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INVESTIGATING STRATEGIES IN A SOUND DESIGN FOR SUSTAINABILITY EXERCISE IN AN EDUCATIONAL SETTING

Georgios Marentakis[1*] **and Stefano Delle Monache**[2]
[1] Department of Computer Science and Communication, Østfold University College, Norway
[2] IRCAM CNRS - STSM Lab / Perception and Sound Design group, Paris, France

ABSTRACT

Designing sound for sustainability is a vibrant research topic as researchers try to find ways to design sound in order to communicate sustainability values. We present here a study focusing on product sound design for sustainability. Students from a sound design course were asked to design sound for an electric device with a focus on communicating sustainability values. Here, we analyze and present our results based on a recently proposed framework for coding sound-driven design activities. We report on the elements which received most weight by the student designers and outline the creative solutions that were proposed. We use the framework to gather insight on how student designers considered different sound design aspects when developing their projects. We conclude by discussing possible methodological aspects that could be addressed more systematically in the future in an educational context.

Keywords: *sound design, sustainability, product sound*

1. INTRODUCTION

Design is an area of major importance in the journey towards more responsible and sustainable production and consumption model [1]. Designing for sustainability is a field within design investigating different ways to support sustainability through design. It is researched actively in product design, architecture and the built environment, transport, resource use and management, computing and interaction design, health but also music, art, and culture.

The relationship between sound and music and sustainability originates in soundscape, acoustic communication, and acoustic ecology [2,3] with later work on soundscape design especially in relation to urban spaces [4–7].

Sound is an essential part of the experience and use of products and can be shaped by design in accordance with predefined requirements. Originating in film sound design is now found in several practices such as sonic interaction design, auditory display, warnings and alarms, computer games, and sonic interactions with products. Sound design for sustainability is a concept unifying different efforts to improve sustainability through sound design.

A recent review [8], analyzed different themes in sound design for sustainability and identified the following themes in designing sound for sustainability: sound, music, and the environment, eco-musicology, environmental impact of the music industry, sound design for sustainable behavior, product sound and sustainable acoustics.

Given the increase in interest in sustainability and sound design, it is interesting to investigate how to engage and teach students in designing sound and sustainability. To this end, we designed and report here our experiences with requesting students to perform sound design for the purpose of communicating sustainability through product sound. The paper is organized as follows: first we present some background on sound design and designing sound for sustainability, then we present the method we used including the exercise we designed, and finally we present the results and our reflections on the project we have undertaken.

*Corresponding author: georgios.marentakis@hiof.no.

2. BACKGROUND

2.1 Perception of Product Sustainability

Design for sustainability is a key area in design investigating how to design sustainable products, systems, and services. Focus may be on lowering the environmental impact of product life-cycle (green design, eco-design [9]), reducing the amount of circulating products [10, 11] or improve the use phase through design for sustainable behavior [12]. A number of researchers looked in more detail into how product aesthetics relate to the perception of its sustainability. Zafarmand et al [13] identify seven aesthetic attributes: 'aesthetic durability', 'aesthetic upgrade-ability and modularity', 'simplicity and minimalism', 'logicality and functionality', 'natural forms and materials', 'local aesthetic and cultural identity', and 'individuality and diversity'. In connection with research on plastics, DuBois et al [14] identified five variables that interfere with the sustainable perception of the participants: weaker color intensity, use of colorless colors, a rougher texture, a speckled structure and the usage of a matte gloss. Sareh et al [15] proposed an aesthetic - sustainable industrial design framework with emphasis on life cycle and reuse strategy, and sustainability in materials selection and manufacturing processes. They emphasize that a product that is elegantly minimal in terms of materials and forms not only avoids waste but also communicates durability. The aforementioned perceptual investigations are routed in visual and tactile perception and less so on auditory perception.

2.2 Sound Design and Sustainability

Sound design is relatively new discipline emerging from film and being applied today in various domains including product design. Most sound design methods iteratively design sound form (i.e., quality) and sound function (i.e., purpose in the context of use). Most follow analysis, creating (synthesis), and evaluation steps [16–18]. The analysis step begins with the analysis of existing sounds used for similar purpose and ends by an acoustic and perceptual specification of the sound product. This is followed by an ideation process followed by creation of alternatives to be evaluated in a last step e.g., [19–22].

Arguably, the perception of product sustainability involves the sustainability of its construction, disposal, and possibilities for sharing and reuse as well as the resources involved in the use phase. Connections between sound design and design for sustainability have only recently been made [8]. Sound design for sustainable behavior e.g., [23–25] can be used to influence product use. However, the relationship between product sound and the perception of product sustainability has not received much attention in the literature. The sound of products is known to elicit strong emotions and associations [26] and is likely to influence the perception of product sustainability however this topic remains unexplored.

2.3 Teaching sound design

There is sparse literature directly investigating teaching sound design. Rocchesso et al [27]discussed pedagogical approaches to sonic interaction design and acknowledged challenges in identifying appropriate materials but also in performing evaluation of early basic designs. Shared observation is brought forward as a method to address this issue. A further issue discussed is this of sensitization to sonic interactions using sound walks, audio dramas, and exploring audio-tactile interactions. Sketching though vocal interactions or sonic overlay of video is considered as a final step in the process before the delivery of the final prototype. [28] advocates towards an action-sound approach. [29] use Foley to function a design process in a workshop setting, continuously scrutinizing sound design and interpretational strategies in three steps: foley--based and electro-acoustic Wizard of Oz mockups and functional prototypes, real time sound making, performance of interactions, and critical reflection. These approaches are echoed in related books most significantly the one by Karen Collins [30]. Some further discussion can be found in [31, 32].

2.4 Summary

While product aesthetics have been found to influence the perception of product sustainability, the impact of product sound has not received much attention. The application of product sound design could provide a creative way to gain insight on the relationship between product sound and the perception of its sustainability. In an educational context, such a project could provide a great opportunity to sensitize sound design students to contemporary design problems and simultaneously obtain insight on how they approach this problem by design. To this end, we designed and present here an educational exercise on designing product sound for sustainability.

3. STUDY

Our investigation is based on an assignment which was designed to lead students to think and experiment with how they could communicate values related to sustainability through sound design. The assignment was the last of four in a course on sound design and production at the Digital Media and Design Bachelor program, Østfold University College. There were two instructors the first was a university teacher and the second a sound artist. During the course students received instruction on theoretical and practical aspects of sound design. Theory lectures and exercises focused on the basics of sound as physical phenomenon, perception of sound, digital audio, as well as recording, arranging and mixing sounds. The students had already completed three assignments which had topics related to soundscape, sound for video/film, and sound for creating an audio-book type of delivery for a short poem. They had already interacted with the sonic artist on three occasions in which they discussed the aesthetic aspects of their projects and received guidance on how to implement their ideas using their chosen tools and DAW workstation.

3.1 Definition of the assignment

The assignment had the form of a design brief. Students were instructed to design the sound of an electric water kettle so as to communicate its sustainability. To do so, they explored the relationship between the sound of kettles and the perception of product sustainability taking into account all sonic aspects of interaction with the product: the sound of product materials, interaction with the control elements, displays, notifications, and the sound of the water boiling cycle.

The assignment was structured in three steps. **Step 1** was a sensitization activity and involved documenting interaction with at least three existing water kettles selected by the students to show variation quality, materials, and sound. Students were instructed to note, share, and discuss observations as a team referring to a short video documenting interaction with each of the kettle(s). In **Step 2**, students ranked the kettles in terms of sustainability with and without visual feedback. This shared observation activity was designed to prompt students to discuss about which aspects they think contribute to the perception of the product sustainability. In **Step 3**, they identified which sonic aspects they would modify to influence the perception of kettle sustainability and created a sonic overlay of one of the videos illustrating their approach. They submitted a short essay documenting the process and audiovisual material.

Students were provided with a working definition of product sustainability as a product whose production, use, and disposal does not lead to depletion of natural resources. In the assignment context, this was to be interpreted as products whose sound implies that their production, use, and disposal does not lead to depletion of natural resources. Natural resources were defined both as materials but also as resources such as energy, water, etc. Sustainability at the disposal phase was defined as the extent to which the product is recyclable.

3.2 Participants

Participants were university college students. There were eight student groups which participated each had between two and four students as members. Students were in the fourth semester of their studies. In total there were twenty-four students which participated nine male and fifteen female. Students provided consent in order for their assignments to be analyzed for research on teaching purposes.

3.3 Analysis

The written assignments and the audiovisual material was imported to MaxQDA for coding and analysis. Coding was done using the TWAF - Designing [The, With, Against] sound [For] coding scheme developed in [33]. This scheme takes in account four main semantic orientations of sound strategies found in design projects that incorporate sound and that reflect the cultures of different stakeholders in the design process:
1. Designing **THE sound** is sonic and creative: under this code, sound designers focus on a sonic problem (i.e., perceptual implications of listening) and use creativity (i.e., artistic experimentation and innovation) to shape aesthetic, expressive and sensory qualities of sound. Sound is created to evoke emotions and moods, and represent a unique sonic identity and convey information, functions and intentions.
2. Designing **WITH sound** is experiential and integrative: under this code, designers focus on the integration problem of sound with other design elements (e.g., lighting, space, and materials) within the environment and context in order to create a cohesive and immersive experience. If sound is designed, it is used to create a more engaging (i..e, multisensorial) and remarkable experience (e.g., adventure) for the user. The experience of listening is complementary to, and integrated in the product experience.

3. Designing **AGAINST sound** is technical and mitigative: under this code, acoustic engineers operate against sources and systems that produce unwanted or harmful sound. A technical problem (sources, mechanisms, physical configuration, regulations, systems, algorithms) is found in the physical, sensory, and functional aspects of noise, acoustics and vibrations. The design action aims at mitigating noise (i.e., unwanted sounds), thus increasing sound quality to create acoustic comfort in an environment.
4. Designing **sound FOR** is cultural and purposeful: this code represents the culture of the expert users, as they seek for culturally relevant (e.g., values, beliefs, and practices) and meaningful sounds for a specific audience or community. Sound is used to tell stories, convey values and information and evoke emotions that are specific to a particular cultural context. The design action is to find purpose for the sounds to exist. Therefore, design process for the intervention encompassing sounds are inherently goal-oriented and context-dependent.

This scheme was developed during participatory sound design workshops and was chosen due to its versatility and ability to capture the multi-facet nature of sound design.

4. RESULTS

Here we summarize the results of the coding process for each of the four main codes in the coding scheme we follow. Coding was done by the first author and validated with the second so that disagreements were resolved. Summarizing was done in collaboration. We present results starting with the FOR code, since this provides an understanding of the students' interpretation of the sustainability context in sonic terms. Three main conceptualizations emerged, that is **product circularity**, **durability**, and **energy efficiency**. Then we proceed with the AGAINST, WITH, and THE codes that highlight the different perspectives and strategies that the students adopted to translate their sustainability conceptualizations into sound design solutions.

4.1 Designing Sound FOR

Sustainability was understood in terms of product circularity, durability, and energy efficiency: 'material choice significantly impacts the perceived sustainability of a kettle. A kettle made from cheap plastic reduces from its sustainability image compared to one fashioned from robust metal or high-quality plastic', or 'it has good durability which is a key aspect of sustainability', 'the harsh sound of a kettle struggling to heat water ... is taking away from the products sustainability'. A sense of the product being in 'harmony with the environment and nature' was also mentioned. Material was considered critical for communicating sustainability values, both in terms of recycling potential but also in terms of providing a sense of durability: '[it] is favored due to easier recyclability and lower risk of emitting harmful substances'. Sound should relate to this of a sustainable and durable material like glass, metal, but not plastic: 'the sound should minimize any hint of plastic, ideally resembling a sturdier, more durable material'. Furthermore, mixing sustainable materials with others was not appreciated and was considered a factor that was reducing sustainability.

Some groups weighted in emotional factors: 'most sustainable I felt was .... it gives off a more cozy and warmer vibe ' or 'this can give the user a sense of calm and well-being, which can reinforce the impression of sustainability'. Sustainability was also associated with aesthetics : '(it) has a minimalist aesthetic, which can also contribute to the perception of sustainability' or 'a more modern design that ... also contributed to a sound that felt more sustainable' or 'the design calls back to simpler times and may help it appear more sustainable than the regular, mass-produced electric water kettles'.

The availability of advanced control options and of a digital display were also associated with higher quality and better control in relation to sustainability: '[it] has different settings where you can choose which temperature you want the water to be'. On the other hand, others value simplicity as 'there's less that could break'.

4.2 Designing AGAINST sound

The most prominent aspect in this category was the loudness of the sound emitted when the water was boiling. Groups attributed this negative association both to the fact that a louder sound led to an impression of cheap construction but also to a higher (and likely wasteful) energy consumption: 'the harsh sound of a kettle struggling to heat water may create feelings of discomfort', '[it] is so loud makes it sound cheap and not sustainable', 'the loudness of it ... brings it down on my list', 'sounded very intense and "felt" like it wastes energy'. Loudness was not only unpleasant and a sign of low sustainability but it also led to annoying interference to other activities from boiling sound. Most 'would prefer if [it] had better sound insulation'.

Creaking and squeaking sounds of 'loose parts' such as the lid or buttons was perceived as a sign of the device

being old or not durable. A device which sounded 'thin and hollow like an empty bottle' was through to reveal poor material used in construction while the sound should have conveyed 'durability and higher quality' and a 'solid and premium sound'. Negative comments were mostly associated with plastic kettles. There were also comments relating to the sound of water pouring in and out as well as acoustical aspects e.g., 'being made of glass ... resonates a lot more'. The lack of feedback to the completion of boiling was also considered to be a problem.

4.3 Designing WITH sound

Groups commented that the impression of sustainability cannot emerge from sound alone but rather as a congruent experience supported by all senses: 'the visual and sonic aspects are not only aesthetic choices, but a way to communicate the product's sustainability'. Failure to create a congruent experience could destroy the impression of sustainability. This could relate to design: 'a kettle with a clean design but made of plastic may raise doubts about its sustainability' or the combinations of materials: 'because the kettle is in stainless steel, the plastic buttons and knobs feel even cheaper'. Sound had an important role to play here: 'it would sound weird to have really sustainable sounds to a plastic kettle'. Material choices leading to perception of sustainability were considered to be weakened or enhanced through sound: 'when being tapped: low, plastic sound (but it seems harder in comparison with others) - more durable material'.

The experience of interacting with mechanical parts was also considered to be supported and enhanced by 'crisp and firm' sounds: 'you can hear the spring in when lifting the lid, and creak when closing it'. Sound was also considered an element completing the experience e.g., producing 'a satisfying click' when starting the device, '(making) pouring water sound satisfying', or making an action 'sound easy and not complicated'.

4.4 Designing THE sound

Several comments were about understanding and designing the sound of the boiling process. The most commented aspect was loudness: 'to make any kettle sound more sustainable we need to lower boiling water sound volume' as 'quiet, gentle sounds during operation signal energy efficiency'. Insulation did not only reduce loudness during boiling but also led to 'a more comfortable and muted sound when you fill it up or boils the water'. Groups realized that loudness varied over time in ways that depended on the model, however, they did not propose dynamic changes in loudness in their designs .

The timbre and to some extent the pitch of boiling water cycle received several comments. Existing sounds of boiling were in general perceived as not appropriate from the point of view of communicating a sustainability perspective. Lower frequencies, when present, were considered to be pleasant and water sounds such as bubble sounds and rumbling were appreciated. Groups commented that sound 'should be less harsh, with a deeper bass, fuller resonance, and a rounder quality'. They identified layers in the sound timbre as 'the sound of bubbles gradually mixed with the initial hum of boiling'. This brought associations: 'a smooth "bubbling" sound reminiscent of a flowing stream'. Original sound was typically removed in the assignments and sounds of nature were layered 'to evoke a serene connection to nature, aligning with the concept of sustainability'. For example, groups used 'waterfall sound', 'rain sounds', 'waves', 'flowing river' as a base layer and added elements like 'wind', 'bamboo', 'chirping birds', 'owls', etc. One group wanted to give the experience of being outside preparing water in the nature so that 'sounds are coming from outside the window' and not from inside the room.

Groups appreciated 'firm and crisp' sound as a sign of robust construction when it comes to interaction with the mechanical moving parts. Squeaky sounds brought to associations with an aging or poorly constructed device. Such sounds were removed in the deliveries: 'instead of brutal clicking noises of the on/off switch, we replaced it with some nice and dreamy chimes, which indicate when the kettle is on and is finished' or 'the sound of bubbles when the lid is opened and closed', or 'bird calls associated with the kettle's button'.

Concerning feedback, several groups considered the high frequency beeping sounds used as audio feedback to digital interactions not to harmonize well: 'the pip sound is unpleasant'. These were replaced using natural sounds but also a 'frog' sound from a group aiming to provide a more playful dimension. One notable addition was 'a voice feature which indicates various thing as time remaining, which mode is on and how much energy you save'.

4.5 Summary

We coded the deliveries according to the Designing [The, With, Against] Sound [For] coding approach which al-

lowed to isolate different perspectives in the sound design strategy. Sustainability was understood in terms of the product circularity, durability, and energy efficiency. Sonic aspects related to each of these dimensions were identified and discussed by the students: the sound of the material, the sound of the moving parts, and the sound of the boiling process. These were found to have the potential to enhance (when congruent with) or degrade (when incongruent with) the level of sustainability perceived by other senses. Sound design was applied to hint to recyclable and durable materials, enhance the perceived durability of moving parts, reduce the loudness of the boiling sound, and remove high frequency elements as well as high frequency audio feedback beeps. Natural water sounds were layered to create an agreeable experience. Non-water sounds were used to augment the soundscape. Voice was used for feedback to the boiling process.

5. PERSPECTIVES AND CONCLUSION

Motivated by the increased interest in sound design for sustainability, we have attempted here to investigate how groups of university students in a sound design course would design sound for a common device, an electric kettle, to communicate product sustainability. Students explored the sensory aspects of found kettles and re-designed their sound with the intention of communicating product sustainability. They presented their ideas using sonic overlay of video. This exercise allowed us to reflect on the teaching approach used while collecting valuable information about designing sound for sustainability.

5.1 Aspects identified

The application of the Designing [The, With, Against] Sound [For] coding scheme helped separate and identify different perspectives in the design process. In their reports, groups identified shortcomings (against) and discussed experiential aspects (with) when designing (the) sound (for) sustainability.

In agreement with the literature in Section 2, sustainability was related to a perception of product circularity, durability, and recycling energy efficiency. Groups thought that the sounds of interacting with device should support such associations e.g. sound of steel or glass was favored over plastic. Mechanical interactions should also sound robust, through a crisp sound. Sound was considered a sensation that can enhance the perception of interacting with a durable device made out of quality sustainable materials when congruent with a similar impression provided by the rest of the senses. On the other hand, if incongruent, sound could reduce the overall experience of kettle constructed of a solid material. Sustainability was also related to energy efficiency as this is understood though the sound of the boiling process. Nearly all groups objected a loud, harsh, and noisy water boiling sound and valued a soft sound enhanced with natural sonic elements as a sign of sustainability. They also appreciated notifications regarding the progress of the boiling procedure.

5.2 Divergence and omissions

Relating to the existing literature on designing sound for sustainability, aspects that were not considered relate to designing sound for sustainable behavior. Even if groups valued feedback about the efficiency of the boiling process, the presence of digital controls to set the desired temperature, and transparency as a way to judge how much water was in the kettle, only one group introduced voice feedback to boiling cycle stage while none thought of using sonification for communicating energy consumption or assisting the user in reducing energy consumption [25]. The same holds also for the source of electricity and the emissions involved in the process. Furthermore, the groups avoided embedding dynamic cues in the sound of the boiling process and rather used a sound that is pleasing and provided a sense of operating the kettle in a way that is connecting with nature. It is not clear if this reflects an objection against embedding information in the sound or just a lack of technical sophistication in the student groups.

Another point that was a source of diverging opinions was judgments on the sustainability of each material. While the durability of the materials was relatively easy to judge, their sourcing and recycling potential was often a source of divergent opinions especially with respect to the extent plastic can be recycled as well as other materials. Another point of divergence related to design, with some attributing sustainability to a modern sleek design while others implying that the use of a time-tested design had the potential to communicate sustainability in a better way.

5.3 Reflecting on the teaching approach

This was a first experiment in training students to think about sound design for communicating product sustainability and some aspects seem to have worked while for others there is potential for improvement. Overall, shared observation worked well in developing a consensus with

respect to the experiential and aesthetic aspect of sustainability of the product involved. It also succeeded in sensitizing the students to the topic. However, given the divergent opinions that emerged an aspect that could have been clarified better was this of sustainability and its aesthetics. While a definition and some examples were given, reflecting on the results it appears that more specialized knowledge on sustainability and how this has been addressed in the literature would have been relevant for the students.

Sonic overlay of video overlay was also quite sufficient on helping student showcasing their ideas. What was particularly useful is that it provided an easy way to 'override' the original sound of the kettle which would have been hard to achieve if a more performative approach was taken. While there is certainly merit in employing a technique in which overlay is done while the students interact with the actual physical device, the danger here is that sound from the two processes would be mixed. Therefore this approach required more careful experimentation which we hope to do in a future iteration of the exercise. Furthermore, examples of designing sound design for sustainable behavior could be used to help students employ such techniques in their designs.

Even if not used while grading the assignment, the use of the TWAF coding scheme helped identify shortcomings in the training approach. It also provided significant insights in the works some of which were not apparent during the marking process. When marking, evaluation was mostly based on what was here coded as designing AGAINST sound and designing THE sound. The FOR and WITH aspects of the sound design process did not receive much weight. Our analysis here revealed how students connected sustainability values to product aesthetics and multi-sensory aspects which could have affected the evaluation had they been noticed earlier. In this sense, the use of the scheme helped see the versatility of the themes involved in the student responses and could also be helpful in student evaluation.

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