Activities to Address Challenges in Digital Innovation

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Abstract. Based on a literature review, this paper identifies four socio-technical challenges relating to innovation actor's interactions in digital innovation. Furthermore, the paper explores how these challenges can be addressed. The challenges are investigated in a case study of digital innovation. The study is based on a two year long research and development project where an e-newspaper concept and a demonstrator based on e-paper technology was developed. Based on empirical findings, the paper presents eight activities which address the identified socio-technical challenges with digital innovation. The activities are: 1) support transparent digital ecosystem relationships, 2) facilitate cross-organizational communication, 3) create digital value blueprints, 4) translate heterogeneous knowledge, 5) involve all relevant user groups, 6) identify, design for, and authenticate digital user values, 7) design for multiple contexts of use, and 8) prototype iteratively.

Keywords: digital innovation challenges, innovation activities, digital technology, e-newspaper, e-paper.

1 Introduction

Digitization of analogue products is currently changing our society [1, 2]. As an example, digital services based on digitization of music, TV, and voice calls have led to digital innovations such as Spotify, Netflix, and Skype. These services are widely adopted and have changed the ways users consume media and communicate via voice over IP. Digitization in this case creates value adding services for consumers who can use these digital services on multiple devices anytime and anywhere. However, digital innovation is not only providing added value to consumers. The mentioned digital innovations are also examples of how digitization creates new markets and rearranges device manufactures and content provider's roles in digital ecosystems. As such, digital innovation has a high impact on firms and entire industries. In the mentioned examples, there have been rapid and profound changes in the music and broadcasting industry, as well as for phone operators.

Digital innovation as a notion refers to the embedding of digital computer and communication technology into a traditionally non-digital product [3]. The notion also refers to the process of creating new combinations of digital and physical components that produce novel products or services [4]. Digital innovation is based on digital technology. Digital technology can be categorized by layers consisting of devices, networks, services and content [4]. As different layers of digital technology

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requires different competencies, knowledge, and resources, innovation actors often need to either setup or join innovation networks to be able to succeed with digital innovation [5, 6, 7]. Given the characteristics of digital technology, digital innovation becomes networked and complex with a need for involving heterogeneous actors and resources [1, 8]. The layered modular characteristic, and the generativity of digital technology, pose two specific challenges for digital innovation. Firstly, it requires actors to cooperate over organizational boundaries and demands knowledge exchanges between actors with different backgrounds, competences and knowledge. In other words, digital innovations require multiple actors with knowledge and resources in the different layers of the technology to cooperate [1, 9, 10]. Secondly, the generativity of the digital technology creates large and varied audiences with heterogeneous requirements on digital innovations [1, 11, 12]. The combination of this added complexity, heterogeneity, and networked features of digital innovation, are challenging how we innovate successful digital technology [1, 13, 14].

The mentioned challenges primarily relate to the interaction, i.e. the relationships and exchanges between actors in innovation networks working with digital innovation. Several calls for research on socio-technical challenges in digital innovation can be found [see e.g. 1, 8, 15]. Much of prior research within digital innovation has been dominated by a conceptual nature [see e.g. 4, 13, 14]. There are few examples of empirical research on how digital innovation plays out in practice [1]. This paper aims to address these calls for research, by firstly investigating the specific challenges relating to actor's interactions in digital innovation, and secondly, by empirically investigating activities to address these challenges. The paper is therefore structured around the following research question: *What are the challenges with actors' interactions in digital innovation, and how can these be addressed?* By identifying challenges with digital innovation in related literature, and presenting suggestions of activities to address these based on empirical findings, this paper primarily contributes with actionable insights to the emerging field of digital innovation.

In this paper, an example of digital innovation from the newspaper industry is used to investigate how these challenges can be addressed. E-paper technology captured the interest of the newspaper industry through revealing the possibility of a newspaper service via an e-paper device with high readability and low power consumption. The digitization of the newspaper presented several opportunities for the industry to reach new markets, and cut production and distribution costs. However, newspapers needed to team up with other actors to be able to explore the digital innovation at hand. The case of the e-newspaper, a newspaper service specifically designed for an e-paper device, illustrates the challenges with heterogeneous actors interacting in an innovation network. Several previously unconnected actors such as newspaper organizations, network providers, software companies, hardware device manufacturers, and advertising companies, had to intertwine their perspectives, business models and technological frames to realize the e-newspaper concept.

2 Related Literature

Digital innovations as artifacts are based on layered digital technology which can be divided into four different layers: device layer, network layer, service layer, and content layer [4]. These layers lay the foundation for two important separations: the

separation between service and device due to re-programmability, and the separation between content and network due to homogenization of data [4]. Designers can combine components from different layers to create new digital innovations due to standardized interfaces. In every layer there has been an emergence of technical and practical capabilities for using that layer on a nonproprietary model that would make access easier, cheaper, and less controllable by any single actor [16]. One effect for digital innovation as a process is that when more actors have access, they also need to collaborate in order to be able to develop digital innovations spanning across all four layers.

Layered digital technology is an example of a modular industry structure that enables independent firms to introduce innovations into established markets. Furthermore, the modularity allows the best players in each of the layers to be involved and innovate, due to users wanting innovations that mix and match components from the different layers [17]. Hence, digital innovation built on layered digital technology often requires different actors from different fields to cooperate in innovation networks. This knowledge heterogeneity is challenging digital innovation [10]. Digital technology is also described to have a generative characteristic [1, 4].

Digital technology becomes more and more malleable and dynamic. This generativity enables new functionality and capabilities which can be added after a product is out on the market [1, 4, 11]. This can once again be exemplified with smart phones acting as platforms for apps or the PC as a powerful adaptable machine. Apps turn smart phones and PCs into adaptable and changeable digital tools, supporting large and varied target groups and many different aspects of use. Digital innovation targeted against everyday use also leads to a change in the view of the user. The notion of a user needs to be expanded beyond users as organizational members [18]. With today's digitalization, users do not solely use computing capabilities for work or organizational purposes, but they also interact with computing technologies in much broader social contexts [2]. As a result, user needs and requirements are often highly heterogeneous in these contexts of use [2, 12, 18].

Concurring with the ideas of heterogeneous digital technology and users, there is a growing acknowledgment that digital innovation is a collective achievement by many actors and stakeholders, often with different meanings and conflicting interests [5, 6]. As digital innovation becomes more networked, it drives a need for collaboration which spans over organizational realms [4]. During the last two decades there has been a shift in how innovation networks are formed and viewed by organizations. This is especially evident within technology development fields such as digital innovation [9].

Digital innovations that are created and driven by increased heterogeneity of knowledge are redefining services and products. Digital innovation is re-organizing industries, generating new business logics, and changing business models [19]. Within fields of rapid technological development, such as digital innovation, there is a great diversity of actors. In the innovation networks formed around digital innovation, firms and universities are critical features to enable innovation capacity. One enabler of this capacity is knowledge dispersion between heterogeneous actors [20, 9]. Innovation networks provide access to diverse sources of capabilities and information, and the interaction between the actors increases the innovativeness at the individual firms. Successful interorganizational relationships therefore fuel firm innovation and growth [9].

Innovating in a network can be viewed as a Socio-technical process [13]. Innovation is a social given that, "obtaining, transforming and sharing knowledge is a negotiation and sense-making process, through which an actor's identity and relationships to others are negotiated and re-defined" [19, p. 10]. Innovation processes within heterogeneous networks that involve multiple actors are complex. The complexity becomes even more evident whilst working with digitization of products and services [19]. Even so, the strategy to involve several actors in an innovation network is based on the possibilities of resource sharing and therefor, also sharing the risks. This is especially evident in fields of technological uncertainty [9]. Social aspects, such as trust, commitment and power, needs to be facilitated in heterogeneous innovation networks as they influence the relationships between actors in innovation networks [21]. Table 1 presents a summary which highlights how characteristics of digital technology challenge socio-technical aspects of digital innovation according to related literature.

Table 1. Socio-technical challenges with digital innovation

Challenge	Description	Reference
1. Modular co-operation	Modular layers of digital technology enable digital innovation. Different layers require actors with diverse knowledge bases to co-operate in innovation networks. As a result, digital innovation processes become complex and networked.	2, 4, 5, 6, 16, 17
1.1 Knowledge exchanges	Knowledge between heterogeneous actors needs to be dispersed to enable innovation capacity. The translation and exchange of knowledge between heterogeneous actors is challenging.	9, 10, 19, 20
2. Diverse consumer groups	Generativity of digital technology enables adaptability of a digital innovation after it is implemented. This generativity leads to large, diverse, and uncoordinated user groups and markets.	1, 2, 4, 11
2.1 Heterogeneous user requirements	Large, diverse, and uncoordinated audiences of digital innovations lead to multiple use contexts and heterogeneous user requirements.	2, 12, 18

3 Research Approach

To enable the exploration of the research question a multi-method approach was chosen [22, 23]. Exploratory studies are appropriate in new fields of study where little is known about a phenomenon [24]. The use of multiple research methods is especially suitable in exploratory and explanatory studies where there is limited or crude know-

ledge [25]. Furthermore, a multi-method approach has the possibility to provide a wide and complete understanding of a phenomenon studied. As different research methods focus on different aspects, combining multiple methods provides a possibility for a richer understanding of a research topic [23]. A case study approach was selected in which a digital innovation case was studied from the perspective of challenges and activities that addressed them.

This paper is built on a two-step process. First, it summarizes socio-technical challenges in digital innovation based on a review of related literature. Secondly, it investigates a case of digital innovation to identify activities which addressed the challenges. A two year research and development project called DigiNews [ITEA 03015] was chosen. The project was active between 2004 and 2006 and included partners from Belgium, Spain, Netherlands, France and Sweden. Data concerning the project was also gathered in 2008 and 2010. The research and development consortium formed in the project consisted of several major technology firms, media houses and universities. The DigiNews project aimed at defining, architecting and demonstrating a solution for a digital newspaper (i.e. the e-newspaper). The solution included all parts needed to produce, distribute and consume digital news, i.e. all steps from publisher to reader. The project also explored ways to maximize the chances of a successful introduction to the market; this included the creation of different business plans and strategies. In this paper the project partners in DigiNews are viewed as actors in an innovation network formed around the e-newspaper.

Even though the data was not collected specifically with the intention to identify activities which addressed challenges within digital innovation, the DigiNews project was deemed suitable to do a retrospective analysis of a case of digital innovation. DigiNews was selected for this purpose due to a) the e-newspaper being an example of a digital innovation as it concerns the embedding of digital computer and communication technology into a traditionally non-digital product, and b) DigiNews enables an analysis of the process of creating new combinations of digital and physical components that produce novel products or services.

The actors involved in the innovation network are coming from several different organizations and industries incorporating a highly heterogeneous knowledge base in the network. Also, the technology used to create the e-newspaper is a valid example of layered digital technology which incorporates components on all four layers with different actors engaging in each of the layers. Also, the consumers of an e-newspaper are an example of a large, varied, and uncoordinated audience. Readers, advertisers, and newspaper staff provide a good example of heterogeneous users of digital innovation. Finally, the e-newspaper case is a contemporary and interesting example of a traditional industry in need of finding new digital innovations in order to have the ability to compete with new actors on the market, such as e.g. Google.

The data collection conducted in DigiNews is based on three different sets of data which are primarily generated from design and business model studies (see Table 2). The data from the first set concerning needs and requirements was gathered from eight workshops and ten focus group meetings. To ensure the involvement of the users and to receive the publishers domain knowledge, three different focus groups were initiated; one with users, one with advertisers, and one with newspaper design-

ers. In the focus group sessions, concepts and prototypes of the e-newspaper were developed and evaluated iteratively.

The second data set was initiated with prototype testing during the autumn of 2005. The prototype test was designed to test different design solutions as well as to investigate user attitudes towards the e-newspaper concept. Data set 2 concluded with a real life test of the e-newspaper. Ten families were involved who tested an early version of an e-newspaper, published on an actual e-paper device (in this case the iRex iLiad) during a two week period in autumn of 2006. The real life test was designed to specifically explore pros and cons with an early version of an e-newspaper, as well as the users' preferences and intentions to adopt.

The final set of data involves seven interviews with eight respondents. The interviewees represented five newspaper actors, and two technology actors in the project. The interviews, ranging between approximately 30 and 160 minutes, were recorded and later transcribed. The interviews were built around themes such as background, learning outcomes, value networks, business models, technical and design aspects of the e-newspaper, internet and other media channels, and the influence of different technologies on the organization and management. This data set also contained documentation which mirrored the whole DigiNews project. The documentation includes project meeting minutes, agendas, preliminary and final reports, and deliverables from the project. The data also consisted of the project application, as well as some external technical reports.

Table 2. Overview of data collection

	Data collection	**No. of respondents**	**Type of data**
Data set 1	*Needs and requirements*	54	8 future workshops and 10 focus group meetings
Data set 2	*Prototype testing*	36	Observation, interview, questionnaire
	Real life evaluation	12	Online diary, questionnaires, interviews
Data set 3	*Interviews*	8	Interviews with newspaper and technology actors
	Documentation	-	Reports, agendas, minutes from meetings

In this paper, data from all datasets are used to enable a retrospective analysis based on the summary of socio-technical challenges with digital innovation. However, it is primarily the interview data from dataset two and three and the documentation from dataset three, that are used to provide the foundation for the empirical case.

The transcribed interview data, as well as the documentation was analyzed as follows. A coding technique [26] was used to thematically categorize the data based on the four identified socio-technical challenges with digital innovation. In order to categorize the data, patterns were sought after and identified in the data [26]. Excerpts in the transcribed material, as well as in the documentation, were marked with assigned colors. This facilitated data categorization according to the corresponding themes. These themes were then summarized and used in the paper to illuminate empirical aspects of the four socio-technical challenges.

4 The Case of the E-Newspaper

In late 2003, an innovation network was formed in relation to a research and development project called DigiNews. At the core of the project was the e-paper technology, a new display technology with promising features.

The main advantage with e-paper technology was that it could provide users with the same reading experience as traditional paper. Compared to traditional displays such as LCD and LED displays, e-paper has a reflective display technology without back light. Most e-paper technologies have a high resolution that is comparable with the resolution used in traditional newspapers. Compared to traditional displays it was also very power efficient, as power is only required when updating the display. All in all, e-paper technology was (and still is) a promising technology for industries such as newspapers or book publishers.

Based on e-paper technology, the e-newspaper concept was a possible digital innovation that could address some of the problems the newspaper industry was facing. At the time, newspapers were forced to think in new ways as most of them faced declining subscription and advertising revenues. The e-newspaper concept included two parts: the e-paper device and the e-newspaper as a service, e.g. the content published on the device. The e-newspaper supported mobility in the sense of allowing updated news anytime and anywhere, and could be seen as a digital news service published on an e-paper device. A wide diffusion of this digital innovation would dramatically reduce production and distribution costs. Therefore, the e-newspaper was an interesting prospect for the newspaper industry. Moreover, there was a belief that the e-newspaper could reach new audiences, e.g. young people. The challenge for a successful launch lied within finding enough additional value for the users to choose an e-newspaper before a printed one. Another challenge with the e-newspaper innovation was that a successful launch concerned both the adoption of a device, the e-paper device, and new services [27].

The innovation network initially formed around DigiNews consisted of 24 actors from nine European countries representing industry, SME, research labs, and academia. The five industry actors initially involved included Philips Applied Technologies, who was responsible for developing the e-paper technology. A technology based on E-ink, one of the dominant designs of e-paper technology available. Within this group of actors several newspapers were either indirectly (via The Swedish Newspaper Publishers' Association) or directly involved. Furthermore, a large R&D unit from

the British Broadcasting Corporation (BBC) was involved. The 12 SMEs that were initially involved included actors developing supporting technologies for the e-newspaper such as text-to-speak, cryptographic communication, secure and mobile payment solutions, wireless communication, display and device developers, audio and video streaming and decoding, and mobile applications. Seven academic or research lab actors were initially involved with expertise ranging from publishing systems, network communication, software and hardware development, collaborative design, interaction design, usability studies, and field studies.

Worth noting is that two perspectives were used when designing the e-newspaper concept. One perspective was more futuristic and disregarded some technical restrictions. The other perspective was used for the design of the demonstrator used in the final evaluations of the e-newspaper. Both perspectives focused on the potential of e-paper technology. However, as this technology was not fully developed when the project was initiated, there was a technological uncertainty regarding the potential of e-paper. To make a distinction between the two perspectives in the case description, the "e-newspaper concept" and the "e-newspaper demonstrator" is used when applicable. If only the "e-newspaper" is referred to, the text is including both perspectives.

4.1 Modular Cooperation

The e-newspaper, based on layered digital technology, exemplifies the need to involve multiple actors to enable this particular digital innovation. Newspapers had to be involved in the content layer to produce news and stories. Also, advertisers had to be involved in this layer. Research labs, newspapers, and SMEs had to be involved in the service layer of the e-newspaper. A multitude of services were involved in the e-newspaper, ranging from secure and mobile payment solutions to location based systems and text to speak. In the e-newspaper, the device layer consisted of the e-paper device. This device included a display of e-paper and communication interfaces to distribute content to the device. Furthermore, it had memory capabilities to store content. Finally, several actors had to be involved in the network layer, both from academia and research labs as well as SMEs to investigate suitable future communication networks to be used. The e-newspaper concept was initially planned to be distributed via different media with different characteristics.

The actors came from four different levels; industry, SME, research labs, and academia. Within every level there were quite different interests, goals, perspectives, and knowledge bases that meshed up in the innovation network. For example, the interests of the research labs differed somewhat from the academic partners who had a more open agenda to what was possible to focus on in the project. There were similar differences in interests and goals when comparing industry actors with SME actors. The SMEs had quite narrow interests mapping towards their profiles and competences while the industry actors had a wider room for movement within the innovation and design process of the e-newspaper.

The different goals, and in some cases opposing interests, of the heterogeneous actors led to conflicts that had to be handled. The most apparent conflicts were between Philips, who developed the main prototype of the e-paper device, and the newspaper

actors. Early on in the project, Philips presented ideas on how the e-newspaper could be produced and distributed. In these ideas they viewed themselves as a central hub where content (both ads and news) were stored in a database owned by them. Philips then planned to package the content and deliver the e-newspaper themselves out to the readers. In this scenario, newspapers were transformed to content deliverers, losing both their distribution channels and their relations to the readers as well as to the advertisers as customers. The first schematics of this e-newspaper concept made it clear that there were very different goals and interests, but also perspectives, that had to be handled in the innovation process.

The management of the project was responsible for handling the conflicting interests of the heterogeneous actors involved in the innovation network. Reviewing minutes of meeting, revealed conflicts of interest during the whole project. These conflicts challenged the collaboration and the commitment of different actors in the project. This became apparent when actors started developing solutions that were not compatible.

Reviewing the documentation, one problem with conflicting interests and collaboration issues was determined to be rooted in the power balances within the network. As the project was managed by Philips, their views and interests were dominant when deciding the focus of the innovation process of the e-newspaper demonstrator. This created problems in some of the meetings and led to commitment issues from some of the other actors. For example, newspapers did not agree on the business model proposed by Philips as it embodied a conflict of business interests. Philips did also disregard findings in the user studies which led to several identified issues during the evaluations of the e-newspaper demonstrator.

Knowledge Exchanges. Another challenge concerning heterogeneous actors is knowledge distribution. Trying to share and distribute knowledge over organizational boundaries about technical aspects, as well as business and design aspects relating to newspaper domain knowledge, were sometimes challenging. These difficulties could be seen in the discussions concerning the needs and requirements of the e-newspaper, as well as business models and value chains (for more details, see [28]). Due to a difference in work culture and tradition, the newspaper industry and the consumer electronic industry had a hard time communicating, sharing knowledge, and overall fully understanding each other's perspectives.

The example of researchers disseminating users' needs and requirements as design and usability guidelines could also be used to explain challenges in relation to knowledge distribution. When researchers provided input to the design of both the e-paper device, as well as the e-newspaper service, much of it was disregarded or not deemed as important by the developers. Based on these examples, it appeared that it was indeed challenging to share knowledge and learn from each other in a network with heterogeneous actors. Finally, the last challenges identified concerned alignment of interests between the actors involved. It seemed as if it was hard for the involved industries to sometimes move away from existing paths and to think in new ways. To enable the realization of the digital innovation at hand, an alignment of interests

between actors involved in the different layers of the technology seemed to be necessary. This could be seen in the occasionally rigid ways that both the consumer electronic and the newspaper actors looked at their products and services. This can be traced in both interviews and minutes where existing business models were most often discussed as role models for the e-newspaper. This lack of alignment in interest between technology developers and the newspapers were in retrospect hindering the development of the e-newspaper concept.

4.2 Diverse Consumer Groups

Viewing the e-newspaper from the challenges related to diverse consumer groups, the following empirical observations can be made.

The e-newspaper is an example of a digital innovation that is targeted towards everyday use. As such, it is a mundane artifact targeted towards a wide group of users. The newspaper industry did not want to limit their target group to the people that already read traditional newspapers on a daily basis. They wanted to also reach new target groups and offer a digital innovation that could be widely adapted and possibly replace the traditional newspaper. As such, the digitization of the newspaper led to that a more heterogeneous user group of readers was targeted.

It was not only the market aspect of the e-newspaper that led to heterogeneous user groups. The context of use for the e-newspaper was also wide. Something that led to this was that new needs and requirements were identified compared to the traditional newspaper. Mobility was identified as an important value of the e-newspaper concept during workshops that were conducted with readers and newspaper staff, as well as in the testing and evaluation of the e-newspaper. This value included portability, e.g. the possibility to bring the e-newspaper with you while commuting or traveling. Accessibility and updates were other identified aspects important for the e-newspaper concept, e.g. to be able to always access and get updated content. Localization was also identified as an aspect of mobility which included contextualized content (e.g. ads and news). Even if portability is something that relates to a traditional newspaper as well, localization together with accessibility and updates are not (for more details, see [27, 29]).

Finally, a challenge for the e-newspaper realization was the willingness to change within the different user groups. In the design, test and evaluation of the e-newspaper it became evident that all three user groups had to have their needs and requirements met in order to be willing to adopt an e-newspaper. For some readers, an e-newspaper would in most cases lead to new reading habits. This was appreciated in some cases, in others not (for more details, see [27]). Again, the heterogeneity of the readers meant that the design had to be very flexible and adaptable. At the same time, the newspaper staff and advertisers heterogeneity challenged the design process to incorporate a very wide set of needs and requirements.

Heterogeneous User Requirements. These aspects of the e-newspaper, together with a heterogeneous user group, did challenge the design process of this particular digital innovation. From a user perspective, the heterogeneous needs and requirements led to

several design challenges. These concerned, for example, creating a design that retained the traditional newspaper feel (to satisfy existing readers habits) while simultaneously having features that would attract a young target group (for more details, see [29]). In addition to this, the different contexts of use meant that a flexible and adaptable service had to be designed. A service that not only included delivering updated and context aware news, but also ads that were targeted to the right group of users, as well as to the right time and location.

As the e-newspaper had to meet heterogeneous requirements and needs, both the device and the service had to be flexible and adaptable. Even so, the e-newspaper was not designed to be generative and malleable, it was deemed to have to provide tangible user values for the readers. Not only the readers of the e-newspaper were heterogeneous, but also the advertisers as well as newspaper staff could be classified as heterogeneous users. These users all had very different purposes of using an e-newspaper (and the backbone publishing system). The design of the e-newspaper had to be able to handle a wide set of different types of ads supporting needs and requirements of advertisers ranging from small businesses to large national businesses. From a newspaper staff perspective, the e-newspaper had to provide an interface to existing publishing systems which were quite diverse. Furthermore, the editing of an article was restricted based on the technical properties of the e-newspaper demonstrator. The design therefore had to handle the different type of journalists' and newspaper designers' requirements.

To be able to handle the heterogeneous user needs and requirements, a user centered design process was planned and carried out in DigiNews. By including all identified user groups in the design of the e-newspaper concept, a complex set of needs and requirements were identified. To be able to handle these, focus groups were created to both design and evaluate the evolving e-newspaper concept. However, as one of the industry actors of the network did not prioritize the findings, the e-newspaper demonstrator used to test the e-newspaper was not fully aligned with the identified user needs and requirements. Several issues influencing adoption became evident and were identified in the final evaluation of the e-newspaper demonstrator (for more details, see [27]).

5 Discussion and Conclusion

The DigiNews case illustrates all four identified challenges and also illuminates some activities which can address these challenges. These suggested activities are discussed below and summarized in Table 3.

5.1 Modular Cooperation

As shown in this case, different layers of the modular technology required actors with diverse knowledge bases and interests to cooperate in DigiNews. As a result, the digital innovation process became complex and networked. This is similarly described in the related literature [16, 17, 4, 2, 5, 6].

In the e-newspaper case, there were several instances of conflicting interests between different levels of actors. It was rather hard for the involved actors to move away from existing paths of innovation, and align their interests with each other in order to find new value chains and business models. In hindsight, it seems like problems relating to alignment of interest, e.g. to find new ways of collaborating and being flexible by meeting half way in order to be able to act on identified user values, might be one of the reasons behind the initial problems with the e-newspaper innovation.

Another challenge in the modular cooperation was related to the conflicts that arose during the case. Some of the conflicts could be traced to the different cultures and backgrounds of the actors. The different backgrounds and cultures, as well as different knowledge basis, challenged the collaboration on several occasions in DigiNews. Some of the reasons for these challenges probably relate back to conflicting interests.

A way to address these challenges could be to create more transparent processes. If the innovation actors are explicit regarding their goals, interests, and agendas during the initiation of a network, some of the problems identified in the case would have been solved. Based on the DigiNews case, it becomes apparent that there needs to be activities which can facilitate the communication and collaboration between the heterogeneous actors involved in digital ecosystems. The activities need to create relationships and involve relevant actors to enable both the development and implementation of digital innovations. One way to handle conflicting interests, conflicts and power balances could be to conduct activities which create and communicate a blueprint for the value network in a digital ecosystem. Such a blueprint would illuminate different actors' roles in both the development as well as the implementation of a digital innovation and could therefore be used to explicitly address actors' interests and roles in an ecosystem.

Based on these insights, the following three activities are suggested to meet the challenge of modular cooperation in digital innovation: a) *support transparent digital ecosystem relationships*, b) *facilitate cross-organizational communication*, and c) *create digital value blueprints.*

Knowledge Exchanges. Knowledge needs to be shared and dispersed between heterogeneous actors in order to support a digital innovation process [20, 19, 9, 10]. The literature highlights some challenges, e.g. how to manage the heterogeneity of IT-knowledge resources when working with digital innovation [2]. Scholars also write about how innovation capacity is enabled by knowledge dispersion [9]. In DigiNews, different knowledge bases challenged communication and knowledge sharing within the network. There seemed to be a need for facilitating knowledge sharing between actors, and finding objects that could be used to communicate over knowledge boundaries.

In digital innovation, there needs to be knowledge transfer activities which are organized in way that support exchanges between actors with different knowledge, agendas and innovation trajectories [8]. In DigiNews, this was done by setting up

workshops with different actors to ideate and transfer knowledge and perspectives between the involved actors. These knowledge transfers were primarily done from users to researchers, and from researchers to the developers. The researchers translated findings from the user studies into personas, user scenarios, mock-ups, prototypes, and requirement documents to enable a knowledge transfer between user groups and technology developing actors. As such, these translations of knowledge activities helped disperse and exchange knowledge between the heterogeneous actors involved in the innovation network.

Based on these findings, the following activity is suggested to meet the challenge of knowledge exchanges in digital innovation: *translate heterogeneous knowledge*.

5.2 Diverse Consumer Groups

Generativity of digital technology makes digital innovations malleable and adaptable. This generativity leads to large, diverse, and uncoordinated user groups and markets [1, 2, 4, 11].

Diverse consumer groups have several implications for digital innovation processes, one of these is the variety of contexts of use. Having a variety of contexts of use requires flexible and adaptable digital devices and services that are malleable. This is both a design and a technical challenge that needs to be addressed when working with digital innovations targeted towards everyday use. The generativity of digital technology needs to be incorporated in the design of both devices and services to support large and varied user groups. In DigiNews, the e-paper device and its technical backbone did not open up for third party apps like e.g. today's smartphones. As the e-newspaper bundled hardware and service, technical and usability limitations in the e-paper device might have inhibited the adoption of the first versions of the e-newspaper. Today, numerous newspaper services exist for different tablets and these services are in most cases not coupled with hardware devices.

Besides different contexts of use, the e-newspaper presented the diverse user groups with different values. In DigiNews, readers, newspaper staff and advertisers all had different purposes and the e-newspaper provided different kinds of user value depending on use group. The added value for the different groups of users had to be acknowledged and designed for. Again, this was handled in DigiNews by actively involving all of the users in the design and innovation process. However, the diverse user groups also required activities that investigated user value, designed for this value, and authenticated the value in real life evaluations.

Based on these insights, the following three activities are suggested to meet the challenge of diverse consumer groups in digital innovation: a) *involve all relevant user groups*, b) *identify, design for, and authenticate digital user values*, and c) *design for multiple contexts of use*. These activities also relate to the last identified socio-technical challenge with digital innovation, heterogeneous user requirements.

Heterogeneous User Requirements. Large, diverse, and uncoordinated audiences of digital innovations lead to heterogeneous user requirements [2, 12, 18]. In the case of

DigiNews, the e-newspaper product with accompanying services aimed to replace the traditional newspaper. However, when digitizing a mundane product as the newspaper, there was a need to involve a very wide and heterogeneous base of users. Examples of users involved were readers, advertisers, and newspaper staff.

Heterogeneous user requirements and needs resulted in difficulties in the design and innovation process of the e-newspaper. The digital innovation process of the e-newspaper included a user centered approach to handle the challenge of heterogeneous needs and requirements. The process aimed at involving all the different user perspectives and therefore readers, newspaper staff and advertisers were all included. However, this approach was time consuming and expensive. Therefore, there still seems to be a need to find methods and techniques that can identify heterogeneous users' needs and requirements, and package these in communicable ways. In DigiNews this was done by prototyping and iterative testing, which led to guidelines for the design of the e-newspaper complemented with the rationale for every guideline.

Based on these findings, the following activity is suggested to meet the challenge of heterogeneous user requirements in digital innovation: *prototype iteratively*.

In conclusion, Table 3 summarizes a set of activities, originating from the empirical findings, which aim to address the identified challenges in digital innovation. Based on these findings, future studies are suggested to further investigate how digital innovation can be orchestrated to address socio-technical challenges in digital ecosystems. This paper could then be regarded as a first stepping stone for these investigations.

Table 3. Activities to address socio-technical challenges in digital innovation

Challenge	Suggested activity	Description
1. Modular co-operation	*Support transparent digital ecosystem relationships*	Create transparent relationships to illuminate actors' initial goals, interests, and agendas in digital ecosystems.
	Facilitate cross-organizational communication	Facilitate the communication and collaboration between the heterogeneous actors involved in innovation networks.
	Create digital value blueprints	Create and communicate a blueprint for the value network in a digital ecosystem illuminating different actors' role in a digital innovation.

Table 3. (*continued*)

1.1 Knowledge exchanges	*Translate heterogeneous knowledge*	Conduct knowledge translating activities such as workshops with different actors to ideate and transfer knowledge and perspectives between involved actors.
2. Diverse consumer groups	*Involve all relevant user groups*	Involve all relevant users in the ideation, development and implementation of a digital innovation.
	Identify, design for, and authenticate digital user values	Identify added digital value for different groups of users and address this in the design and evaluation of a digital innovation. Authenticate the digital values in real life evaluations.
	Design for multiple contexts of use	Design flexible and adaptable digital devices and services that are malleable.
2.1 Heterogeneous user requirements	*Prototype iteratively*	Iterative prototyping can be efficient to identify and evaluate heterogeneous user requirements.

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