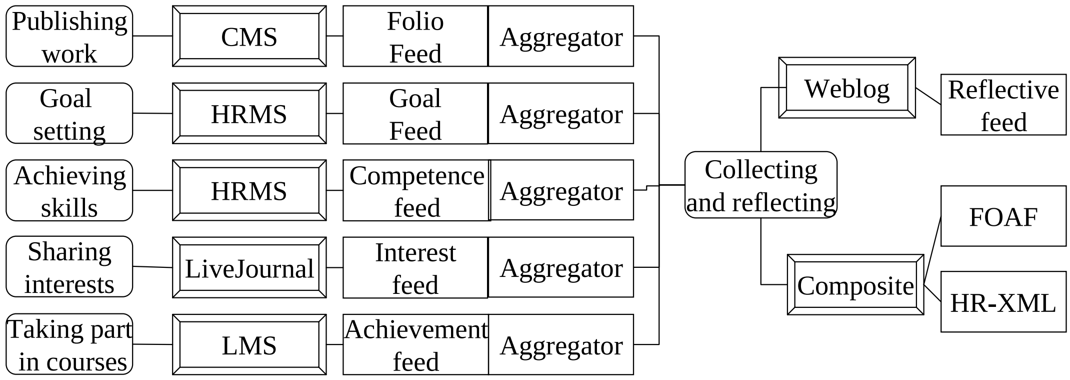

Figure 4.7. ePortfolio consisting of feeds that are aggregated to a composite record (Wilson, 2005).

One solution for constructing an ePortfolio is to aggregate a range of feeds to create an aggregated (integrated) ePortfolio. The FOAF (Friend of a Friend) model is useful here, as it contains properties that can hold most of the information you might want, such as contact information, goals, interests, and publications. This is related to identity management. Another useful model is the HR-XML Resume (http://www.hr-xml.org/), although this is more structured than the FOAF, and it may not be as simple to map the parts of the feeds into it. (Wilson, 2005) There are definitely several alternatives for our artefact design and we can add one more design principle from Figure 4.7.

Design principle: Support data elements (feeds) from external systems.

Could ePortfolios facilitate creativity by supporting both individual reflection and collaboration around ideas? ePortfolios can be integrated or built on other technologies, like weblogs or blogs. Blogs combine the immediacy of up-to-the-minute posts, latest first, with a strong sense of the author’s personality, passions, and point of view (Nardi, Schiano, Gumbrecht, and Swartz, 2004). The use of blogs started as writing on-line diaries and has taken new forms in the recent years.

Blogs have been considered to be a new hybrid of web pages and web forums in which the use of different media elements (text, pictures, animations, video clips) is combined with the dialogical nature of web forums. The RSS (Really Simple Syndication, an XML dialect) offers a possibility to use blogs also as aggregators of information or them as "communication hubs", offering readers multiple communication channels to choose from to enter into conversation and participate in or start a discourse (Zhang *et al.*, 2007). Recently, microblogging has increased with very small messages as demonstrated by the Twitter service (http://www.twitter.com). Even these microblogging services utilise XML-format in their messages and an information feed can be provided.

How these information feeds and personal tools like blogs can be used in problem-finding, problem-solving and learning? The employee should have the opportunity to build further in isolation his/her learning plans to the level of a learning project (Vavoula 2004). Additionally, there may be good reasons for allowing and perhaps encouraging learners (employees) to create their own 'learnplaces', configuring the physical resources available to them in ways they find most comfortable, efficient, supportive, congenial and convivial (Goodyear 2002). This is the reason, why we see accessibility of the artefact necessary. These ePortolio tools need to be accessible in true sense, supporting both offline and online activities and instant note-taking (Ahonen, 2005). When the employee has worked further his idea, he or she may ask confirmation and feedback about his/her ideas (actually an ePortfolio consisting of several learning projects around ideas) from superior and colleagues. In that sense there is a continuous problem-finding and problem-solving process going on. Additionally, the sharing of own (e)portfolio and related ideas with others and seeking similar interests might be beneficial. To understand these portfolio maintenance processes a table is next presented. In the following table Barrett (2004) describes how the maintenance processes of paper portfolio has changed when ePortfolios have been introduced.

Traditional	**Technology**
Collecting	Archiving
Selecting	Linking/Thinking
Reflecting	Storytelling
Directing	Collaborating
Celebrating	Publishing

Table 4.6. Portfolio processes (Barrett, 2004)

As Barrett (2004) points out, many paper-related processes have been replaced with linking and integrating of digital resources (document-, image-, sound- and video files). We see that there can exist also hybrid portfolios, containing traditional, paper-based activities and more modern, technology-based activities.

Kainulainen, Suhonen, Sutinen, Goh and Kinshuk (2004) were among the first to introduce problem-solving tools in an ePortfolio; the main function of their problem solving tool is to give students a fresh stimulus for processing the occurring problems. In the next table (4.7) is described a set of tools they used in their Problem Processing Assistant (PPA)-tool.

The Problem-Solving Tool	Explanation
Random Thinking Models Page	*Random Thinking Model Pages* provide a random stimulus for learners' to associate new perspectives on acute problems. The web is used as a repository of seeds to associate with. Tool is implemented by giving a link to a new web page. Standard web search engines do the search by randomly picking a seed word. The tool can be modified to use words that are distantly or closely related to the problem. At the different phases of the problem-solving process there might be a need for a different type of stimulus.
Question Lists	*Question Lists* are standard problem solving methodology. With the questions lists the system can irritate the students to think about their problem from different perspectives. Question List function includes several categories of predefined question lists.
BruteThink Tool	*BruteThink* tool gives problem solver a fixed word to work with. The idea is that the student should relate the problem with the word. By using different viewpoints, the student can process the step from various perspectives. BruteThink allows skipping the given word and ask for another to get new insight.

Table 4.7. Elements of the Problem Processing Assistant (Kainulainen et al., 2004)

In overall the above mentioned tools by Kainulainen *et al.* are based on divergent thinking versus convergent thinking metaphor (Guilford, 1953) as described in the Sub-section 2.2.1. We would like to point out that concept 'problem-finding' is perhaps better here, since ideas (problems) are originally ill-defined. We used the modified Question lists-tool already in our first MPDP-artefact.

In the information systems literature, there are also examples of pure problem-finding (idea-finding) artefacts for individual use. We may ask: do these problem-finding tools have elements of ePortfolios? Next will be described the IdeaFisher artefact by Marsh Fisher.

CASE: IDEAFISHER - FISHING FOR NEW IDEAS

> Marsh Fisher was first captivated by creativity in 1964 when he attended a writing class at UCLA. Much to his amazement, he discovered that he lacked the ability to ad lib and generate ideas as quickly as his fellow students. As he drove home, however, he thought of a funny idea and wondered why he could not think of those same ideas in class. As Fisher pursued the elusive ability to make creative connections, he realized that his own production of creative ideas was limited primarily by his memory abilities and the variety of associations generated by his life experiences.
>
> In general, the human mind is much better at recognizing information than recalling it, which explains why multiple-choice tests can be so much easier than essay exams. Fisher believed that his limitations to recall and to make a variety of associations were roadblocks that might be overcome with the help of computer software. Therefore, when he retired as cofounder of Century 21 Real Estate Corporation in 1977, he devoted himself full-time to developing a software package that would help people generate ideas by expanding their limited memory capabilities, helping them make associations, and asking probing questions.
>
> Through his years of studying the creative process, Fisher concluded, "Creativity is about as magical as the skill required to add two plus two. Both can be taught and learned. And the more one practices any discipline, the more proficient one becomes."
>
> The software package that resulted from his research is IdeaFisher: a 25-megabyte associative database (compressed to 7 megabytes) designed to stimulate thinking about virtually any subject and capable of being tailored by the user to include industry- or product-specific terms and links. IdeaFisher contains two databases that are linked in a unique manner to perform these tasks. The first database, the QBank, contains nearly 6,000 questions organized to clarify problems, modify ideas, and evaluate solutions. The second, the IdeaBank, contains more than 70.000 idea words and nearly 800.000 associated links. It is somewhat analogous to a huge free-associations thesaurus.
>
> The psychological foundation of IdeaFisher rests on the principles of association, memory retrieval, and the use analogy and metaphor. Thinkers interact with and use idea words to stimulate ideas and associations in their own memory banks. New connections and associations are stimulated and a tremendous number of ideas can be generated in an extremely short period of time. (Marakas, 2003, 502)

With the information system of Fisher, described in Marakas (2003) it is possible to produce large numbers of ideas. These ideas are often produced after longer problem-finding period by associating ideas with new contexts. The current version of IdeaFisher, called ThoughtOffice (http://www.thoughtrod.com) contains larger databanks and access to various web content (including information feeds). An ePortfolio with learning targets might help in developing these ideas even further. However, the selection of good, applicable ideas might be problematic. Like Dean *et al.* (2004, 675) propose: Quality ideas should meet a specific threshold on workability and relevance. Creative ideas should meet a specific threshold on novelty, workability, and relevance. A group of people or a collaborative process would be needed to improve the quality of these ideas.

Design principle: Support collaborative review of ideas and idea evaluation tools

After defining these design principles, we must remember that ePortfolios have been rarely integrated in the human resource development and innovation management in companies. ePortfolios have been mostly used in transition periods from an educational institute to a company (see examples what we have recently found in Herman and Kirkup, 2008). ePortfolios are more familiar in schools and in universities, not in companies. Therefore, the following design phase may turn out to be challenging.

4.2.3. Design and development

Conceptually, a design research artefact can be any designed object in which a research contribution is embedded in the design. This activity includes determining the artefact's desired functionality and its architecture and then creating the actual artefact. (Peffers *et al.*, 2008, 55)

Next we will start developing a combined innovation, learning and HRM artefact. This work is based on the previously mentioned design principles (objectives) and eventually targeted to create a special kind of ePortfolio, namely the iPortfolio artefact.

If you want to achieve Y	**In situation Z**	**Then do X**
Make iPortfolio easily transferable between places.	When the iPortfolio is used at work, at the university and at home.	Store data on server. Make it possible to replicate data between server and client devices. Enable software clients to work in off-line mode.
Focus on long-lasting, lifelong learning support	When the employee works for several employees and may study occasionally	Review ePortfolio and HRM standards. Use standard-based metadata descriptions.
Make evaluation focus on collaboration but also on individual effort	When iPortfolios are evaluated based on group achievement, but personal motivation should be supported simultaneously.	Create a mentor role that supports iPortfolios, but also acts as a moderator. Elaborate, how this mentor can be part of the HRM process in a company.
Support identity management.	When there are needed various levels of privacy	Build security and privacy management as well as authentication.
Support social network management.	When part of interaction takes place outside the iPortfolio	Create connections to the most popular social network sites, use open APIs.
Support content management.	When iPortfolios are maintained and ideas are formulated.	Implement content management and editor tools.
Support static and dynamic publishing.	When unofficial and official versions of iPorfolio needs to be printed or published in the web.	Review platforms which support various content formats. Encourage employees to work with both paper and digital portfolios (hybrid portfolios).
Support data elements (feeds) from external systems.	Currently blogs and various news sources are implemented in XML-format, especially its RSS-dialect.	Implement an aggregator that combines different information resources and feeds. Select a platform that supports XML.
Support collaborative review of ideas.	When an employee/individual provides an idea for commenting	Provide a framework that measures novelty, workability, and relevance.

Table 4.8. Design principles and design actions, the second prototype, summarised.

An iPortfolio can be an intranet-like artefact. However, an iPorfolio can also be an aggregator like ELGG (http://www.elgg.net) combining information from several information systems and representing this information in a coherent way. Our iPortfolio artefact was decided to be similar to an ePortfolio with certain extensions.

We integrated selected elements of our earlier Mobile Personal Development Plan (MPDP) artefact, added design principles from Table 4.8 and developed the following architecture to integrate various data streams and activities.

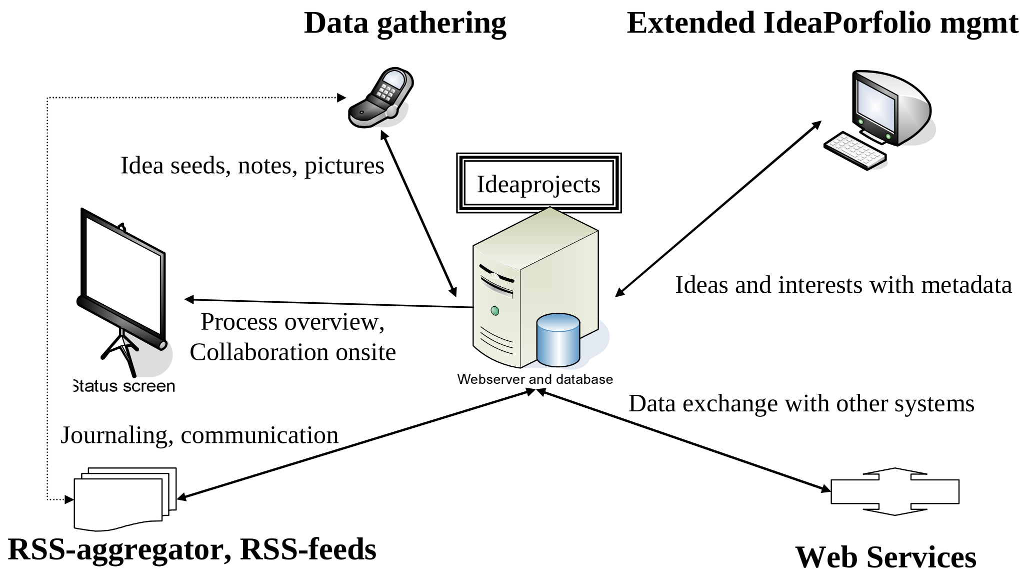

Figure 4.8. iPortfolio software artefact and architecture.

We saw, that in the figure above “Data gathering” (including idea seeds, notes, pictures) is the basic functionality of the mobile client (‘m-Portfolio’), but at the same time we recognised a need for more advanced data processing with the PC client (‘Extended IdeaPortfolio management’). For an organisation it might be valuable to get an overview of various iPortfolios. Therefore we implemented a status screen that could visualise the process in a large video screen for example in a company’s lobby. We also found external information sources valuable, therefore an RSS-aggregator (news service) was integrated and Web Services meant an interoperability layer for other services. In the middle was the server with storage space for idea projects as well as for iPortfolios.

The following picture presents the PC browser -interface (‘Extended IdeaPortfolio management’).

Figure 4.9. The PC browser -interface (Extended IdeaPortfolio Management)

The Collaboration-window in Figure 4.9 contained all shared projects from all participants. The Personal-window contained private Idea-projects that were not shared for the whole group. ePortfolio –related time management was taking place in the Time Management-window. Within each mini-window there were tabs that contained various functions.

We did not have resources to integrate very sophisticated ePortfolio and problem-solving tools (see Kainulainen *et al.* (2004), Table 4.7) into our second prototype. The development of associate database was not possible because of time limitations. Therefore, we used the Question List approach.

Which design alternatives were there? We mentioned earlier the ELGG (http://www.elgg.org), an integrated ePortfolio and social media oriented information system, but we rejected this design alternative, because we did not know enough of it the time we were building the second artefact. Another viable alternative would have been a semi-paper solution, namely DigiMemo-type of approach (for example http://www.digimemo.com). This approach would have allowed writing notes with a pen on a special paper notepad and transferring these notes occasionally to the computer and eventually to the information system. However, this approach would perhaps have required special forms and templates. So, we rejected these two alternatives.

4.2.4. Demonstration

Our challenge was to design an ePortfolio that is also a long-term problem-finding and problem-solving tool. This design was demonstrated in a prototype modelled inside a suitable portal framework (OpenLaszlo, http://www.openlaszlo.org) and the iPortfolio architecture was described in the previous Sub section.

The early iPortfolio-prototype was only demonstrated in a meeting in the SME in December 2004. We promised the CEO that the company would have a new, larger pilot starting in Spring 2005, but we could not start it because of programming difficulties. We managed to get the server running with OpenLazzlo Portal framework and connected this with the PC's internet browser, but the mobile client did not work any more with all requested functionalities. The following picture contains a screen capture of the mobile prototype ('M-Portfolio'). The functions were on purpose very similar to the previous prototype, the Mobile Personal Development Plan (MPDP).

Figure 4.10. An example of the user interface of the mobile portfolio (M-Portfolio).

The executives had requested multimedia support, therefore, we put lot's of emphasis on visual note-taking (Camera control and image organising) and related software development. Shown as a sub menu in the Figure 4.10). We showed this not fully functional mobile client version to the case company in January 2005 and emphasised that we do not have resources to make it fully functional.

4.2.5. Evaluation

Here we will observe and measure how well the artefact supports a solution to the problem. Like mentioned in Sub section 4.2.1, our target was to design an ePortfolio that is also a long-term problem-finding and problem-solving tool.

Next we will describe, how those requirements (objectives, design principles) described in Sub section 4.2.2. were realised.

Design principle	**Action**	**Evaluation**
Make iPortfolio easily transferable between places.	Store data on server. Make it possible to replicate data between server and terminals.	Data were stored on a server. The replication mechanism was missing from the prototype.
Focus on long-lasting, lifelong learning support	Review ePortfolio and HRM standards. Use standard-based metadata descriptions.	We studied HR-XML and EIfEL, but did not implement related metadata descriptions.
Make evaluation focus on collaboration but also on individual effort	Create a mentor role that supports iPorfolios, but also acts as a moderator. Elaborate, how this mentor can be part of the HRM process in a company.	This role was not created and no special mentor tools were available.
Support identity management.	Build security and privacy management as well as authentication.	The OpenLaszlo prototype had different user levels (administrator, user etc.)
Support social network management.	Create connections to the most popular social network sites, use open APIs.	APIs existed, but they were not utilised.
Support content management.	Implement content management and editor tools.	The mobile client had a simple editor. The OpenLaszlo prototype had an editor.
Support static and dynamic publishing.	Review platforms which support various content formats. Encourage employees to work with both paper and digital portfolios (hybrid portfolios).	Neither OpenLaszlo nor Java MIDP client supported dynamic publishing. The second alternative, the planned ELGG platform would have supported it.
Support data elements (feeds) from external systems.	Implement an aggregator that combines different information resources and feeds. Select a platform that supports XML	The OpenLaszlo and ELGG had a built in aggregator. However, this aggregator was not utilised in a real pilot with the case company.
Support collaborative review of ideas.	Provide evaluation framework that measures novelty, workability, and relevance.	No such evaluation framework was in place.

Table 4.9. Objectives and actions, how they were realised in the iPortfolio design

We ran into big problems in programming. Like mentioned in the evaluation of previous prototype, the development tool (Midlogic Studio) that we had used was discontinued. Therefore, we sought help from a teacher and PhD colleague who teaches Java-programming. This teacher suggested us to have a student to do the programming. So, we drew flowcharts based on the existing prototype and provided guidance to this student. However, the student was not very familiar with programming, he was often ill and we had also technical difficulties with prototype stability. Even our family (wife) and friends were involved in bug hunting, but the server-side errors could not be corrected. Additionally, the MIDP mobile java software component was in that sense immature, that almost every mobile phone or PDA model needed a specially tailored version for it. We learned a hard lesson: use software that is tried and tested.

Our prototype focused on identity management and content management. The architecture, however, was left open for further enhancements like mentioned in the EIfEL interoperability framework.

In 2005 there was one technological platform called ELGG (http://www.elgg.org), which allows users to combine ePortfolio elements. This ELGG technology supports also the integration of various information resources to an integrated user interface.

If we now would start the project from beginning, we would definitely utilise ready-made packages like ELGG and would be involved in their open source developer community with extra functionalities wishes and implementation resources. The semi-paper notetaking approach using concepts like DigiMemo could be integrated to the ELGG platform as well. This approach would allow important problem-finding phase to be done in solitude, technology being as natural as hand-writing and as accessible as the pen and paper while being also transferable to digital format.

4.2.6. Communication

We wrote a paper for the ePortfolio conference in La Rochelle in France (Ahonen and Murto, 2004). We presented a paper in the IADIS Mobile learning conference in Dublin (Ahonen and Syvänen, 2006). Additionally, we contributed to an ePortfolio book ‘e-Portfolio – Adding Value to Lifelong Learning’ (Korhonen, Kohonen, Tolkki, Syvänen and Ahonen, 2007).

This work with the iPortfolio artefact led to business development and early patenting procedures with a Finnish technology centre. However, it was early understood that software and related methodology is difficult to patent and we halted this process. The legal terms of that technology centre were also too strict for us and we could not get the software development resources we requested.

Our second design, the iPortfolio, was still inadequate to support collaboration between companies and between customers. Therefore, our last design and artefact will be next described.

4.3. Third design: Brokering Platform for Open Innovation

A particular research project (Tekes Parteco 2006-2008) allowed us to study an area called open innovation (Chesbrough, 2003) where focus is on customers and networks. During this Parteco project we conducted a Delphi expert panel and collected opinions which are utilised here as requirements for the development of our third artefact, the Brokering Platform for Open Innovation.

4.3.1. Problem identification and motivation,

Peffers *et al.* (2008) remind us that we should define here the specific research problem and justify the value of a solution.

Our earlier two designs focused on individual and group-based, in-house view on learning, creativity and innovation. This viewpoint has limitations as the following quotation reveals.

> "Open innovation removes many of the boundaries – geographical, technological and corporate - that stand in the way of new product development and new markets. Open innovation provides access to knowledge and technologies that would take years and millions of dollars to develop inhouse. The approach makes it possible to shorten product development cycles and leapfrog the competition. And it makes it possible to harness so-called "disruptive technologies" instead of being blindsided by them. "
>
> - Mehran Mehregany (cited in Chesbrough, 2006, 148)

Like Mehregany mentions, the open innovation makes it possible to save time and money in product development. To our mind, ideas and improvements can be constructed systematically with customers. The creation of innovation is seen as a systematic process by Drucker (1985, 31): Systematic innovation therefore consists in the purposeful and organised search for changes, and in the systematic analysis of the opportunities such changes might offer for economic or social innovation.

From a company specific database (Cohen & Levinthal, 1990) this systematic search for changes extends to innovation intermediaries (Chesbrough 2003, 2006b) and to innovation marketplaces which try to systematically analyse opportunities for change and innovation. This analysing activity is central for our third artefact, the Brokering Platform for Open Innovation. Earlier, in Sub section 2.1.2 we presented the weak signal processing and analysing by humans and information systems.

The research problem with our 3rd artefact is related to collaboration between companies and between individuals. Therefore, our research problem for our third artefact is formulated: How to build an information system to support brokering of information for innovation purposes?

4.3.2. Definition of the objectives for a solution

Following Peffers *et al.* (2008), before we will define the objectives, we will first explain how we collected requirements. In the Parteco research project (full name: *To* ***Part****icipatory* ***Eco****nomy and Beyond: How community content and ideas cash in. Tekes research project*) we studied during 2006-2008 the emerging open innovation phenomenon (Chesbrough, 2003). As part of this research project, we were able to do future studies of open innovation with an expert panel using the Delphi method (Dalkey, 1969). The experts we interviewed were 5 internationally respected professors in the area of open innovation. The expert panel also consisted of 5 business executives, working in two global companies and in an SME. So, the expert group was altogether 10 people. The expert panel with Delphi method was organised between July and December 2007.

Delphi is characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem (Linstone and Turoff, 2002). Nambisan, Agarwal and Tanniru (1999) studied user innovation in information technology utilising Delphi method and found it useful to do research on innovation in information systems research area.

The Delphi research method normally progresses in the following three steps and we will also illustrate the format we used in communication.

Description of the phase	Format
1. Exploration of the subject under discussion, wherein each individual contributes additional information he feels is pertinent to the issue.	A multi-page questionnaire in a web form.
2. Process of reaching an understanding of how the group views the issue (i.e., where the members agree or disagree and what they mean by relative terms such as importance, desirability, or feasibility).	Wiki
3. If there is significant disagreement, then that disagreement is explored in the third phase to bring out the underlying reasons for the differences and possibly to evaluate them.	None (not implemented)

Table 4.10. The phases of Delphi Method (Linstone and Turoff, 2002) and how they were implemented in our work.

When we look at Table 4.10, in the phase 1, our web form consisted of several (fictive) scenarios. Each scenario had a story, a picture and a question in an open format. We do not illustrate here all those scenarios and questions. Instead, we will focus on two open innovation (Chesbrough, 2003) related scenarios: Intermediaries and Brokers. We start with the Intermediary scenario which is illustrated below.

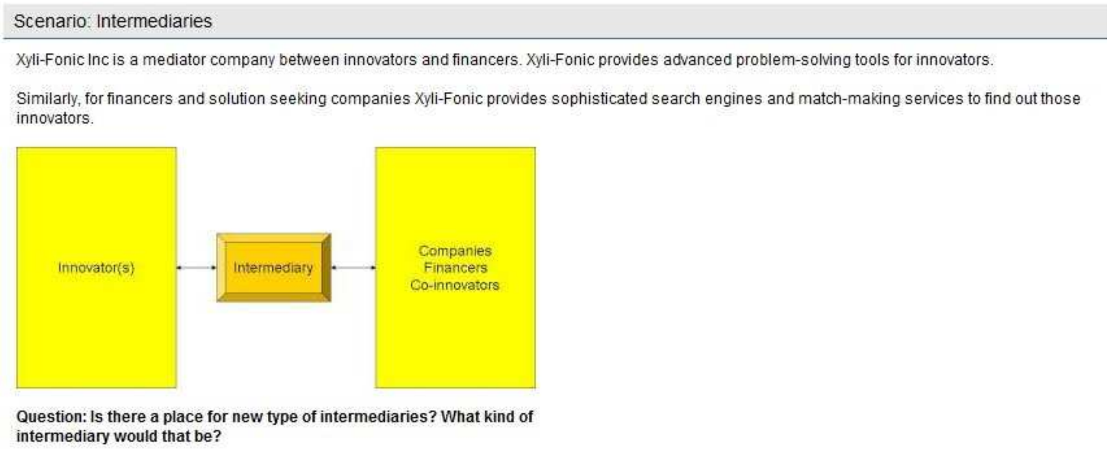

Figure 4.11. An example of intermediary scenario in the Delphi method study.

Earlier, in Sub section 2.4.4 we provided a description of intermediaries. These companies or even persons work between different parties. We were curious, what kind of intermediaries do these experts recognise and emphasise. We received the following answers, listed in Table 4.11.

Answers to the Intermediary scenario question: *"Is there a place for new type of intermediaries? What kind of intermediary would that be?"*
A. Absolutely. All that is necessary for intermediaries is that they have some preferential access to one or more communities on the one hand, and a way to serve and protect clients on the other hand. See Chapter 6 in Open Business Models for six examples of intermediaries in widely differing industries.
B. There are always places for different types of intermediaries. It all depend on what business models they want to base upon. for e.g. In terms on innovations, you could have a "auction house" for innovations which would provide the highest bidder with the appropriate innovation. There could also be other Hedge fund-like investors that spread their risk on new innovative companies or co-create value with innovation networks.
C. I'm not sure if here a new kind of intermediary is needed. We already know about successful inventor databases and matchmakers (e.g. InnoCentive). I don't see the business value for a tool provider building up additional data bases with inventors beside creating a service for their customers in linking them with possible short term employers.
D. Not familiar with Xyli-Fonic, I would think there will always be new type of intermediaries in the future.
E. The intermediary could create a mutually acceptable reward schedule for all involved...
F. How to know the right questions? There could be an intermediary who collects customers needs and complaints and gives corporations feedback and ideas based on real needs.
G. Maybe in certain cases.

Table 4.11. The Intermediary Scenario and answers

When we consider Table 4.11 and Sub section 2.4.4., we can list the following objectives that come out of the Delphi expert panel:

Design principle: Support confidentiality

Chesbrough (2006b) like our Delphi panel representatives see confidentially crucial when an intermediary tries to provide reliable services.

Design principle: Support monetary rewards

Amabile (1983) has showed how demanding it is to support external motivation without having an effect on intrinsic motivation. Fairbank *et al.* (2003) discuss about suggestion management systems and see alternatives to offering cash rewards: offering credit that can be used to purchase merchandise.

After the Intermediary scenario we asked in the Delphi panel representatives about brokering and provided experts the Hargadon and Sutton (2000) knowledge brokering process for comments. This same process was introduced earlier in Sub section 2.4. Below is our brokering scenario with a fictive company as an example.

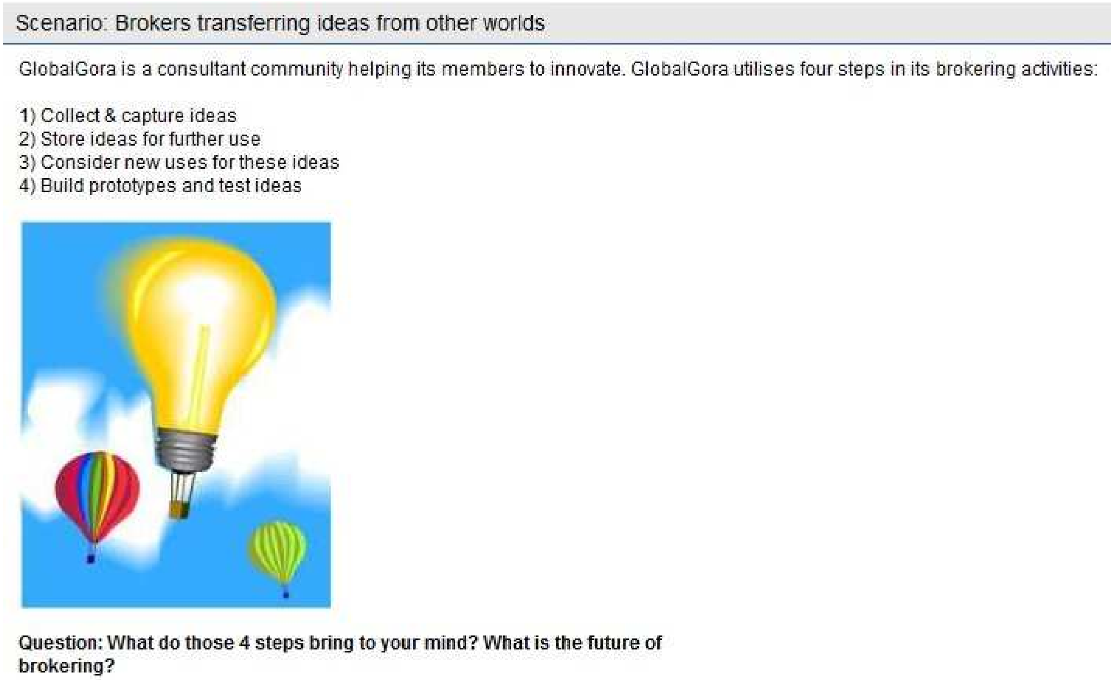

Figure 4.12. An example of brokering scenario in the Delphi method study.

On purpose, we listed in Figure 4.12 the simplified brokering process, namely knowledge brokering (Hargadon and Sutton, 2000), not the more advanced technology brokering process model (Hargadon and Sutton, 1997). After introducing this scenario to our Delphi expert panel participants, we received the answers concerning the knowledge brokering (Table 4.12).

Answers to the Intermediary scenario question: **“What those 4 steps bring to your mind? What is the future of brokering?”**
A. Clear step-by-step process. I would add some ideas from Robert G. Cooper and his stage-gate process where you have decision points as well. The future of KB seems to be growing because knowledge is becoming more and more focus, detailed etc. We need brokers in new very innovative fields where innovations are like frogleaps, not incrementals. See Medici effect on this issue (spoken originally in II Principe by Machiavelli and later by Frans Johansson in his book)
B. Rather basic "straight forward" four step-process. Future depends on operating model: how to build business around brokering or is broker free of charge service e.g. subsidised by governments
C. I'd be interested to see what Andy Hargadon offers here. One thought that springs to my mind is the (re)combination of ideas and knowledge that a deep knowledge management system could offer. However, there has been a great deal of disappointment with knowledge management systems in practice. Much of the deep knowledge is tacit, which is expensive to capture, and may also require shared experience in order to transfer. This suggests that brokering can play an important role going forward, but will face limits on its practical effects.
D. Whether its 4 steps or 3 or 5, Those activities represent a basic innovations process (In the above specific example ,it is more of a technical innovations process than a business innovations process) As for brokering for innovations, it is still in its infancy. The main issues to be solved being *Legal and IPR issues * Education and Training for companies who don’t understand that concept * Marketing and communicating * Creating an environment that is friendly and adaptable for companies to accept those companies who do brokering.
E. Step 1 and 3 seem to be the most important for me and might posses the best future perspectives. Collecting ideas (maybe solutions for stated problems) from a broad variety of members with very different background and interests seem to be a useful way to increase the solution space (see IBM's innovation jam). On the other hand side, finding new uses and applications for ideas or development in other markets or industries is a fruitful but yet underdeveloped way to create radical innovation with limited development risk (cross-industry innovation).
F. I think they are part of "typical" design steps. The future of brokering is to transcend boundaries, be geographical, industry type, functional etc.
G. 1. The idea generation process 2. Ideas are easy, implementation and commercialisation are not 3. Overcoming organisational stasis is the toughest challenge It would be more efficient if these steps are not done inside one community but open interfaces allow other communities to share preliminary ideas.

Table 4.12. The Brokering Scenario and answers

The Delphi participants emphasised in Table 4.12 following objectives:

Design principle: Enable a clear step-by-step process

Earlier we presented the CDSS (Creativity enhancing Decision Support System) model of Forgionne and Newman (2007) which, like our Delphi panel representatives, emphasise a clear step-by-step process.

Design principle: Develop skills in brokering

This request of a Delphi participant has the similarities with the Amabile's Componential model of creativity which suggests that creative behavior is the result of the confluence of three individual-level components—domain-relevant skills, creativity-relevant skills, and task motivation (Amabile, 1995).

Design principle: Target audience and focus in the innovation process

We looked at literature about collaborative brokering in information systems. There was not much literature about this topic, one exception was the book Open Business Models (Chesbrough, 2006b). When we seek the closest possible artefact we found the BRIDGE prototype from Farooq *et al.* (2006).

They describe this artefact: "Our collaboratory prototype is known as BRIDGE (Basic Resources for Integrated Distributed Group Environments; http://bridgetools.sourceforge.net). The BRIDGE infrastructure is seamlessly integrated with browser-based wikistyle asynchronous editing and also supports synchronous shared editing of complex documents through replicated objects. Replicated objects are objects that are retrieved by multiple collaborating sessions and whose state is kept synchronised when any replica is changed. The underlying code base is implemented in Java using software design patterns and components. For accessibility and familiarity, BRIDGE client systems look and behave like a normal web site, with all content rendered as HTML and images. Simple forms of authoring are supported. Each page has an "Edit" link which supports editing and new page creation using a simple shorthand notation that requires no external authoring tools or knowledge of HTML. This is designed to present the kind of easy transition from browsing to authoring, and from authoring to collaborative authoring, which is supported in similar wiki-based systems. Each BRIDGE web page also has a "Full Editor" link that launches an interactive Java-based client. The Java client supports interactive authoring functionality that is not possible or practical using HTML-based forms. Further, this client supports synchronous, distributed collaboration between users on shared artifacts, such as drawings, documents, data tables and charts, and interactive maps." (Farooq *et al.*, 2005, 221)

Since Farooq *et al.* used this prototype to enhance creativity in collaborative environments, we had interest in the functionality of this artefact in the open innovation settings. The wiki-based approach was also interesting, because it enables versioning and accumulation of different viewpoints. From this description of Farooq *et al.* (2005) we distil the following, additional design principles.

Design principle: Integrate support for individual, dyadic, and group brainstorming.

Farooq *et al.* (2005, 222) describe their approach: ”During the creative work stage, group members alternate between times when they work alone, in pairs, and times when they meet as a group. Therefore, supporting these different brainstorming modalities and the alterations between them seems feasible.”

Design principle: Leverage cognitive conflict by preserving and reflecting on minority dissent.

Farooq *et al.* (2005) see that moderate task-related conflict and minority dissent in a participative climate will lead to innovation by encouraging debate and to consideration of alternative interpretations of information available, leading to integrated and creative solutions.

Design principle: Support flexibility in granularity of planning.

Farooq et al. (2005, 223) argue that a flexible, more opportunistic and less imposing, planning tool with different levels of detail would facilitate creativity.

These three above mentioned design principles are similar to those we discussed already in Sub section 2.2.5 in connection to group-based problem-solving and creativity.

All these design principles will be further elaborated in the following design chapter.

4.3.3. Design and development

According to Peffers *et al.* (2008): "…a design research artifact can be any designed object in which a research contribution is embedded in the design. This activity includes determining the artefact’s desired functionality and its architecture and then creating the actual artefact. Resources required for moving from objectives to design and development include knowledge of theory that can be brought to bear in a solution”. (Peffers, 2008, 55)

Based on the objectives coming from the previously mentioned Delphi study scenarios and the Wiki artefact, the following objectives appeared. These objectives are added in the table with development actions.

If you want to achieve Y	In situation Z	Then do X
Confidentiality	When there are several companies working in the same innovation community.	Implement private areas for a small group collaboration. Study how intermedieary companies operate. Technically, install certificates and use SSL (Secure Socket Layer).
Support monetary rewards	When the best ideas need to be rewarded.	Make monetary rewards collaborative, dependent on both group output and personal output. Make rewards visible in software.
Clear step-by-step process	When there are plenty of ideas, but not enough control on innovation development	Integrate a stage-gate process. Implement a clear decision-structure to each step.
Develop skills in brokering	Between organisations	Collect best practices of brokering.
Select a specific audience and focus in the innovation activity.	When the participants come from several countries and industries	Create different language versions. Create separate working areas for each industry.
Integrate support for individual, dyadic, and group brainstorming.	When there is a need to support both individual and group-based activity.	Implement various problem-solving tools for various situations and audiences.
Leverage cognitive conflict by preserving and reflecting on minority dissent.	When also sceptical voices need to be heard.	Make sure that all comments and opinions are stored and can be later retrieved.
Support flexibility in granularity of planning.	When information is inputted in various formats and only later on organised and tagged.	Make it possible to send idea seeds to system by e-mail. Similarly, support blogs and wikis in standardised XML-format.

Table 4.13. Design principles and actions, the third prototype, summarised.

Earlier, before the Delphi expert panel, we had written an article about brokering in the innovation process. The following text describes how we saw the innovation process with customers within the open innovation paradigm.

Ketola and Ahonen (2005) showed that allowing customers to participate in the innovation process requires new relationships between customers and (internal) developers. By observing users and identifying user innovations manufacturers have an opportunity to implement functions that support innovation activity, or build functionality that better meets explicit and latent user needs and supports existing or new work practices (Ketola and Ahonen, 2005). This can lead to new concept innovations, and new cycle of innovations.

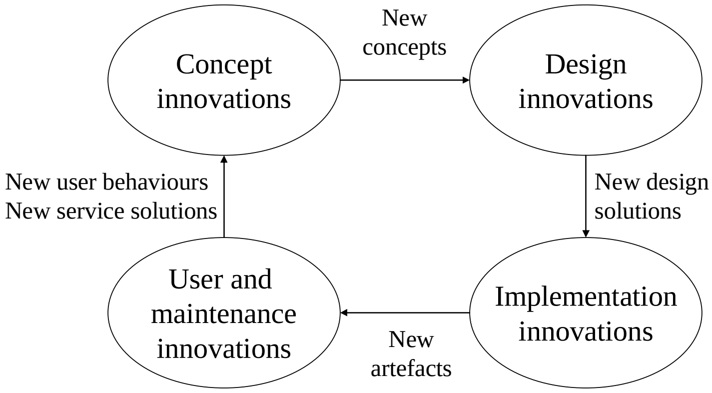

Figure 4.13. Cycle of innovations (Ketola & Ahonen, 2005).

The Open Innovation approach means that innovations are built together with users, partners and customers. The limitation of this thesis is that only partially users and customers have been involved in the artefact design. Ketola and Ahonen (2005) further integrated the brokering cycle to the cycle of innovations (concept innovation, design innovation, user and maintenance innovation, implementation innovation).

Ketola and Ahonen (2005) saw the that cycle of innovations shows the opportunity to develop user-centred development methods where the innovation and competences are better taken into account than in earlier methods. During the innovation and development cycles users and developers can and should have continuous communication. Depending on the development phase the communication takes different forms and serves different purposes. Figure 4.14 finalises the cycle of innovation with exploitation and exploration, with user-developer co-development. In this point we realised also how challenging exploitation and exploration are as shown by Sanchez (2001) and Lyytinen *et al.* (2002). Crossan, Lane and White (1999) argue that a tension exists between assimilating new learning (exploration) and using what has been learned (exploitation).

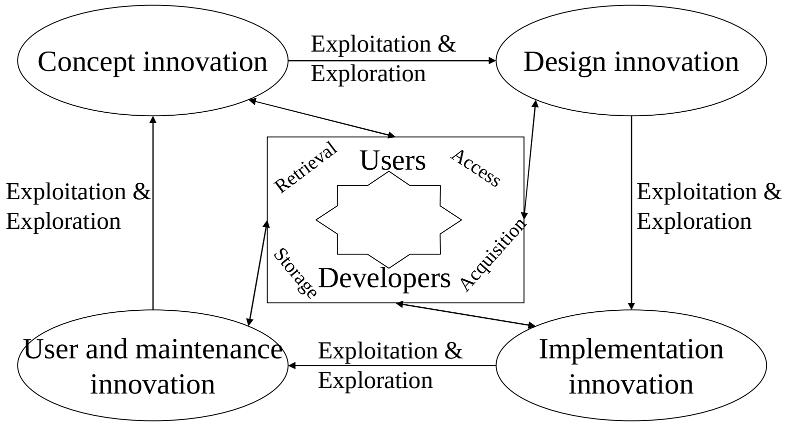

Figure 4.14. Cycle of innovation: learning and innovating between users and developers. (Ketola and Ahonen, 2005)

In the centre of Figure 4.14 there are illustrated those 4 steps of working with organisational memory (Hargadon and Sutton, 1997). So, the end result was the model that combined learning and innovation. Since this was merely a theoretical construction, it should be tested in real-life settings. The weakness of Ketola and Ahonen (2005)'s cycle of innovation is therefore the lacking input from practice, while the strength might be the introduction of different innovation types (concept innovation, design innovation, implementation innovation and user / maintenance innovation).

Järvinen (2004) recommends that all design alternatives should be listed and explained why some alternatives were rejected. The second best design and platform alternative was to utilise an existing brokering platform like InnoCentive (http://www.innocentive.com) or Zazzle (http://www.zazzle.com). Both platforms can be modified for targeted brokering and Open Innovation purpose. However, they are quite expensive and possibly not available for testing purposes. Therefore we rejected these design alternatives and relied on our earlier developed prototypes with certain extensions.

4.3.4. Demonstration

We did not build further on the actual software prototype. The iPortfolio prototype was the last we implemented in the OpenLaszlo (http://www.openlaszlo.org) framework. However, the same kind of web services based SOA (Service Oriented Architecture) architecture could have been demonstrated in the OpenLaszlo framework with several companies communicating and doing brokering in the Open innovation manner.

Our demonstration was actually the requirements gathered and processed through the Delphi study. These results could be utilised to build an enhanced prototype for open innovation and collaboration with customers and crowds. The following Evaluation sub section discusses this in more detail.

4.3.5. Evaluation

Within this sub section we will observe and measure how well the artefact supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from use of the artefact in the demonstration (Peffers *et al.*, 2008, 56). Since the third artefact, the Brokering System for Open Innovation, was not fully developed, our evaluation remains short.

Target	**Steps**	**Evaluation**
Confidentiality	Implement private areas for a small group collaboration. Study how intermediary companies operate. Technically, install certificates and use SSL (Secure Socket Layer).	Not implemented.
Support monetary rewards	Make monetary rewards collaborative, dependent on both group output and personal output. Make rewards visible in software	Not implemented.
Clear step-by-step process	Integrate a stage-gate process. Implement a clear reward-structure.	Not implemented.
Develop skills in brokering	Provide best practices of brokering.	Not implemented
Select a specific audience and focus in the innovation activity.	Create different language versions. Create separate working areas for each industry.	Not implemented.
Integrate support for individual, dyadic, and group brainstorming.	Implement different problem-solving tools for different situations.	Not implemented.
Leverage cognitive conflict by preserving and reflecting on minority dissent.	Make sure that all comments and opinions are allowed and stay visible in the timeline.	Not implemented.
Support flexibility in granularity of planning.	Make possible to send idea seeds to system by e-mail. Similarly, support blogs and wikis in standardised XML-format.	Not implemented.

Table 4.14. Objectives and actions, how they were realised in the Brokering System for Open Innovation -artefact design.

Interestingly, Nambisan *et al*. (1999) conducted a Delphi study based on manager interviews. They focused on IT knowledge and found out three types of knowledge (firm specific, industry specific and context free). They also looked at creativity, freedom and motivation related items like “ability to explore” and “intention to explore”. Eventually, they found three key antecedents of user propensity to innovate in IT – technology cognizance, ability to explore a technology and intention to explore a technology (Nambisan *et al*., 1999, 365). We must comment here that Nambisan *et al.* (1999) were focused on truth while we are focused on utility.

So, we utilised Delphi method in 2007 to get expert opinions about open innovation, especially brokering and intermediaries. At the same time we were ambitious and used both web-based questionnaire software and a wiki platform in connection to our Delphi study. The first round with web-based questionnaire was successful, 7 out of 10 participants provided comments. We were able to define requirements and their outcome is listed in Table 4.13. The second round (commenting in the wiki) was not a success in the Delphi study. Only 2 participants commented on the second round. The wiki-editing probably was not familiar to all participants. Our instructions may also have been too detailed and complicated. Instead of asking experts to comment each others answers, we should have asked them to comment overviews.

We were already in this phase more critical about mobility and access anytime, anyplace computing. First, we had noticed that ideas take time and solitude to nurture like mentioned by Perry *et al.* (2001). It was even useful to be off-line without interruptions. Secondly, there was more and more scientific evidence that long-lasting exposure to wireless technologies creates a health risk (Khurana, Teo, Kundi, Hardell and Carlberg, 2008; Makker, Varghese, Desai, Mouradi and Agarwal, 2009; Hyland, 2000; Cherry, 2002; Phillips, Singh and Lai, 2009; Glaser, 1976). For these reasons, our original idea about using the client-server architecture (MIDP Java with RMS data storage + Linux-Apache-MySQL-server) seemed viable, since it minimises the time when the wireless connection was on and transmitting. Those systems that use synchronisation, replication and contain off-line functionality are more favourable than systems requiring continuous wireless connection to the external server. In fact, these selections may provide also usability and speed advantages in certain situations, as Ratner, Reiher and Popek (2001) describe: Replication is especially important in mobile environments, since disconnected or poorly connected machines must rely primarily on local resources. … The monetary costs of communication when mobile, combined with the lower bandwidth, higher latency, and reduced availability, effectively require that important data be stored locally on the mobile machine. (Ratner *et al*., 2001, 531)

So, if we now would re-build our third artefact again, this IS would be based on components which support replication, operate in the offline mode and limit radically the time when the wireless connection is on and transmitting. We are not alone with this viewpoint, MIT Technology nominated Offline Web Applications as one of ten Emerging Technologies of 2008 (MIT, 2008).

We can also evaluate the openness of the Brokering Platform in Open Innovation. The architecture allowed extranet-like access from customers and consumers. However, the open source communities could be integrated as well. This would require Eclipse-type of user interfaces and toolkits for continuous improvement of the information system.

4.3.6. Communication

Antikainen, Mäkipää and Ahonen (2009) wrote a paper for the European Journal of Innovation Management. We focused on two research problems: How can users be motivated to collaborate in open innovation communities and what kind of tools and methods can support collaboration in open innovation communities. We viewed three existing intermediaries: CrowdSpirit, FellowForce and Owela. The motivational factors we found were somewhat similar to those design principles we listed for our third artefact, the Brokering Platform for Open Innovation.

Whelan and Ahonen (2008) authored a paper for the ECIS Galway information systems conference. This paper was about gatekeepers in the innovation process.

Ahonen (2008) was one of the authors in the first Finnish language book about Open Innovation. We wrote a chapter about innovation marketplaces in the Internet and studied the business models of intermediaries.

On the Parteco research project we conducted an internal interview round in a global company. This company also participated the above mentioned Delphi study. As a result of the internal interview and Delphi study, this global company requested comments about their official innovation management plan and we provided them with comments in the form of internal reports.

We wrote a paper about the healthier, more sustainable information systems for the IRIS Scandinavian Information System Research conference (Ahonen, 2008a) and contribution also for the Online Educa Berlin conference in 2008 (Ahonen, 2008b) and for the Environmental BioIndicators Moscow conference in 2009 (Ahonen, 2009a). A journal paper was eventually published in the International Journal of Occupational Environmental Health (Khurana, Hardell, Everaert, Bortkiewicz, Carlberg and Ahonen, 2010). For the 5th World Conference on Mass Customization & Personalization MCPC2009 we wrote about the innovation evaluation framework of Peter Drucker (Ahonen, 2009b).

4.4. Overview of different designs

Next we will point out how we have followed the proposed seven guidelines of design science. According to Hevner *et al.* (2004, 82): "design science is inherently a problem solving process. The fundamental principle of design-science research from which our seven guidelines are derived is that knowledge and understanding of a design problem and its solution are acquired in the building and application of an artefact."

Guideline	How it was followed in our research
1: Design as an Artefact	Three artefacts: 1. Mobile Personal Development Plan 2. iPortfolio 3. Brokering Platform for Open Innovation.
2: Problem Relevance	Challenges in innovation processes in the case organisation. From literature: innovation process that does not support creativity and long-term learning goals.
3: Design Evaluation	Goodness of 3 artefacts. Goal function of artefacts.
4: Research contributions	Unique artefacts, new (improved) models, design principles
5: Research rigor	Applying earlier learning, creativity, innovation and information systems research results. Following the Peffers *et al*. (2008) Design Science Research Methodology (DSRM) process model. Note: The DSRM was selected when 3 artefacts had already invented.
6: Design as a Search process	Identifying deficiencies in prototype versions and other similar artefacts. Based on mutandum, improving gradually own prototypes. Building multiple prototypes and rejecting certain constructions.
7: Communication of Research	Academic: This dissertation + Publications in journals and conferences Business: Discussions with case companies, presentations in PDM and learning conferences, consulting and teaching about open innovation

Table 4.15. Design science research guidelines (Hevner et al., 2004) with comments

As a summary of Table 4.15 we can say that our design work followed the design research guidelines of Hevner *et al*. (2004) at every step. However, the research rigour was implemented somewhat differently in our designs than in those examples Hevner *et al*. (2004) provided in their journal paper. What we found is that the utility and goodness of an artefact are very difficult to evaluate. To give an example: We as researchers trained users to use the artefact and provided the case company ideas about utility. So, how should we evaluate this kind of activity? Additionally, as mentioned in Section 3.1 Alter (2003) recommends designing an IT-reliant work system instead of an artefact. Therefore, those guidelines of Hevner *et al.* (2004) could perhaps be improved.

5. DISCUSSION

Our work has implications to science. Our three designs were unique and similar artefacts are missing from literature and from practice while we are writing these final words. The DSRM process model (Peffers *et al*., 2008) we utilised, was functional, but we would request an additional phase where the researcher would comment how he or she affects the research target. This is because the presence of a researcher doing design research invariably affects the organisation. In our case we affected our case organisation so that one of their current products has features and functionalities of our first design. Similarly, the consulting pattern of that SME company was changed. Nevertheless, we see this development as positive. One more improvement to the DSRM process model of Peffers *et al.* (2008) is visible in our work: we utilised on a limited scale those technological rules of van Aken (2004) to aim at prescription-driven research.

Some of our results were contrary to existing practices. Especially our second artefact, iPortfolio, represented those new results. Those contrasting results were exemplified in the usage of ePortfolios which was very different from portfolios usage in the educational and also in a financial sector.

There are also recommendations for practitioners we would like to share. Human resource management (HRM) practices could benefit from making development talks more focused on creativity and learning. Often managers experience development talks very rigid and discontinuous. We suggest that the personal development plan (PDP) should be updated and reviewed more often by making it a more ubiquitous and more easily updateable. Similarly, by bringing individual interests to development talks and also to the innovation process, this would perhaps add motivation of employees and generally benefit the company. Our recommendations are similar to Poutanen (2010) and Kossek *et al.* (1994) who saw that managers are often reluctant to use information systems for HRM since these information systems do not support enough leadership activities and communication.

Lifelong learning and different working roles make the design of information systems complex (Korhonen *et al*., 2006; Ahonen and Syvänen, 2006). Modern tools like ePortfolios and blogs are very personal in nature, they can not and should not be owned by organisations. However, organisations should be able utilise these information systems or at least aggregate information and messages from personal information resources in agreement with employees.

Our case company actually implemented in 2008 a limited version of our first prototype for their clients. So, their R&D activity was influenced by our discussions and piloting, although the software prototype in our pilot was faulty and limited in functionality.

Our work has also some limitations which require further research. The first one is about learning. Garrick (1999) illustrated four approaches to learning: (1) human capital theory; (2) experience-based learning; (3) cognition and expertise; (4) generic skills, capabilities and competence. Our focus was on purpose on experience-based learning and in less extend we focused on collaborative, informal and organisational learning. Our work had a very limited view on expert systems and cognition. These areas should definitely be studied in connection to open innovation in the future.

While decision-support systems (DSS) are a central part of IS and organisation research literature, we deliberately mostly cited review articles. However, we managed to bring new elements to the Creativity enhancing Decision Making Support System, CDMSS (Forgionne and Newman, 2007). We demonstrated with our second artefact, the iPortfolio, how important it is for a DSS to support long-term learning and problem-finding. A basic question that needs more attention in future studies is: why should I share? Grudin (1989) talks about disparity in work and benefit meaning that groupware applications often require additional work from individuals who do not perceive a direct benefit from the use of the application. A DSS is a groupware, so these benefits issues are important.

Within innovation research, we were forced to limit our view. We deliberately omitted most of the research focusing on IT innovation, since it is defined as generation and development of new ideas or organisational behaviours related to IT (Patrakosol and Olson, 2007, 53). Our interest in innovation was in larger scope; therefore we did not concentrate on this area. However, our three artefacts could be evaluated from the IT innovation perspective by other researchers.

Creativity was introduced mostly through psychological, educational, information systems and organisation science literature. Our focus was on ideas, their development and evaluation. Evaluation of ideas was touched only through the literature review of Dean *et al*. (2006). Definitely, a more systematic view on psychological literature of creativity would be needed to understand how a human gets motivated of problem-finding and how ideas are mentally processed. This information would provide new insights to artefacts and storing and memorising needs. The WEI (Work Environment Inventory) instrument (Amabile and Gryskiewicz 1989, Amabile 1995, Amabile, Conti, Coon, Lazenby and Herron 1996) was only referenced in our work. This instrument contains creativity related questions and interviews. This instrument could be utilised more extensively also in the information system development as well as part of management development programs.

Brokering was examined mostly through individual and group activity. Earlier innovation gatekeepers research (like Tushman and Scanlan 1981, Allen and Cohen 1969) was referenced. Special brokering organisations, intermediaries (like InnoCentive and IDEO) and their activities were mentioned. We intend to collaborate with intermediary companies and generally do more research on intermediaries in the future. Social networking theories including weak ties (Granovetter 1973; Granovetter, 2005) and the structural holes theory (Burt, 1992) were only referenced, while the main focus remained in the brokering activity within the innovation process (Hargadon and Sutton, 1997).

Interestingly, in the course of our principal work between 2008-2010 we were studying these weak ties in engineering communities in Finland through social network analysis (SNA) but we did not manage to integrate that data to this dissertation work.

The actual artefacts remained rather limited in functionality. Similarly, the pilots we run were in smaller scale than we anticipated. Since the first artefact was tested only in one company, the applicability of results is limited. We must admit that we spent too much time solving coding and programming problems. This frustrating, years long work delayed our actual dissertation writing and occasionally we lost the focus. Since we have published several conference papers, book chapters and journal papers, the article-based dissertation would perhaps have been faster to write than this monograph.

When this research continues in the future, the problem-finding and problem-solving phases of participants in pilots need to be observed more thoroughly. We still need more research to answer following questions: What is the best way to utilise personal development plans in learning and problem-finding? How functional are ePortfolios in a corporate innovation process? Is brokering a skill that can be learned or should we recognise ‘born’ brokers and support them? Can existing intermediary services and platforms be improved with long-term problem-finding and problem-solving tools? It will be interesting to see if electronic portfolios and weblogs can provide, not only technical, but mental tools to illuminate these problem-finding and knowledge creation processes. The earlier mentioned RSP (Research Surplus Portfolio) research artefacts and related literature could therefore be compared with our second iPortfolio artefact. The research challenge in the future is to design an artefact that supports intellectual capital management while simultaneously it has support on intrinsic motivation in the innovation process. Therefore, we see that these designs of ours should be developed further and piloted using perhaps action research or design science in additional organisations.

6. CONCLUSIONS

Artefacts for innovation management have traditionally been too much process-oriented as demonstrated by suggestion management systems and innovation campaigns. In our design work we demonstrated how difficult it is to support creativity and learning from individual level to organisational level.

The results of our design work are visible as artefacts. Three artefacts were introduced. All our artefacts were systematically described using the Design Science Research Methodology (DSRM) of Peffers *et al*. (2008).

The first artefact was the Mobile Personal Development Plan, which was built to a software prototype level and piloted in an organisation (an SME). This artefact enhanced the human resource development process and it was integrated to the development talks. To our understanding this was a unique approach, there were no similar artefacts. The case organisation requested additional functionalities for collaborative problem-solving and learning.

The second artefact, the iPortfolio, was an extension of its predecessor and focused on supporting intrinsic motivation and long-term innovating. The iPortfolio relied on the ePortfolio literature and the related artefact and information system architecture development. A mock-up prototype was developed, but it was never piloted in the case company because of technical difficulties. However, this prototype demonstrated that ePortfolios could be perhaps utilised in the innovation process and social media tools (blogs, wikis) are actually elements of ePortfolios. More research and testing is definitely needed.

The third artefact was the Brokering Platform for Open Innovation. This artefact was modelled for the Open innovation environment. The requirements were gathered from experts (business people and academics) who participated a Delphi expert panel. The challenges of brokering were illustrated. No demo or prototype was built any more.

In our work we demonstrated that information systems for innovation management should support long-term learning goals and interests of employees. This can be seen as our input to the Decision support systems literature. In the future it will be challenging to test our three prototypes in larger scale and in connection to company networks and customer communities.

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