

The Design Process of an Interactive Seat for Improving Workplace Productivity

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Abstract—Creative industries' workers are becoming more prominent as countries move towards intellectual-based economies. Consequently, the nature and essence of the workplace needs to be reconfigured so that creativity and productivity can be better promoted at these spaces. Using a multidisciplinary approach and a user-centered methodology, combining product design, electronic engineering, software and human-computer interaction, we have designed and developed a new seat that uses embedded sensors and actuators to increase the overall well-being of its users, their productivity and their creativity. Our contribution focuses on the parameters that most affect the user's work on these kinds of spaces, which are, according to our study, noise and temperature. We describe the design process for a new interactive seat targeted at improving workspace productivity.

Keywords—Human-computer interaction, usability, user interface, creativity, ergonomics.

I. INTRODUCTION

WORKSPACE and its surrounding ambience play a decisive role on how people's levels of productivity and creativity are influenced. Zelinsky [1] underlines the importance of recognizing that workspaces need to be inspiring places. The research of Vischer [2] shows how people are affected by the environment in their workplace. Many factors contribute to these quite subjective productivity levels. Sometimes it is the room temperature, while for others the surrounding noise but even visuals play a role (e.g. if the work desk is messy and cluttered).

Based on these preliminary findings, we have deepened research on this area in order to obtain a wider array of parameters and factors that affect worker's productivity and creativity. Picking up those findings, our research parted from the premise that novel interaction paradigms coupled with the rethinking of the workspace in itself could lead into a new solution that would increase the worker's productivity and creativity levels, as well as their well-being.

Aiello's research [3] has proven that the workspace environment can influence one's productivity and creativity, while Dul & Ceylan [4] demonstrated that there are correlations between the supporting working environments and product innovation. Furthermore, novel interaction paradigms have been used in many contexts and are becoming increasingly popular among subjects. Campos and Pessanha [5] have taken a new approach into user interfaces for learning in kindergartens to help them motivate for the act of learning. These previous research projects showed us that there is space

for innovation in this field; especially, in the merge of designing creative-oriented workspaces with subliminal technology and novel human-interaction paradigms. The question purposed to answer was: What really influences a worker's productivity, do visuals matter and influence and especially, what kind of solution could our team envision, and would it work in order to benefit and increase productivity levels?

II. AMBIENCE FACTORS

The most valuable aspects of the ambience of a workspace can be quite subjective. However, several conclusions can be taken from the direct insights that workers provide when questioned.

In an effort to discover the most relevant factors that affect people's work, we have conducted a study based on informal interviews, observation and surveys. The subjects were mostly creative users (e.g. designers, musicians, copywriters and software engineers) located in co-working spaces of several dimensions in Portugal, Netherlands, Italy and Sweden. We have also done the same process with standalone workers who have their own office or prefer to work from home. In total, there were eight observation sessions in different times of the day, 47 informal interviews and 133 valid surveys (these were filled online). The focus areas divided into "external factors that negatively affect your work", "positive external factors that affect your work", "working habits" and "ideal working ambiances". Based on these activities, we have compiled the notes and replies in order to better achieve conclusions.

As for the negative external factors, 31% mentioned the "noise", 27.5% the temperature (either too hot or too cold). Some 11% referred to the working space light (most complained about lack of proper neutral light or reflection from too much artificial or natural light).

Regarding the positive external factors, 33.5% of the subjects' value pure silence in order to better focus on their work, 27.3% underlined the importance of having a comfortable seat, 20.5% said that an open space was ideal because the cooperation model help them be more creative, and 19.3% said that the "trendy" or "modern" look (we understood this has spaces with industrial look or Scandinavian-design look) of the overall space made them more energetic, and therefore, more productive.

As for working habits, 27.9% said they do more work during the first hours of the morning (between 8 a.m. 11 a.m.) but also a similar percentage, 28.2% said they rather work during night hours after dinner (between 10 p.m. and 12 p.m.). 67.1% said they usually work while listening to music. From

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these, 40.7% said it was simply “radio”, and 13.3% had their specific playlist. An interesting percentage of 40.9% users said that they do like to work listening to “relaxation” music (understood as “lounge music” or “Zen music” that usually is related to chill-out spaces or meditation activities).

Some 67.1% said that they usually take “two or more breaks of 15 minutes” during the day, 15.1% said that they take a break “every hour”.

From our research and by crossing the subject’s working location, there are no significant differences in working habits and preferences from workers who develop their work from their home or from co-working spaces or traditional offices.

III. THE SEAT

Based on these findings, our research team started sketching ideas of the perfect workstation that would increase one’s productivity.

We have envisioned an electronic seat that would be embedded with basic sensors and actuators that would collect user’s data and store it on the Cloud, while algorithms would determine the working habits and preferences.

Of course, that given that the visual effect play an important role on the acceptance of usage of such a seat – given the insights stated in the precedent section – the team firstly decided to come up with a couple of design concepts and to A/B test them.

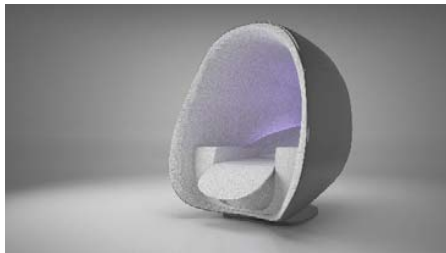


Fig. 1 Design Concept A



Fig. 2 Design Concept A (side-view)

The two designs were a bit similar but in fact contained some relevant functionality aspects that were worth exploring and presented to the users. The Design Concept A had a very soft interior with reclinable chair, retractable table, sound-proof interior, temperature control through vents and pumps, LED colour lighting ambience and 3D sound. The structure allowed to easily be rotated by the user and the seat would be embedded with pressure sensor matrix using Velostat material

to detect usage and posture.

The Design Concept B would have similar design; however, as a fixed structure that would not allow rotation. The design lines would be more prominent and rigid. In terms of sensors and actuators, the only concept difference would be the inclusion of a thermal camera to try to detect user’s stress by analyzing body temperature.

The A/B testing survey was sent out to an international database of users from which 357 replies were validated. The survey questioned several topics ranging from “Structure Design Appeal” to “Technological Functionalities”. Subjects were also invited to freely comment and provide more insights on these.

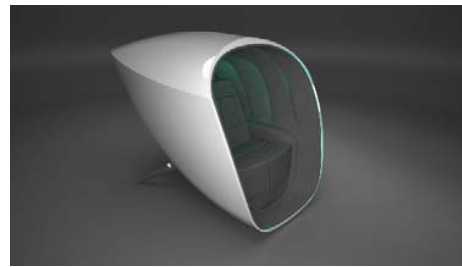


Fig. 3 Design Concept B

When asked which design concept was preferred, 69.3% of the subjects chose Concept A. However, Concept B was still praised when analyzed individually with a 4 out of 5 medium rating, while Concept B got up to 4.5 out of 5.

Subjects underlined the featured ambience light and temperature control as “very useful” but rejected the idea of being monitored by a thermal camera. The ability to rotate the seat in itself was also decisive for the Design Concept A, since 43.1% of the users stated that they usually rotate their current office seats daily, many of them making it as an habit while thinking (unconscious of that rotation). However, some free comments had some common points between subjects and came up with some interesting design facts. Design Concept A was compared to the first-generation of iMacs for its roundish design or even to an egg-shell.



Fig. 4 3D print Design Concept A (side-view)

The team took note of these comments and reflected on it, deciding that probably it was more a question of the 3D renders in themselves that did not reflect properly the design. Therefore, in order to validate this thought, a 3D print was

made and sent out to the users who made those comments.

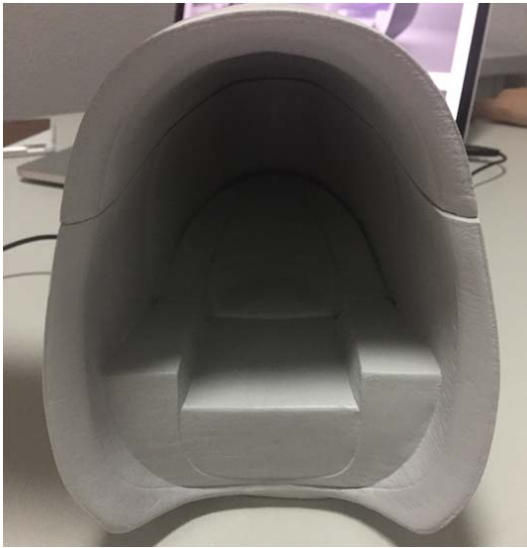


Fig. 5 3D print Design Concept A (front-view)

After seeing the 3D print, the majority of those users (67.8%) changed their opinion and praised the model. The remaining users gave neutral feedback. This shows how important 3D visualization, manipulation and printing can be to influence individual's opinion.

IV. PROTOTYPING

Bearing in mind the feedback given from the users, our research team started construction on a prototype of the seat in itself and the technology associated with it.

Our goal was to see how the technology behind such a seat could work. Therefore - and since this was just a mere prototype - the team decided that the visuals should not resemble the 3D renders that were produced, so that users could focus on the feedback regarding the sensors and actuators. This kind of approach resembles some studies that have been done in human-computer interaction. Campos e Pestana [6] claim that software designers are now embracing their development by creating clutter-free interfaces to allow users to focus on their tasks. We envisioned that this could be extended to end-to-end products such as this chair and especially for prototyping activities.

Based on [7] Enzo's Mari Autoprogettazione chair design, we set to create such a structure in plain wood and then incorporate a series of Adafruit sensors connected through photons to the Cloud.

We have tried to cover several of the basic senses but also to go a bit further, as there are senses that are not formally considered a sense but can actually be interpreted as such; for instance, the feeling of temperature. With these premises in mind and after building up the chair - of which, the back inclination could easily be adjusted by the user - we have started working on the trickiest part of sewing and ironing sensors together.

First, we used pressure-sensitive conductive sheets (Velostat) sewn onto the woven conductive fabric with a thin conductive thread to build two squares (matrix) for the seat and its back. These would allow to check the user's posture and presence. Afterwards, we added an electret microphone amplifier and an Adafruit's air quality sensor. Both would be used to check if external factors such as noise and oxygen levels pollution would interfere with the productivity of a user.



Fig. 6 The prototype chair just after construction



Fig. 7 Soldering the sensors was a challenge in itself

At last, a temperature and humidity sensor was added so the system could check the outside air temperature and set some vents on to try to simulate a cooler ambience (all testing was done indoors in a 22°C room). These sensors were connected to particle photons who offer a cloud service to register the data. This was also ideal because everything worked wirelessly without the need to run wires, allowing testing and repositioning of the sensors to be much easier.

In terms of actuators, the team added Adafruit's Neopixels colored RGB LED strips to the sides and back of the chair as well as a directional sound beacon just above. These were controlled through a Raspberry Pi that received the interpreted data from the Photon Cloud and changed the outputs of the actuators (color and type of music played).

Overall, the prototype would register when a user was sitting down, his posture (for this formula, if posture was correct, the pressure would be distributed along the pressure-sensitive pads), the noise, outside air temperature and air quality (this data would then be cross-checked by the team in terms of minutes against the times when a user would be writing or typing, to see if those had any influence). Finally, the ambience, sound and the LED coloring would be adjusted to test what users would prefer for their two main activities (relaxing and working).

V. USER TESTING

Having a minimum value prototype up and running, it was time for some user's testing activity, so conclusions could be drawn with regards of the stimulus and ambiances that affect people's working space and habits while using such a seat. For this testing, we gathered 15 subjects ranging in age from 18 years to 55 years, both male and female, and all with a good knowledge of computer usage and with the majority coming from the creative industries sector.

There were two sessions (30 minutes each) for each of the subjects. In the first session, users were invited to freely experiment with the seat and develop their daily activities related to work and relax. While they were doing these, the team adjusted the values of the actuators, changing the sound from silence, to meditation music, coffee shop buzz and rain, and the RGB LED strips from strong white to soft blue and high red. All other parameters collected from the embedded sensors were all recorded. At the end, the user was invited to comment on the solution in terms of its usability and usefulness.

For the second session, users were told to perform a series of tasks related to work (e.g. write a short story) and do a quick nap. They were invited to change freely by themselves all the parameters of the seat for the configurations they felt more comfortable with for each work/relaxation stage.

At the beginning of each session, all users were reminded to be oblivious of the seat design and seat comfort and instead focus on the asked tasks, usage and functionalities.

Compiling the feedback and data values from session 1, the majority of users were more productive (productivity is here defined by the action of typing) in a combination of silence and light blue color (57.5%). followed by the combination of rain sound and light blue color (33.3%). For the relaxation mode, the majority of users seemed to enjoy more the ambience with the meditation music, and again, blue light (61.5%) or with green light (30.5%). As expected, high-volume outside noise inputs affected the user's work with a vast majority simply unable to do any kind of work during this time (79.3%). However, air quality variation did not seem to have any effect, we suspect that this is due to the short length of the session itself (maximum 30 minutes). In our future research, we will continue to explore this topic in lengthy sessions. Temperature also played a role, although users kept working, they complained that both a higher temperature or a too-low temperature, was taking a toll on their focus since it was becoming too uncomfortable to work. These effects on

the relaxation mode weren't significant. Users were still able to rest and relax despite the temperatures variation without any significant complaints. This validates that, in fact, the temperature of a workspace can indeed affect one's work productivity although it is such a subjective variable (e.g. a 28°C room temperature was rated as "too much" for the majority of users, yet some just mentioned it as "a bit hot, but Okay").

Looking through the feedback from session 2, about 76.5% of the subjects were able to control and adjust the seat and its configuration. In fact, they found it quite "funny" (54.1%) and "interesting" (30.3%) to spend some time just exploring the concept and configurations by themselves.

The time users took to complete the task varied according to the configuration each one chose. A total of 61.0% of users completed the task in less than 15 minutes when they were satisfied with the seat configuration. From these, 89.3% said that the simple fact of combining color LED light with a music ambience was surprisingly effective for their comfort and productivity. However, when confronted with their data reports (which included all the compiled values related to their sessions to better understand their preferences and work habits), 55.5% of the users said it was "interesting" to know these, but were not very confident that this knowledge would be that useful for their daily work (45.3%).

VI. CONCLUSIONS

Although the research is still on-going, it is already possible to draw some conclusions. It is our opinion that there are many external factors that influence one's work productivity. That includes noise and temperature, although the amount of these inputs and its influence can vary from user to user. Also, human-computer interaction can be used to create better workspaces, either by embedding sensors and actuators in a seat or any other tangible element (e.g. desk).

The human-computer interaction will play its role solely if the technology is embedded in a visual subtle way; that is, in such a way that it contributes positively for the productivity only by giving visual or audio stimulus without distracting the user or adding a lot of complexity to adjust such ambience.

It is interesting to note that visuals play an important role not only in how people work, but also the predisposition that they would have towards using a solution such as the one we have envisioned.

Most certainly there is still a lot of field to explore in this matter but it seems that by combining technology with furniture design and interior design can actually contribute for the worker's productivity and mental well-being.

It is surprisingly upsetting that players in these markets have not explored this theme (and even researchers), as it can truly influence and revolutionize workspaces in the future.

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