SENSE-SEAT: Improving Creativity and Productivity through the Redesign of a Multisensory Technological Office Chair

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Abstract—The current trend of organizations offering their workers open-office spaces and co-working offices has been primed for stimulating teamwork and collaboration. However, this is not always valid as these kinds of spaces bring other types of challenges that compromise workers productivity and creativity. We present an approach for improving creativity and productivity at the workspace by redesigning an office chair that incorporates subtle technological elements that help users focus, relax and being more productive and creative. This sheds light on how we can better design interactive furniture for such popular contexts, as we develop this new chair through a multidisciplinary approach using ergonomics, interior design, interaction design, hardware and software engineering and psychology.

Keywords—Creativity, co-working, ergonomics, human-computer interaction, interaction, interactive furniture, productivity.

I. INTRODUCTION

CREATIVITY is defined as the production of novel and potentially new useful ideas for problems solving, development of newer artifacts, processes and ways on how to accomplish tasks. Organizations, companies, workers and employee's creativity can be translated into novel products, better services, systems and even innovative work methods [6]. However, creativity is such a subjective trait of a human person, as it is closely related to the person's personality traits, cognitive style and even his own native creativity skills and mind [9]. The majority of people are creative by intrinsic motivation, they are motivated primarily by the interest, satisfaction and challenge of the work they present to themselves [9]. However, despite being such a subjective and personal trait, creativity can be deeply influenced by other factors such as social-organizational factors (e.g. job design, teamwork, reward system, time pressure, even job salary) and physical exterior elements of the workplace [9], [6]. These factors can greatly impact the individual's creativity, as on how they affect it (besides its neurological activity), i.e. the experience of emotion or feeling effects on the creative process, in which most experimental studies have shown that positive affect leads to higher levels of creativity, whereas when the negative has an influence, it is generally negative [9].

In this paper, we only focus in the physical workspace aspects affecting creativity, foreseeing the creation of a workstation unit that can simulate a creativity-supporting work environment.

Our approach combines the reimagination and redesign of an office chair by incorporating sensor (pressure, temperature, movement, accelerometer) and actuators (LED lightning, temperature cooling system, directional sound) and mobile application to control the system. We combine a multidisciplinary team with competences ranging from ergonomics to industrial design, software engineering and psychology.

II. PHYSICAL WORKSPACE AND PRODUCTIVITY

The physical workspace refers to the person's context in terms of the physical surroundings, such as the immediate workplace and surrounding buildings. Typical physical environment improvements that positivity affects employee's creativity, as suggested by various researchers, are: a non-crowded workspace, presence of plants, the use of inspiring colors on the walls, a new carpet in the office, more pictures and posters on the walls, windows with outside view, privacy, dim lightning, etc. [1], [2], [6]-[].

It has been theorized by Ulrich [4], that biophilia, our biological affinity for natural environments, is associated with creative performance, i.e. seeing natural objects decreases work-related stress and affects positively people's overall well-being. McCoy and Evans [8] seemed to confirm what Ulrich theorized, in their study in which they observed that views of natural environments or exposure to natural materials affected positively the creative process. In addition, Shibata and Suzuki [3] concluded that the presence of the leafy plants could affect creative work positively, and Stone and Irvine [5] observed that windowed rooms with a view to nature seemed to affect positively perceptions for the creative task; however, they also verified that any window with a view has the same result.

Aiello and his team [1], [2] conducted research on the effects of workspace crowding on employee's creativity, and they concluded that crowding could have negative effects, regardless of crowded subjects interpersonal distance preference, which showed a lower level of creativity than their non-crowded counterparts. Also, Stokols and his team [8] observed that high levels of environmental distraction, such as noise or prolonged exposure to crowded environments, were associated with less perceived support for creativity at work, and they furthermore suggested that private or non-overcrowded workspaces could have a counter effect, i.e. it could boost employee's creativity.

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Steidle and Werth [10] conducted six studies on the effect of light and darkness over creative performance, and they observed that dim lights promote creativity. These researchers claim that darkness stimulates a feeling of freedom, self-determination, and reduced inhibition, which promotes a risky, explorative, and less vigilant task processing style.

There is a correlation between creativity-supporting work environments and product innovation performance, in the sense that these work environments boost product innovation and also enhance the success of new products in the market [6]. Organizations seeking to enhance innovation and new product success can engineer their workspaces into creativity-supporting environments through the help of the ergonomics discipline by including several physical elements that can systematically positively affect their employee's creativity [6].

Productivity is the effectiveness of productive effort in converting inputs into useful outputs. In general, organizations seek to improve their productivity because it is a critical determinant of cost efficiency and better outcomes. Our approach is based on reimagining office furniture and designing it in such a way it becomes a place to relax, to regain focus and to conduct creative work. We are currently prototyping in 3D (renders, 3D prints and also a physical prototype) a new workstation for improving creativity at work.

III. SENSE-SEAT

A. Design Approach

An office chair in its core functionality has not seen any evolution since it was basically created. Therefore, the proposed challenge was to try do add real added-value to the office chair and not just adding technology by *per se*.

Open-offices and co-working spaces workers often need to escape in order to regain focus. If collaboration is stimulated and praised for the positive effect on one's work, it also has several negative impacts with an individual easily being distracted by colleagues, surrounding noise or visual distractions. Therefore, the first challenge to be addressed was how to design a furniture piece that can give enough privacy but at the same time offer the right amount of openness for other individuals to approach and talk to the user if really needed. This was met by determining the right degree (max. 45º) of the side-ways angle of the chair. Since the chair is a slightly closed space, when the user is seated they get a feeling of privacy, reducing external inputs from colleagues. Psychologically speaking, external individuals receive a visual cue that the user is in need of focus and privacy, but that they can still be contacted and approached if really needed since the seat is not a completely closed space.

Another major challenge is related to the fact that the working spaces that we address are very diverse in terms of design. In an effort to create different and spectacular office spaces, companies have been creating office spaces that are equipped with unorthodox perks. There are offices with Indian tents, others with bare minimum furniture, and therefore, the design has to keep in mind that the chair needs to fit naturally in all sorts of spaces. This is achieved by studying materials and creating a modular construction chair in which finishes and materials can be easily chosen.

Another aspect is connected to the adoption rate of the solution and its viability and usage during many years. Basically, the Sense-Seat needed to be *timeless*. It should offer an appealing visual aesthetic at first sight and this inviting feeling should endure and be felt by individuals of different generations. To face this challenge the team researched the most timeless furniture pieces that exist and are well-known; so as to obtain a greater picture of what makes a furniture piece, *timeless*. This was mostly inspired by Scandinavian designers who during the recent decades have put a great amount of attention to this challenge that is common to all furniture designers.

Summarizing, the design approach focused mainly on three goals:

- Make it **inviting**: the design of the chair should be simple, inviting and timeless. It should be minimalistic enough, but also original.
- The design should keep all needed options and technology for a given task **visible without distracting** the user with extraneous or redundant information. He should keep focus for his task and work.
- **Private, yet approachable**. Correlated with all the previous goals, the Sense-Seat should provide a private enough space in which the user can work in a calm, relaxed ambience but not totally isolated from the external world. He should be approachable since he is working in an office, which is a very dynamic space, as businesses are.

With these goals in mind, the team designed several mockups of the Sense-Seat and finally settled with a 1.9 diagonal meter semi-closed seat (Fig. 1). SENSE-SEAT is made of a fiberglass chair with a reclinable seat and retractable table. The interior has a subtle color LED lighting that changes according the user's preferences or detected needs (e.g. if the system knows that the user is restless and stressed, it will provide a *blueish* environment as it is known that the color blue has a calming effect. Plus, the interior also provides a noise-reduction ambience since the interior walls are lined with anti-noise materials. We have also placed a directional-sound beacon that provides a sound ambiance within the seat itself. This device plays several musical ambiences that are correlated with the lighting ambience that the user has chosen (e.g. the same way blue stimulates relaxation, the subtle sound of rain gives a feeling of comfort).

B. Embedded Technology

In terms of HCI and software engineering, the main challenge was to know which features should be included and which ones can provide a real added-value. Manufacturers and designers have been trying to embed technology in furniture pieces for some time now; however, these attempts tend to fail in some sort of way. Many times, what is offered are minor perks such as contactless chargers or USB ports.
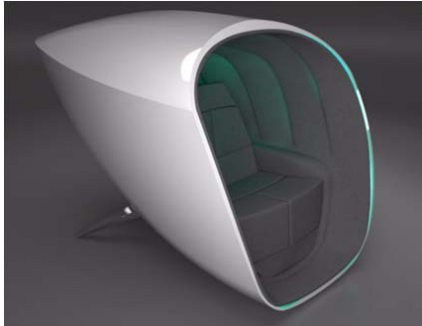
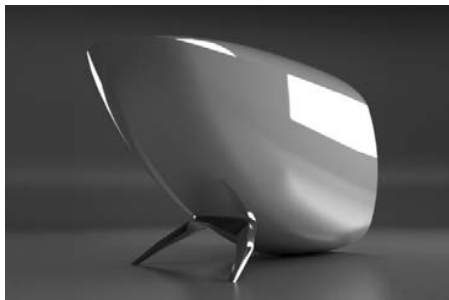Fig. 1 SENSE-SEAT 3D design exterior view

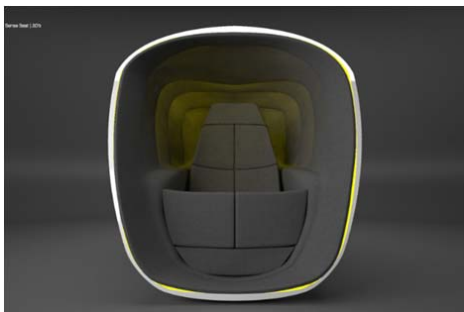Fig. 2 SENSE-SEAT 3D design exterior view, back perspective

Fig. 3 SENSE-SEAT 3D design front view

Our approach was based on all the technology that could be included past on the team's own experiences with sensors, actuators and HCI clutter-free interfaces. Stress-detection by using thermal cameras and heart-beat sensors were considered at some point but failed the final cut as they were too invasive and not subtle enough to not require any kind of action or slight distraction for the user.

Psychologically speaking, the SENSE-SEAT needed to be an office chair, not a technology gadget. The technology only exists to improve the experience in a subtle way, to provide useful feedback on the users' working habits and to offer real added-value in terms of comfort, relaxation, focus and increased productivity and creativity. Therefore, the seat is embedded with pressure sensors and accelerometer that helps determine if the user is seated, when, how (e.g. restless or not) and for how many time. These sensors connect to a Raspberry Pi that controls the system and sends the data to the cloud.

Several actuators are connected to the Raspberry Pi including color LED strips that change according to the users'

preferences and moods, directional sound beacon that provides several ambiences ranging from rain or Zen music, to coffee shop sounds or wind.

A temperature system records if the interior is getting too hot and a cooling vent system – similar to the ones that can be found in computers – helps the chair remain at a reasonable temperature that can even be controlled.

As all collected data is transferred to a Cloud, users can use a mobile application to register themselves and define how they wish to use SENSE-SEAT, in "Auto" mode or "Manual" mode.

The "Auto" mode will keep track of the changes made by the user in terms of setting up the light and sound ambience, the reclining seat angle, how restless the user is and how much time they are seated. Combined, it will define a set of preferences that by its core Artificial Intelligence believes are the best to stimulate the users' productivity; while, the "Manual" mode simply allows the user to freely set these preferences.

The mobile application also functions as a useful tool for the users to perceive their working habits. Which color ambiance they prefer and which sound or music, how many time a day they usually remain seated, and which hours they work the most etc. This information is stored anonymously in the system as the users are tracked by ID number and not by any personal data. This has the advantage of also being quite useful for employers and companies who can therefore study and analyze the performance of their workers and what positive changes can be made in the overall ambiance and company organizationally that can increase productivity and innovation levels.

IV. EVALUATION AND REAL-WORLD ACCEPTANCE

In order to validate the concepts and design approach, the team conducted a formal evaluation process based on the 3D renders, 3D model print and technological prototype.

We were interested in (a) assessing if the solution was indeed "distraction-free" when compared to the common workspace, (b) study if the design by itself was appealing and played a major role in productivity, (c) validate if the embedded technology represented an added-value for users and was subtle enough, and (d) investigate the acceptance of the tool in real world industrial context and if it would increase productivity and creativity levels.

A series of surveys and prototype model user tests were made to 105 individuals who work for creative industries in Funchal (Portugal), Lisbon (Portugal), and Rotterdam (Netherlands).

Immediately before starting the evaluation sessions, we told participants we were evaluating the furniture and not them, so as to reduce any discomfort they could have. After-session questions were made to each participant, including questions about the personal experience and feedback they might have.

A. Regarding the Features

As interesting as it might sound, the addition of a Zen music revealed to be quite a popular feature with 79.1% of users

reporting that they did not turn off the music during their work on our prototype and an impressive 70.3% claiming that it really helped them "focus". However, the most praised feature was the interior LED lightning system. Such a simple idea, if assembled correctly, can really influence the way people work. A total of 90.9% of users confirmed that lighting

environment plays a major role on how they work and focus, and 87.8% confirmed that this feature is most important in the SENSE-SEAT with many referring that it could help them both relax and focus but also stimulate and energize them to finish their work (in high brightness mode).
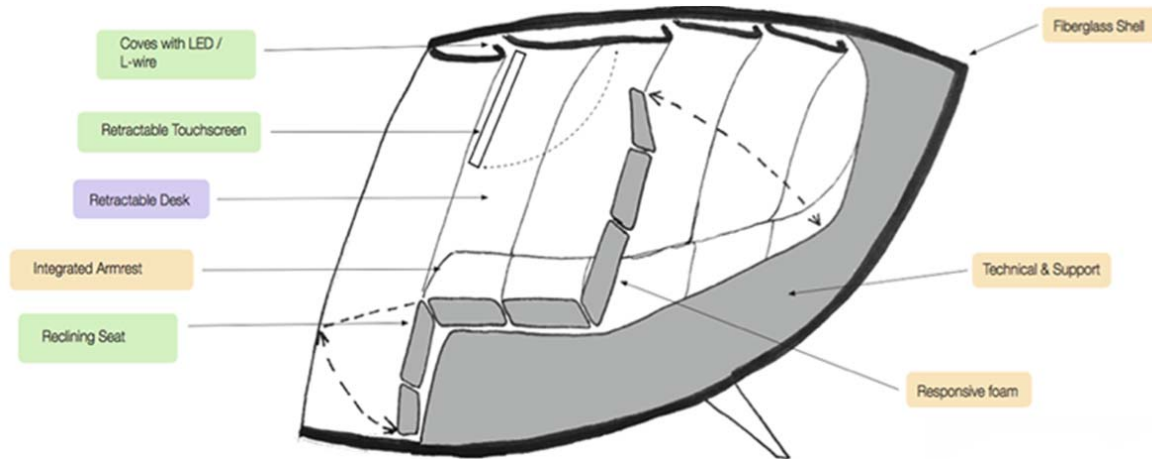

Fig. 4 The draft sketch with the technology features

User testing showed that these two features combined were already quite original enough for users to adopt and regularly use the SENSE-SEAT (69.9% said they would use it with just these two features).

The software modes however did not show such high approval rates. Despite the first impression being positive on the "Auto" mode (55.8% felt that it was "interesting"), 35.7% said that it would not really bring a great value as being creative professionals they tend to try to "control" every aspect and letting the system do this would be annoying, although they could turn it off and switch to "Manual" mode. Also, the temperature control and cooling system was rated by 81.5% of the participants as a "mandatory" feature for the success of the SENSE-SEAT. This validates our research that temperature plays a major role in working spaces and that temperature can in itself be a very personal and subjective variable.

B. Regarding the Design

Overall, the majority of the users praised the design concept quite high. A significant 59.7% said it was "excellent" and other common terms used were "original", "pleasing" and "beautiful". Most participants felt that based on the design and ideas, SENSE-SEAT seemed very comfortable to use because of the quality of design and materials to be used, but also how it just "looked right", "cozy" and "inviting".

The need for SENSE-SEAT to offer a private space was rated as "mandatory" by almost all participants (98.5%) and the majority felt more inclined to our research conclusion that the solution should not be completely closed, as this could potentially annoy or make uncomfortable people around you which in consequence would take its' toll in the users' social ambiance. As well, 63.7% felt that they did not want to be in a

full-closed space as it could be too "claustrophobic" and counter-productive. A minority of 7.9% said it should be "fully closed" and another minority of 11.7% stated that it should be "fully open". Curiously, none of the participants suggested a mixed solution with a movable canopy. This might be due to the fact that this would translate in a distraction for the user, as there would be a tendency for him to open, close and adjust the canopy frequently.

Other remarks that validated our research included the need for the solution to be lightweight enough so it could be easily moved within the office space, as well as the reference for the unit to have its own battery so that aesthetically there would not be any visible cables or space limitations (e.g. having SENSE-SEAT necessarily working close to a power plug).

C. Regarding the Creativity and Productivity

In general, 65.3% of participants think that SENSE-SEAT would increase their performance "significantly" despite that during these tests and surveys they were not able to test a final prototype.

Knowing their habits and preferences was also mentioned as a stimulating tool for productivity by 58.5% of the participants.

Some 88.1% mentioned that the combined lightning and sound would help them relax for a bit before tackling work again, and that this flexibility that the SENSE-SEAT could offer – not just being a workstation but also a relaxation-station – was a major point, as productivity many times increases with a short break and the same is valid for creativity.

D. Conclusions

Overall, participants and reviewers seem to have adopted

the concept and found the features quite useful. We concluded that in line with our research, the design should definitely hide the technology as much as possible and that the aesthetics play a deceiving role, since a solution can be beautifully designed; but, it will not encourage users to keep making use of it or switch from the traditional workspace to SENSE-SEAL unless the latter offers uniqueness and features that improve their work.

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