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INVOLVING USERS IN THE DEVELOPMENT OF EMBEDDED TECHNOLOGY IN CONSTRUCTION

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Based on a project about user driven innovation and embedded technology in construction (BIIB), the paper discusses methodological issues on user involvement. In the paper especially focus is on the experiences on involving users in collaborative development of scenarios, in the validation of scenarios and in developing innovative solutions on a conceptual level. The project discusses 1) concepts of users and 2) methods for collaborative involvement. The first discussion involves presentation of an extended user concept and a discussion of differences between lead users and need-advanced users. The second discussion on collaborative involvement, discuss experiences with methods for communication across cultural and professional competences with reference to boundary objects, tangible systems and visualization. In the project four segments of situations for use of embedded technology in construction is analysed: the building process, professional operation and maintaining of buildings, tenants in social housing - and occupants/owners in detached houses. In the article the different methods for involving users are compared across these types of users.

KEYWORDS: embedded technology, user driven innovation, need-advanced users, boundary objects, tangible systems

INTRODUCTION AND BACKGROUND

Several studies has pointed out that embedded technology in building materials might have beneficially results: in the building process itself and for operation, maintaining, the residents and end-users (ERABuild, 2006) (Storgaard et al., 2007). In spite of high benefits for introducing the technology in the building materials it is seen that the marked alone do not drive this innovative development. In the building sector the client is seen as an agent for innovation, because of the ability to demand specific innovative solutions. In the case of embedded technology this has been questioned at the least on the Danish scene (Storgaard & Forman, 2009).

As stated in the above mentioned reports and articles, developing new products based on embedded technology in building materials is a case of complex products. This complexity means that a process of developing such a setup of a system of product, only with difficulty, may develop on market conditions only (Storgaard & Forman, 2009).

In a project on User Driven Innovation and Embedded Technology in Construction (BIIB) several of the actors in such a process of development were brought together[1]. The BIIB-project was carried out by the Danish Building Research Institute (SBi), Confederation of Danish Industry, Building Materials and IT and 30 firms from the organisation; respectively building materials manufactures and IT developer companies. The results of the projects was to produce a digital *Concept Catalogue* based on user driven innovation methodology and a *Guideline/Handbook for User Driven Innovation*, supporting firms wanting to include user driven innovation activities in their work with product innovation (van Heet Erve Grunnet et al., 2008).

By including the firms from the building material sector and the IT/embedded technology sector in the process of the project itself, the project also had the potential to create an internal readiness for the new type of innovations in the firms – both concerning the type of products – and for user driven innovation. Also the project – bringing the issue into play – potentially might be able to contribute to the establishment of a readiness in the external world, including the marked.

Especially in the building material industry, the challenges for the participating firms were many. They had to participate in *collaborative innovation* with external firms from another sector/branch (the embedded technology branch), they had to learn about the new technology and the potentials for their specific future line of products; and they had to learn about how to cope with user driven innovation.

The challenges for the BIIB-project were hereby high on all three themes: To construct a method for developing complex products based on inter-firm collaboration. To generate the making of digital concepts based on a process of user driven innovation involving both users and firms. And to suggest methods for user driven innovation adaptable for firms in the building industry. These methods should have a high focus on tools supporting collaboration and knowledge sharing across boundaries between stakeholders differing in competences and background – e.g. between firms and users, between firms from different branches, and between persons and departments in the single firm.

Embedded Technology as Complex Products

In construction ICT has been discussed and analysed for many years, for example as the Intelligent House or the Smart House and real-life experiments with smart technology in buildings has been seen (Moltke et al., 1997) (Ambrose & Nielsen, 1997). As the technology has evolved through minimization and capacity expansion focus has been on embedded Technology. Here RFID-tags[2], micro-sensors (Sensortec, 2011) and Home Information Systems as CST[3] have been on the agenda.

As described in Storgaard & Forman (2009) the combination of local embedded technology and devices with information based on the Internet has widened up the perspectives for using embedded technology in buildings – and for the whole process of digitalisation in construction. Jaselskis et al. (1995) had already in the mid-nineties stated that the RFID technology was especially promising for the construction industry because it "*can be*

[1] The project, Brugerdreven Innovation og Indlejret teknologi i Byggeriet, BIIB, is financed by support from Governmental funds on User Driven Innovation.

[2] RFID (Radio Frequency Identification) (ERABuild, 2006: 14) (Bassi & Parand, 2002).

[3] CST systems are intelligent semiautomatic systems, which might be operated through the internet and mobile devices as the cellar phone. (Storgaard et al., 2007).

integrated into systems that can track materials, identify vehicles, and assist with cost controls" (Jaselskis et al., 1995). A position which was taken up in the ERABuild Organisation (European Research Area in BUILDing) as investigated in ERABuild, (2006). On the European scene several other initiatives has been taken to stimulate the innovative development in the construction sector based on a smarter use of ICT and embedded technology. In EU the ROADCON project provided inputs for the RP6, identifying key actors and preparing cooperation (Hannus et al., 2003). In 2005 the ECTP (European Construction Technology Platform) was formed to provide input to the RP7 and embedded and ambient technologies played a significant role in the recommendations[4].

To understand the process of innovation combining products from two sectors - the building industry and the ICT-sector - it may be fruitful to see the new products as complex products (Storgaard & Forman, 2009). In accordance with Gann & Salter (2000) the need for at collaborative innovation process between many actors and firms create conditions for innovation which are very different for innovation in the individual companies (Gann & Salter, 2000: 957). An important aspect of such new complex products of new mixed technologies is that the agents of the future, which would drive a demand in the marked, often will be completely missing when the innovation process may be started (up cit. p 959).

In the case with embedded technology in construction this explains why an innovative process of integrating embedded technology in building materials has not been seen. And it brings an understanding of which elements should be brought together if such a process should be seen. This may include stakeholders from the building material industry and technology firms, architecture, design and consultants, users on the building site, client, operation and maintenance, users of the building, and even from the regulative body, finance etc.. (Storgaard & Forman, 2009: 137).

In the BIIB-project it was the intention to set up a process of innovation, based on a process of collaboration between the actors. This process should hereby not only include the technology actors or the user, but include external stakeholders as well – both stakeholders which had a role to play in a new setting where new products has been developed – but also actors in the existing setting, where a change in role and functions may occur.

USER DRIVEN INNOVATION

In the Scandinavian countries there is a tradition for involving user in product innovation, especially in the ICT fields in "The Scandinavian Traditions for Participatory Design" (Wise & Høgenhaven, 2008). But also strong international firms as Danfoss (Heating systems) and Lego have involved user in their work for innovation in products (Bisgaard & Høgenhaven, 2010). In Denmark two programs for user driven innovation was established: A research program for Strategically Research (Forsknings- og Innovationsstyrelsen, 2006) and an Innovation Programme for User driven innovation (Erhvervs- og Byggestyrelsen, 2011). At the Nordic level Nordic Innovation Centre launched a programme for user driven innovation (Nordic Innovation Center, 2011). Central in all initiatives is the understanding that involving users in the work with new products, hidden knowledge may be discovered; e.g. knowledge about unacknowledged needs, ways of using and handle the products, context in which the user consume the product.

[4] PICT (Process and ICT) was Focus Area no 7 in ECTP (ECTP, 2011)

There are many different ways of involving users, which are all known as user driven innovation. What separates the different approaches is why the users are involved. Overall users are either involved to figure out WHAT to offer the users or HOW to produce it (Wise & Høgenhaven, 2008). Involving users to find out WHAT to offer them, will often happen in the beginning of the innovation process and it involves trying to understand both acknowledged and unacknowledged needs. Acknowledged needs means that the user has a clear understanding of which problems are experiences, while unacknowledged needs is when the user is not aware of what the problem is or cannot articulate it. Involving users to find out HOW to produce a product or service will happen later on in the innovation process, and therefore it involves explicit and acknowledged needs and it often is based on participatory design (Bisgaard & Høgenhaven, 2010).

In BIIB the primarily focussing has been on the WHAT to offer the users phases, while the phases regarding HOW to produce it is assigned to the firms from the building material sector and the IT/Embedded Technology sector.

AN EXTENDED CONCEPT OF USERS

Identifying the actors participating in user driven innovation the BIIB-project has involved four types: end-users – other stakeholders – developers – and the project team. Each part has an important function in developing innovative products. And each part has its own cultural and professional competences, agendas and interests. In the BIIB-project it was the intention to bring the actors together in a collaborative process. Therefore the need for tools for communication and knowledge sharing across these social settings was high.

From Lead users to Need Advanced User

Central in the understanding of how to work with users is the concept of lead users, originally lanced by von Hippel (1986) and von Hippel & Katz, (2002). For von Hippel, lead users were in front both concerning their needs and in finding solutions to those needs. Therefore involving lead users in defining needs and finding new solution to these was an important method for stimulate innovation on new product. Bisgaard & Høgenhaven (2010) take the involvement of lead user a step forward. They separate a group of lead users which work in a professional setting to innovate for and with the company in order to commercialise their products. These lead users they designate Advanced Users (Bisgaard & Høgenhaven, 2010). Storgaard & Forman has used the same designation, advanced users, for users which are in the forefront concerning needs, but often not concerning technological based solutions (Storgaard, 1998: 99) (Storgaard and Forman, 2009: 141). Here they often will be on front at a structural pattern; they possess the needs of tomorrow on a scale not immediately connected with technology. They may have demands to life – family, children, leisure time, working life, personal development etc, - that only difficultly can be solved in today's setting (Storgaard, 1993). One have to distinguish between Technological Advanced User - TAU - to designate the Bisgaard and Høgenhaven situation; and to use the designation of Need-Advanced Users - NAU - to designate the Storgaard et al. situation.

Selecting the Users

Often the end-user is defined as the actor, which at the end consumes a product. In construction one often identifies this as the user of the buildings – ex tenants (in homes) or employees in offices. But actually the whole value chain may be users of embedded technology enriched building materials. In BIIB four scenes and segments of end-users was selected:

1. In the building process: The men/women at the building site; workers and building managers
2. In building operation: The professional operators and services providers
3. In dwellings: Tenant and administrators
4. In detached houses: Tenants, which also is owners, operators and investors

These users was seen as end-users, which might benefit from the new type of building materials – but benefitting on different topics and needs. These end-users were not typical lead users in the traditional understanding of the concept. Most of them were not interested in the embedded technology at all; they were experts – not on technology, but on their own life and setting; in needs and contexts. In the BIIB interpretation they were NAUs.

Especially in the detached house segments some of the users did have a special interest in part of embedded technology (heat and ventilation) and in devices and ICT systems, and thereby being lead users. In one of the household the involved person might even be seen as a TAU. Also on the building site actors with a special focus on the technological was involved as well as actors with focus on supplementary technologies (digitalization in Construction ex BIM). On the building operation segment one of the involved persons was used to CST and thereby also might be seen a TAUs.

Thus the end-users involved in BIIB included especially need advances users/NAUs (all of them) and lead users including two TAUs (in the detached house segment).

Selecting other Stakeholders for Validation of Scenarios

The success of innovation is not only a case of needs meeting the right solution, based on collaboration between developers and users. A chain of external stakeholders do have significant importance, ex as part of legislation, insurance, finance, purchasing, designing, advice as described before. In BIIB such external stakeholders was invited to participate in validation of the scenarios, where context, needs and solutions was presented. In BIIB they had been represented by people from construction, organization for business and for unions, architecture and design, consultancy, assurance, building legislation, research, clients and FM operators. They participated in the Dialogue Meetings. Here scenarios were validated and concepts of new product based on embedded technology in building material were collaboratively developed.

The Developers

The firm participating in the projects was given the role as leading agents concerning technical themes on embedded technologies and building materials. On turn they were part of the teams which participated in the focus groups meeting. Their role was to be technical experts, to follow up on reactions from users and stakeholders, and to contribute to the collaborative development of concepts. At the strategically level the firms did have an interest in participating in the effort to stimulate an innovative development of intelligent products - when it first was started up. But how long would these collaborative activities go, when real innovative solutions were to be developed? In the BIIB-project this barrier of interfirm competition was planned to be encountered through a focus on developing concepts – and not final end-products competing in the market. Throughout the project another severe barrier developed, which could not be taken care of in the design of the project: the financial crisis. When the project was designed and started up, high conjuncture in the economy was the situation. But soon after the start-up of the BIIB project, the international economic crisis ran over the western economies and a rapid decreasing marked for the building sector, including the building material market, was soon seen. Immediately the crisis diminished the

resources for innovation in the firms – but at the same time it increased the need for innovation. For the BIIB-project it had the consequences that most firms had to economize with the resources they could put in the involvement and some firms even had to leave the project because of insolvency.

The Project Team

The project Team included staff from the organizations behind the consortium – that is from the two branches of the Confederation of Danish Industry (DI Building Materials, DI ITEK) and for the research institution (SBi, Danish Building Research Institute, Aalborg Universities). Their task were to manage the project (the two branch organizations), to investigate, research, evaluate, documentation and report (the research institution). And the Project Team had to facilitate the meeting between end-users, stakeholders and developers, and to participate in the collaborative process of innovation of concepts. As a research project it was action research. As an innovation project it was a collaborative project across the borders at least on three different dimensions: 1) Between users, other stakeholders and firms, 2) between (in principle) competing firms, and 3) between agents from the commercial sector and from research. In these ways the project team was standing before challenging tasks – across boundaries.

METHODS TO STIMULATE PARTICIPATION AND COLLABORATION

The main methods for setting the frames for collaborative process between users, stakeholders, developers and the project team in BIIB were "focus groups" and "dialogue meetings".

Focus groups meetings were used to analyse and understand the need of the users, the context and to give room for possible solutions. It was a meeting between users, developers and the project team. Data and information was gained through help-tools such as "pre-meetings", "interviews", "walk through" and "photo safaris". The results was analysed and formulated in scenarios illustrating context, user, needs and solutions.

Dialogue meeting was used to validate the scenarios and to start up the process of developing concepts of new embedded building materials. In the meetings users, an extended group of stakeholders, developers and the project team participated.

Boundary objects and tangible systems

In a process of exploring a design of needs and solutions based on collaboration between agents with differences in social context, competences and interests (the firms are competitors), there was a need for methods which supported the process of communication and knowledge sharing across these cultural boundaries, competences and interests. Besides, the methods should also support the understanding of future yet not existing solutions seen in a pattern of needs which at the time only may to be found in the form of "germs and seed". A dialogue and sharing of knowledge, assessments and beliefs may easily become very abstract and difficult to make explicit – being on edge of a future which only are at a state where it might be going to be made realized.

Boundary objects was used by Star & Griesemer (1989) to describe objects which were suited for translation between different social settings. The objects had structures which allowed the different segments to recognize the topic. And it was so weak that it allowed different meanings between the segments. Later on Carlile defined it as question on a syntaxial, a

semantical and a pragmatical approach (Carlile, 2002). Adding the pragmatical dimension Carlile emphasized that knowledge was localized around, embedded and invested in problems in practice. As such only boundary objects, which facilitated a process where individuals voluntary and jointly transform their knowledge between segments, would be effective. In his study of knowledge sharing in the industry Carlile analyzed how knowledge is structured differently within the four primary functions in a firm (sales/marketing, design engineering, manufacturing engineering, production) and how it is communicated and shared across these boundaries. Based on the study he describes knowledge as localized, embedded, and invested in specific practices (with reference to (Bourdieu, 1977) (Lave, 1988)) and he sums up that a boundary objects should support the establishment of a common a shared syntax, create a semantic which provides a concrete means for individuals to specify and learn about their differences and dependencies across a given boundary (Carlile, 2002: 451). And it shall facilitate a process where individuals can jointly transform their knowledge (up cit p. 452). In his case study especially CAD drawing functioned as an effective boundary object. But boundary objects are *no magic bullet*, as he expressed it. Problems and humans do vary. "A CAD can be effective communication tool in one meeting, then a bludgeoning tool in the next" as he cites one of his case study persons for. (up cit 452).

In the Danish construction sector the partnering process was analyzed with a special focus of knowledge sharing between Communities of Practices (Koch & Thuesen, 2009). For them the success of knowledge sharing is the redundancy in information mediated through boundary objects and actors/brokers. They mention that boundary objects in the process may be tangible or nontangible. Drawings have a special tradition in the construction communities of practices as one of the most used type of boundary object.

In Software Engineering, especially in HCI (Human Computer Interaction) and in design, tangible user interfaces and tangibility has become an important issue (Hornecker, 2005) (Brandt, 2005), (Walenstein, 2003). "Things to think with" (Brandt, 2005) and the growing experience how this tangibility did help the design processes between different agents in a collaborative process in learning, sharing and designing has been widely recognized (Hornecker, 2005). But why these tools really do work, only little research based knowledge exists. There is still a lack of theory about why tangible interactions work so well (Dourish, 2001, from Hornecker, 2005).

An understanding of this strength of tangible systems and grounded object may be seen in Storgaard (2005) explaining the strength of visualization in collaborative knowledge sharing by the Nonaka (1995) – Takeuchi SECI model approach, embracing the effect of the visual element in sharing and learning both tacit and explicit knowledge (Storgaard, 2005: 285) (Nonaka and Takeuchi, 1995).

EXPERINCES FROM THE METHODS USED IN BIIB

Focus Groups Meetings

To collect data about the four segments of situations for use of embedded technology in construction in order to find out WHAT the firms should offer them, the method "focus group meetings" were used. The traditional focus group meeting, where one get different stakeholders together and ask their opinion about a certain topic, was combined with ethnographical methods such as "interviews", "walk through" and "photo safari" (Erhvervs- og Byggestyrelsen 2, 2010). Focus group meetings were used to get an understanding of the end-users and the context in which needs existed in and where solution and potentially new

products were to be used. In BIIB the focus group meetings were conducted as a facilitated workshop, where the end-users met the developers and the project team. The meeting took place at the end-users own territory (home, work space etc.). In all cases except the case with detached houses there were pre-meeting with key-persons from the user group before the focus group meeting itself, and a follow up post-interview afterwards.

Pre-Knowledge and Readiness

Pre-meetings were conducted with selected key-persons with formal/informal administrative responsibility in order to create readiness and pre-knowledge for all involved. It prepared the administrators about what was going to happen at the focus group meeting and it gave the project team pre-knowledge about the setting. For the user part it minimized the uncertainty about the topic, the methods and what was going to happen. For the project team it showed up to be of even importance, by giving it hands-on knowledge about how to organize and facilitate the specific focus group meeting according to organizational, social and personal aspects.

Individual Type of Users and Developers Setting the Demand for Facilitating

In BIIB it was experienced that the facilitation and the organization of the focus meetings highly depended on the types of end-users and stakeholders who participated. It was our experience that end-users preferable should be need-advanced users, who were experts within their own field being the home or the work space. At the individual level they should be open towards letting strangers into their private sphere, to participate in a dialogue in a public domain and to express themselves and their views. Tenants in social housing for example were innovative and inventive in a different way than high-end occupants in detached houses, who were much more self-expressive and full of ideas. The reason for this could be that the high-end occupants besides being Need Advances Users, also was lead-users with technical expertise. The developers participating in the focus meetings were technical experts from both the building material firms and IT firms. They provided inside knowledge to the end-users about what was actually possible and they made follow-up questions on the need and use. The developers not only represented their own special niche production, but in principle the entire branch.

Generally the BIIB-project showed the importance of a solid and robust script for the meeting and a facilitation which were responsive to not only to the stipulated tasks, but also to the individuals participating. An important function of the facilitators turned up to be the ability *to play ball* between the different actors, and get them all involved. Thereby it was not necessarily negative to have different personalities (e.g. introvert and extrovert) present, since they all contributed with different aspects. Sometimes it even emphasized the group dynamic since different personalities could supplement each other better.

Post-interview to get clarification was used when needed. This meant that iterations during the data collection phase often were seen.

Focus Group Meeting as an Effective Low Cost Method

Based on our experiences it can be concluded that focus groups meetings were a simple method to obtain a good understanding of the context, functionality, needs, and possibilities. With the right competencies, the project team could acquire a fair amount of knowledge about the context and functionality with a very small effort. A skilled project team with hands on knowledge about their customers and the users – as many small firm developers often possess - do not require a lot of investigation and documentation to identify new needs and possibilities. Therefore focus group meeting may be an effective low cost method in many

situations. But if the scene is new or if one wants to investigate all corners and hidden spots of use and need, more resources are needed.

Having prior knowledge about the field which is being investigated, may both be considered a strength or a weakness. It may be a strength since it made it easier to understand the interplay between context, needs and new solutions. But at the same time it may weaken the ability to be objective and identify domesticated and hidden aspects because of selective perception.

Dialogue Meetings

In order to validate the data collected at the focus group meetings and to generate new ideas and concept, BIIB held dialogue meetings where end-users, who participated in the focus group meetings, developers and stakeholder from the entire value chain, participated. The dialogue meeting lasted 1-1½ days, and consisted of different presentations and exercises such as scenario assessment and design games. The presentations dealt with subjects relevant to the topic of the dialogue meeting and served the purpose of providing knowledge to the participants so that they all had a foundation to participate in the different exercises.

Room for Collaboration, Competitive Games and Refreshments

The setting should stimulate active participation; it should be fun to participate but the subject knowledge should not be undermined. The fun factor was stimulated by dividing the participants into groups, competing against each other in order to win a small award. This was well received by the participants who took on the different task with great enthusiasm. Another way to stimulate the participant was to nurse them with refreshments, breaks and reshuffles (change in group formation, table/room layout etc.).

Need for Customization of the Meetings

Every dialogue meeting had to be customised to the segment of participants and the purpose of the meeting. As an example the size of the groups during the exercises depended of the purpose. It was our experience in BIIB that larger groups work well for brainstorming and validation on a broad scale, while smaller groups were better at clarification and specific conceptualisation. However, this was just a thesis since it has not been explored in regards to other topics. It worked well when the project team and the facilitator played active roles during the exercises and participated along with the other participants. This was a more indirect way to facilitate, but it was our experience that it stimulated to a better dialogue and made the exercise less scary and more approachable to the participants.

Setting the Stage for Dialogue by Using Visualized Scenarios

One of the help-tools used at the dialogue meeting in order to validate the needs, and possibilities identified at the focus group meetings was scenarios, functioning as boundary objects. Scenarios are a fictive description of a likely / the most likely future scenarios and the consequences they might have to the users (Erhvervs- og Byggestyrelsen 2, 2010). The scenarios described the identified needs in a social context and suggestions as of how to fulfil the needs. The scenarios were validated by the participating firms and other users from the extended value chain at dialogue meetings. Dialogue meetings was/ the framework in order to create dialogue, inter-firm collaboration and readiness in both the internal and external world. The dialogue meetings was/ also used to generate concept ideas and for conceptualisation. The main method for doing so was design games. A design game is a creative brainstorming game customised to the specific users in order to involve them in developing new ideas that solves the identified needs and wishes (Horgen et al., 1999).

Since visualization was a key aspect in BIIB, the scenarios was presented on posters illustrating a roll of film showing selected scenes and an appurtenant text. The scenarios were posted on the walls in the beginning of the meeting to draw attention and set the stage, and during the assessment, the scenarios were put on the table in front of the participants, so that they could draw on it or put post-its on it, following the assessment step by step. During the assessment the participants were asked to validate the needs, solutions, users and implementation. This sometimes brought forward new needs or adjustments to other needs, and therefore there were some overlap / iteration with the previous phase of collecting data.

Experiences from BIIB showed that the visualized scenarios were crucial in order for different participants with very different background to understand context, needs and solutions. In other words the scenarios succeeded in the function as boundary objects. Both the pictures and the text were a good way to get the participants to understand e.g. a complex technology and other things that might be difficult to describe and understand. By making the visualized scenarios the participants did not only get a better understanding of the technologies and needs; they also got an impression of the realism since the scenarios took place in a specific context. The visualized scenarios provided the different participant with the same qualifications and understanding, which allowed them to enter into a constructive dialogue and collaboration on concepts, which actually broad new aspect forward.

Developing Complex Products by Using Design Games

Design games are a help-tool to concretise abstractions, ideas and concepts. The games functioned as boundary objects with a tangible element – cards to be drawn, post-its to be written and placed. By giving the participants different task, which were related to the chosen subject (e.g. the building process), one set the framework for collaborative innovation. The tasks varied depending on the subject and the purpose, but some examples of tasks were to define problems in a given context, to develop new concepts based on identified needs, to redesign existing products and to sketch new products, based on new identified needs, to explore the effort needed in order to implement new concepts etc.

Experiences from BIIB showed that design games created dialogue and got the participants to collaborate. Just as with the focus group meetings it was in the best favor if the participants functioned as extroverts, optimistic, visionary and open. The participants should both be experts of their everyday- and work life, and representative of their own professional competencies / profile. However, the whole setup of the design game combined with a skilled facilitator forced all participants to participate actively; they could not withhold passively. However, for some participants (e.g. need-advanced users) it could be hard to come up with new ideas, but our experiences showed that their input in form of comments about functionality and context could trick others to get inspired. The interaction between different stakeholders from the entire value was highly valuable.

CONCLUSIONS

The methods used suited their purpose well.

Table 1 summarises what was learned about the different methods used, and what others should be aware of in regards to different types of actors if they were to use the methods.

The scenarios were based on the results from the explorative dialogue in focus group meeting between users, developers and project team. Here were used illustrated cards and plates as methods to supplements the interview themes as means for enforcing knowledge sharing and

Table 1: Summary of experiences about different types of actors in regards to different methods

Methods/Actor Type	End-users	Other Stakeholders	Developers	Project Team
Pre-Meetings	Matches of expectations Creates reciprocal, readiness and pre-knowledge			Knowledge to organize and facilitate focus group meetings Matches of expectations Creates and reciprocal, readiness
Focus Group Meetings	Preferable need-need-advanced users Letting strangers into private sphere Express themselves publicly Expose life, needs, problems etc.	No participation	Technical experts Represent the entire industry Should be open and curios Opportunity to see own products in use	Facilitate the meeting Created peace of mind and confidence for the participants Actively involve all participant Prior knowledge about the context is both strength and weakness
Post-interview				Opportunity to ask follow-up questions
Dialogue Meetings	Foundation for participation is given through presentations Participation of selected end-users, and stakeholders from the entire value chain		Provides them with an opportunity to learn about context and functionality, and to generate new ideas and concepts Need tangible ideas and concepts in order to justify participation	Location and setting is key Meeting should be customized to the segment of participants Good with indirect facilitation to hide facilitator role
Scenarios	Visualization made it easier to understand context, needs and solutions Visualization provided everyone with the same qualifications and understanding			Visualization is key to create dialogue
Design Games	Participants should preferably be both be experts of everyday- and work life, and representative of own professional competencies / profile Interaction between end-users, different stakeholders from the entire value and developers is valuable			A skilled facilitator should encourage all participants to participate actively

collaboration. The methods worked well and gave a fine platform for constructing the scenarios. At the dialogue meetings scenarios was used to support the understanding of social context, needs and solutions and knowledge sharing between users, developers, other stakeholders and the project team. The visualized scenarios functioned as boundary objects and were crucial in order for different participants with very different background to understand context, needs and solutions.

Design games were used in the collaborative process of *developing concepts* for the new products which took place at the dialogue meetings. They functioned as a help-tool to concretise abstractions, ideas and concepts. The games may be seen as boundary objects with a tangible element – cards to be drawn, post-its to be written and placed. The collaborative process succeeded in getting the active participation across disciplinary and cultural boundaries.

Illustrated cards, scenarios and design games as well as the post-its and the table and wall sheets may be seen as boundary objects with an element of tangible systems concerning the hands-on situation which was partly established in the design game situation as well as in the use of post its. In BIIB the experience was that these combinations of boundary objects and tangibility worked well to establish knowledge sharing across the social and disciplinary boundaries. But these methods do not work alone. Facilitation still becomes an important issue. Responsiveness, improvisation and the grasp on situations and individuality are by no means not important when using these methods. But a good script and the use of tangible objects is an important step.

In BIIB it was found that the end-users actually were active and willing to expose themselves, their lives, and needs at the focus group meetings. The project identified different aspects of their life, and the interplay between interview, dialogue and actual showing of the context worked well. The other stakeholders did not participate in the focus group meeting, but participated actively in the dialogue meetings in order to validate scenarios and to generate ideas and concept.

The participating developers were in a very difficult situation because of the financial crisis. This meant that the participating firms had fewer resources to invest in the project than expected. It was found that it was very important for the developers to get tangible ideas and concepts to bring home to their companies since it justified their participation in the dialogue meeting. Despite the economic crises which intensified competition between firms and augmented the need for innovation, it is the conclusion that most firms welcomed and continued the collaborative process perhaps because of potential for branding, for getting new inspiration, learning about the new technology, learning about user involvement, or getting possibilities for match-making with other firms. Already half a year before ending the project at least one product was demonstrated, and 6 firms had participated in commercial match-making activities on new embedded products facilitated by the BIIB project.

The project team got a more active role than expected since they were both facilitators and participants in the collaborative innovation process. The facilitator role was of great importance since it, in interlay with the tools of boundary objects and tangible systems activated the participants. A good and robust script is important. But facilitation must be responsive not only to the topic, but in a high degree to the type of participant on an individual level.

One of the main purposes of BIIB was the process itself, since one of the goals was to suggest methods for user driven innovation adaptable for firms in the building industry. The main methods used could be scaled to fit the participating firms in building materials manufacturer and in IT developer companies. The project recommend companies to try these methods, because it was experienced that these methods were actually capable of stimulation knowledge sharing between users and developers, inter-firm collaboration, and dialogue between different stakeholders across professional, personal, and cultural differences.

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