Xperium: A place to experience research and innovation with students

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ABSTRACT : Xperium is an innovative showcase of ongoing research and innovation developed by laboratories and their partners. It is dedicated to students of upper secondary school, university students and the grand public. The main objective for high school and first year students is to achieve a successful transition to university and an awareness of careers in research. It is also an opportunity to facilitate the emergence, convergence, exchanges and collaboration of all innovation actors in the region. This article explains how the presentation of stand 1, "haptic return tablet", is created by the team and executed by a PhD. student.

Key words: educational device, transfer of know-how, return of experience.

1 INTRODUCTION

Since October 2018, the main author, D.A. Torres, as a PhD. Student, has taken part of the team of presenters dedicated to share our research on surface haptic devices at Xperium [1]. Since then, she has performed over 100 hours of presentation in front of a varied public consisting, mainly, of high school and first year university students. This process has allowed her to take part in an innovative pedagogic experience, having a nurturing experience and positive return from the students and visitors in general.

The team presented stand 1, a station dedicated to share in 15 to 20 minutes the work performed by our team at L2EP, IRCICA, concerning our research project to produce surface haptic devices using ultrasonic vibration (STIMTAC) [2]. The speech and presentation was designed by the research directors of the team, to be adopted and performed by a team of selected PhD. students.

During the presentation, the concept of texture illusions, haptics, and finally surface haptic devices is presented, with an explanation of the physical phenomena through which "active lubrication" is achieved using ultrasonic vibration [3]. The exposition contains as well a set of 'hands-on' experiments, where the attendees can touch and experience themselves the technology, including the presentation of a demonstrational device from an innovative startup Hap2U [4].

In this article, the Xperium project is explained, together with the content delivered from our stand and the value of the mediation experience. Some feedback and results are introduced from the overall experience.

2 XPERIUM

2.1 Project Description

Xperium is one of the three poles of Lilliad Learning and Innovation center. It has three essential characteristics which, combined, constitute its original and unique signature. Firstly, the experiments shown are indicative of the scientific creativity of the researchers. These experiments constitute an "itinerary", a guiding thread that can be travelled through encounters with research players - mainly doctoral students. Secondly, the itinerary and sometimes the experiments themselves are by nature transdisciplinary, favoring and even seeking crossovers between science and technology, human, social and economic sciences. Finally, the experiments are related to the technical, scientific, social and societal issues they address, allowing for a better perspective of the research, and a better understanding by the general public.

Xperium opened in February 2014, and has been part of Lilliad since September 2016. In February 2020, after 6 years of existence, Xperium will have received more than 15,000 visitors, 2/3 of them being high school students. The other audiences are companies, university staff and students, elected representatives, delegations, documentation professionals, the general public, etc.

In addition to welcoming visitors, the mission of Xperium's scientific team members, in conjunction with those of Lilliad, is to propose innovative events. For instance, the Challenge Xperium allows 40 high school students from the Lille Academy and as many university students to propose together a solution to a problem posed by an expert in the current season's theme. Initially conceived as a closing event for season 2, its success led the organizers to decide to renew it every year. In March 2020, the 3rd Challenge Xperium is being organized.

2.2 The visit to Xperium as an academic exercise

A global educational process is proposed to the students visiting Xperium.

Before the visit, the students are made aware by their teachers on the theme of the exhibition, on the research activity it involves, and how it could be related to their future career choices. During the visit, the students are able to learn the different research subjects, watch the experiments, listen to the doctoral students, ask them questions, and even perform experiments with them. Back in the classroom, students comment and deepen the visit in relation with their view on concerned social issues and impacts of the research they have encountered. Additionally, teachers are accompanied throughout the process by the Xperi-

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um staff, who assists them and provides them a documentary kit.

The 2 hour visit begins with an introductory presentation of 15 to 20 minutes, concerning the University of Lille, Lilliad, and the Xperium project. This introductory talk also presents the field of research as envisioned by the university and specialized institutions, and presents how a career in science at the university would take place. The students are, thus, presented with future career opportunities, and are made aware of all the different profiles that work as a team in the research laboratories. Finally, the season's theme is introduced, as explained in section 2.3.

After the introductory presentation, a selection of stands is visited by the students. Xperium offers a route in 8 stands, i.e. 8 experiments gathered around a single theme. Each of them is presented, performed, guided by a PhD specialist in the field, able to adapt and respond to questions of visitors. The visit of stand 1 is presented in section 3.

The expositions at Xperium have been organized by 2-year seasons, dealing with a specific subject of research. Season 3 took place from academic years 2018 to 2020.

2.3 Season 3: Towards the augmented human?

"Making the human more efficient, more effective, more involved with his environment, and in better health, is a major field of research and innovation. It concerns scientific issues, as well as technological, economic, social, legal and ethical considerations regarding the evolution of the structural aspects of society.

The third season of Xperium highlights two aspects of this evolution: the change and the emergence of new digital technologies and innovative materials. It also opens a reflection on historical, epistemological and educational issues on the approach used by researchers to increase human capacity and more generally advance science. " [5].

The eight stands presented on this season, with their main description are summarized in table 1.

Table 1 : stands presented at Xperium season 3

#	*Title*	*Description Summary*	*Presented by*
1	Haptic return tablet	The use of ultrasound in order to see and touch virtual objects on a surface. (See section 3)	L2EP - IRCICA
2	Neuro-inspired vision systems	The use of low voltage, artificial neurons and synapses in an artificial vision systems (image capture and processing), which will improve their performance and, at the same time, drastically reduce their energy consumption.	IRCICA - IEMN
3	Innovative glass and NMR	This stand explains NMR spectroscopy and presents examples of glass characterization using Lille's NMR spectrometers. The example of glass recycling from cathodic tubes is presented	UCCS
4	Repair the human thanks to bio-materials	The work consists on immobilizing, on various implants, a "cage molecule" derived from a starch called cyclodextrin, capable of forming "inclusion complexes" with drugs, thus giving these biomaterials new trapping properties, and achieving prolonged release of the drugs. A demonstration of this new property is presented concretely from a vascular prosthesis.	UMET - INSERM
5	Parallelism and analogy	"Nature of Science" (NoS) is a method and product of interdisciplinary research, between science and education, which consists in systematically referring to representations of science, taking into account their historical, epistemological and scientific foundations. "NoS" is exemplified in this stand through experiments that are part of the history of science but have first-rate current applications.	CIREL
6	Robotization of additive manufacturing	Today, the challenge for 3D printing is to be able to print large parts on an industrial scale with performance and quality criteria. This stand presents a project of robotization of additive manufacturing through the design of machines based on industrial robots, which can guide instrumented nozzles to deposit materials continuously, applied to construction and plastics processing.	IEMN
7	Electro-chemical, miniature and nomad energy storage	Batteries or miniature supercapacitors (a few mm2) are electrochemical energy storage devices that can power small communicating objects to map sensitive areas where humans cannot go. On	IEMN

		this stand, micro-supercapacitors are presented in operating conditions. A second experiment demonstrating the power supply of a flashlight by a massive supercapacitor is also presented.	
8	From the molecule to the medicament	This stand presents the drug shaping processes (lyophilization, atomization, mechanical grinding, compression) regularly used in the pharmaceutical industry which allow to reach amorphous states inaccessible by conventional processes such as temperature variation.	UMET

3 STAND 1 : « HAPTIC FEEDBACK TABLET , SEE AND TOUCH VIRTUAL OBJECTS»

Touchscreens have become commonplace, on computers, computer boards, computer monitors, cars, and household appliances, amongst others. Nonetheless, even though they are tactile, the sense of touch is not stimulated.

Touch can be used to identify the roughness of a surface, to type text or to hold a doorknob, without having to look. Nowadays, in order to use touch screens the sense of vision must be engaged. This may render our interactions with several devices complex and even dangerous.

Thanks to new technological advances, it is now possible to imagine touching a virtual object, pushing a virtual button or carrying out a precision task at a distance. This is possible thanks to haptic interfaces. A haptic interface is a device that allows the user to interact with a software application or a virtual object through the sense of touch.

The devices being investigated in this work concern 'surface devices', which utilize techniques to achieve friction modulation in order to simulate texture. Creating differences in friction, with the help of a device, affects the forces moving along the finger pad, which influence the nature of the vibrations generated by the relative motion of the skin, creating the sensation of a differentiated texture [6].

The STIMTAC project [2] exploits this principle by developing a haptic feedback device, similar to a "touchpad", providing an unprecedented realism to the human-machine interaction. This object, therefore, is able to simulate surfaces of different textures, thanks to a technology based on ultrasonic vibration.

The issues are addressed in this work are:

a) The sense of touch, and how it works
b) What physical principle should be used to modify the finger-surface interaction?
c) How to implement this principle?
d) How to realize man-machine interfaces that use the sense of touch in communication?
e) Can virtual surfaces be simulated?

3.1 STIMTAC

3.1.1 The sense of touch

Since the beginning of our lives, the first sense available to us is the sense of touch. It is necessary for human life to thrive, and is essential to our awareness of the world and of our own bodies.

Touch involves two main modalities: tactile and kinesthetic sensitivities. Tactile sensitivity, which is the one dealt with in this project, serves to evaluate phenomena on a small scale, such as differentiating the texture of objects. The mechanical displacement of the skin tissues provided by the contact with an external object is sensed by the mechanoreceptors located in the skin. [7], [8].

3.1.2 Texture illusions using ultrasonic vibration devices

When touching a surface, the finger does not explore it statically, but it slides. As it glides, the roughness of the surface produces variations in the friction between the skin and the surface, which induces specific vibrations on the finger.

These vibrations are perceived by the mechanoreceptors of the skin. The brain interprets these variations in frictional forces as roughness, and therefore, as surfaces with a structure and a texture.

For this reason, if we prepare a surface alternating sticky and slippery areas of the same height, it is possible to create a texture illusion: by exploring this smooth surface with our eyes closed, we have the sensation of having touched an undulating surface.

It is possible to reproduce this illusion on a surface without changing the material itself. For this, ultrasonic vibrations can be used to create "active lubrication". The principle of "active lubrication" serves to dynamically reduce the friction between the finger and a surface. This is obtained by vibrating at a very high frequency (>20 kHz) but very low vibration amplitude (1µm peak to peak).

By programming the friction reduction according to the position of the finger, it is possible to make the user feel textured surfaces.

3.1.3 Structure of the haptic return tablet

Touch feedback interfaces consist of a conventional tablet - which measures the position of a finger - on which our technology is included.

The principle of this technology is based on the use of piezoelectric ceramics, which are glued to the haptic surface, and supplied by a sinusoidal alternating voltage. Piezoelectric ceramics are able to contract and expand in function of the magnitude and 'sign' of the voltage at their terminals. Their motion will be trans-

mitted and amplified by the material, at its resonance frequency.

3.2 Presentation content

The stand features several devices that explain how STIMTAC is made, as well as the XPloreTouch tablet, marketed by Hap2U [4], which exploits the principle of STIMTAC. The setup can be seen on figure 1.
The presentation begins with the introduction of the presenter and their career development (explain how the presenter arrived to a career in science). Then, in order to introduce the subject, the attendees are requested to reflect upon what a "tactile return" tablet may be.
Tactile return is presented as a way of "seeing and touching virtual objects on a screen".

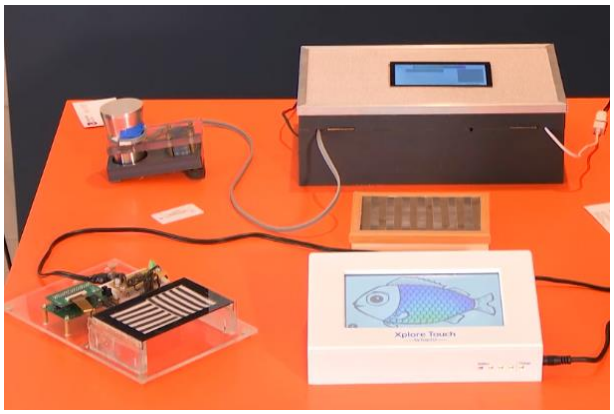

fig 1 : Setup of the devices showcased at Xperium stand 1

The method by which this is achieved is presented through the explanation of 'illusions', and the possibility to create 'texture illusions'. At this point, an actual texture illusion is presented. It is a surface which contains strips of two materials containing different friction properties. Thanks to this illusion, it can be explained how texture illusions are formed on surface haptic devices, thanks to variations in friction.
A second experience is then performed, where a card, which is placed on an inclined plane, does not fall thanks to the friction properties of the two surfaces. The surface is a Langevin transducer, which is then turned on. As a consequence the card falls. The attendees realize that the friction which was holding the card in place has now been reduced and they are asked to reflect upon how this can be achieved. It is then revealed that friction reduction can be achieved through ultrasonic vibration. Moreover, if the friction is chosen in function of the placement of the finger, then a texture illusion can be achieved. Finally, the attendees are questioned on the possible applications of this technology, including how it can contribute to society, economy and the environment.
A final portion of the visit invites the attendees to experience themselves the different devices showcased, and thus, the principle of how piezoelectric transducers are used to create vibration is more clearly understood. The complete presentation of the stand is available on video online [9].

3.3 The value of interactive experimentation on the presentation

The main advantage of showcasing the devices made at the laboratory is that it has a larger impact on the student, and it connects them further with the technology and the research itself. It is at this portion of the presentation when they pose most of the questions and provide their own ideas. It is fairly clear that without this, the involvement of the attendees, thus the impact of the experience, would be greatly reduced.
The devices are explored at will by the attendees, each at a time. Each device serves to explain different concepts, and are used as main device to transmit the knowledge. We verify that the amusement, surprise and sense of discovery produced when interacting with the haptic devices help providing an open discussion with the attendees and an increased interest in the science involved.
Using the material texture illusion (center left on figure 1), the attendees understand better the concept of a texture illusion and how friction is involved in their creation. The Langevin transducer (upper left on figure 1), helps the attendees understand and feel the effect of active lubrication using ultrasonic vibration. The two-dimensional texture simulation device (bottom left on figure 1), helps explain how the piezoelectric devices are positioned, and how resonance is used to achieve vibration on the complete device. It also helps the attendees to feel a texture illusion (of lines), without changing the material of the surface. Finally, the XploreTouch (bottom right) serves as a demonstrator of a finished device and how some applications may be integrated.

3.4 Pedagogical contributions of STIMTAC

The haptic device itself can be an interesting tool for proposing numerous pedagogical contributions to many different types of public in many different contexts. It is a device that allows to discover, through experience, the sense of touch in an original way and also to raise awareness of the notion of friction.
In the case of its use in the Xperium experience, the visitors are able to discover the notions of piezoelectricity, mechanical vibrations, ultrasonic waves and active lubrication. Moreover, thanks to the discussions around Stimtac, visitors can understand the applicative and economic impact of tactile feedback devices.

4 EXPERIENCE GAINED BY THE PHD PRESENTER

The PhD student, highly motivated to carry out a scientific mediation mission within Xperium, gained a large and valuable set of knowledge and skills through the interaction with her colleagues, the public and the

scientific mediation team. Some of these are explained in this chapter.

4.1 Creation and appropriation of an innovative scientific mediation tool around a research subject

The research directors of the team were assigned with the mission of creating this mediation tool illustrating our research topic. It started by the conceptualization of the phenomena, the technology and the choice of the interactive material to share. This is by itself a challenging task, given the short time allocated for the presentation (15 minutes). Finally, a complete story was proposed from this pondering, which is a real progressive, interactive, experimental approach aimed at having the public understand the functioning of this tablet. It is an example of a new pedagogic exercise, which is not only 'top-down', but comprehensive around a complex research topic.
Learning appropriating and transmitting the narrative proposed for this stand was, therefore, a true pedagogic exercise for the PhD students involved.

4.2 Interaction with the students and the public

Amongst the most valuable knowledge that was gained by the presenters came through 'learning-by-doing' thanks to the interaction with the students and the public.

fig 2 : Presenting stand 1at 'open doors day' (JPO)

The PhD student was confronted with the real pedagogic questions of scientific mediation, such as how to encourage exchanges through questioning, listening and reformulation, master different postures (facilitator, coach, expert) depending on the audience and the time of the exchanges, learning to evaluate and rely on the knowledge of the audience, and adapt in consequence the presenter's speech and content (level, richness, language).

5 RESULTS AND FEEDBACK

Since the beginning of season 3, 5336 visitors have come to Xperium (data taken on January 2020). Out of these, 67.9% have been students of different levels. During the latest exposition at the 'open door day' (JPO), we welcomed about 230 visitors: 2nd record attendance since the creation of Xperium. The visitors were interested and stayed (some up to 3 hours in Xperium).
The feedback and improvement suggestions are documented thanks to an analysis based on interviews and qualitative surveys, prepared and presented for the Xperium organizing team in an internal work document containing a deliverable written by Claire Casedas (Fun in museum agency) [10], as part of a service to support Xperium (Internal working document of the Xperium team. Not published to a wider audience). The surveys took place in November 2019.
A new interview was launched by the authors on March 2021, to a group of 12 master students in automatic and electric systems, which engaged with Xperium in the context of the "Virtual Xperium Challenge" which happened in February 2021.

5.1 Impact evaluation on visiting students

32 students were interviewed in November 2019. Overall, visiting students are satisfied (95%). However, some admit that the experience could have been more "fun" and did not understand the "rules of the game" (in which order to visit the stands) and the "complicated words". This problem of vocabulary mismatch between doctoral students and students is frequently mentioned. Finally, most agree enthusiastically to a more "gamified" experience, based on fun and collaboration.
The results of the 2021 interview showed that, having visited 2-3 stands in average the answers of the students to the experience was as follows:, 95% found it interesting, 85% reported "having fun", 73% said they understood the scientific content (with an approval rate of 87% for the presenters), only 48% said they could participate and ask questions, 80% said that thanks to their visit they understand better the world of research and 92% understand the research going on in Lille. A very large 92% said they would be interested in research as a career choice, and 93% would recommend it to friends.
This result shows especially an important impact that the Xperium might have in career choices and approaching the public to research careers.

5.2 Impact evaluation on visiting teachers and professors

9 professors were interviewed in November 2019. An overall positive appreciation is confirmed. However, 44% of them pointed out the issue of the vocabulary used and a need to further link the booths to the official education programs. 66% also call for a more gamified environment, while 55% would like more booths to be "open" (typically 3-4 are open at a time).

5.3 General appreciation of the project on the Lille University context

Xperium is thought to be accessible to the University community and general public. However, most students (88%) have not yet visited, and many professors have not yet decided to propose a visit. This shows that awareness raising is an issue that must be reflected upon with this public.
32 non-visiting students were interviewed. Amongst them, over 65% expressed their desire to explore Xperium. 13%, on the other hand, admit not having seen the space. Some (16%) think this is a reserved space, with no access to students.
Considering the expectations of this public, 66% of the students would prefer a fun experience and above all, an enjoyable experience. 76% would prefer to have access "when they can" visit, instead of scheduled visits. Finally, 38% express that the thematic is a determining factor in their motivation to visit the site.

5.4 Regional government appreciation

Sharing the feedback provided from the Directorate of Research, Higher Education and Health and Social Training: "On behalf of the staff of the ES department of the Region, I would like to thank you "warmly" for your welcome. Our thanks also go to the doctoral students for their high quality presentation".
This feedback confirms the success of the project, and helps validating it as an academic exercise.

5.5 Lookahead

In function of the general feedback provide by the different parts of the Xperium project visitors and organizers, [10] proposes a series of actions and improvements to be included in the planning of the upcoming seasons. The "winning equation" consists on the implementation of 8 key issues:

- "Gamification" of the expositions
- An original 'Teaser' to invite students and the public and increase visibility
- A spectacular and large signage on the vitrines and windows
- Offer written support for the visit in autonomy, playful, in paper format
- A 'phygital' and collaborative scenographic space associated with this "game path"
- Gamified experiments on the stands
- Offer written support for the presentations in the form of booklets
- Offer online resources.

6 CONCLUSION

This article served to explain Xperium, its main objectives and how the experience is put in place. Through this platform, our team was able to present Ultrasonic Haptic Devices, and inform the public of the ongoing research and development on this area.

The feedback from the presentations has been largely positive, which serves to validate the project and our own communication skills. It has also served as a learning tool for the PhD student presenters, which gained an important set of skills and knowledge in scientific mediation through the interaction of the Xperium team.
Finally, the proposed actions to further improve the Xperium experience have been enumerated.

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