Knowledge in the Innovation Process:
An Empirical Study for Validating the Innovation Knowledge Life Cycle

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*Based upon an **Innovation Knowledge Life Cycle (IKLC)** and the six phases of the Innovation Process the project INNOVANET studies the processes applied in innovation and the knowledge management technologies in use for innovation support in European industry and science. This paper presents the IKLC and the process model together including the results of a study based on qualitative interviews conducted with leading European innovators.*

1. Introduction

New discoveries and innovation have always been crucial to the success of industries and science. The increased pace with which innovation must happen today [Pérez-Bustamente,1999; Bolwijn & Kumpe, 1990], due to global competition and tighter budgets, makes successful innovation more and more challenging. To accelerate innovation, more effective and efficient acquisition, creation, enrichment, retrieval, reuse, combination, and sharing of knowledge is required.

INNOVANET, an EU funded accompanying measures project aims at examining the state of the art as well as promising future directions in effective innovation support. Special focus in this project is on Information and Knowledge Technologies. INNOVANET will provide a Science & Technology roadmap that aligns technological capabilities with true business needs of key knowledge intensive industries and identifies emerging research areas that contribute to the vision of improved systematic innovation and scientific discovery support.

Although the innovation process clearly depends on the application domain and on the targeted type of innovation, a six phased model for the innovation process has been identified: Problem Identification, Ideation, Approach Development, Operationalisation, Evaluation and Exploitation form the domain-independent, partly overlapping core phases of the innovation process.

Since innovation is a knowledge-intensive process, in which existing knowledge is applied and new knowledge created [Pérez-Bustamente,1999; Ruggles & Little, 1997], the innovation process is strongly connected with the Innovation Knowledge Life Cycle (IKLC) that consists of two complementary cycles: a knowledge cycle and a problem cycle.

In order to validate these models and to investigate tools and methods in use for innovation support in practise, a study based on qualitative interviews with 39 European innovation leaders has been conducted which is presented in this paper.

The paper is structured as follows: Section 2 discusses the Innovation Knowledge Lifecycle and the Innovation Process Model. The Study conducted for the validation of these models is introduced in section 3, whereas the results of the study are presented in section 4 and discussed in section 5. The paper concludes with an overview of the next steps in the INNOVANET project with further investigation into improved Innovation support.

2. Innovation Knowledge Lifecycle and Process Model

Innovation comprises product and process development, the production itself as well as the successful exploitation of new ideas (compare e.g. [Specht et al., 2002], [Rogers, 1998], [OECD 1997]). Innovation occurs in the development of new scientific approaches and theories (scientific domain) and in enhancing the business processes (new production models, new marketing campaigns).

Independent of the application domain, innovation is a knowledge-intensive process, where knowledge of different types is applied and created in the various activities of the process. In the INNOVANET project a six phase model describing the innovation process as well as a related Innovation Knowledge Life Cycle have been developed as a conceptual basis for the development of an R&D Roadmap on Innovation Support.

2.1 The Innovation Knowledge Lifecycle

It is the general baseline of all approaches to knowledge management that knowledge is more useful if it does not reside in the minds of individuals, but is applied and made available to others (see e.g. [Alavi&Leidner 1999]), and that this is even crucial for the creation of new knowledge ("*Knowledge that does not flow, does not grow"* [Borghoff & Pareschi, 1998; Spiegler (2000)]. Therefore, several models for knowledge flow and knowledge lifecycles have been proposed that capture the dynamics of knowledge, knowledge transformation, and its relationship to the context (e.g. [Nonaka & Takeuchi, 1995; Borghoff & Pareschi, 1998; Fischer & Ostwald, 2001]).

The Innovation Knowledge Lifecycle (IKLC), describing the use and creation of knowledge in the innovation process includes the knowledge cycle and the problem cycle (see Figure 1).

The knowledge cycle is based on existing knowledge life cycles and covers the flow of knowledge in the innovation process with a special focus on knowledge application. Especially, it follows the argument of [Fischer & Ostwald, 2001] that knowledge creation is integrated into the work process and is not a separate activity.

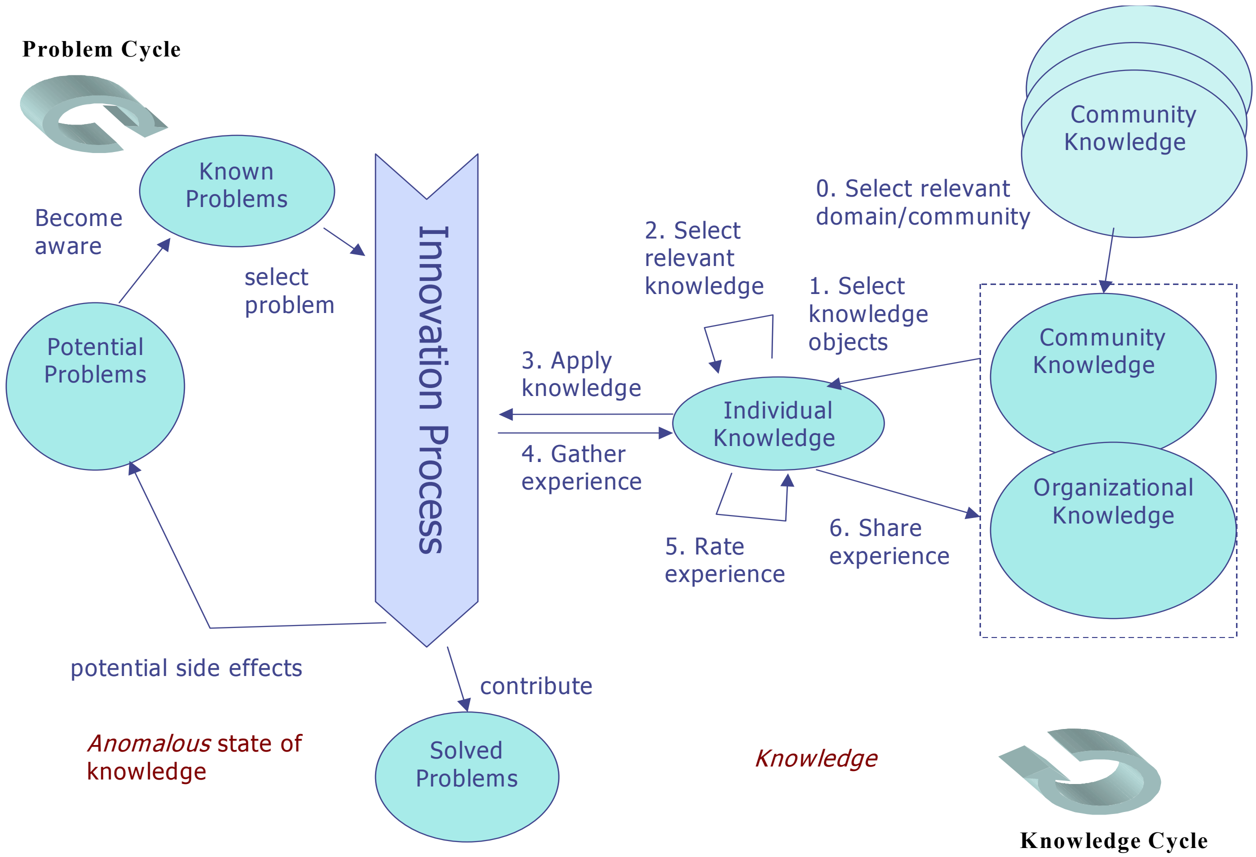

Figure 1: Innovation Knowledge Life Cycle

The knowledge cycle distinguishes three basic types of knowledge: community knowledge and organizational knowledge, shared by a community of a domain or within an organization, respectively, and working knowledge, the knowledge at hand in a concrete working or task context. In case of an individual activity this is the personal knowledge of an individual, whereas in case of a team effort, the working knowledge is the relevant joint knowledge of the team members. The knowledge cycle (right hand side of Figure 1) has 7 steps:

Select relevant domain/community: An innovation process is embedded into an application domain with an associated community, whose knowledge is applied, when solving problems during innovation. However, facing problems of a new kind requires radically new solutions. It might become necessary to explore the knowledge of different communities/domains. The identification of one or more relevant knowledge domains is an iterative process that requires the exploration of different knowledge domains, the development of an understanding of this knowledge, and assessment of the relevance for the task at hand.

Select Knowledge resources: After identifying relevant domains/communities adequate knowledge resources for the innovation task need to be selected. This can be a knowledge object, a collection of knowledge objects or an expert; selected knowledge becomes working knowledge. Working knowledge refers to individual or team knowledge. Identifying knowledge objects also includes internalisation of the knowledge [Nonaka & Takeuchi, 1995].

These first two steps are only necessary, if the existing working knowledge is not sufficient to perform the current activity or solve the current problem. Typically larger steps in innovation will put more effort into these two phases.

Focus on relevant knowledge: At each point of the innovation process only a small part of the working knowledge is relevant. Focusing on the relevant knowledge is an iterative process of selecting and rejecting knowledge objects. This can be an individual mental process or may require negotiation in a cooperative context.

Apply knowledge: The selected knowledge is applied in performing a step in the innovation process, e.g. solving a problem or developing an idea. Before the knowledge can be applied it has to be adapted to the current context of use. The required effort depends on how different the current situation is from the situation the knowledge was gained from.

Gather Experience: Experience is gathered from observations and insights during the performance of the activity and from the application of the knowledge in this situation. This refers e.g. to the question, if the chosen knowledge has been adequate to solve the current problem.

Rate Experience: In this step the gathered experience is put into relationship with the goals of the innovation process and is rated in this context. This rating provides the basis for the decision about further actions to take. For cooperative activities the rating may require a negotiation between the team members.

Share Experience: Gathering and rating of experiences produces new knowledge. In the ideal case, the rated experience and the resulting knowledge are made explicit as knowledge objects, so they can be shared with other people and by this way closing the knowledge cycle. This requires extra effort, which has to be well motivated [Fischer & Ostwald, 2001]. Even negative experience represents knowledge that might become valuable at a later point in time [Ruggles & Little, 1997].

The main purpose of the knowledge cycle is to provide a sound starting point for considering the specific knowledge handling requirements in *all* innovation process phases. The steps of the knowledge cycle are, therefore, described on an abstract level.

Comparable to the anomalous state of knowledge in the context of information retrieval [Belkin et al., 1982], we can identify an anomalous state of knowledge when looking at the innovation process. In this case open problems represent a lack of knowledge. The problem cycle (left side of Figure 1) is directly connected with the innovation process:

Become aware: There is a pool of actual and potential problems in the considered innovation area, but only a part is known to the innovator. When the innovator becomes aware of a problem the problem achieves the status of a known problem.

Select problem: The set of known problems is the starting point for the innovation process. Selecting a problem is a crucial step, as the choice of the "right" problem is an essential precondition for successful innovation. Factors influencing this choice are relevance, feasibility, strategic considerations, etc.

Contribute: If the innovation process is successful it provides a solution for the problem it was triggered by. The innovation process provides a contribution to the set of solved problems. When disseminated and exploited, innovation also changes its environment, which in turn may lead to new challenges and problems triggering further innovation.

The model developed in the INNOVANET project takes into account another fundamental dimension related to the IKLC, called the contextual dimension. Many studies from philosophy (e.g., [Kuhn, 1962]), organization science (e.g., [Boland & Tenkasi, 1995]), cognitive science (e.g., [Fauconnier, 1985; Johnson-Laird, 1992]) and knowledge representation (e.g., [Giunchiglia, 1993; McCarthy, 1993]) stress the fact that knowledge cannot be viewed simply as a collection of "objective facts" about reality, as any "fact" presupposes a context which contributes to give it a definite meaning. If we assume that each community has its own shared context, which eases and speeds up communication and sharing of knowledge, we must take into account that communication and knowledge sharing across different communities presupposes a process of "perspective taking" [Boland & Tenkasi, 1993] which is qualitatively different from the process of "perspective making" (building and using the shared perspective within a single community, [Bouquet et al., 2003]). This has an important impact on many of the phases we described above. For example, the way a community acquires another community's knowledge is not a simple step of incorporation, but may require a "translation" from one language to another, from a conceptual schema to another, etc. Analogously, the perception of how relevant a problem is depends also on a community's context, as many examples show that relevance is relative to what is implicitly assumed. The issue of combining different perspectives is mentioned many times by our interviewees as a trigger in many concrete innovation processes.

2.2 Model of the innovation process

Considering the wide variety of possible innovation forms and application domains, generalisations are difficult. However, on an abstract level it is possible to identify six basic phases. They can be described in the innovation process model (IPM) whose phases are common to most innovation processes. They are depicted in UML activity diagram of Figure 2.

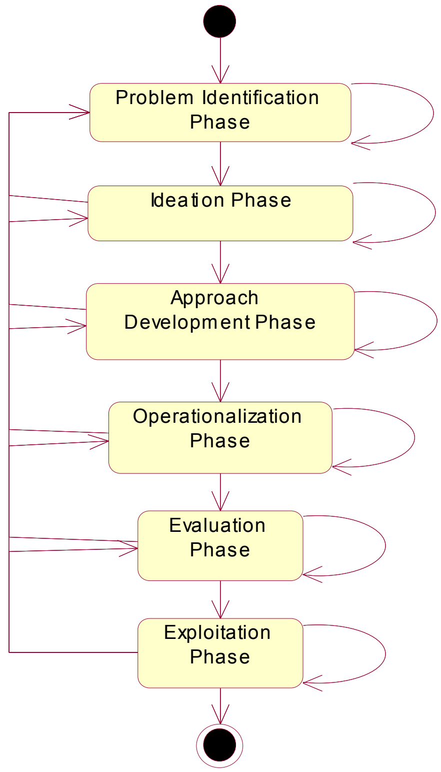

Figure 2: The six basic phases of the innovation process model (IPM)

As depicted, there is basically a sequential order between these phases. But there may be overlaps between the phases and there are loops, where, due to (intermediate) results or external events, revisiting earlier phases becomes necessary. This need for feedback is also stressed in [Pérez-Bustamente, 1999].

Before looking into the phases of the innovation process in more detail, we discuss a generic view on activities inside each phase.

2.2.1 Problem Identification Phase

The identified problem is considered as the starting point for the innovation process. Systematically, two forms can be distinguished [Pérez-Bustamente, 1999]:

- *Proactive* forms (trend setting, recognition of market opportunity, need creation, identification of research opportunity) and
- *Reactive* forms (open problem in production or processes, changed requirements, reaction to changed environments).

The type of problem and context determine the choice of an adequate form to describe a problem. If innovation, for example, is done in a team more explicit forms of problem description are required. Validation checks the adequacy of the description with respect to the targeted problem as well as the novelty of the problem. Further, a first estimation about the feasibility and the relevance of the problem has to be conducted to reduce the risk of investing resources into further steps of the innovation process.

2.2.2 Ideation Phase

Developing the central idea for the innovation, the ideation phase is in the core of the innovation process. There are several systematic ways to discover ideas for the solving of the problem like analogy, data mining, paradigm shift and luck. They all involve the exploration and/or selection of related knowledge and the focus on relevant knowledge. The exploration can include the search for similar problems, solutions to similar problems, applicable theories or practices, etc.

The idea has to be formalized and described so that it can be negotiated and submitted to a validation process against different factors like adequacy for the problem, novelty and feasibility.

2.2.3 Approach Development Phase

Approach Development is the first step towards solidifying the idea towards an implemented solution by a forma description. In addition, a conceptual model for the implementation may be developed, which describes the planned operationalisation of the approach on a conceptual level. This phase takes two knowledge objects as input, the problem description and the description of the idea.

The first set of activities in this phase involves the identification of a useful approach for conceptually describing the implementation of the idea. This involves exploration, selection, application and creation of related knowledge in terms of approach, conceptual model, and formalisms for the description of both. Both the approach and the conceptual model have to be validated, like for adequacy, novelty, and feasibility of operationalisation before the whole approach can be considered a valid input for the operationalisation phase.

2.2.4 Operationalisation Phase

In Operationalisation the developed approach is transferred into an operational form. The kind of operationalisation depends highly on the application area. For software this means implementation. In product development this may be building a first prototype. In each case, operationalisation is quite resource consuming making the validation in the preceding approach development phase a crucial activity.

The validation activity in Operationalisation checks the adequacy of the operationalisation with respect to the approach/conceptual model. The operationalisation itself as well as the validation activity also tests feasibility of the developed approach with respect to production and other forms of exploitation.

2.2.5 Evaluation Phase

In addition to the validation activities in each phase there is also a separate evaluation phase that evaluates the results produced during the innovation process. In order to assure representativeness and validity of the evaluation results for the application context, the evaluation requires careful planning and a targeted design of experiments and analysis. The choice of evaluation criteria and methods depends on the type of the innovation results and the intended application area. Possible criteria are usability, user satisfaction, performance with respect to efficiency or effectiveness, etc.

2.2.6 Exploitation Phase

Exploitation is an integral part of innovation. This does not have to be commercialisation, although this is the most important form. The invention can also be integrated into a product or system for its improvement. Exploitation may also mean changing existing business or production processes according to innovation results in order to achieve better or more cost-effective performance. In the scientific area, innovations can also be exploited by disseminating the ideas via publication.

3. Innovation Study - Method

Based on the models described a study on innovation and innovation support has been conducted in the INNOVANET project. In a first phase of this study, which is described in this paper, qualitative interviews were conducted with innovators from industry and scientific research.

Content of the Interview: The interview covers challenges of innovation, networking, and collaboration between industry and science. A special focus of the interview is on the innovation process and on tool support for the different phases of the innovation process as well as on the flow of know-how and ideas.

The questions about the innovation process examine the phases of the interviewees' innovation process. Further questions refer to the single phases of the innovation model described above, asking for employed software tools and methods as well as for desired software tool characteristics. The information collected in the study will be used directly to validate the described model of innovation. Furthermore, it will be used to model future improved software support for the innovation process.

Selection of sample: To get an unbiased understanding of the general nature of the innovation process interview participants were selected from a broad range of innovation domains. From the countries of the consortium partners leading innovators differing in the branch of industry/research as well as in their organizational position have been contacted aiming at a good mix of different views on innovation.

Interview Procedure: The interviews were mostly held face-to-face. The interview partners were given the opportunity to receive an advance copy of the interview questions to enable preparation. Some interviews were sent out by mail due to a lack of meeting opportunities. In this case, incomplete interviews were completed in a telephone conference.

Evaluation: The resulting qualitative data are analyzed by clustering and condensing them for each question. The answers are qualitative in nature and the number of possible answers is not limited.

4. Results of the Innovation Study

The INNOVANET study described above has been conducted in spring and summer 2003. In total, 39 interviews were conducted. 25 interviews were held with representatives from industry coming from 13 different branches. 14 interviews were held with representatives from science coming from 7 different branches. The branches include: food & beverage, computer science, automobile industry and pharmaceutical industry, cosmetic industry, electrical engineering, packaging industry, provision of service, knowledge & innovation management, chemistry, telecommunication, engineering, biotechnology, physics and geoinformatics.

Note that the questions allowed more than one answer. In this case the number of answers can be larger than the number of interviews.

4.1 Challenges and barriers during the innovation process

There were 96 different answers to this question which can be grouped into five clusters: lack of information (32 answers), resources (25 answers), interpersonal challenges (20 answers), factors concerning organizational culture (15 answers) and software (4 answers).

Lack of information includes e.g. too little understanding of the consumer's or market needs, lack of information about materials, procedures, legal issues, etc.

Missing resources, like funding, staff and time, can inhibit innovation. But missing resources are also a trigger to start thinking about a new and cheaper/more efficient solution, i.e. innovation.

Interpersonal matters include conflicts, inadequate communication or the lack of trust within the team.

Organisational factors are e.g. resistance against change, high bureaucracy, different mother tongues or different technical terminologies.

Finally, the lack of appropriate *software* is also named as a barrier to innovation.

4.2 Major motivation for innovation

93 reasons for motivating innovation are named. There are four motivation clusters: economic reasons (57 answers), personal motives (21 answers), application specific problems to be solved (10 answers) and socio-political reasons (5 answers).

Economic reasons – especially the need for competitive advantages – are the most important motivation factor for innovation. Further reasons are motivation for knowledge gain, enlargement of market shares, serving market needs, improving the product quality and widening the product range. The speed of innovation is considered crucial in this context.

Personal motives include managing interdisciplinary collaboration, fun and interest in innovation and rewards. Innovation itself motivates just as the wish for a person's own personal scientific progress and the wish to implement new processes.

Application specific problems are problems unique to the specific industry of department of research.

Socio-political reasons include enhancing living standards and promoting a country's society socio-politically.

4.3 Validating the Innovation Knowledge Life Cycle

Out of the 39 interviews conducted, 28 interviewees described their innovation models. The described models are compared with the model developed in the INNOVANET project to see how accurate our innovation model matches innovation models in use. The alignment of the interviewees' innovation model phases with the IPM phases is based on the description of the phases. The number of phases ranges from 3 to 9 phases (see table 1).

Number of phases	Frequency
3	5
4	7
5	6
6	3
7	4
8	1
9	2

Table 1: Frequency of innovation models

It can be shown that almost all the phases described by interviewees can be mapped into the IPM phases. Innovation models with fewer phases than the IPM are easily mapped. For models with more phases it can be shown that some phases can be understood as sub activities of one IPM phase.

After mapping the process phases a good match between the IPM and the described innovation models can be seen. However, some of the IPM innovation phases are missing in some of the described innovation models. Problem Identification is not mentioned twice and Ideation three times. Approach Development does not occur 10 times, Operationalisation 8 times. Evaluation and Exploitation is not mentioned 16 times each.

However, there are two types of activities mentioned, which can not be integrated onto the IPM phases: Assembling innovation teams and evaluating the market after exploitation. Each of these activities is mentioned two times.

4.4 Software Support for the Innovation Process

Software tools and non software methods are used throughout the innovation process. Below, the tools and methods in practise are separately displayed for each phase. After each phase, the requirements for an ideal tool are listed.

Problem Identification Phase

Software

In Problem Identification a wide range of tools and software are applied. Special innovation software is named only once, whereas software for standard office support like MS Office and for project management plays a more important role. Furthermore, support for the management of innovation-relevant information is crucial: databases for ideas, projects, and new products have been mentioned several times. This is complemented by software support for searching in the internet. As software highly relevant for validation activities statistical programs and, less frequently, cost/benefit analysis tools have been named by the interviewees. In addition, various application-specific tools are relevant for the problem identification phase.

Non software

Very often, ideas and problems come from contractors, employees, customers or experts. Dealing with a group of existing problems often leads to identify one specific problem which becomes the starting point of an innovation. Observing competitors, creativity methods and interdisciplinary innovation/creativity workshops are used. Inspiration is mentioned twice.

The ideal tool for Problem Identification has…

The interviewees wish for a resource database in which ideas, product data, technologies, networks and experts are listed. It is accessible for a large number of persons, visualises 3-dimensional, provides meta-techniques and canalises qualitative suggestions.

Ideation Phase

Software

The ideation phase is governed by creativity. Surprisingly, not as many creativity tools are mentioned as one might expect for this phase. The only obvious employed creativity support is a science platform for the exchange of questions, ideas, and methods. Again a strong focus is on generic standard tools like MS office, text processors and calculation tools, e.g. for technical computation. For retrieving information search in the internet and in special innovation related sites like technology marketplaces as well as in databases with more specific information like the assortment of goods are used. Innovation specific software is also mentioned as a supporting tool for the ideation phase.

Non software

To generate ideas for a solution, research is conducted very often. Ideas come equally often from employees/internal departments or external experts of companies. Also, networks and personal contacts are engaged. Patent research is conducted less often, just like internal and external databases and literature.
Occasionally the interviewees attend conferences in order to come up with ideas. Creativity methods like brainstorming or scenario technique are used as well.

The ideal tool for Ideation has…

There were only a few suggestions for the ideal tool. It has an expertise database and structures knowledge and results hierarchically. Also, it prioritises results and delivers automatic up-dates and visualises. The software should be team software and intuitive.

Approach development

Software

Going from the idea to the more concrete approach for solving the problem under consideration drawing and design programs, ranging from MS Power Point to 3D-CAD play an important role. For searching information relevant for Approach Development search engines are used, whereas

data analysis and validation is supported by statistical and other mathematical tools. For developing, discussing, and fine-tuning the approach in a collaborative way communication tools like chat, email, and video-conferencing are exploited.
As in the previous phases standard office tools are again mentioned frequently as tool support for this phase. As application-specific support for this process phase simulation software as well as development platforms (innovation in software) are mentioned. Furthermore, innovation specific tools are also used in this phase.

Non software

In Approach Development calculations are conducted frequently. Often there are standardized procedures which are put down on paper and do not change. Less often approaches are developed by using assessment tools and by attending conferences or discussions. Also, the internet and literature is used.

The ideal tool for Approach Development has…

The few ideas for the ideal software tool include a template and the use of databases. It allows transferring pictures, files, sounds and communication at the same time. Further, it is "realtime" and implemented on a processor platform.

Operationalisation

Software

Operationalisation is highly application dependent. Thus, the focus of the mentioned tools was on application specific software for developing system or product prototypes. In this group, software for simulation support and for systematic modelling is mentioned very frequently. In addition, tools for drawing and designing/modelling are also considered important for the operationalisation phase. With respect to information and knowledge technologies, the effective management of data of the developed product as well as of other important results of the operationalisation phase in a database are considered relevant in this phase. Finally, innovation specific software is also used in this phase of the innovation process.

Non software

Building prototypes and product testing happens very often during operationalisation which is accompanied by project management. Also, the success of the innovation is constantly monitored. Templates on paper, ranking methods, portfolios and financial ratios are in use. One researcher advertises for some diploma thesis to start research. Scale-up processes and simulation methods are conducted and patents are created. The most important results are collected in a database.

The ideal tool for Operationalisation has…

The ideal tool should support validation of production data and support the knowledge flow during this phase.

Evaluation

Software

In the evaluation phase, software that supports assessment, validation and testing plays an important role. Various simulation tools and tools that support testing are mentioned in addition to MS Office as basic task support. Furthermore, tools for data analysis like e.g. statistical programs are used. Evaluation is also understood as a collaborative process that requires communication and negotiation of results, which is supported by communication software (chat, email, video conferences). Finally, the phase is also supported by innovation specific software, where integrative, work flow oriented support of the entire process is highlighted.

Non software

Very often evaluation is conducted with customers or partners. Product specific tests or cross-checks with a list of given criteria are part of evaluation. The Stage-Gate-System with reoccurring evaluations is used.

The ideal tool for Evaluation has…

An ideal evaluation tool offers visual aids like graphics and tables and it supports decisions. The tool needs to be accessible easily over internet or intranet. Less often, standardised tools, evaluation templates like questionnaires and the possibility for annotations are asked for.

Exploitation

Software

Exploitation is strongly related to the customer of the innovation. Support for Customer-Relationship-Management is mentioned as software used in the exploitation phase. Assessment and evaluation of the exploitation is supported by software for cost/benefit analysis and for economic/financial analysis. Furthermore, the use of standardized technologies like XML and the use of standard software like SAP are considered crucial for effective exploitation.
Text processing software (MS Office, TeX) is used often for the creation of publication and other information artefacts like presentations as a dissemination activity (innovation exploitation in the scientific community). As an additional form of dissemination support, e-learning software is mentioned, and in general the internet as a channel for dissemination.

Non software

Publishing scientific publications and presenting at conferences is quite frequent. Applying for a patent is mentioned. Some industrial interviewees distribute their products to the market or customer directly or over license partners.

The ideal tool for Exploitation has…

The ideal tool includes a customer relationship management feature. The project management tool is linked directly to the production and supports automated decisions. There is need for high security since contractors use parts of the company data system.

4.5 Tools that facilitate innovation

Asking the participants about software tools that facilitate innovation in general 60 tools are named. These can be clustered into six groups:

- Communication and community support (17 answers);
- Management support tools (12 answers) include general project management and office tools as well as specific and innovation management support;
- Management of knowledge and information (11 answers), which enables intelligent information modelling and structuring as well as information and knowledge processing;
- Application specific tools (9 answers);
- Improved (Web) Application Technology and IT Infrastructures (8 answers);
- Prototyping and Distribution Support (3 answers).

Suggestions for the ideal tools which support the whole innovation process include more efficient search support, improved knowledge structuring, and personalization; tools should be easy to use and affordable. Less frequent is the wish for a flexible tool adjustable to different innovation contexts.

5. Conclusion and future work

This paper reported about a study about innovation and innovation support conducted in the context of the INNOVANET projects. We believe that the following results are the most interesting ones from the study.

The results about challenges and barriers during the innovation process indicate that lack of information (32 answers) is the biggest barrier to innovation. This is even more interesting since the lack of appropriate software is only mentioned four times. This raises the question if there is sufficient software in practice but the availability of relevant knowledge is not given or if the interviewees do not know about better software solutions to retrieve the knowledge needed.

The major motivation for innovation is for economic reason, especially for competitive advantages (57 answers). Due to the nature of innovation, this is not surprising. Surprising is that 21 personal motives were named and that five answers regard to socio-political reasons. Innovation is not only understood as a means for economic success. It also satisfies personal interests and needs.

In spite of some deviations, the study validates the Innovation Process Model IPM, since almost all phases of the individual innovation models can be mapped onto IPM phases. However, there are two types of activities, assembly of innovation team and market evaluation after exploitation, which can not be mapped and which will be discussed as possible extensions of our model.

The analysis of the tools employed in the innovation process shows a large number of different tools. The set of software tools used during innovation is a mix of both widely used tools in all phases and by many interviewees, and application specific tools which are only used in a certain phase and by single interviewees. Some tools are present in all phases: MS Office products, statistical programs, internet and databases. Besides these broadly used product types there are highly innovation phase dependent tools which are mainly used in Operationalisation and Evaluation.

Over all phases there were only few answers regarding the characteristics of the ideal tool. This may give the impression that the interviewees are content with the tools they are using. More likely, this fact comes from the very open nature of this question. In the very tight time frame of the interviews the interviewees could not take enough time to think about desirable features. A follow-up study needs to be considered to explore attractive characteristics in more details.

It is surprising to find so few software tools employed during Ideation. Concurrently, there is a large number of non software methods mentioned. The generation of ideas to solve the problem happens to a considerable amount without computer support.

There are phases in which the characteristic of the ideal tool includes features that are already mentioned in the question about the used software of this phase. This is because the qualitative data are aggregated and give an overall picture over the tools in use in many different institutes and industries. This aggregation may give the impression that the software in use covers most of the features needed in the innovation process. Again, we need to stress the point that this display is a summary. *The* ideal innovation software tool which integrates all the functions still is to be invented.

Out of the 60 tools that facilitate innovation, 29 tools are used to transfer, distribute and manage information and knowledge (communication tools and Management tools). Tools for applications, knowledge processing and prototyping and distribution support (31) are used almost equally often. This suggests that the handling of knowledge – management and transfer – is just as crucial for innovation as the production of data.

This survey provides a deep insight into the use of tools and methods during the innovation process. It will be used as the basis for an online-questionnaire, which focuses on knowledge management software tools. The results will give a strong indication on the use of knowledge management support and the characteristics of the ideal support. Next, the INNOVANET team will use the information gathered from both surveys to define the specifications an Innovation Engineering Environment (IEE), namely a software augmented environment in which systematic innovation is enabled and fostered. All this material will be used in the final phase of the project, namely the construction of a strategic roadmap, namely plan for filling the gap between current innovation environments and the IEE.

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