From Interactivity Towards Ambience Through a Bottle-brick

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According to the dictionary ambient architecture should be kind of object or space that relies to its surrounding or spontaneously reacts on the presence of human. Ambient architecture can also be musically expressed [1] or painted [2]. We developed special architectural building units that offer space for incorporation of intelligence and media for human interaction and for ambience. We are introducing an object called PET(ch)air made of PET(b)rick [3], a hollow transparent bottle-brick. The first intention was to generate new building unit from recycled PET material. Now that we observe its qualities, we can see it is well prepared for ambient intelligence application, especially in combination with light. For the purpose of a brick we are transforming old recycled plastic into new bottle-bricks. Using the bottle-brick as building unit we build interior objects that are ready to turn spaces into ambient rooms, places that can be customized by their visitors or spontaneously react on them. Together with this, we opened a design studio, where students were asked to develop ambient interior pieces for a special event using the method of learning by doing.

Keywords: Interactivity, ambient architecture, waste reuse, bottle-brick, PET(b)rick, PET(ch)air

INTRODUCTION
Ambient intelligence is a term introduced by Phillips in 1999 as a vision for the year 2020. [4] The scenario of ambient intelligence is invisible technological support of human everyday life. In many cases it was associated with the home situation and dealing with procedures such as organization of time, temperature fitness, and light comfort. Examples may be automatic light behaviour according to the daylight, and home facility adaptation on the inhabitants via voice or gestures. Ambient intelligence has been described as clever technology (Cook et al. 2009) that surrounds the user regularly and thus may be customized to his needs. The advantage of intelligent equipment of home is that it saves time, which is usually spent on maintenance or that it extends human memory with reminders. Regardless the purpose of its application, this technology must interact with humans via various media: screens, reactive surfaces, kinects, sensors, and so on, which become also ambient. Definition of ambient media is used in advertising industry and was described by Arthur Lugmayr in 2007 as the most relevant combination of message and media available in order to adver-
tise products [6], (Lugmayr 2007). Combining ambient media and intelligent technology needs real environments to be embodied in. In addition to the idea of Internet of things, architecture and design offer relevant platform for implementation of ambience. Ambient intelligence researchers are aiming for a situation, where the home is a pleasant and beautiful space without visible hills of technologies: wires, chargers, black screens, computer boxes and HiFi.

Also the publication called Invisible future (Aarts et al. 2001) mentions, that technology will be generating a new social landscape, and new type of architecture.

**A building brick for ambient structures**

In this paper we report on a building brick that we used to create ambient structures and its use in a studio task. Initially the building brick was developed as a bottle, which holds consumable drink-water - after consumption it could be used as a stackable construction element in non-load bearing structures such as space dividing walls (see below for more detailed description). After we developed the brick, it immediately occurred to us that we could put intelligence inside the brick. The advantage of such an invention is that the brick is transparent, light and hollow and still withstands stress. Therefore electronic devices can be easily included in the interior of the bottle. For initial test-use, we designed a small seat that was able to interact through lights. Our idea was to let people play with the objects that anyway surround them with the use of their own electronic devices and together generate an interior furniture that changes whenever somebody starts to interact. This could be done through a web application, which is entered by a qr code. The interaction had a form of a game. We developed objects, that are apart of their initial function prepared to become also media and education platform for interactivity. We are targeting objects that hide naturally interactivity/ambience in themselves.

**Short report on bottle-bricks**

The idea to develop a building brick with material used for bottles is at least one decade old. There are many reasons why to attempt this: the main material polyethylene tereftalate (PET) is produced in abundance, can be recycled, and is quite strong; many bottles end up after consumption thrown away in nature; areas which face an immediate need for building materials after natural disasters also have a need for fresh drinking water, and so on. Based on this it makes sense to develop a brick that at first hold drinking water and then be used as a building brick. Several people have attempted to create a building brick out of PET material. We found an idea mock-up made by Tim Dubitzky, who tried to interconnect square plastic bottles, generating a small wall. [5] Two working prototypes of blow moulded PET bricks were found in the world very far from each other. (see Figure 1) In 2007 united_bottle [7] was developed by a research group from Switzerland. This bottle was intended to be filled with water and transported into war/catastrophic regions, where the disposed bottles would serve as filling into broken walls. In 2010 united_bottle was followed by Polli-brick, invented in Taiwan by a company called MINIWIZ (Xu and Wang 2013). This bottle was not used as a beverage container, it only served as a facade panel. It was interconnected by a plate.

![Figure 1](image)

Bottle-bricks from the left: polli-brick, united_bottle, PET(b)rick

At Czech Technical University, Faculty of Architecture, we developed a brick - named PET(b)rick - made from recycled polyethylene tereftalate. Out of the list of known bottle-bricks PET(b)rick is the only one which can be bound in six directions and thus it is possible to assemble it into never-ending structures. The development of the brick had to answer several boundary conditions. The most important ones were that
it could be produced in a regular production line for PET bottles, and that it can be stacked to create architectural elements such as walls. For the production we used blow-moulding technology that is the same as for regular PET bottle production. In the future, its price will be the price of a bottle. Because of its particular shape, the PET(b)rick can be bound in all three cardinal directions - therefore it allows the construction of planes and volumes. The PET(b)rick bottle is 7x14x9 cm big and has volume of 0.6 l that can be filled with various media and technologies.

**From PET(b)rick to PET(ch)air**

The advantage of a structure made of hollow transparent units is that these units can be filled either with material or media or technology. The shape is original [3] and allows for connecting in all 6 directions. Any rectangular shape can be built from this bottle-brick, the final product must be bound together and the vertical force must be distributed. Being internally lit and equipped with batteries, processors, and WIFI antenna it can join Internet of Things, waiting for instructions or respond to the presence of people.

The PET(ch)air (see Figure 2) was a small cubic structure bound together with nylon threads and covered with a Perspex grid (see Figure 2). We constructed a number of these chairs and experimented with various technologies to incorporate in the PET(b)ricks that make up the chairs. Interaction with PET(ch)airs was tested with the function of light control at the EXPO in Milano (May-October 2015) and TEDx Prague (date) where peoples’ enquiry and interest was observed. Visitors were allowed to change colours of the objects manually or via their smartphones through Internet application. Both systems had their advantages and both failures, but once an object shines, people look for the possibility to operate it.

The basic quality of light is that it attracts attention and users start playing with the colours manually immediately. It was easy to operate rotating a simple round button or choosing various modes of change. Led lights being ruled by an application via Internet had the advantage that lights could be changed remotely - even from far away - meaning that the system was independent of the position of the user. Visitors were able to play more sophisticated game. More than one cube could be controlled at once. The constraint was that there had to be a smart device with qr code reader in order to master the change of colour. Also WIFI had to be distributed by access point device.

**From PET(ch)air to PET(b)ar**

An experimental studio topic was prepared on the base of this research: "an ambient bar." Students were asked to use the developed technology and invent new principles of ambience in architecture. The aim of the project was to design and build a number of stage sets and objects for the so-called "student's night" at the Faculty of Machine Engineering of Czech Technical University. This event takes place on several locations of the faculty building, and included objects such as a bar, stage, seating area, corridor decoration, lighting, and so on. The whole project would have to run in a very short time. From the start to design and full realization of all the objects for the "student's night" event was only one month. Through the knowledge gained by making the PET(ch)air we could introduce the task of the ambience to a group of students who had never worked with this material before. We prepared a cooperative seminar for students of humanistic discipline of New Media at SNM Charles University in Prague together with students from Faculty of architecture at CTU Prague. Participants of this pilot project got the PET(b)ricks and the hardware (plus sensors on request) in order to be able to directly test their ideas in reality. The result of their cooperative work was immediately used within a public event, where they could observe the installation in real time interaction with lay-users. With this experiment we hope to ob-
tain answer to several questions: does perceiving of ambience differ in both branches? What are the demands? How much are both fields complementary? And will the output fulfil the request of ambience?

Analysis phase. The experiment with the use of PET(b)rick plus lights and sensors started by introduction about interactive bars, that we found as examples on the Internet. We tried to introduce diverse types of interactive technologies, digital as well as mechanical. Spintouch Interactive Solutions bar was found as an example of interactivity. [10] The interactivity was performed by a multi-touch surface, which reacted on any kind of weight laid on the table. Students were inspired by this system, and wanted to use principle of stress although they had no possibility to use any screen. In 2015 MIT introduced TRANSFORM. A transformable mobile furniture was developed by Professor Hiroshi Ishii and the Tangible Media Group from the MIT Media Lab. [11] Students could see the transformation of data into mechanical movements in this example. Ambience was described on an example of Philips research as well as their precedent Hiroshi Ishii's AmbientROOM (Ishii 1998).

Ideas from non-technical students (see Table 1) were based on analysis phase. Students from the Charles University had different attitude than architecture students. They did not derive their ideas from material possibilities, but came up with rather megalomaniac ideas of transmitting of big data (like videos) into installations. Their ideas were rather detached from real possibilities we had. We can also see, that their ideas were mostly interactive and playful rather than ambient, since the installations were only reacting on visitors conscious activity.

Ideas of ambience from technical students (see Table 2) were rather simple and connected to the real objects. The ambient or interactive activity was attached to the designed interior installations and derived from their form. All overall activity was performed by the change of light intensity, flashes or colors of light. Students could also try out their ideas immediately.

The process of designing. We used the method of learning by doing and the agile designing, which meant that short phases of designing switched with hands-on work with PET(b)ricks. Students were given the material and conditions and we observed them designing. It followed the principle of Experimental studio (Nováková et al. 2010), apart of that each phase lasted maximally for one week:

1. Analyses
2. Design
3. "Selling the idea to the investor" - presentation
4. Building prototype
5. Public exhibition

Building prototypes (Figure 3) formed their designs. Students were designing while constructing proto-

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Ideas from non-technical students.</th>
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<tbody>
<tr>
<td>Idea</td>
<td>Ambience</td>
</tr>
<tr>
<td>Real time 3D visualization: LED cube + software unit + kinect</td>
<td>no</td>
</tr>
<tr>
<td>Digital drinking games: big multitouch screen</td>
<td>no</td>
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<tr>
<td>Reverse silent disco</td>
<td>no</td>
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<td>Shining wall: huge screen of light mesh</td>
<td>no</td>
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<tr>
<td>Magic carpet: piece of fabric and special liquid shining under UV light</td>
<td>yes</td>
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<tr>
<td>High speed to slow motion: camera and big projector, projecting in slow motion what is happening in front of thw stage</td>
<td>no</td>
</tr>
<tr>
<td>The Gate: motion sensors</td>
<td>yes</td>
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<table>
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<tr>
<th>Table 2</th>
<th>Ideas from students of architecture.</th>
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<tbody>
<tr>
<td>Installation</td>
<td>Ambience</td>
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<tr>
<td>Calculating the amount of alcohol consumed on the bar throughout the night. This would be seen through a red light level, which would get higher towards the bartender.</td>
<td>no, too much work for the bartenders.</td>
</tr>
<tr>
<td>The bar detects if there is a male or female standing at the desk and answers blue or red light. The bar also makes sound when there is a man and women next to each other.</td>
<td>no, too complex, students did not know, how to distinguish between man and woman.</td>
</tr>
<tr>
<td>The bar calculates people entering the same room through a gate. Installation reacts on touch, which is naturally made by passing through.</td>
<td>yes, same idea as non-technical students.</td>
</tr>
<tr>
<td>Installation invites visitors by diverse intensity of flashes.</td>
<td>yes, ambient jellyfish.</td>
</tr>
<tr>
<td>Installation reacts on music.</td>
<td>yes.</td>
</tr>
<tr>
<td>The bar attracts visitors by change of the color. The bar reacts on different volumes of drinks in the glass.</td>
<td>yes.</td>
</tr>
<tr>
<td>The bar reacts on coming people by flashing.</td>
<td>yes.</td>
</tr>
</tbody>
</table>
The process of designing lasted for 10 days and then ready designs were presented. All of them were accepted and students started constructing their installations. The event took place at the faculty of Mechanical Engineering, but the designs were built at the Faculty of Architecture, which meant they had to be deconstructed and transported. The actual event lasted only for eight hours and all of the installations were fully functioning there. The real objects looked always quite like the designs, usually the light effects were different due to the last minute changes of the actual design at the site (see Figure 4).

**Discussion.** In order to see, what knowledge students gained within this studio, we created a Questionnaire, where we asked, what was the biggest contribution of such a studio and we asked students directly, what they think they learned. From the total number of 42 students we received 34 responses. In this quantitative part of qualitative research we searched for following keywords: First time/mew, Experiment/invention, Build own design, real event, intensive, material / reuse, group-work, interactivity. No ambience appeared among the answers. (see Figure 5)

More than 1/3 of respondents appreciated the rhythm of the studio: that it was short and intensive and the same number of students mentioned the positive effect of group-work. The possibility of building own design was also highly appraised by 30% of respondents. 25% of students mentioned they learned about interactivity and material reuse. Although we explained the ambience as natural reaction of the architectural objects on people, students kept calling their installations interactive, even though some of them were really rather ambient, giving the users spontaneous information about something. According to the questionnaire, the design phase of the projects was underestimated - students experienced it as too short. Students had to embody lights and sensors into the structures from the beginning of the construction process. The objects had to be deconstructable and reassemblable, which had the consequences on the connection of the lights inside of the designed object. Because of the technical challenges concerning electronics, consultation with programmers and people from Faculty of Electrical Engineering was inevitable and highly valued. The students unanimously appreciated the teamwork and learning how to organize themselves. Many of them started to appreciate the concept of ambience and interaction as this was the first time they were confronted with it. Students also mentioned that the time for designing was too short. We
also pointed out comments, which were beyond the standard answers.

- "I felt responsible for my installation and had in mind it must be secure and withstand the users activity throughout the evening."
- "For me, doing experiments is important for my learning process, maybe for a learning process generally. I changed my attitude in my regular studio too."
- "Designer must be ready for change."
- "An person becomes an architect, when he/she realises first design."
- "I saw how important it is to see the dimensions of my design in reality, it was bigger than I thought."

By developing PET(b)rick, a building unit of a new type which is flexible but withstands stress, we have prepared a platform for easy implementation of interactivity and ambience. We tested interactivity of our chairs at several public events and we could observe visitors’ reactions in confrontation with objects they could operate. The software/hardware combination allowed for playing with the colour of light, the actual form of interactivity embodied in lightweight movable objects such as chairs. We designed, built, and stress-tested a simple transparent cube, where the PET(b)ricks have proven their qualities as bricks as well as technology containers.

**Conclusions**

From the experience with the ambient bar, we can state that the most significant advantage of doing research with real objects is that everything can be directly tested and we did so. We found out, that using smart devices in order to operate simple functions is a constraint for the user. The next step was application of ambient intelligence into bigger structures built from PET(b)ricks We improved the design from boxes into more sophisticated objects where the technology was hidden and the objects became ambient intelligent, in a very simple and limited way. Students of architecture and from Charles University were able to work with the PET(b)ricks, but it also became very clear that the help of students from the Faculty of Electrical Engineering was crucial. Without their assistance students of architecture were neither able to generate concept nor able to manually put it together. There is a thin border between interactivity and ambience. Students were not able to understand it within one month of the studio, and they called their installations interactive. The concepts of ambience were rather complex in the beginning and radically simplified when it came to their real implementation. We could see that many students have never been thinking about implementing neither ambience nor interactivity into their architectural designs and they were also building a real object they designed for the first time. The studio had two "wow effects":

- I can build my own design, it is working!
- Implementing ambience/interactivity is cool, but not easy.

In further work we will surely continue to explore ambience and interaction in architecture. In order to avoid overly simplistic action-response schemes, it is of vital importance to work together with people from other disciplines such as Electrical Engineering. In this sense we found that the rather limited scope of the studio also gave the students valuable experience for future practice.

**Acknowledgements**

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