Infrastructuring Participatory Development in Information Technology

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ABSTRACT
In this paper we present our experience in building a socio-technical infrastructure for supporting social innovation in Information Technology. We start by describing a case study on the design and use of a smartphone application for the canteen services of a local university; based on this, we propose what we call the *hourglass approach* to support participatory design and development in Information Technology. The hourglass is defined by the intersection of two co-evolving dimensions of infrastructuring: the social and the technical ones. Different subsets of the community, characterized by the increasing involvement of self-selected volunteers, position themselves along the two axes and have different roles in the design and use of the generated artefact. We conclude by discussing how this approach can help addressing some of the current challenges (i.e. scale, milieu and responsibilities) of social innovation in Information Technology.

Author Keywords
Participatory design; social innovation; infrastructuring.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Social innovation has been designated as one of the main goals in Horizon 2020, the EU Framework Programme for research and innovation (Barroso, 2011). For the EU, social innovation is about "meeting the unmet social needs and improving social outcomes" as well as "empowering citizens to become co-creators of innovative social relationships and models of collaboration." This voice is echoed in different communities of practice and research (Chesbrough, 2003; Björgvinsson et al., 2010; Fischer et al., 2004) which, while sharing an awareness that citizens are fundamental actors in the innovation process, have a different understanding of the general assembly in which the innovation is to happen or, in Latour's (2004) terms, identify different "matters of concern".

The large base of expertise developed within the field of Participatory Design (PD) over the past 20 years (Ehn, 1998; Bødker et al., 2000) provides a distinctive perspective on leveraging the move towards social innovation. However, this perspective does not easily scale from work environments to public spheres (Dalsgaard, 2010); it is largely sensitive to the cultural diversity of the innovation milieu (Björgvinsson et al., 2010); and it opens a number of important ethical issues related to unsatisfied expectations of participants who devote their time to the project (Bossen et al., 2012).

Social innovation in public spheres requires extensive amount of infrastructuring (Björgvinsson et al., 2010; Pipek and Wulf, 2009), which we intend as the process of creating the social and technical conditions for innovation. This process unfolds in, and needs constant adaptation to, the specific context where it is developed. Borrowing the theme of this year's conference, we suggest that social innovation "reflects connectedness" in the double sense of being influenced during design by the existing culture of participation, and generating new possibilities for feeling connected to others during use.

In this paper we reflect on the *Smart Campus* project. This project started two years ago and has several concurrent objectives situated within a "Smart City" framework: first, it aims at empowering the students to take a more active role in designing the services they want and like, and to participate in their development, delivery and evangelization; second, it aims at building a socio-technical service infrastructure for the local Province. The University campus was selected as the playground to experiment with a vision that emphasizes the role of the community not only as decision-maker, but also as builder of services.

The Smart Campus project led to the design and implementation of a mobile app for canteen services of a local university, called *iFame* (a play on words, since in Italian it is pronounced as "hai fame?" which means "are you hungry?"), by the students; we reflect on this case study and on how it can be applied in the future. In particular, we abstract from our experience and propose an approach addressing two concurrent dimensions of innovation infrastructuring: the social and technical ones. While acknowledging the ongoing debate over the distinction between these terms (e.g. humans versus nonhumans: Latour, 1999), for the sake of simplicity in this paper we refer to *technical infrastructuring* as the ensemble of computing technologies which support the use and production of Information Technology services and to *social infrastructuring* as the set of human actors who influence, shape and represent the community. Together, these two dimensions define an *hourglass* structure, which is elaborated further on in the paper. This

PDC '14, October 06 - 10 2014, Windhoek, Namibia

http://dx.doi.org/10.1145/2661435.2661448

structure is meant to create the conditions for the application of PD in an environment which is favourable to participation only to a limited extent and involves a large community of different mobile stakeholders.

The paper is organized as follows. Discussing related work we identify three main challenges affecting PD in the public sphere: scale, context and ethical responsibilities. We then discuss our case study about iFame, also describing the process that led to its realization and to the initial establishment of a community. Finally, we reflect on our experience and propose an approach about how to put in place the socio-technical infrastructuring of innovation and foster citizens' participation in large-scale public projects, even in an environment that is not always ready for this.

RELATED WORK

Social innovation, conceived as the development of products, services and models that meet social needs and enhance society's capacity to act (Murray et al., 2010), is a complex and multifaceted process, which has been investigated by different scholars, including those belonging to business, design and computer science areas.

Business and management studies propose the concept of "open innovation" and "democratizing innovation", regarded as a top-down approach where "lead users" provide innovative ideas (Chesbrough, 2003; Von Hippel, 2005). A few key users are carefully selected by the management team based on some unique personal characteristics, often linked to popularity. Conversely, crowdsourcing can be used as a way to pursue innovation by profiting from a large number of creative "working-consumers" (Kleemann et al, 2008). In both approaches, companies and institutions select and implement the ideas generated. This approach has been often criticized because of its narrow interpretation of the democratic aspect of innovation and a main emphasis on objects and products (Björgvinsson et al., 2010; Bossen et al., 2012).

The European reading of democratizing innovation was strongly influenced by PD approaches (Björgvinsson et al., 2010). This vision emphasizes the role of end-users not only as sources of innovative designs and functionalities, but also as active and reflective designers who are capable of positioning themselves in a real situation, reflecting on it, and taking decisions based on their knowledge (Schön, 1983; Kanstrup, 2012). In this way, democratizing innovation can be seen as an "open innovation milieu where new constellations, issues and ideas evolve from bottom-up long-term collaborations amongst different stakeholders" (Björgvinsson et al., 2010).

The contribution of computer science in social innovation originated at the border between software engineering and HCI and resulted in the paradigm of End-User Development (EUD) (Fischer et al., 2004; Lieberman et al., 2006). EUD advocates flexible technical infrastructures offering a "gentle slope" of programming complexity, so users can adapt software artefacts to new and changing needs as they occur in their practice. Several conceptual frameworks and tools have been proposed, ranging from the paradigm of meta-design or tailoring, to visual programming languages and debugging tools. Although the social implications of EUD were clearly stated in early work (Lieberman et al., 2006), most research in the field concentrated on the building of technical infrastructures and was limited to usability concerns when dealing with the human actor (Namoun et al., 2010).

All these streams of research mainly concentrated on working contexts and may demonstrate considerable weaknesses when stretched to fit the public sphere (Dalsgaard, 2010). As outlined below, several issues emerge in terms of scale, context and ethical responsibilities, among others.

Scale: from work to public spheres

In the early days of PD, the general scope of what was to be designed was bounded to workplace contexts in which projects were commonly framed (Ehn, 1998; Bødker et al., 2000). These contexts usually had the competences required to transform envisioned designs into real objects and services. When moving to the public sphere, the boundaries of what was to be designed – and by whom – became blurred. According to (Björgvinsson et al., 2010) innovation in the public sphere entails "Thinging and infrastructuring": referring to Latour's discourse (Latour, 2004), "Thinging" relates to the evolution from the design of objects and services (i.e., "things") to the assembly around "matters of concern" (i.e. "Things"); "infrastructuring" relates to the on-going processes of pursuing democratizing innovation by aligning and adapting to changing situations.

In the public sphere, these processes bring forward several challenges. Stakeholders usually belong to large and heterogeneous groups, which are difficult to manage and keep informed (Dalsgaard, 2010); in addition, achieving active participation can be an arduous endeavour since stakeholders might not recognize the immediate relevance of their involvement (Dalsgaard, 2010). The development of infrastructures is another main challenge: it is not uncommon to find PD projects delivering innovative, feasible and desired designs which ultimately are not realized partially due to "the gap between politics and techniques" (Kyng, 2010).

This paper contributes to the literature not only in terms of scaling up the number of users, but also scaling up their space for participation. We reflect on a case of participatory development, which we interpret in the literal sense as leaving the development to volunteers in the community. These members have the capability of embedding the outcome of PD (Things) in objects or services (things). This approach can lead to sustainability in the long run. Involving users in the design process is in fact not enough; users should also "gain in their ability and willingness to take the role of the animator(s)" (Clement and Van den Besselaar, 1993). As EUD approaches still suffer from several conceptual and usability issues hampering general adoption (Namoun et al., 2010), we experimented in participatory development with users who are familiar with technology, but we are confident that different scenarios will be available in the coming years.

Context: innovation milieus

Another aspect to be considered is the extent to which the environment is ready and receptive for a PD initiative. Even though PD has witnessed worldwide reach (Muller et al., 1991; Kensing and Blomberg, 1998), reproducing its success outside Scandinavia might be difficult due to "significant differences in labour, legislative, and workplace environments" (Muller et al., 1991). Several calls have been made for deeper reflection on the role of the innovation milieu and several researchers acknowledge the need for adapting techniques and approaches to the local context (Björgvinsson et al., 2010; Byrne and Sahay, 2007).

This paper reports a case study in Italy, a country which is increasingly disengaging from participation in public matters, as clearly witnessed by the number of voters, which fell from 94% in 1976 to 75% in 2013[1]. In this context, a number of design initiatives subsuming active and democratic participation have been launched (Manzini, 2007; Jégou and Manzini, 2008): for example, "Cittadini creativi" aims at helping citizens of a district in Milan to propose, design, and experiment with local services; "Vicini vicini" is "a service that promotes social conviviality of a community by providing people a kit to organize neighbouring parties" and was initiated by the Municipality of Rome. However, to the best of our knowledge, challenges and limitations related to the Italian innovation milieus have not been thoroughly articulated in the literature.

Ethical responsibilities: gains versus losses

Innovation in the public sphere especially requires the definition of responsibilities. Ethical issues about unfulfilled expectations are often not directly discussed in the PD literature. In spite of designers' commitment and good-will, it is difficult at times to ensure that participants' efforts will be rewarded and expectations created by envisioning desired designs will be fulfilled. A few studies have identified a potential for personal improvements for participants in PD projects (Bossen et al., 2012), such as increased social capital, better understanding of technology and improved career opportunities. However, absence of a clear set-up for collaboration, and different conceptions of technology have been identified as barriers to ensure users' gains in PD processes (Bossen et al., 2012).

Since few PD projects move from a research setting to full-scale development (Kyng, 2010), the discussion on the ethical implications of engaging in PD has been difficult. Yet, it is the designers' responsibility to ground their intervention on serious considerations of the possible consequences for the participants if the project should not deliver as requested. In the Smart Campus project we have been fine-tuning our approach over time in order to maximize gains and minimize possible losses for involved users.

THE SMART CAMPUS PROJECT

The Smart Campus project started in the context of establishing a Living Lab (Eriksson et al., 2005) in the Trentino Province. In the short term, the goal of the project is to create an ecosystem that can foster students' active participation in Campus matters. In the longer term, the goal is to act as a sandbox for the development of infrastructures to foster active participation of citizens in social innovation (Björgvinsson et al., 2010).

The project has now been running for over two years. Four main stakeholders participate in it. TrentoRISE (the innovation catalyst funded by public sources in the local Province to act as the Italian node of the European Institute of Technology) is the funding body. The members of its management board, and most of the researchers, come from a computer science background, but they are developing an increased awareness of the process and the need for social innovation. Some evidence of this growing interest includes the evolution of the tagline in the last couple of years from "open innovation rooted in research and education" to "social innovation… " and then to "societal innovation..."; however, funding distribution has not followed the same evolution so far. Within this context, the innovation model proposed by TrentoRISE aims to benefit the local community in the Trentino Province through results of computing research and education.

The University of Trento and FBK are core partners of TrentoRISE. Within the Smart Campus project, they represent both the beneficiaries and the providers of the research capability. These two bodies share a history of alliances and conflicts, and they both perceive TrentoRISE at times as an ally or as a challenge to their status. At the beginning of the project, the University agreed to act as a use case, though its commitment and interest varied through the years. In particular, despite supporting the agenda of open innovation, the University was not yet ready to engage with PD processes when the project started.

The primary stakeholders are represented by the University students, the population we aim to engage in social innovation. Developing and evaluating strategies for motivating them to play the role of active designers and developers has been the main challenge the authors have pursued over the last two years.

Innovation milieu

Trento is a medium-sized city (115,000 inhabitants approximately), technologically advanced and with a very high quality of life: it ranked 45 in the 2007 European Smart Cities Ranking[2] and first in the 2013 Italian ICity Rate[3]. Moreover, in the last few years the local administration has started several projects in order to establish a Living Lab, resulting in the city being selected among the ten cities worldwide to be included in the IEEE Smart Cities Initiative[4]. The city and Province therefore constitute a receptive environment for

[1] http://elezionistorico.interno.it/

[2] http://www.smart-cities.eu/ranking.html

[3] http://saperi.forumpa.it/story/73757/icity-rate-2013-la-nuova-classifica-italiana-delle-citta-intelligenti

[4] http://international.unitn.it/news/quality-life-trento-among-worlds-ten-smart-cities

innovation; the emphasis of this process is however often put more on the technological side (i.e., on the development and testing of new systems) rather than on the understanding of the social effects caused by such innovation.

The local University campus represents a medium-sized community, consisting of ten departments, approximately 16,000 students, 600 academics and as many administrative staff. The campus is spread across several districts of the city. The collegiate system is governed by academic and administrative staff and allows a marginal level of representation to the students. In the last years, however, the participation to the university governance of students has been very moderate. The 2012 election for representatives at the University Board witnessed a turnout of less than 20% undergraduate and master students, and 10% doctoral students.

Innovation approach

The evolution of Smart Campus to date can be divided in two phases: design and use. The design of the social and the technical infrastructure unfolded over two years; the use phase began in November 2013 with the release of iFame.

The technical and the social infrastructure were designed in parallel, with several phases of intervention, analysis and iteration. The technical stream is grounded on open data and service oriented architectures; the social stream has experimented with principles and techniques of interaction and PD. These two streams met in a process of community building around the design of artefacts. The social goal is to facilitate student participation in service design and seed the ground for a larger scale intervention in the city; the technical goal is to develop a service platform, a permanent facility to be handed over to the community of citizens that has been cultivated around the project. This paper concentrates on design and use of the social infrastructure; the technical infrastructure is briefly described in the following section.

Technical infrastructure

For the Smart Campus project, the service platform is a necessary technical infrastructure for social innovation; its architecture is represented in Figure 1. The bottom part represents a set of systems provided by external institutions or third parties: they correspond to basic functionalities and available information sources. A service back-end has the responsibility of wrapping these systems and ensuring that they can be composed into more complex processes.

The core of the platform sits on top of the service back-end: it consists of an environment that supports the execution of the services delivered to the students. These services are built by exploiting the back-end services as well as a set of enabling (i.e., infrastructural) services.

The core of the platform also takes care of collecting the available services and supporting their discovery and selection. Finally, the top level of the platform corresponds to the service front-end, which guarantees a multi-platform access to the services. The project has espoused from the beginning an open source philosophy for the development process. Furthermore, the project funded 500 smartphones and a generous data plan for the students who participated in the experience.

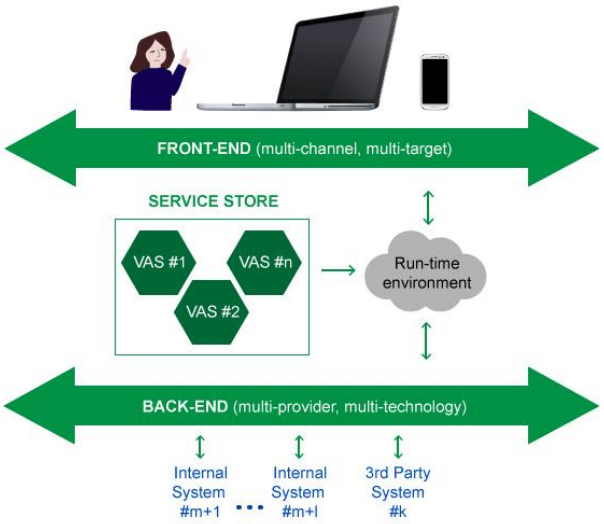

Figure 1. The platform architecture.

DESIGN PHASE

To seed a receptive environment for social innovation, we engaged in a number of design activities that can be broadly clustered in four phases ordered along a continuum of increasing participation of selected volunteers.

Fieldwork

The fieldwork lasted nine months and ended with the delivery of a set of six initial apps that were developed within our lab. These apps help students on a variety of professional (tracking their university achievements; managing university email), social (creating university-based groups; getting information about events in the city), and private tasks (travelling through the city; keeping a multimedia diary). They were used as infrastructure probes (Pipek and Wulf, 2009; Dörner et al., 2008) to give the students an impression of the platform possibilities and to encourage the establishment of the Smart Campus community.

During this phase, we adopted a UCD approach, involving a large number of people through questionnaires, diaries, interviews and focus groups. This work was supplemented by online ethnography and benchmarking studies. We also enrolled two cohorts of Master students in Computer Science (N = 60) who worked in groups of 4 on the design of new ideas for Smart Campus as part of their course-work in HCI and CSCW: some of these conceptual designs also evolved into five MSc dissertations.

Reflecting on this rich source of information with our students, we extracted 63 design dimensions. They included matters of concern about studying, saving money, healthcare, transportation, university cafeterias, and campus life. Combining the different dimensions, we developed 20 scenarios (e.g., disabled student, undergraduate student thinking about her thesis, the foreign Master's student), enriched by a PACT analysis (Benyon, Turner and Turner, 2005). These scenarios were analysed by the Smart Campus team on the basis of their

suitability to act as effective infrastructure probes according to three criteria: their technical feasibility within the first year of the project, their potential to engender the emergence of a lively community, and their relevance to the technological experimentation carried out by the team. This screening led to the identification of a set of 20 services which addressed issues related to the academic, social, and practical life of the students: these services included video-streaming of lectures and social-network applications to share experiences and opinions on courses and teaching staff, apps aimed at helping students to find new friends in the campus, mobility apps and services for administrative procedures.

Figure 2. The Smart Campus suite.

The proposal was discussed during a project management meeting including representatives of all stakeholders but no students. The University raised several issues regarding the design of services for supporting study activities, which were seen as too close to e-learning: these issues partially derived from the existence of a standard e-learning platform enforced by the institutions and often disregarded or criticised by staff and students. They were exacerbated by a fear of over-empowering students and of the possibility of anti-social behaviour, requiring moderation. Publicly disclosing un-moderated students' judgments on academic quality is indeed quite a bold statement, in a country where the use of standardized questionnaires for teaching evaluation has been enforced by law only in 1999[5], and is kept as confidential information for teaching staff. These considerations led to the collective agreement of postponing the development of services addressing study activities to the second year of the project, and to the selection of the six initial apps.

[5] Italian Law 370/99: "Regulations about universities and scientific and technological research", http://www.miur.it/0006Menu_C/0012Docume/0098Normat/1568Dispos.htm

In parallel with the selection of the services, we defined the project visual style following the pattern of 'flat design'. We favoured strong colours and simple icons based on the "toolbox" metaphor. Smart Campus was conceived as the box containing an increasing set of tools in the form of service apps. Each app was graphically associated to a tool and a colour. The interface design followed an agile usability-based approach, which often struggled to keep up with development. Figure 2 presents the Smart Campus launcher as it appears at the beginning of February 2014: it contains the initial apps and iFame. *StudyMate* is currently under development in the lab by students.

Seeding the community

The apps were released to the students attending the HCI class in October 2012 at the department of Information Engineering and Computer Science (N = 90). In this way, our original base of users was introduced to the Smart Campus project as a real-world context of application of the methodologies and techniques taught in class; furthermore, they could not only provide feedback on existing artefacts, but also generate, design, and code new services for their own needs. During this period, we incorporated UCD and PD practices into the academic career of these students; after providing them with such needed knowledge, we also provided them with smartphones to evaluate the Smart Campus apps. We believe that seeding PD practices in the community is important to ensure the sustainability of both the project and of its underlying vision of technology as a facility for community empowerment.

Several communication channels were set up to decrease the gap between designers, developers, and users (Pipek and Wulf, 2009). These channels ranged from forum and social networks to personal diaries, face-to-face meetings, and questionnaires. In the forum students can propose new ideas, report issues, or participate in thematic discussions regarding each of the developed apps. As of February 15th, 2014, it has 455 members, of whom 128 have written at least one post. In total, active members have contributed 1972 posts.

Over the months, we have started expanding our core community to other departments: currently, 406 different students have been involved as users for Smart Campus. We believe in fact that a multi-faceted community can bring an added value both to the project and to its sustainability, as different competences can contribute to different extents.

Participatory design

Progressively we have shifted towards a PD approach, with students being involved in all phases of the project. The conceptual design of the iFame app started in fall 2012: as a final deliverable for their course-work, students were invited to design and prototype an app that could solve a problem they considered relevant within their daily academic life. Several good quality proposals were presented: among these, a small number were selected for participating in an "ideas contest".

The contest was meant as a chance for students to showcase their work and for the Smart Campus staff to

evaluate new proposals for applications. During this public event, the most interesting projects were presented; a committee, composed of researchers and university staff, selected iFame as the best idea. The app was designed in response to several concerns: students often note that the quality of food varies among dishes and canteens, that at peak hours they are likely to queue for a long time and that the menu composition (and thus the cost of their meals) is unclear to them. iFame addresses these issues in its four sections, which are listed below:

- *iDeciso* illustrates daily and monthly menus plus how a meal can be composed (first course, second course, snack…) and how much it will cost;
- *iFretta* ("Are you in a hurry?") shows a streaming view offered by webcams located at the different canteens, in order to allow the user to see how long the queue is in real time;
- *iSoldi* ("Do you have any money?") allows checking the balance of the user's pre-paid card;
- *iGradito* ("Did you enjoy?") allows the user to rate and comment the dishes served at different canteens.

Participatory development

The five students who came up with this proposal were offered a paid internship in the Smart Campus lab, so that they could receive technical and organizational support to refine and actually implement their idea; four of them accepted. Two of the students chose to focus their work on the front-end side of the application (refinement of the prototypes, development of the interface) while the other two chose to focus on the back-end side (business logic implementation and integration with the Smart Campus platform). The internships varied in length from three to six months depending on the concurrent academic commitments of each student and evolved into BSc dissertations.

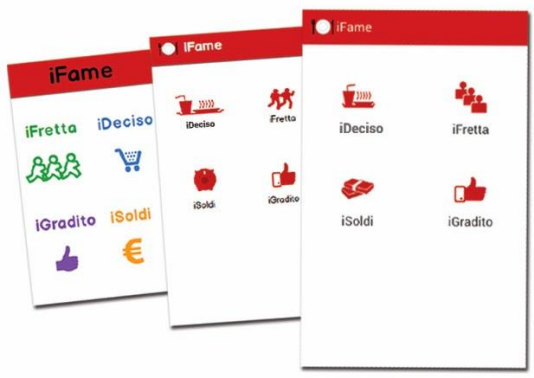

Figure 3. An example of the evolution of the iFame interface.

While in the lab, the development was mainly done by the interns, who were supported by the staff: the innovation milieu in fact helped the students to learn. For example, Figure 3 shows how the main screen of the app evolved over time, as the developers refined their ideas with the help of the graphic designer. The staff also took care of making agreements with the local university in order to obtain the required information about the canteens, such as their opening times, the menus, the prices of each meal and so forth. This endeavour proved to be far from easy: the issues were both technical (due to the effort of providing on-the-spot support to interns, but also of building resources that could support design and development on the long run) and organizational (such as the factual unavailability of claimed open data or the restrictions posed to social innovation by political resistance to service quality assessment).

USE PHASE

A first official version of iFame was released to the Smart Campus community in early November 2013. Some time later, a moderation activity was introduced so that the lab could ensure the appropriateness of comments that students were writing about the canteen dishes. This was a strong requirement imposed by the University.

We now present the first evidence of the fact that iFame is starting to generate a community of its own among its users and that the latter show different degrees of involvement. All subsequent citations have been translated from Italian. Furthermore, the data presented refers to the period going from November 2013 to February 2014; we are aware of the fact that such a period has a limited duration, yet we can already see some trends that we report in the following sections.

Opportunistic use

Once the app was released, it did not fall into a vacuum, but was rather received by the community we had seeded in the design phase. Most of the students who chose to actually use the application did so in order to benefit from the information it provides, but did not enter any comments about the food or provide feedback about iFame in the available communication channels.

Since the release of the app there have been on average approximately 100 daily server requests (SD = 125.14); the high standard deviation is due the fact that the usage decreases steeply during the weekends, winter break and examination periods. The highest peak happened during the week of the release (immediately before Christmas holiday), where we observed 440 server requests in the same day. The most used functionalities (amounting to some 70% of the total usage) are checking the length of the queue, checking the credit balance, reading comments about food and checking the daily menu.

Content contribution

Some of the iFame users not only benefited from the information provided by the app, but also actively populated it with their comments and ratings about the food served at the different canteens. In four months, 212 reviews have been posted by 61 users, with an average of 3.50 reviews per person (SD = 4.20). Some 60% of them also contained a comment and not just a rating.

The reviews about the dishes underwent an automated filtering of offensive language and has then to be manually approved by a member of the team: however, of the 127 comments left by users during the period at hand, only 2 required blocking. Comments usually consist of an overall judgment of the quality of the dish ("excellent!", "very tasty"), or more specific suggestions ("the sauce is very good, shame about the badly cooked pasta", "the sauce is always excellent and you must always ask for more. Worth it!").

Ratings were left for 130 different plates, with an average of 1.61 ratings per plate (SD = 1.30). We note that, apparently, the more positive a person's opinion is, the stronger is the tendency to leave a comment rather than just a rating: this induces us to think that our users tend to report food they particularly like. Users could also like and dislike comments: this feature was however seldom used (24 students only, with an average of 2.01 votes; SD = 2.46) and always in a positive way.

Reflective contribution

Some users took advantage of the various communication channels (e.g. survey, diary, forum) available to discuss their opinions about the app, suggesting improvements and commenting on the existing functionalities; here we summarise the main insights.

A survey was run in December 2013 regarding use of iFame. In total, 201 people answered the questionnaire (159 M, 42 F). Most of them (40%) claimed using iFame at least several times a week; some of them used it once a week (12%) or less than once a week (14%). Some people claimed to have tried it once (14%) or never (20%). Some respondents however noted that they never eat at the University canteens. People were also asked to judge their experience with iFame on a 6-points Likert scale. People were moderately positive about the app (mean = 4.0, SD = 1.44) and would slightly agree to share it with others (mean = 4.19, SD = 1.59).

We also asked a few open-ended questions about how they would improve the app. Students seem to be satisfied with iFame and often expressed positive comments. In particular, it appears that having students design and develop apps for their peers is highly appreciated, although the extent of the participatory development was not always clear. One person wrote "…as a concept, it is probably one of the most successful apps in the Smart Campus set"; another one wrote, "…for what I know, it is an app created at the request of some students. I would recommend you to continue on this path because the result is excellent".

iFame is mentioned several times in personal diary entries, mainly by users that were involved at the same time when the app was released. People mainly comment on how they use the app: checking the balance on their canteen card, checking the line at the canteen, viewing the daily menu. Opinions are mainly positive, describing the app as useful, easy to use and complete; some users also provide suggestions for improvement, including the calculation of the nutritional value of a meal, which we expect could lead to new design and development.

The forum dedicated to iFame started with one of the intern students announcing the imminent release of the app. So far, 21 people have written 80 posts in 16 topics, which had 2190 views. Four project staff members wrote 17 posts, with an average of 4.25 posts each (SD = 3.77). Seventeen students posted 61 times, with an average of 3.59 posts each (SD = 4.87). The most active contributor (21 posts) was one of the intern students who participated in the development of the application.

We performed an inductive thematic analysis (Braun and Clarke, 2006) on the posts. Topics were categorised in three themes: new ideas, problems and positive comments on the application. Most of the new ideas referred to design recommendations and new functionalities in the context of the application. Some of the people suggested possibilities for future development, ranging from high-level descriptions to low-level pseudo-coding. Problems mainly contained usability issues and bugs.. Intern students, designers, and developers often replied to the reported problems asking for further elaboration. Some students used the forum to share their excitement about the application ("I really like your ideas and this app! It really makes life easier").

Active engagement

Although we are too early in the use phase to reflect on active engagement, throughout the Smart Campus project we have been surprised by the enthusiastic participation of some students. For example, during a full day workshop aimed at discussing how to improve the community involvement, a group of social science students volunteered to carry out what they called the "3000 challenge". Their proposal is to achieve a community of up to 3000 members in less than three months.

The lab is currently mediating between their enthusiasm and the University in order to ensure maximum success to the initiatives. Unfortunately, the University has not yet embraced the project with the same enthusiasm and rapidity as the students, but we are confident that eventually conflicts will be overcome. In parallel, the Erasmus Student Network has contacted us to take an active role within Smart Campus. We are now reaching the stage of publishing the apps on the Play Store: this will be a key turning point of the project.

DISCUSSION

In the previous sections we have presented the iFame case study; we now abstract from our experience and propose an approach addressing two concurrent dimensions of innovation infrastructuring, i.e., the social and technical ones. Together these dimensions define an hourglass structure, which can support PD and participatory development in this extreme case where users themselves develop the result of a PD study.

The hourglass approach

The hourglass is shaped by the two axes defined by the social and technical dimensions (Figure 4). The upper part of the hourglass structure concerns the design of the artefact and culminates in the point of infrastructure representing the iFame app: this is the moment in which "an infrastructure becomes visible to its users" (Pipek and Wulf, 2009) due to innovation, generating new local practices at use time (represented in the lower part of the hourglass structure). The hourglass shows the progressive evolution of the social and technical infrastructuring together with the kind of community involved at each stage. The horizontal sections represent different subsets of people with different degrees of involvement: the darker the colour, the more involved the related group is. Moreover, the size of each section also reflects the size of its related group. For instance, the number of users involved during the design phase in the fieldwork is much larger than the number of users involved in participatory

development. Similarly, the number of users taking advantage of the information contained in iFame is much larger than the users actively engaging with new development.

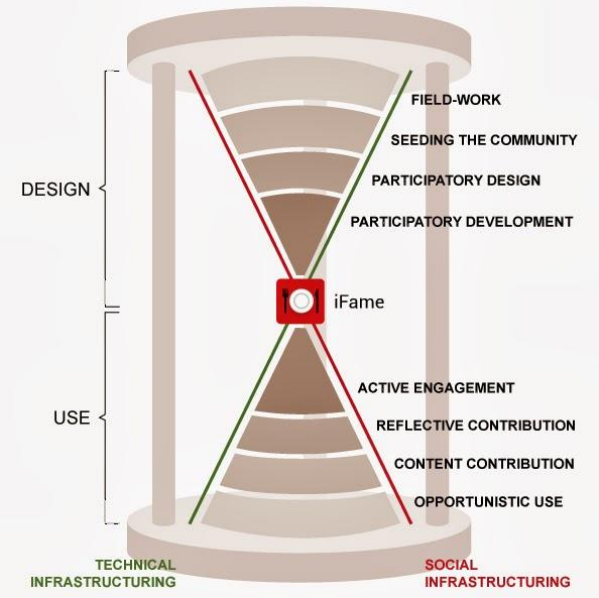

Figure 4. Hourglass approach.

The design process started with the *field-work* phase, where we applied UCD techniques to understand who the users were and set up the adequate context for the project. In other words, we had to lay the foundations for our infrastructuring endeavour, in order to better understand the general domain and establish the conditions for applying PD. This implied the involvement of a large user base and the development of the platform and of the first Smart Campus apps. Several activities were then put in place to *seed the community*: UCD and PD practices were incorporated into the academic career of computer science students to whom the Smart Campus apps were released for testing; in this way, this set of students was equipped with the knowledge needed to evaluate the apps. At the same time, several channels were set up to facilitate the communication between students and the Smart Campus staff. From this stage on, we moved from the gathering of social needs to action, and from UCD to PD: at this point the conceptual design of iFame began. We finally moved to the participatory development phase with the internship the iFame developers took at the Smart Campus lab, actively contributing to the creation of the app. During the design, we witnessed a constant self-selection of the community, leading to a small number of highly motivated people who built iFame as a tool fed back to the community itself. However, most of the other participants did not disappear but became potential member of the community of users.

Similar to a grain of sand, iFame fell through the lower part of the hourglass to be received by a community characterised by different degrees of involvement, as highlighted by the shades of colours in Figure 4. Most of its members just profited from the information provided by the app (*opportunistic use*); some of them, however, contributed content to the app by commenting and rating the food. A smaller group of users chose to contribute at a higher level, reflecting on the app and on its functionalities: they shared their opinions with the staff and the rest of the community through the communication channels available. Finally, even though we are just entering this stage, we have some evidence of the willingness of some members of the community to engage even more actively by contributing to the further development of the technical and social infrastructuring, in different ways according to their different skills. For instance, technically-skilled users are more likely to become part of the development group, yet we are witnessing increasing interest from social science students offering their help for future functionalities and community establishment.

The hourglass is a temporal process where the social and the technical infrastructures developed synergistically. By the time we reached the stage of participatory development, we had also created a receptive environment through the incubation in the lab (which provided technological, political, organizational and logistic support), the establishment of the platform as a technological infrastructure, and an acceptance of participation also at an institutional level (instead of the limited political support we received in the early stages of the project, especially for what concerned the choice of services to be implemented). Moreover, a knowledge base instrumental to the PD phase was built, for instance by incorporating PD practices into the academic career of participating students. As users go through the hourglass, they are more and more exposed to methodologies and techniques about what to design, social innovation and PD. The hourglass also represents a dynamic system that in some cases can be turned upside down: the community can feed new requirements into the process, starting a new cycle of innovation.

Considerations

The hourglass approach unfolds on the process of infrastructuring. We frame this concept on the proposal of (Björgvinsson et al., 2010), and we apply it to an ICT innovation project in a University campus. Furthermore, we contribute to research on work-infrastructure (Pipek and Wulf, 2009) with an emphasis on public settings and a stronger emphasis on the social stream. To facilitate this process we propose the use of infrastructure probes not only as artefacts aimed at bridging the gap between use and design (Dörner et al., 2008; Gaver et al., 1999), but also as materials for reflection as in the case of our apps. The use that people did of these materials allowed evaluating the technology and served as a source of inspiration for both users and designers.

The hourglass approach integrates and expands previous proposals to social innovation. The beginning of the design phase resembles a crowdsourcing approach in the emphasis put on the wisdom of a large number of people (Surowiecki, 2005), but it aims at transforming the crowd into an active community. The participatory steps unfold on democratizing innovation (Björgvinsson et al., 2010), but they push the boundaries of participation to the physical assembly of the artefact. However, rather than pursuing a EUD approach (Fischer et al., 2004), we relied on the different skills of a self-selected community of

volunteers. The student developers can resemble lead-users (Von Hippel, 2005) in that they have special skills: however, in the hourglass approach they spontaneously emerged from the social infrastructure, rather than being selected based on some unique characteristics. We do not believe that these students were able to identify needs before other people did, or were better positioned to obtain a solution to those needs; instead, involving a smaller group of students was the practical approach to move towards the development of the envisioned designs while incorporating the feedback provided by the larger group.

The co-evolution of the social and technical infrastructures allows coping with issues of scaling (Dalsgaard, 2010), adapting to the innovation milieu (Björgvinsson et al., 2010), and defining responsibilities (Kensing and Blomberg, 1998). To *scale* and reach a larger number of potential users we exploited a variety of techniques from UCD; furthermore, participation to the project was integrated into practice, and evaluated as part of students' curriculum. In this way, students were educated to new perspectives on design and participation while being given immediate recognition of the importance of their involvement. The potential of this approach is witnessed by the many students who maintained an active role in the project well after the course was over.

The hourglass approach originated in a specific *innovation milieu*: a mid-size University campus in Europe characterized by limited possibilities for direct participation. Since the beginning of the design, we had the opportunity of working together with the students, yet the selections of roles they could play was initially constrained to that of evaluators, as they were denied a role in decision-making. However, the milieu has been changing during the project as students had a strong voice in the design of iFame and an application for student assessments of the educational offering is currently under development. This suggests that we succeeded in creating a space for community-based development, and at the same time in creating a receptive environment for participation. However, exporting this approach from the campus to the city of Trento might pose additional challenges (e.g. diversity, motivation for engagement); and citizens' opinions might complement or confront with those of university students. However, we are confident that the established socio-technical infrastructure will help us better understand and respond to the complexity of the city as innovation milieu. Infrastructuring provides the required resources to take action when addressing different matters of concerns (Le Dantec and Di Salvo, 2013); participation can help discussion among different opinions, but.

The staged process proposed by the hourglass model facilitates the *definition of responsibilities* in a dynamic environment. Designers fine-tuned their intervention preparing a technical (through the development of the platform) and social ground (through the application of UCD techniques and a progressive involvement of institutional stakeholders) to maximise participants' gains and minimise failures (Bossen et al., 2012). These two streams evolved in parallel to create the social and technical conditions for the actual pursuit of social innovation: however, neither of them alone was sufficient to achieve this goal, and thus they needed to intersect at some point (in our case study, generating iFame). The staged process was particularly adapted to a context that is not historically and culturally oriented to public participation. For instance, the fact that the canteen community and the forum constituted channels where comments and user-generated content could help monitoring the quality of service was seen as a controversial point by the University, which feared that these channels would be used in an inappropriate way: our social and technological intervention has allowed them to overcome these worries. On the other hand, user participation also raised some difficulties; bringing user representatives through the hourglass is especially hard in the moment of unpopular decisions. For example, in several occasions the iFame developers showed resistance to change when the design or the choice of functionalities were constrained by political opportunity or technical unfeasibility, or when they addressed "matters of concern" they did not personally share: for instance, the app does not account for special dietary requirements, even though this point was frequently raised by different user groups.

The domain of students as users might appear somewhat constrained and limiting of the validity of achieved results: however, we have witnessed a great variability in it, for instance in the needs of students whose departments were located in different districts of the city. This appeared particularly clear in the early UCD phase, where the user sample was larger, rather than in the participatory development phase. It should be noted that reducing the number of involved actors during the process necessarily implies carrying along values that are representative of this. Another limitation is the fact that only a selected number of stakeholders were involved in the project: in the case of iFame, for instance, none of the canteen staff was consulted during the process. However, the existence of the infrastructure now allows us to overcome this point.

FINAL REMARKS

Nurturing and maintaining "infrastructures" are among the main challenges that bottom-up approaches to innovation are currently facing. These challenges are intensified if innovation is the hub where research, education and business converge. Involving and accommodating different stakeholders and activities to unfolding situations requires a shift from current approaches adopted in these areas that entails constant dialog among stakeholders, modification of current processes, and the capability to adjust to changing circumstances. The hourglass approach we propose to social innovation in ICT can facilitate these processes.

ACKNOWLEDGMENTS

We thank all the Smart Campus team, in particular Sylvie Noel and Cristina Core, and all the students who have been developing and evaluating iFame. We also wish to thank TrentoRISE and the University of Trento for their monetary and institutional support.

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