PUSHING SUSTAINABILITY TOPICS IN SOUND TEACHING

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ABSTRACT

In teaching in the field of sound engineering and sound design, the urgent debate of sustainability issues is still underrepresented. Some students bring along their personal commitment, while many are uninformed — amazingly, within tertiary education. We present the website of our SIDlab, i.e. Sonic Interaction Design lab [1], where we highlight projects of sonic interaction design and sonification that have a focus on sustainability. Mainly, these projects have been developed within our courses that bring the students in contact with topics originally foreign to their discipline. The main strategy of the courses is limiting the choice of topics for their sound projects to an issue related to sustainability. In the first place, the website presents the SIDlab of the Institute of Electronic Music and Acoustics, fertilizing new project ideas within the university. Furthermore, the website and this paper are intended both as a model for other educational institutions and as an evolving project of communicating environmental facts in new ways. At the moment, two members of the institute curate the collection, but a further community driven approach is envisaged.

1. MOTIVATION

When teaching university students, the knowledge of the climate crisis and the need for a fundamental system change may be assumed. Or may it not? For instance, a basic understanding of the Earth's climate system, including the anthropogene influence on it, supposedly should be part of primary and secondary curricula, as education for sustainable development [1]. Still, when we included such topics at the periphery of sound related courses, as will be discussed in this paper, it turned out that a considerable number of the attending Master's students were quite ignorant of this topic. This is the initial motivation to write this paper. It is also supported by literature, e.g. Mann et al. [2] performed measures of ecological worldview and ethical sophistication with freshman computer students, and found that these students had poor ethical understanding and were only partly pro-ecological – the authors state that a substantial shift in their worldview would be needed for them to become "sustainable practitioners". In a different perspective, Easterbrook [3] claims the need for a shift from computational thinking, where each problem has a technological solution, to systems thinking, of a more fundamental and interdisciplinary nature.

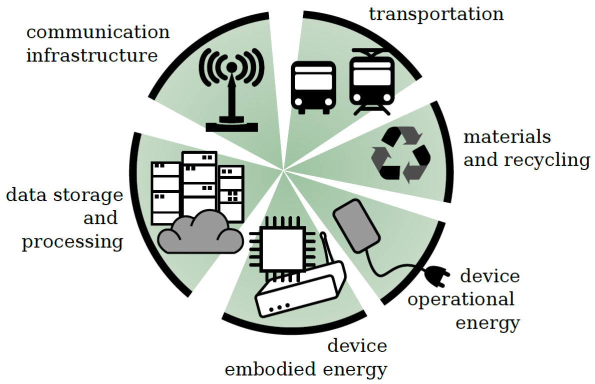

Figure 1. Key areas that contribute to the ecological footprint of the Internet of Sounds. (The proportions are not representative.) Source: [4]

Recently, Gabrielli & Turchet [4] discussed the sustainability of the internet of sounds — or, more generally, of the internet itself with a focus on sound related technologies. The authors found key areas to monitor the impact of the Internet of Sounds, as shown in Fig. 1: materials and recycling, device operational energy, device embodied energy, data storage and processing, and communication infrastructure. All of these areas contribute to the ecological footprint of the internet and related devices. In a life cycle analysis, the greenhouse gases (GHG) can be attributed to all phases of the life cycle of a product, from the extraction of raw materials, the manufacturing, and the usage to its disposal. These factors can be assessed for all areas of Fig. 1. We refer to a handful of prototypical facts resulting from such and similar analyses in the following. The internet is responsible for about 2% of worldwide CO_2 emissions — which is roughly equivalent to the carbon footprint of the aviation industry. [2] More detailed information can be found in [5], who estimate the carbon footprint of the ICT (Information and communication technology) sector with 1.4% of the total carbon footprint. Out of this, multimedia streaming has become the dominant causer with around 87% of share [6]. With respect to the focus of SoniHED, we may also refer to the energy use of the internet;

[1] https://sidlab.iem.sh

[2] https://www.ovoenergy.com/blog/green/the-carbon-footprint-of-the-internet

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for instance, the ICT sector is responsible for 3.6% of the global energy footprint [5].

In the same time, the internet may help to reduce emissions, for instance, teleconferences have a positive impact under certain preconditions, and can reduce the carbon footprint by up to 44% in academia in a study from 2013 [7] and even up to 94% in a recent study [8]. In modelling alternative scenarios for the showcase of one international research project, the total of emitted CO_2 equivalents could have been reduced to 53% of the emissions of this project by applying standard measures or to only 2.4% in a strict scenario [9]. Still, it has to be considered that, while the internet may be part of the solution, the general trend may overcome the positive effects, a rebound effect known in Economics as Jevons paradox [10].

To come closer towards a more sustainable internet, the authors of [4] certainly have no ultimate solution. Instead, they suggest simple strategies for the individual internet user and producer of sound: reusing — on the hardware side reusing equipment with similar functionality [11], on the software side creating software with backwards compatibility to older versions; consuming less in general avoiding to follow every trend; and enhancing video meetings if they substitute traveling.

General trends of Sustainability in Human Computer Interaction are explored in the field of SHCI for which a recent review is a good starting point [12].

On a meta level, the ubiquity of "the internet" can be used to share ideas and concepts of (education for) sustainable development, by giving examples on how to raise awareness for the "Grand Challenges". This ranges from stereotypical "life hacks" to full-fledged platforms to share and disseminate learning material and didactic methodologies such as the "Sustainicum Collection" [3] of the University of Natural Resources and Life Sciences, Vienna [13].

We are worried about climate change and we teach sound related courses at the Institute of Electronic Music and Acoustics (IEM), University of Music and Performing Arts Graz in Austria. Therefore, in the last years, we have explored formats to make sustainability part of this teaching. In this paper, we present a collection of mainly student (co-) works on the SIDlab website, see Fig. 2. They are part of our SIDlab, the Sonic Interaction Design lab at our institute, for which we have established and intend to further stimulate a focus on the topic of sustainability (SID4future).

2. TEACHING APPROACHES

For teaching topics related to sustainability within the disciplines of ICT, Eriksson and Pargmann [14] discuss how to actually reach students in this field. They argue that future engineers and professionals of ICT have to be sensibilized to the topic, reflecting the outcome of their future work. Furthermore, students can be engaged on a personal level. The course described in their paper included didactical elements such as the use of challenging, open questions where no simple answer can be given; a learning game where discussions in small groups can take place to explore the students' own values without ideolocially bias from the educators; and use energy as an intermediary concept to make environmental effects more graspable than abstract CO_2 units. While different authors have suggested for a more integrative way of introducing sustainability into a whole curriculum (see [14]), the minimal approach is a modular one, which can be implemented more easily. In Sweden, dedicating one course of any curriculum to sustainability issues is even required by law, but the authors of [14] state that this is not enough in the long run.

Teaching in the area of sound design, sonification, and creative coding, our advantage is the project-oriented nature of these courses. Students learn in self-chosen projects where they prepare, present and discuss sonic prototypes or algorithms. In all our lectures, the idea is to use sound as a medium to communicate *something* — a data set, an interaction feedback, an algorave. The *something* can be circumscribed to our chosen topic, i.e. sustainability. For instance, the United Nation's Sustainable Development Goals provide an extensive set of topics. [4] For sonification, the choice of data with a background of sustainability is straightforward. Sonification allows itself to be used as an objective perceptualization of scientific data. At the same time, sonification creates interest for the data, as people are still not used to "hearing data".

Students of the courses are typically at Master's level (with a few exceptions of elective subjects in Bachelor's degree) and the sizes of the classes are rather small, with about 5-15 students. They have slightly varying backgrounds as they study either electrical engineering-sound engineering, sound design, computer music, or musicology. Therefore the classes already have an interdisciplinary nature.

On the part of teaching sonic interaction design, the chapter of Rocchesso et al. in [15, ch. 4] provides a great resource. Rocchesso describes five methods for teaching sonic interaction design that can actually be adapted to other sound related studies. All of these can also be put in a specific thematic spotlight and are thus useful for conveying side-information on sustainability issues:

1. When performing sound walks outside, students can reflect on the relation of natural and human-made sounds.
2. Creating audio dramas, i.e. sound-based but "speechless" stories, can already be a project on its own, where, for instance, nature sounds can be applied.
3. In sketching and prototyping sonic interactions, basic mockups can be created to prepare for the real implementation of prototypes and test ideas; in this stage, the topic of the chosen project is already central.
4. With their fourth suggested method, Problem-Based Learning (PBL), we come to the core of the didactic strategy, that we use at the core of the SID classes. In PBL, students are regarded as active learners who collaboratively solve problems. This is especially

[3] `https://sustainicum.at/`

[4] `https://sdgs.un.org/goals`

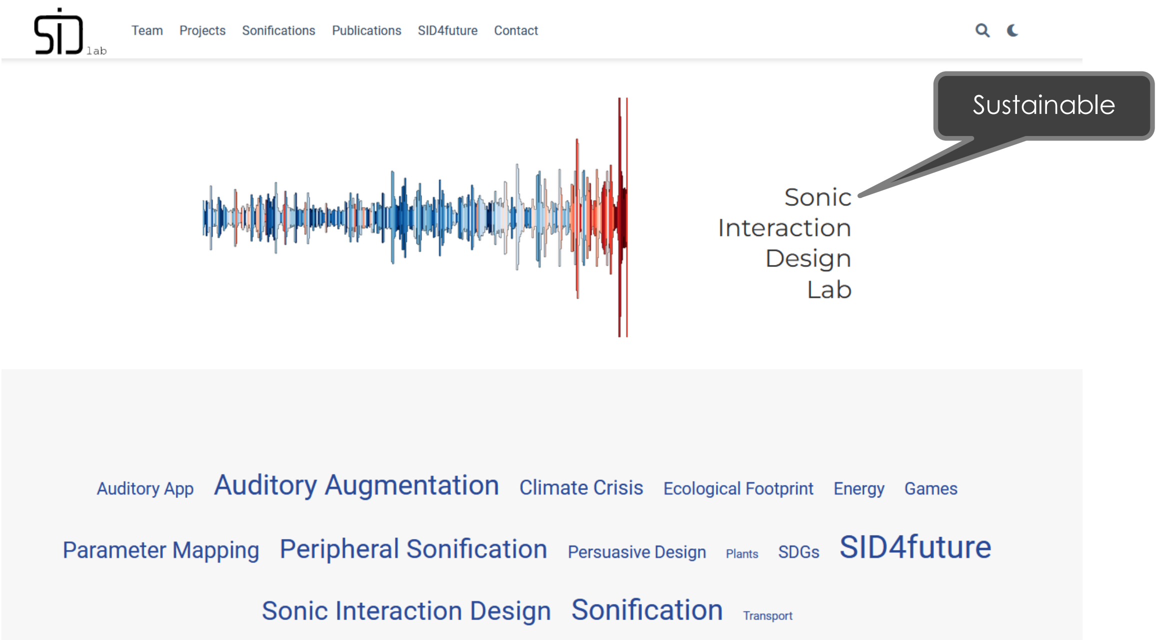

Figure 2. Screenshot of the `SIDlab` starting page. The word "sonic" is altered (blinking) with "sustainable". The SIDlab logo is based on the *Warming Stripes*, reminding of a digital sound wave. The tag cloud gives an overview over the currently added projects.

interesting when a variety of disciplines need to be incorporated to address a problem — certainly true for all systemic problems of humankind. Problems should be chosen by the students themselves, but we suggest that they make a choice within a limited field of options. Rocchesso cite [16] and [17] where PBL has proven to be particularly suitable for education dealing with design of interactive systems and multidisciplinary settings.

5. The final stage is the physical prototyping with interactive sound — which can be seen as the realization of the mockup prototypes and the PBL based preparations. Videos and sounds of some chosen prototypes are presented on the website.

Creative brainstorming methods in the area of sound design have been explored by Franinovic et al. [18]. Especially the speed dating approach proved to be fun and to open new perspectives in some of our courses. In that way, students come up with "crazy ideas" for the PBL approach. The speed dating is a series of short brainstormings in alternating pairs of students, on a pair of –equally alternating – topics. The topics' pairs are defined by a matrix of, for instance, SDGs, on one dimension, and a location on the other (the location can be anything, e.g. the tramway, the kitchen, the office desk). Students then have 2 minutes time to come up with a sound design idea in the context of the location with a focus on the respective SDG. In the following, students elect the best ideas and choose what they want to work on.

3. THE WEBSITE AND EXEMPLARY PROJECTS

On occasion of a new setup of our university's website we decided to present the results of our lab with a focus on sustainability projects. In this way, we do want to (1) fuel new projects of other student of our curricula who might become interested, (2) promote the many smaller and larger ideas of students for sounds for sustainability, and (3) inspire others in any scientific disciplines to set up similar projects in their teaching and research.

The website is a simple collection of our projects, searchable by tags, at `https://sidlab.iem.sh`. A screenshot is shown in Fig. 2. For reasons of completeness, there are also projects that do not have a focus on sustainability. In case of very prominent or larger projects, they have been added to the website. The majority, especially smaller student projects, are curated out of all projects for their focus on sustainability issues, and are tagged by "SID4future". The website is hosted by ourselves in order to have the freedom to adapt to new demands or formats of usage depending on how this collection develops in future.

In the following, a handful of exemplary projects at the lab are shortly presented; they show the range of activity from single-student works to externally funded research projects. The latter ones have their own ways of being disseminated, while the first ones, small student works, account for the critical mass of the website.

3.1 Individual student's works

These projects and the next ones (student's group works) shall constitute the core part of the website and will be

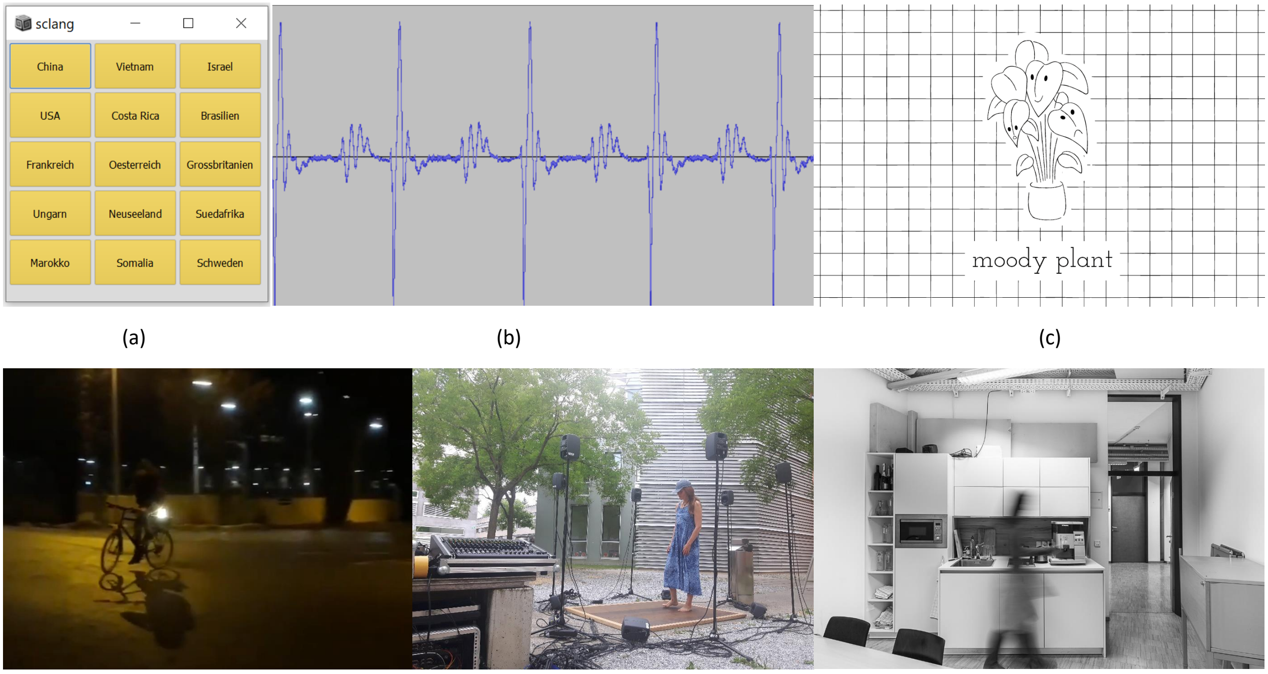

Figure 3. An exemplary selection of works presented at the SIDlab website.

added up in future. They are normally not presented elsewhere except on the SIDlab website. In the following, we present a few sonifications very shortly:

In a straightforward approach of parameter mapping, Robert Hofer mapped the amplitude of different sound samples (fire burning, water, alarm sound, wind) to the ration of types of energy sources (fossil fuels, water power, nuclear power, and wind energy). By interactively choosing different countries (see GUI in Fig. 3(a)), the listener may experience our dependence on fossil fuels.

Within a more metaphoric approach, Simon Windtner mapped the data on the worldwide temperature rise to the regularity of a human heartbeat and used a breathing sound to map precipitation data. Over the time span of the data (1880–2020), the physiological sounds appear to become more and more ”unhealthy” as they speed up and become more intense (see Fig. 3(b)).

3.2 Student's group works

The only difference to the above is a more extensive nature of the projects, as several students are involved in their creation (typically, 2–5). We give two short examples:

The *Moody Plant* (see Fig. 3(c)) was developed by Hanna Brühwiler, Elisabeth Hacker, and Michael Reiter in 2021. By equipping a house plant with simple sensors for conductivity, they could measure reactions when the plant's leaves where touched. The result was an anthropomorphous design to make people more aware of, otherwise silent, plants, as co-creatures that need to be cared about. The system has been awarded a price for start-up ideas and is considered to be further developed.

The *Sonic Bicycle* (see Fig. 3(d)) was developed by Felix Wagner and Thomas Alpers in 2021. The prototype works with a motion detection sensor and a Bluetooth loudspeaker, mounted in the back of an ordinary bicycle. The faster the bike is going, the faster a beatbox rhythm is played. The prototype is a playful motivation to use bikes more (and, faster).

3.3 Student's works that have been extended beyond the class

At a few occasions, student's works have been continued over the end of the course, for instance as initial research projects where the students had the opportunity to present their research in conferences or as artworks. An example of the latter is the *Anthropocene Maze*, an interactive listening experience of our ecological footprint on selected habitats, see Fig. 3(e) and [19]. This interactive sound installation consists of a wooden floor equipped with Pyzoflex® technology and an Ambisonics audio environment. Footstep sounds are modified in the ambiance of different habitats' soundscapes that suffer from human influence. The story is following a narrative, where a future computer travel guide leads a tour into the past — which really is our present. The installation has been exhibited and evaluated at the university's campus, and was subsequently published and presented as an installation within the *DACA 2022 — data art for climate action.* [5]

[5] https://dataclimate.org/

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3.4 The lab's research projects

The research of the staff of the institute has less focus on sustainability, as we do more basic research concerning sound synthesis and perception. Still, we try to add this focus more and more. An example is the *PilotKitchen*, depicted in Fig. 3(f), [20]. In this project we built a pilot system for sonifying the electric power consumption of our institute's kitchen — or, any room in general. The reverberation of the kitchen is changed depending on the actual consumption and its difference to a weekly baseline. If the actual consumption is low, it is mapped to a plausible kitchen reverberation that is similar to the real reverb of the small room. If it is high — as compared to the baseline — the reverberation becomes unnatural, in extreme cases the kitchen then sounded like a big cathedral. Evaluating the system gave insights on perceptibility and acceptance of auditory augmentation in a semi-home context. As outlook, such systems could be used as peripheral displays in smart homes in order to help their inhabitants to save electricity. This prototype has been followed by a more perception-oriented study to understand how many degrees of reverb can be differentiated at the periphery of our perception, i.e. while the subjects were performing a primary task without being distracted. See [21] for details.

3.5 Externally funded projects

In the externally funded research project *SysSon* [6] we explored a systematic procedure to develop sonifications, working with climate data. Within this project, a sonification platform [7] has been developed that can be used to create sonification on climate model's data to allow mainly for exploratory analyses. The project ran from 2013 to 2015 and was conducted in cooperation with the Wegener Center for Climate and Global Change, a major institute for climate research in Austria. The established research cooperation still proved very useful for a variety of smaller projects that have been realized since then.

4. CONCLUSIONS AND OUTLOOK

We motivated our paper by facts on the footprint of the internet and sound related activities to show the necessity to become active even if working within disciplines that are not directly related to climate change. From this, our major handle lies in public outreach and teaching. Both fields are especially apt for sonic displays and sonic interaction design, as new media create awareness. We discussed approaches in teaching sound, and suggest to use them in combination with topics of sustainability. In that way, both students gain a better understanding for the current crises, and ideas can be taken up to create more public awareness. For both goals we set up a website for our lab, the sonic/sustainable interaction design lab at the IEM. The website is a collection of projects of various sizes, ranging from individual student's sonifications to large research projects. The presented works are curated in a way to highlight the ones that are related to SID4future. We hope that these works inspire students to new ideas and other research institutions to similar activities.

[6] https://sysson.kug.ac.at/index.php?id=14007
[7] https://sysson.iem.at/

Acknowledgments

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