Tiles-Reflection: Designing for Reflective Learning and Change Behaviour in the Smart City

Francesco Gianni(✉), Lisa Klecha, and Monica Divitini

Department of Computer Science,
Norwegian University of Science and Technology, Trondheim, Norway
{francesco.gianni,monica.divitini}@ntnu.no, lisark@stud.ntnu.no

Abstract. Modern cities are increasing in geographical size, population and number. While this development ascribes cities an important function, it also entails various challenges. Efficient urban mobility, energy saving, waste reduction and increased citizen participation in public life are some of the pressing challenges recognized by the United Nations. Retaining livable cities necessitates a change in behaviour in the citizens, promoting sustainability and seeking an increase in the quality of life. Technology possesses the capabilities of mediating behaviour change. A review of existing works highlighted a rather unilateral utilization of technology, mostly consisting of mobile devices, employment of persuasive strategies for guiding behaviour change, and late end-user involvement in the design of the application, primarily for testing purposes. These findings leave the door open to unexplored research approaches, including opportunities stemming from the Internet of Things, reflective learning as behaviour change strategy, and active involvement of end-users in the design and development process. We present Tiles-Reflection, an extension of the Tiles toolkit, a card-based ideation toolkit for the Internet of Things. The extension comprises components for reflective learning, allowing thus non-expert end-users to co-create behaviour change applications. The results of the evaluation suggest that the tool was perceived as useful by participants, fostering reflection on different aspects connected to societal challenges in the smart city. Furthermore, application ideas developed by the users successfully implemented the reflective learning model adopted.

Keywords: IoT · Reflective learning · Smart cities

1 Introduction

Nowadays, more than half of the world's population lives in cities [6]. Urbanization at this scale ascribes cities a key function, as cities have a vast influence on economic and social aspects, as well as environmental impacts [1]. However, as cities grow, so do the challenges they face. Challenges comprise, among others, a difficulty in waste management, scarcity of resources, air pollution, human health concerns, traffic congestion, and deteriorating infrastructures together with increasingly complex social problems [11]. Those issues exert a harmful influence on habitability, and measures urgently need to be taken to ensure sustainable conditions. In this context the notion of smart city has increasingly gained in notoriety, describing cities that devise smarter ways to manage the challenges imposed on them [5]. Retaining livable cities, and achieving urban sustainability goals requires a change in behaviour towards more sustainable societies [15,18].

While information and communication technologies (ICTs) and the Internet of Things (IoT) appear to be the common denominator in defining a smart city [12], it is increasingly recognized that a smart city is indeed a multidimensional and multifaceted concept and, therefore, smart cities should be studied and analyzed on the basis of multiple components [10]. In Nam and Pardo's conception [22], a pervasive IT infrastructure is essential, but not enough without the engagement and collaboration between city stakeholders. Hence, also human factors are stressed, emphasizing such things as creativity, education and social inclusion. Smart people is a concept that is crucial, as well as smart communities, underlining that collective intelligence and social learning make a city smarter [22].

Technology can help also in mediating behaviour change. The work presented in this paper aims to facilitate end-user participation in the design of behaviour change applications for cities, which utilize IoT as mediating technology, and reflective learning as behaviour change strategy. This is motivated by a systematic review of urban mobility behaviour change applications, which highlighted several opportunities in areas of technology usage, behaviour change strategies, and end-user participation in the design and development process of such applications [16].

While consumers voice concerns about the impact of their behaviour on the environment or on the society, their actions do not conform with those worries [2]. This gap between pro-environmental values and pro-environmental behaviours can be partly explained by the notion of routines or habits, being behaviours that are highly automated, requiring little cognitive effort to be performed [19]. With almost a half of everyday activities being classified as habitual [30], finding effective measures and strategies to break and replace those habits with more sustainable ones is crucial and challenging.

We chose to support this process by creating Tiles-Reflection, an extension for the Tiles toolkit, a card-based ideation toolkit for IoT applications [21]. The extension centres on behaviour change applications in the context of a smart city, with reflective learning posing as the utilized strategy to foster behaviour change. The feasibility and utility of this approach are assessed in workshops with citizens. Reflective learning was chosen as an approach to promote slowness in learning and understanding, meaning to provide people with time for reflective activities and conscious use of technology [13]. Similarly, the concept of *slow change* interaction design, evolves around the idea of creating technologies that facilitate attitudinal and behavioural change over time [29]. Slow change acknowledges that change may take a long time, being an endless and difficult process that should not be forced on people, essentially requiring people to take the first step [29]. Recalling identified issues of persuasion [16], reflection may prove as an alternative strategy for behaviour change. Reflection has been described as having a strong social dimension and being often accomplished collaboratively [17]. This characteristic might be particularly beneficial in a smart city context, in which it should be considered that citizens not solely constitute individuals, but also communities and groups [5].

Boud et al. [3, p.18] ascribed reflection particular significance in any form of learning. They see reflection as "a form of response of the learner to experience", in which the experience is recalled, pondered on, and evaluated in order to gain new understandings and appreciations. In short, reflection turns experience into learning. The trigger for reflection may thereby emerge from an external event, or from a state of inner discomfort, but likewise from more positive states, for instance upon the successful completion of a task. Krogstie et al. [17] follow this perception of reflective learning, they see it as the "conscious re-evaluation of experience for the purpose of guiding future behaviour". Boud et al.'s model of reflective learning further informed the development of Krogstie et al.'s Computer Supported Reflective Learning model, hereafter referred to as CSRL model [17]. The model is presented as a four-staged reflective learning cycle, comprising plan and do work (1), initiate reflection session (2), conduct reflection session (3), and apply outcome (4), each encompassing a number of activities. Results from these stages feed as input to the next, including data on work, a frame for reflection, the reflection outcome, and a change on the activity.

2 Related Work

In a previous work, we surveyed technological applications for behaviour change in the city [16]. A systematic literature review was conducted, exploring previously envisioned or implemented solutions, addressing urban mobility behaviour change. Three areas were thereby mostly of concern: (i) the utilized technology, (ii) the behaviour change strategies, and (iii) how end-users participated in the design and development of these applications. The review revealed an unilateral use of technology, favouring mobile applications. Persuasive strategies were foremost guiding behaviour change, and end-users appeared to be involved mainly for testing purposes, late in the process. Furthermore, it emerged that most of the applications were primarily tailored for individual use, rather than collectives. These conclusions exposed several opportunities in the aforementioned areas that are unexplored, briefly summarized in the following.

Adopted Technology - Ubiquitous technology and the IoT emerged as opportunities for breaking new technological grounds. This approach is supported by research on technology-enhanced smart city learning [8]. In a systematic mapping of the topic, mobile devices were likewise identified as the prevailing category, whereupon interactive objects and the IoT are recommended, as they provide novel interaction modalities. This argument was further reinforced in a subsequent article, in which the limited interaction possibilities of mobile devices were addressed [9].

Behaviour Change Methodology - Due to the identified shortcomings of persuasive systems, previous research advocates a shift from prescription to reflection [4]. Reflective learning resulted as a more efficient and long-lasting approach than strategies based on persuasion.

User Participation - Active citizen or end-users participation is emphasized as a prerequisite for behaviour change system development in a smart city. This view suggests a move from "making technology designers arbiters of all things sustainable" towards "a more deeply involvement of the users" [4]. On the same line, Pettersen and Boks [26] describe participatory design as a method that can "contribute to the development of socially robust, ethically justifiable technologies for behavioural change".

End-user involvement is advantageous also in the context of sustainable behaviour change applications. Participatory design approaches facilitate democratization of design, empower people, and not least, emphasize diversity in the groups they include [26]. However, user involvement in the development of behaviour change applications is scarce in the smart city domain [16,28], as well as in other research fields concerned with sustainability themes [4]. Only a small percentage of works report the adoption of participatory design methods, or other forms of user engagement, during the design phase of the applications.

3 Supporting Tools

We investigate the possibility to extend the Tiles toolkit [21], which has proved to be an appropriate tool for co-design of IoT applications targeting a diverse set of stakeholders, ensuring inclusive design and support creations that are citizen driven. However the tool does not specifically target the design of behaviour change that is rooted in reflective learning. Therefore in this paper we propose Tiles-Reflection, an extension of the original toolkit introducing the reflective learning component.

Tiles is a card based design toolkit for IoT, meant to serve as a source of guidance and inspiration when brainstorming applications involving augmented objects. For this purpose, it encompasses a set of 110 design cards and a workshop technique, structuring the use of the cards by means of a playbook reporting step by step instructions, and a cardboard.

Seven distinct decks of cards are devised to abstract the complexities of IoT technologies, making the concepts tangible for non-experts. Customizable personas and scenarios provide constraints to help focusing the idea generation process, while further facilitating participatory design of smart object applications as user-centred design artifacts. Another notable aspect of the toolkit is its flexible adaptability to a variety of domains [21]. Creative workshops can be conducted with 2–6 participants, and are meant to be supervised by professionals. The playbook and cardboard foremost guide the activities during the workshop. Within the playbook, seven design steps are described, walking the participants through the design of one or more augmented objects.

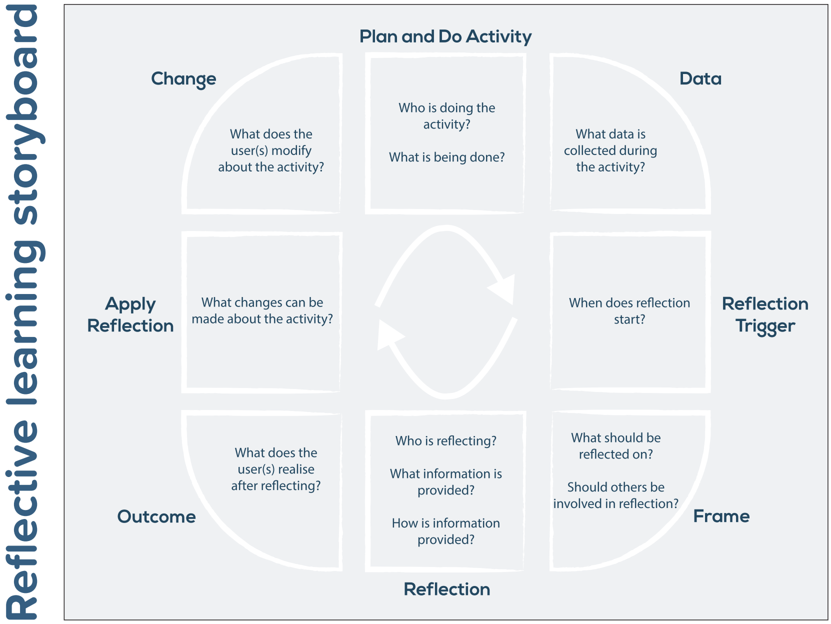

Fig. 1. The reflective learning storyboard used during the workshops.

The original Tiles toolkit has been extended to support the development of IoT applications promoting reflective learning. Four suitable stages were identified at which reflective learning had to be introduced, two of which were directly integrated into already existing Tiles components (*mission* and *criteria* cards), while two novel elements were introduced in the form of an additional reflective learning storyboard (Fig. 1) and a more detailed frame to describe the persona, based on a simplified version of the *persona in practice* model, introduced in the MIRROR design toolbox [25]. In addition, to facilitate the inclusion of multiple target users in the reflective idea, users were asked to list a possible set of persons or communities pertaining to the *social circle* of the chosen persona (Fig. 2).

The additional, reflection oriented, *misson* and *criteria* cards served to focus the design of the application from the very beginning and provided criteria to retrospectively assess, and eventually fix, the reflective dynamics embedded by the participants in the application idea. The *persona in practice* model provided additional structure in the definition of the target user. Participants were encouraged to define upfront the sub-optimal behavior to be changed through the reflective IoT application, and the attitude towards technology and behaviour change of the persona. The reflective learning storyboard (Fig. 1) essentially corresponds to the CSRL model [17] in shape and content, however, some aspects were altered to better fit the context of behaviour change, considering that the CSRL model has been designed to depict reflective learning in the workplace. The model is composed of four stages interleaved by four transitions. Starting from an initial activity,

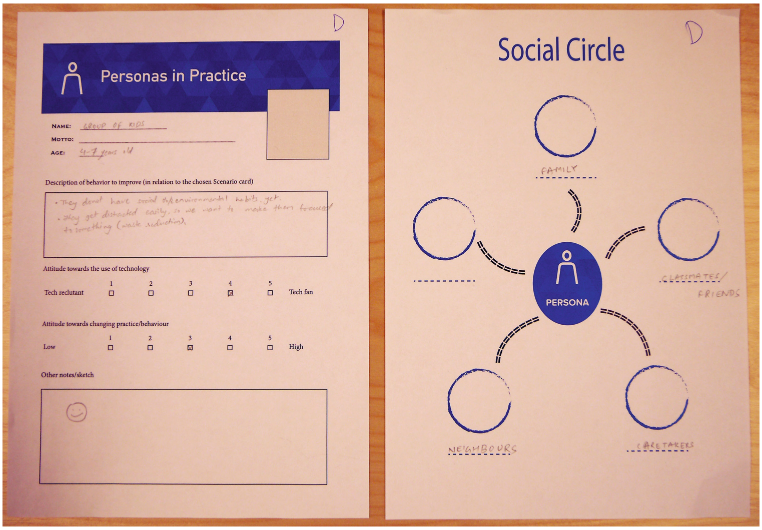

Fig. 2. Persona in practice and social circle models used during a workshop.

data is presented to the user in order to trigger the reflective process, the outcome of which fuels and describes a concrete change that is then applied to modify and improve the original activity, closing thus the reflective circle. Each stage is represented on the storyboard by a square, while the transitions represent the corners of the diagram.

4 Design Process and Evaluation

Three focal assessment objectives for the workshops were researched:

– **[O1] Usefulness** - the perceived usefulness of the Tiles toolkit and workshop in supporting the design of reflective applications;
– **[O2] Reflective Learning** - the effectiveness of Tiles-Reflection in supporting the design of reflective IoT applications;
– **[O3] Co-Design** - the perceived usefulness and intrinsic motivation provided by the co-design approach of the workshop, stimulating inclusion and participation.

Human-computer-interaction defines usefulness as the sum of usability and utility [23]. In order to assess the cards' usefulness, this equation was used to frame the evaluation. While usability describes the ease and pleasantness of using the tool, utility relates to whether it provides what the user needs [23].

Data about the workshops were collected in two ways. Prior and after the workshop the participants were asked to fill out questionnaires. Data collected included information about participants' demographics and their perception of the workshop experience. This approach yielded in quantitative data, which were aggregated and analyzed using a spreadsheet software. During the workshop, notes documenting the observed dynamics were taken and a camera recorded the cardboard, capturing how the participants interacted with each other and with the extended Tiles toolkit. Eventually, the video footage allowed to extract qualitative and quantitative data about: (i) issues with the Tiles elements (playbook, cards, cardboard); (ii) issues with provided guidance and information; (iii) suggestions about improvements; (iv) time spent on each step of the workshop and in total; (v) the devised augmented object application.

Lastly, group interviews were held to obtain a more thorough understanding of participants' opinion on the workshop matter. Research objectives O1 and O3 were thereby mostly assessed through questionnaire data, whereas research objective O2 was assessed solely with the gathered video and photo material. The evaluation was then informed by the guidelines outlined in [24]. The design of the reflective learning extension of the Tiles toolkit was performed and refined during multiple iterations. The evaluation focus is kept mainly on the Tiles-Reflection extension, since the generic workshop and toolkit have already been evaluated [21]. For each iteration, one or more workshops with the users were performed to evaluate the design and collect feedback. We hereby briefly present such iterations, which are summarized in Table 1.

I - two master students of the department of computer science were invited to test the workshop protocol and the Tiles extension prototype during a pilot workshop.
II - three researchers participated in the second iteration, the workshop protocol, cards and reflective storyboard experimented in the pilot were finalized and employed during this phase.
III - a rather diverse group of users took part in the third evaluation. The four groups included high school students, municipality employees, freelancers, entrepreneurs and programmers from a local coworking space. In an attempt to possibly reduce the time needed to browse the many cards, additional mission cards aside of the preset reflective learning mission card were removed.
IV - the last iteration comprised five groups composed by computer science university students. In order to decrease the level of support needed by the participants and to provide better guidance during the workshop, the *persona in practice* and *social circle* models were introduced in this iteration.

Table 1. Details of the workshops.

Iteration	N	N. groups	Age	Occupation
I	2	1	19–27	University students
II	3	1	40–55	Researchers
III	13	4	17–50	Students, municipality, entrepreneurs
IV	25	5	20–40	University students
TOT	43	11		

5 Results

We now present the results of the four iterative evaluations, following the research objectives previously presented in Sect. 3.

O1: Usefulness - Data from the questionnaires, presented in Fig. 3, shows that the workshop was perceived as useful for the design of reflective IoT applications. The following statements are reflected in the statistics:

- **S1:** The criteria cards helped me to evaluate my idea with respect to reflection;
- **S2:** It was easy to design an application that supports reflection;
- **S3:** The reflective learning storyboard was easy to use;
- **S4:** I can imagine conducting a workshop using Tiles without guidance, on my own or in a group;
- **S5:** I can think of other scenarios in the city where IoT could be used.

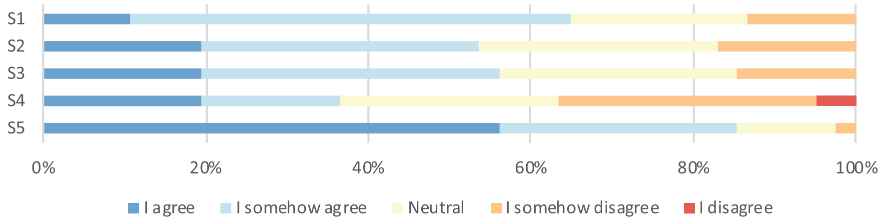

Fig. 3. Results of the questionnaire statements relative to O1.

The overall utility of the tool was rated positive (statements 1–3), as more than 50% of the participants adjudged the tool to be easy to understand and helpful during the ideation of reflective applications. Particularly well perceived was the statement pertaining the potential of the tool for other urban scenarios. Mixed opinions were extracted from S4, where there's near perfect balance between participants that can imagine conducting a workshop on their own and participants who can't.

O2: Reflective Learning - Most of the groups were successful in developing an idea involving IoT and reflective learning. Among the ideas created during the workshops, an augmented wheelchair that provides feedback when a more accessible route in the city is available; a mug which shows to people in the room random tweets posted by the owner, to increase privacy awareness about the information shared online; a smart recycle bin that reacts with emojis and visualizes environmental impact data about the trash when kids fail to recycle in the correct way.

We now analyze in more detail the smart recycle bin application. The cardboard, cards and reflective storyboard used during the workshop can be seen in Fig. 4. The chosen *persona in practice* is a group of children 4–7 years old, which have no education in social environmental habits. The application provides the children with information about the trash and a direct feedback whenever they use the bin. These outputs act as reflection triggers, envisioned during the second stage of the CSRL storyboard, and are intended to have a double effect on children's perception of environmental sustainability. On one side they are confronted with the impact of the trash produced, and in addition they receive a negative feedback, in form of sound or emoji, if the trash is not placed in the correct recycle bin. The intended outcome of the reflective learning process is an increased awareness of the environmental impact of waste and knowledge about how to correctly recycle trash. The devised application is mapped into the CSRL model's stages and transitions through the reflective learning storyboard reported in Fig. 1, to reveal the degree to which the idea is potentially able to support reflection.

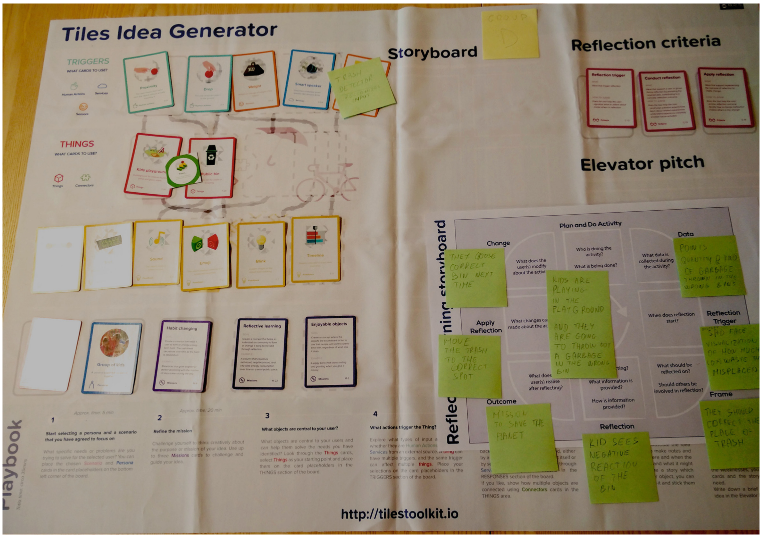

Fig. 4. The cardboard, cards and storyboard at the end of one of the workshops.

O3: Co-Design - The results collected through the questionnaires are shown in Fig. 5, the following statements are reflected in the statistics:

- **S6:** I think that being involved in the design of such applications would motivate me to later use them;
- **S7:** I think that involving citizens/end-users in the design of such applications will result in more innovative solutions.

The majority of participants strongly agreed with both the statements, underlining that the respondents considered the involvement of end-users in the design process as crucial.

6 Discussion

O1 - Observations and questionnaire results underpin that the Tiles-Reflection workshop was very well received, and perceived as useful by participants. Diverging opinions were only observed in relation to if people could imagine conducting a workshop by themselves, without guidance. The statement essentially aimed at assessing whether people may utilize the Tiles-Reflection workshop themselves for ideation, hence for citizen-driven, bottom-up innovations that would address their specific needs. This view is in line with the concept of "empowering people to devise ways to run their daily lives as smartly as possible, making their extended community –the actual embodiment of a city– smarter, too" [27]. Despite the questionnaire results on the matter, we observed an improvement in the ability of the groups to work more independently, while still delivering relevant ideas. This improvement has been registered during iteration *IV*, and might be due to the additional support provided by the extended persona models. For comparison, all the groups in the first three iterations were directly supported by at least one of the authors for the whole length of the workshop, while during iteration *IV*, only one of the authors supervised the workshop, attended by five groups simultaneously. Results suggest that the Tiles-Reflection workshop is indeed useful for co-creation practices. It is, therefore, more reasonable to consider the Tiles tool with the reflective learning extension, as a mean for stakeholders to provide meaningful input to the design of reflective learning applications, rather than a way for novices to design an application in all its details by themselves. Eventually, results of the different design and evaluation iterations further suggest that the format improved over time.

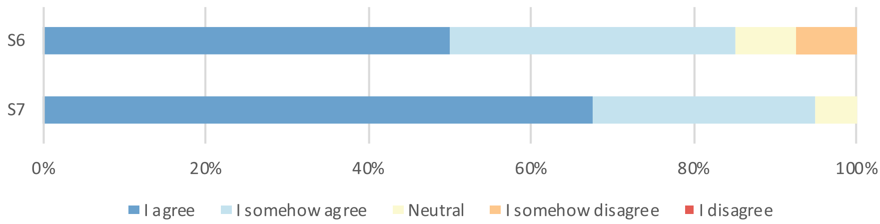

Fig. 5. Results of the questionnaire statements relative to O3.

O2 - It was pleasant to observe that participants fully immerse themselves in the task scenario, discussed personal experiences regarding sustainability, and put themselves in the position of future users. Overall, the outcome illustrate that all groups managed to incorporate reflection sufficiently in their application design. Some groups had more difficulties envisioning how technology could facilitate the last step of the reflective process, explaining how to modify the practices applying the results of the reflective process [7]. Krogstie et al. [17] state that certain aspects of the CSRL model are "more or less explicit", such as the reflection frame or reflection outcome, or "more or less elaborated" and "brief and closely integrated with other activities", such as the reflection trigger stage. Hence, researchers and designers eventually involved in the co-creation process, can help tailoring the reflection elements to the specific ideas envisioned by the participants, emphasizing the reflective steps when needed. Pertaining to the reflective learning additions of the Tiles toolkit, participants appeared to be confident in using the cards and the storyboard, with some groups even explicitly using the storyboard to pitch their idea to the authors. Finally, since many of the participants were new not only to the concept of reflective learning, but also to the nature and definition of an IoT application, it was particularly challenging for them to first get familiar with the new notions and then successfully apply them to create an innovative solution.

O3 - Participants in iteration *III* affirmed that the co-design workshop facilitated their reflection, they even voiced interest in using the workshop as a mean to reflect with their co-workers and management. Most participants perceived end-user involvement in the development of the reflective applications as beneficial. This viewpoint underlines people's interest in participatory design, which might lead to an increase of both innovation and adoption, thus research on co-creation tools appears particularly eligible.

Summarized, results from the workshops showed that an adequate time frame, illustrative examples regarding IoT and reflective learning, as well as participants actively communicating and collaborating during ideation, are all crucial factors for a successful workshop session. As anticipated by participatory design methodologies, workshop facilitators were confirmed as an essential component to guarantee a valuable outcome, their role in supporting the users during the ideation process has been once again fundamental.

7 Conclusions

With this work, we proposed a tool to involve citizens in the ideation of technological applications, promoting sustainability, behaviour change and lifelong learning through reflection. Shifting the focus to cities has gained in momentum, in particular enabling citizens to take an active role in the development of cities of the future [14]. Bottom-up innovation and collaboration are needed alongside top-down approaches [14]. Concepts such as Human Smart Cities [20], and the notion of Smart Citizen [14] underpin this standpoint. Tools like Tiles-Reflection can contribute to these objectives by providing means for ideation of reflective IoT applications with diverse stakeholders. Furthermore, as the Tiles toolkit provides possibilities for prototyping [21], citizens can become makers and active contributors. Eventually, "there can be no smart city without smart citizens" [27].

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