Audio, Acoustics, Wellbeing and the Environment

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ABSTRACT

Audio, Acoustics, Wellbeing and the Environment is a Masters level module designed to develop an applied understanding of how sound and noise can impact on the wellbeing of society, and the quality of the environment. It encourages students to consider how their practice, and that of their industry, can affect the environment as well as how audio and acoustics technology can be used to improve our sonic environments at work and in the home. The module explores the links between environmental noise, sound insulation and the quality of our work and home environments. It looks at how noise can affect the human auditory system and investigates mitigation and techniques for reducing the impact of noise on our health and well-being. The rationale for the module is built on the desire and expectation from students for this type of content and the requirement by professional bodies for graduates to be competent in this area. There have been challenges mainly in the sheer range of topics that fall under the remit of the module and finding a narrative through these. These were addressed by providing lots of signposted reading material and also focusing on a small number of key narrative themes (the impacts of noise, wellbeing and the environment). Policy and standards documents were vital tools to drive the teaching and learning process. The module has been successful in engaging students and stimulating interesting discussion in taught sessions.

1 Introduction

This paper explores the design and delivery of a Masters level module titled Audio, Acoustics, Wellbeing and the Environment. The module is taught as part of the MSc Audio and Acoustics course at Leeds Beckett University in the UK. It is a unique and ambitious module which brings together a wide variety of topics, which are often taught separately, all relating to the impact of sound and noise on society and our environment. The module also explores sustainable development and how this should be embedded in all professional activities.

2 The Course Environment

The MSc Audio and Acoustics course is a new course (launched in September 2022) that has evolved from an existing MSc Audio Engineering course. The global pandemic and the moving of the department to a brand new dedicated building prompted many curriculum developments and this course was written to take advantage of the world class facilities in the new Leeds School of Arts building.

This course recognizes the need for technically competent problem solvers who can work with, and design, the audio and acoustic technologies of the future. The creative industries are increasingly reliant on complex technologies for their work and the commercial world is constantly looking for new ways to deliver sonic experiences. A masters award in this subject area allows students to explore the very latest technologies, techniques and practices in audio and acoustics in order to prepare them for a fast changing and exciting industry.

In many contexts audio and acoustics are taught as separate disciplines but this course recognizes the intrinsic relationship between audio systems and the

acoustic environments within which those systems operate.

A key feature of the course is the embedding of sustainability, wellbeing and environmental issues within the curriculum. Society and our planet are facing huge challenges in these areas and this course addresses these issues head on in order to provide students with the knowledge and skills to make a real difference in their future careers.

The course features a range of specialist subject modules and general academic modules. Each module represents around 200 hours of study (or 400 hours for a double module).

- Audio and Acoustic Engineering (double)
- Interfaces and Interactivity
- Spatial Audio Applications
- Audio, Acoustics, Wellbeing and the Environment
- Research Practice
- Negotiated Skills Development
- Final Project (double)

During this paper 'The Course' refers to the whole Masters (Postgraduate) course, studied over 1 year full time or 2 years part time. 'The Module' refers to the Audio, Acoustics, Wellbeing and The Environment module that represents around 10% of the study for the wider course.

3 Rationale for the Module

When putting together the initial plans for the course the course team wanted to ensure that sustainable development and environmental issues were embedded on the course. Previous work in the area highlighted the importance of this [1].

The course team also wanted to ensure that there was
a) a desire for prospective students to want to study this type of material and
b) a need from industry for graduates to have skills in these areas

In terms of building the student side rationale, there has been an ongoing research project in the UK by the organisation Students Organising for Sustainability (SOS-UK), a subsidiary of the National Union of Students in the UK. SOS-UK has carried out research into student attitudes towards climate change and the UNESCO Sustainable Development Goals (SDG's). The data shows clear and growing concern about climate change among the student body, with 90% of respondents concerned or very concerned about climate change. This is higher than the general population (at 80%) and increased from 76% in 2014 [2].

The research also suggests a clear appetite among students for sustainable development to feature in their courses. 88% of students say they agree their place of study should actively incorporate and promote sustainable development. 79% would like to see sustainable development actively incorporated and promoted through all courses. 66% of students say sustainable development is something they would like to learn about [2].

The latest survey also found that 69% of students agree that course tutors should be required to incorporate sustainable development within their teaching, international students from outside of the EU are most likely to agree that sustainable development is something they would like to learn more about and demand for learning more about sustainability increases as students progress through their university experience [2].

When asked to reflect on why they wanted to learn more about sustainable development responses were broadly coded into the following areas [2]:

- *Anxiety / concern about the environment / future*
- *To ensure it's a part of collective life / improve society / the environment*
- *Further knowledge, and use knowledge*
- *Career and course aspirations/relevance*
- *Make personal changes / take action personally*
- *Believe it's important generally*

There is often a worry among educators that sustainability issues might appear to be boring or superfluous to students when put alongside the core curriculum in a subject area that they have chosen to study. However, the research suggests that students want (and expect) this type of content on their courses and gives a clear rationale for it to be present (and embedded) in the curriculum.

When building the 2nd part of the rationale in terms of skills for industry, the professional bodies give clear guidance for this.

The Engineering Council in the UK publish a Standard for Professional Engineering Competence (UKSPEC) which makes it clear that certified engineers must 'understand the principles of sustainable development and apply them in their work' [3]. The UKSPEC was used throughout the course design process to inform learning outcomes and assessment methodologies.

They also produce accompanying guidance on Sustainability for the Engineering Profession. This guidance 'describes the role of engineering professionals in enabling society to live sustainably. It lists six guiding principles to support and motivate them, at whatever stage of their careers, in working sustainably and is intended also to be of help to others working in engineering' [4].

1. *Contribute to building a sustainable society, present and future*
2. *Apply professional and responsible judgement and take a leadership role on sustainability*
3. *Do more than just comply with legislation and codes: be prepared to challenge the status quo*
4. *Use resources efficiently and effectively*
5. *Seek multiple views to solve sustainability challenges*
6. *Manage risk to minimise adverse impact and maximise benefit to people and the environment*

The Institute of Acoustics in the UK are highly active in publishing and promoting material around the impact of noise on society and adopt the Engineering Council pathway to certification discussed above. The organisation's code of conduct state that:

'members shall at all times ... safeguard the public interest in matters of safety, health and the environment and Members shall act in accordance with the principles of sustainability and not do anything, or permit anything to be done under their authority, of which the probable and involuntary consequences would, in their professional judgement endanger human life or safety; or expose valuable property to the risk of destruction or serious damage; or needlessly pollute the environment except when legally authorised to do so' [5].

There is no reference to sustainable development in the Audio Engineering Society code of conduct [6]

which is disappointing, especially given that this was rewritten recently in 2019. However, AESTD1007.1.20-05 'Understanding and managing sound exposure and noise pollution at outdoor events' must be commended here as a detailed and helpful contribution to furthering discussion and developing good practice in noise management [7].

The Quality Assurance Agency (QAA) defines benchmark standards for Higher Education in the UK. It has rewritten its benchmark statements in 2022 and 2023 for a range of subjects, including engineering, which this course used in the course development process. The benchmark statement documents now feature dedicated sections on sustainable development. These are included below from the Engineering document [8].

Engineering courses should inspire students in their journey to become more sustainable engineers by equipping them with the knowledge and skills to evaluate the environmental and societal impact of solutions. Reference to the United Nations Sustainable Development Goals to inform curriculum design, pedagogy and assessment is encouraged. This includes the importance of digital accessibility and the promotion of resilience, adaptability and problem-solving. Engineering and sustainable development are closely linked, and the role of engineers is critical in building a sustainable future.

Education for Sustainable Development (ESD) supports the development of subject-specific knowledge and skills to promote sustainable development for the challenges of today and the future. ESD is an integral part of enhancing the quality of higher education and it stimulates Engineering students to make informed decisions and responsible actions towards more sustainable solutions for greener societies. The Education for Sustainable Development Guidance outlines pedagogic approaches for implementation in UK higher education institutions

It is clear (in the UK at least) that our professional bodies and standard setting agencies require sustainable development and related issues to be in our courses.

4 Module Design

The module design process led to the overall module aim statement of developing an applied

understanding of how sound and noise can impact on the wellbeing of society and the quality of the environment. The module also aims to explore how audio and acoustic practice and technology can be exploited to mitigate against these impacts.

The module explores how the impacts of noise and sound can affect the wellbeing of society and the quality of our environment. It encourages students to consider how their practice, and that of their industry, can affect the environment, and how audio and acoustic technology can be used to improve our sonic environments at work and in the home. The module explores the links between environmental noise, sound insulation and the quality of our work and home environments. It looks at how noise can affect the human auditory system and investigates mitigation and techniques for reducing the impact of noise on our health and well-being. Key policy and standards documents are used to help students understand and navigate the topics.

The module also has the following learning outcomes which students are expected to be able to do on completion of the module:

1. Demonstrate a critical understanding of the impact of sound and noise on the environment and the wellbeing of society
2. Select, apply and evaluate appropriate methodologies for the assessment of sound and noise
3. Design audio and acoustic solutions for the mitigation of any impacts of sound and noise

The module is taught over 14 weeks in the 2nd semester of the course (between February and May). The final 2 weeks are reserved for assessment and feedback and there is a CARE week in the 7th week which is a week without teaching for students to consolidate, absorb, reflect on and embed their learning. This is common across the whole subject area and not course specific.

The schedule can be seen in Table 1. The module begins with consideration of the ear and hearing and discussion of noise impacts and metrics. There are then 3 weeks discussing environmental noise, focussing on transport, aviation and commercial noise. As these are the main sources of noise in our world they are great topics to establish a solid base understanding of how we describe, measure and quantify noise.

Week	Topic	Content
1	The Ear and Hearing	Hearing Loss, Hearing Protection, Audiology, Impacts of Noise, Noise Parameters, WHO Guidelines
2	Environmental Noise 1	Road Noise, Rail Noise, CRTN, CRN, UK Noise Maps
3	Environmental Noise 2	Aviation Noise, ANCON, NTK, Leeds Bradford Airport, CAA regulations, BS ISO 20906, ILS,
4	Environmental Noise 3	Commercial Noise, BS 4142, The urban soundscape, NPPF, PPG24, PPG-Noise, ProPG
5	Wind Turbines	BS EN 61400 Standards, Noise, Light, Impact, Feasibility,
6	Noise and the Creative Arts	Music as Noise, Festivals, Headphones, Music Venues, The Purple Guide
7	Care Week	
8	Sustainable Practice	Energy Sources, Carbon Footprint, Net Zero, COP, Paris, Albert, ISO 14001
9	Assistive Listening Systems	T-Loops, Hearing Aids, Bone Conduction, Speech Intelligibility
10	Workplace Noise	Open Plan Office Noise, BS EN ISO 3382-3, Control of Noise at Work Act
11	Sound Insulation	Sound Reduction Index, Level Difference, BS EN ISO 10140, BS EN ISO 16283, Façades, Impact Sound, Building Regulations
12	Noise and the Natural World	Noise Impacts, Underwater Noise, Noise and Navigation
13	Seminars	Student led seminars, feedback, discussion
14	Seminars	Student led seminars, feedback, discussion

Table 1 – The Module Schedule

The module then travels through a range of quite disparate topics which all contribute towards the quality of life, noise levels and sustainability of society. Weaving a narrative through these topics was one of the most challenging aspects of the module but also brought about opportunities to discuss many interesting issues.

5 Module Curriculum

Environmental Noise
The main focus of the module is the impact of noise on people, society and the environment. This runs through the whole schedule. A key reference point for this subject area is the WHO's Environmental Noise Guidelines for the European Region [9]. This

document is a great resource for students and teachers and is the perfect starting point for the topic of noise. It provides valuable context and takes a clear evidence based approach to the discussion of noise. Key metrics are explained and justified and the impacts of noise are explored in great depth and detail.

The module also spends time considering the issue of music as noise. Music has the potential to damage our hearing and that of other listeners. It also has the potential to cause annoyance and affect the quality of life of those in the vicinity of loud music. This is a challenging discussion for students as they have to face up to the fact that what they may perceive as entertainment has the potential to damage health. The AESTD1007.1.20-05 'Understanding and managing sound exposure and noise pollution at outdoor events' is of great use here along with various parts of government legislation on nuisance noise.

Transport Noise

Transport noise is the 2nd most significant environmental danger in western Europe and it is estimated that at least 1 million healthy life years are lost every year from traffic-related noise in the western European countries [10]. Any module that considers noise, wellbeing and the environment must discuss this subject area.

Road traffic and rail noise is, fortunately, much written about and heavily researched. Measurement and prediction methodologies are also very well established (Calculation of Road Traffic Noise, CRTN, and Calculation of Railway Noise, CRN, in the UK). Road traffic noise is almost ever present around us. This makes it an easy subject to approach for students as there is lots of reading material and many experiential examples.

Aviation noise, similarly, although less ubiquitous, has established methodologies and a wealth of research available. Fortunately for this course, both university campuses are under the flightpath for the local Leeds Bradford airport, as is much of the student housing in the area. This provides a really useful case study with observable effects. The airport publishes noise action plans and noise mapping periodically which provides great case study material.

The topic of aviation noise is also an opportunity to bring in a little discussion of aero-acoustics, the design and noise reduction of jet engines and the Instrument Landing System (ILS), which is a beautifully elegant system to navigate to a runway using 90Hz and 150Hz signals.

Wind Turbines

Wind Turbines are a really useful subject area to bring together both noise issues and renewable energy generation. It is also a topic that rarely features in audio courses and one that students often know very little about. With the proliferation of wind turbines and their obvious role in energy infrastructure is it essential to consider their impact.

Wind power contributed 26.8% of the UK's electricity generation in 2022 [11] and is a significant part of the energy infrastructure worldwide. Wind Turbines also generate noise and this is a very active research area. A specific section on Wind Turbines is included in the most recent version of the WHO Environmental Noise Guidelines highlighting the importance of considering the noise impact of wind turbines.

The topic also allows for discussion of a really interesting application of audio in the form of using SODAR (sonic detection and ranging) for weather and air movement analysis in the planning and feasibility study stages of wind farms.

Sound Insulation

Sound insulation may not initially seem to fit with the module narrative. However, effective sound insulation is essential to control noise exposure in our homes and workplaces. Effective sound insulation makes our homes and workplaces quieter, safer and better places to live our lives.

Sound insulation is taught elsewhere in the course from a more engineering and measurement point of view but it was felt an important inclusion here and is approached from a more holistic angle where the discussion is focussed on the need for sound insulation and its role in the quality of life of society.

Wellbeing

The term Wellbeing is included in the module title so obviously is a key part of the module narrative. The wellbeing angle of the module covers individual wellbeing, in terms of understanding and using hearing protection, managing personal noise exposure, headphone use and safe working practices. The Wellbeing of society as a whole is also widely discussed in the module in terms of noise exposure in the environment, in the workplace noise and during entertainment and leisure activities.

Other Topics

There is not space in this paper to explore the whole module curriculum but it is worth noting some of the other areas that were explored. Workplace noise focuses on the UK Control of Noise at Work Regulations and assessment methodologies for workplace noise exposure. Assistive listening systems looks mainly at systems that allow hearing impaired members of society interact with the world (including T-loops, hearing aids and cochlear implants). The module also considers the impact of noise from human activity on the natural world.

Standards and Policy Documents

A glance at the module schedule in Table 1 will show a range of standards and policy documents from the ISO, European Standards, British Standards, UK Government, WHO and many more. These documents were used as key reference points in the teaching and have a key role in the module. It is important to encourage students to engage with these documents as they are the standards and policies that dictate how our industries should operate. It is also appropriate at postgraduate level to help students to go 'beyond the textbook' and engage with industry practice.

The policy and standards documents can also help educators who are not necessarily specialists in sustainable development, noise, transport, etc., to build a curriculum and a reading list that has its roots in professional practice and governmental policy. Students can be signposted towards these documents and given ownership over their own learning.

For this module specifically, each topic was given a dedicated area on the university Virtual Learning Environment (VLE) and key policy and standards documents provided there as PDF document where copyright issues allowed. A list of further standards to access, download and read was also provided where copyright issues prevented the actual document being available (e.g., BS, EN, ISO).

6 Assessment

An interesting feature of the assessment for the module is the use of a student managed seminar as an assessment tool. This requires the planning and delivery of a 40-minute seminar on a topic of the student's choice that falls within the remit of the module. The seminar should include some lecture type delivery to cover the background, context and key issues of the subject. There should be some form of activity for the participants to engage in and time for discussion.

This assessment goes beyond the often-used presentation format and requires students to consider how to engage their audience. It fits well with the Engineering Council guidance on taking a leadership role in sustainability [4], developing important skills in communication, engagement and discussion.

The 2nd part of the assessment for the module requires students to write a report on a specific case study investigation. This requires students to make measurements and use standard methodologies to investigate a problem. They should then recommend solutions and mitigation approaches. This type of activity is common in the acoustics industry and develops the student's investigative skills, measurements skills and report writing.

'An engineering curriculum for sustainability must embed education for sustainable development learning principles and create opportunities for students to learn and practise critical, holistic and systemic thinking, apply it to real-life situations and enhance lifelong learning, responsible decision-making and professional practice' [12]. Both assessments for this module fit well within this model.

7 Discussion

One significant concern throughout the module design phase and the delivery was that the module was trying to do too much. The remit for the module is very wide and ambitious. The teaching team often felt that they were trying to cram too much content into the allocated teaching time.

As this is a postgraduate level module it is very much appropriate to hand much of the learning over to the student. One strategy that was employed was to use a lot of signposting of reading material during the taught sessions and providing a lot of extra reading material on the Virtual Learning Environment for the module. This left space in the taught sessions to explore the core of the topic and raise issues for discussion. This approach requires an engaged cohort but worked well in general.

Finding a narrative through the wide range of topics was also a challenge. Beginning the module with the core environmental noise topics (transport and industry) helped to cement the basic principles of noise generation, propagation, measurement,

parameters and prediction. This allowed exploration of the more esoteric topics later in the module. The core principle of the impact of noise on society and people was used throughout as a narrative thread.

Engagement with the module has been excellent. Students have been able to see why the module is important, both in relation to their studies and careers and also in relation to the wider world.

Students were already very well informed in many areas covered by the module. In particular they were very passionate about hearing protection, sound levels at live events and headphone use. This made the taught sessions enjoyable and stimulating.

There have been challenges to the delivery of the module. Industrial action in the Higher Education sector in the UK in 2023 affected the module resulting in some taught material being condensed and a couple of planned topics dropped from the delivery.

8 Conclusions

The development and delivery of the Audio, Acoustics, Wellbeing and the Environment module has been and exciting and interesting process. There is a clear rationale for the module and its content and the students were highly engaged by the subject. Students have a desire and an expectation that topics in this area will be part of their course and the professional bodies are mandating this as well.

There have been challenges mainly in the sheer range of topics that fall under the remit of the module and finding a narrative through these. These were addressed by providing lots of signposted reading material and also focussing on a small number of key narrative themes (the impacts of noise, wellbeing and the environment). Policy and standards documents were vital tools to drive the teaching and learning process.

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