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Designing through ideation cards for Internet of Things: can cards help engineers out of the box?

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Abstract

This paper reports on our experience of applying a cards-based ideation method and tool in a design for Internet of Things (IoT) workshop. In this workshop, master students of engineering participated, who had a good understanding of IoT technologies. The workshop run for two years, and has produced some interesting findings in terms of applicability of such method to this context, with special focus on supporting innovation.

Keywords: Internet of Things, ideation method, card-based design, engineering education

Introduction

Flexibility and ability to work in a broader multi-disciplinary perspective are recognized as key skills for the 4th generation industrial revolution and ones that engineering education should try to address (Glazer, 2018). Attempting to approach this need, a teaching intervention was set up aiming to see what students gain from design methods, when these are introduced to them as part of their–IoT applications design- assignments.

In this context, an IoT cards-based ideation method was introduced to engineering master students, in order to assist them with IoT scenarios ideation, facilitate their skill development in ideation design methods, and assess the method in an educational workshop using gamification cards as a facilitator for ideation. The workshop ran for two years and has produced some interesting findings in terms of the applicability of such a method to this context, with particular perspective the generation of innovative ideas to the specific problems of the workshops, i.e. aiming to assess if this approach allows for 'out-of-the-box' design thinking.

Background

Design cards have been used extensively as tangible objects, around which many discussions and arguments are anchored, guiding the processes of ideation and negotiation, allowing introduction of new and different perspectives (Hornecker, 2010). Also, cards can help focus shift when the discussion becomes unproductive. Finally, cards can be used as guidance for evaluation of the produced solution. Examples of ideation cards in design include the *Tango Cards* (Deng, Antle, & Neustaedter, 2014) for tangible learning games, *Inspiration Cards* (Halskov & Dalsgaard, 2007) that included cards on the domain, as well as technology, *PLEX cards* (Lucero, & Arrasvuori, 2010) for game design, *DEMO cards* for motivational design (Chasanidou, 2018), while a particular approach with focus in tangible interaction with IoT devices is the *Tiles cards* that have been used in this study (Mora, Gianni & Divitini, 2017). Motivation for using this approach has been the special focus of the workshop on IoT. In addition, the domain of the design workshop has been that of cultural heritage, where there is a particular need for introducing physical assets in combination with digital ones as discussed and demonstrated in (Petrelli, Ciolfi, van Dijk, Hornecker, Not, & Schmidt, 2013).

The Tiles toolkit version 0.6, was used, available from (Tiles, 2018). It contained the following different cards: *missions*, proposing 21 design missions centered on human needs and desires, *things*, 25 objects that may be augmented with technology to become connected and interactive, human *actions* and *feedback* (9 each), describing how people can interact with things, *services* (25 cards), that concern popular apps and online services that can communicate with the things, and finally 10 *evaluation criteria* cards. The rules were adapted in order for the ideation activity to be constrained within the time limits of the workshop and give more playful character by introducing turn taking, and roles of defender and attacker of cards, as discussed next.

Context of the study

The design workshop was organized in two consecutive years in the frame of the graduate course 'Design of Interactive Systems' of the Combined Master's in Electrical and Computer Engineering of the University of Patras. In total, 30 final year students participated in the workshop (ages 24-26) that formed 7 groups made of 4 to 5 members each. The first cohort (2017) had 12 students, in 3 groups of 4. The second one (2018) had 18 students, in 4 groups of 4 or 5 students each. All students' major subject of study was electrical and computer engineering, split between some with more emphasis on hardware and systems design, and the rest in software technologies. The design workshop had a duration of approximately 2 hours. At the beginning the students were introduced to the *Tiles* ideation toolkit and key concepts of Internet of Things (IoT). It should be mentioned that all participants had a good background on key technologies related to IoT, as *embedded systems*, *networking*, *Internet programming* and *virtual reality* are part of their curriculum.

Figure 1: Images from the workshop

Then they were given the task of designing an innovative application or device to be used in the context of a cultural heritage site. The 2017 students were asked to work on an application to support visitors of an unspecified museum. The 2018 ones were asked to design an application for the visitors of an archeological site, specifically that of Pompeii in Italy, a familiar site, since they had participated in a game design workshop for Pompeii, a week before, during which they were given information, like site maps, historical background, etc. In Figure 1 some views of the workshop are shown.

The workshop was organized as follows: For each design phase, each player drew cards in turn, and when the player found one she thought was relevant, she argued defending it, while the rest argued for rejecting it. The first phase (50 min duration) involved investigation of possible missions, using the 21 *mission* cards, shown in Figure 2, followed by 25 *thing* cards (Figure 3). Participants were asked to use 2 to 3 cards from each category. Then they looked at *services* that they could use (see Figure 4), and finally they used the human *actions* cards (Figure 5) and corresponding *feedback* (Figure 6). Using the selected ideation cards, they had to proceed with defining some scenarios of use of their design.

In the final phase of the workshop they had to use *criteria* cards for evaluating their proposal. Finally, they had to photograph the material (board, cards, notes) and reflect individually on the design and prepare an individual report, to be handed in a week later. They were also asked to evaluate the tools and the group activity.

Missions								
custom mission								0
trojan horse								0
coded information								0
habit changing								0
social interaction						■		1
enjoyable objects								0
time saver							■	1
transactions				■				1
immortality					■			1
in the mood								0
omniscience	■	■	■		■	■	■	6
obstacles						■		1
feeling blue								0
teleportation		■	■	■				3
tangibles								0
sixth sense			■					1
safekeeping								0
supper shopper								0
big brother	■				■	■	■	4
telepathy								0
expression					■			1

Things								
custom thing			■	■	■	■		4
bike								0
wallet								0
watch						■		1
eyewear		■		■			■	3
keychain								0
pen or pencil								0
luggage								0
clothing			■					1
refrigerator								0
office desk								0
shoe								0
headgear	■						■	2
camera	■	■						2
piggy bank								0
furniture								0
coffe cup								0
umbrella								0
sport equipment								0
plant								0
jewelry								0
medication								0
pets								0
stove								0
shower								0

Figure 2: Cards used for *missions* by the groups, each column corresponds to a group (order: 18A, 18B, 18C, 18D, 17A, 17B, 17C), Figure 3: Cards used for *things* by the groups.

Results

The produced designs of the groups were based on the Tiles shown in figures 2 to 6. In particular, the *Missions* that attracted the attention of most workshop participants were *Omniscience* (objects that provide the user with knowledge, or with access to information) selected by 6 groups (86%), followed by *Big brother* (an object whose purpose is to collect data that is valuable either to you or a third party), used by 4 groups (57%), and *teleportation* (objects that allow the sensation of being in multiple places at once, or that let you experience some aspect of a different place), used by 3 groups (43%). An interesting point is that no group thought of any missions beyond those suggested by the tiles, and therefore no-one used the *custom mission* card. In total, 10 out of 21 mission cards were used (Fig. 2).

Next in terms of *Things* used (Figure 3) the design ideas employed are even more confined, just 6 out of the 25 suggested things were used. Some groups referred to the same concept using slightly different wording, and thus using different cards. For instance, some groups referred to the *custom thing* 'headsets', while other groups referred to the same equipment as headgear, or eyewear to refer to head-mounted displays for VR or AR applications that, as we will discuss in the next section, were the prevailing technology in most cases. One group thought of using temperature sensors, another an 'ultrahaptics array' for sensing objects in

VR environment, and another one a tablet and stylus for drawing. A group suggested use of a watch and another clothing (gloves).

In terms of *Human Actions* the groups identified *proximity* as the most used action (71% of the groups) followed by *tapping* (57%), location change (43%). Here we observed the need for more complex human actions, as the groups introduced their own actions, like photo taking, body movement, grabbing virtual objects (e.g. through ultrahaptics arrays) and zooming actions. These special needs derive from the complex VR and AR technology used and therefore relevant interactions in many of the scenarios.

In terms of *feedback* provided, *sound* was used as a means of feedback by 5 groups (71%), followed by *text* and *vibration*, while some special needs were related to movement in a virtual reality scene.

Finally, the *services* that the different groups used ranged quite extensively as it can be seen in Figure 6. A service requested by 4 different groups was related to geolocation and movement tracking, while storage service was also requested by 4 groups. In total 11 different services, out of 25 were used by the participants.

Human actions								
custom action	■		■	■			■	4
rotate	■							1
shake								0
drop								0
lift								0
tilt								0
location change		■				■	■	3
tap		■		■	■	■		4
proximity		■	■		■	■	■	5

Feedbacks								
custom feedback	■						■	2
emoji								0
motion	■		■					2
text		■			■	■	■	4
sound		■	■	■		■	■	5
color change					■			1
blink								0
vibrate		■		■		■		3
shapeshift								0

Figure 4: Cards used for *human actions*, Figure 5: Cards used for *feedbacks*

The produced designs

A brief presentation of the produced designs is as follows.

2017 workshop:

group 17A: (For a Modern art museum), augmented reality glasses, and a tablet and stylus. Through the stylus the visitor can pick up the colour of a real object and use it to draw shapes on the tablet, inspired by the exhibit. The artwork of the visitors can be saved on the site of the museum, and the best artwork included in the collection.

group 17B: A personalized guide in the museum, in the form of a smartwatch and headphones. The guide suggests exhibits based on previous user behaviour and other visitors' traces. Suggestions are also made about collocated visitors with similar interests.

group 17C: An augmented reality glasses-enabled tour of the museum. When in front of an exhibit, the visitor can select to watch a video related to the exhibit. The order to provide a personalized experience and make recommendations.

2018 workshop:

group 18A: Immersive virtual reality application providing experience of Pompeii before the volcanic eruption, at various VR stations in the site. Public web cams will capture movement and faces of real visitors that will populate the artificial world. Possibility of taking a picture of the visitor in the artificial setting at a photo boot and uploading it in Instagram.

group 18B: Smart glasses augment view with audio and text about locations and images of the exhibit as it used to be. It also provides the visitor with data about popularity of exhibits, ratings of other visitors. (Augmented reality application).

Services								
custom channel			■	■		■	■	4
health and fitness service								0
mail								0
bank account								0
weather								0
twitter							■	1
instagram	■						■	2
facebook							■	1
todolist						■		1
cloud documents		■						1
maps				■				1
calendar								0
stocks								0
traffic								0
public transit								0
storage			■		■	■	■	4
messages								0
music								0
news								0
alarm/reminder						■		1
car								0
public webcam	■							1
market place data								0
smart speaker/amazon echo		■					■	2
smart home data								0

Figure 6: Cards used for *services*

group 18C: A special room in the archaeological site is used for providing virtual reality experiences of the site as it used to be. The visitor is equipped with a head mounted display and gloves. The experience is augmented with sensing smells and haptics, while room temperature is adjusted accordingly. A walking surface allows for providing the experience of moving.

group 18D: An augmented reality application that allows the visitor to see the place as it used to be. Guidance is provided in textual and voice form. In special locations, ultrahaptics arrays provide extra controls on the scene, the visitor can change the historic period and the time of day using special controls. There is possibility of selecting themes that will modify the narrative (economy, etc.). In specific locations, the visitor can watch episodes of action related to the spot.

Reflection on the experience

29 out of 30 students reported their view on the Tiles cards and the process. The comments were overwhelmingly positive. They thought that the time given for the activity was limiting and the fact that they were constrained to use a limited number of mission cards sometime frustrating. They observed that combining cards helped them generate new ideas and the cards helped them explore various alternative ideas than their original ones. They claimed that they found particularly useful the *criteria* cards, for which however they had not enough time to fully explore. Some observed that they had not enough constraints on their design, in terms of requirements of the owners of the cultural heritage site. Interesting comments made were related to alternative design ideas that they dropped, due to the fear that they will be too hard or impossible to implement.

Discussion

What is noted from the results of this educational intervention is that engineering students tend to resort to technologies that are familiar to them. Student ideas involved use of smartphones, social media, and existing, familiar to them, mainstream technologies. There was no emphasis on taking another perspective as a starting point for the ideation (addressing needs other than technology use), within this group of engineering students.

The ideation method used is aiming for the production of unforeseen, out-of-the-box application scenario, and in order to do so the method encourages a broader ideation setting. Nevertheless, students avoid to address broader (i.e. societal, organizational, etc.) concerns and fail to open discussion on a broader set of issues, and tend to focus on a technology-centered discussion. The resulting scenarios seem to lack innovation, do not address any novel problems or gaps, and student thinking seem to be “inside the box”, failing to address nonfunctional specifications or broader concerns.

The results observed may be owing to the educational background of engineers, who are trained to think incrementally with a focus on technology specifications and features. One major point to take into account, was that the design was not contextualized in the domain of cultural heritage, and no specific requirements or guidelines were provided from the problem owners. We should note that a more recent version of the Tiles toolkit, has moved to this direction by introducing more constrained problems and cards, relating to the specific problems of smart cities (Gianni & Divitini, 2017). A similar direction towards designing interactive applications and devices for the cultural heritage domain may be proved useful for our purposes.

Given this context, we observed that the use of the specific method (of ideation with game cards) was accepted very positively and used for producing an enjoyable design experience. Despite of this, the workshop did not allow the specific group of engineering students to produce innovative, out of the box ideas. Possible reasons for this outcome may be lack of illustrative examples of IoT in the introductory section, absence of background domain knowledge, and not clear definition of the problem space, as well as the general character of the given set of cards.

Yet, the results of this exercise raise issues for discussion on the effectiveness of the educational curricula within which they are used, and subsequently on the training of engineering students to utilize design methods effectively. Questions as to what kinds of background skills are missing from their (formal or informal) curricula in order for them to be able to approach problems from different perspectives, address broader issues involved, and generate ideas from different starting points, need to be further investigated.

Conclusions

This paper reports on a teaching experiment on introducing card-game methods for the design of IoT application scenarios to engineering master students.

There have been mixed findings related to the specific exercise. On one hand the participants reported a positive experience and they managed to fulfil the design requirements, however the specific approach and workshop design, as part of MA engineering curricula activities, failed to produce improved designs, compared to previous similar workshops, with no introduction of such approaches. So, there are questions raised regarding the motivation and ability of engineering students to use broad techniques and design ideation methods, and, specifically how they should ideally be trained (perhaps as part of foundation training or outside their engineering education curriculum), in order to cope with broader thinking and adoption of multidisciplinary approaches, to assist them with the forthcoming challenges of the 4th industrial revolution.

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