Educating Engineering Educators for Sustainability – a case of online resources for staff development

Holgaard, Jette Egelund; Smink, Carla Kornelia; Guerra, Aida Olivia Pereira de Carvalho; Servant, Virginie Felicja Catherine

Published in:
Educate for the future

Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record

Educating Engineering Educators for Sustainability – a case of online resources for staff development

Jette Egelund Holgaard
Aalborg University, Denmark, jeh@plan.aau.dk

Carla Smink
Aalborg University, Denmark, @plan.aau.dk

Aida Guerra
Aalborg University, Denmark, @plan.aau.dk

Virginie Servant-Miklos
Erasmus University Rotterdam, The Netherlands, servant@euc.eur.nl

Abstract

Engineering Education for Sustainable Development (EESD) has been on the agenda for decades in order for engineers to develop sustainable technology for future societies. Increased international attention to the signs of an overarching sustainability crisis have further increased the sense of urgency in order to move from sustainable discourse to actions – in industry as well as in educational systems. At Aalborg University, several actions have been taken in order to highlight the importance of sustainability in engineering and science education. As an example, in the beginning of the 1990s, all engineering students entering the University were placed in inter-disciplinary groups and faced with sustainability as a crosscutting semester theme. Likewise sustainability in different shades has been introduced as semester themes within programmes initiating engineering and science students to identify, analyse, formulate and address sustainability challenges in science and engineering. Furthermore, sustainability issues have been introduced in workshops for students and staff, and sustainability has been an integrated perspective in the developments of new prototypes and products in problem based projects. The challenges have however been to balance the focus on sustainability with more domain specific perspectives – to foster engineers with enough engagement and knowledge to contribute to a sustainable development in their everyday practice, and knowing when to bring in sustainability specialist when needed. The comprehensiveness of the United Nations Sustainability Development Goals have recently underlined the need for combining the generic with the specific in meaningful ways in order to cope with the complexity of the sustainability challenge. In this practice paper, we present an initiative to support staff in engineering and science to integrate sustainability in their educational practice. The online resources are organised in three stages of ambition supporting staff in: i) making students aware of the sustainability challenges in relation to their study domain, ii) providing students with an entrance to know more about sustainability, and finally yet importantly iii) empower students to do more and take action in their project to contribute to a more sustainable development. As such, the on-line resources are presented as a way to frame education for sustainability for engineering and science students, as a stepping-stone for staff to appropriate EESD for specific programmes.

Keywords: Sustainability Education, Engineering Education, Online resources, Staff training.

Type of contribution: Practice paper

1 Introduction

The discourse arguing for universities to play an active role in creating a more sustainable world is not new. In the last decades, guidelines and procedures have been developed at the conceptual level, prescribing how to integrate sustainability in universities - including education, research and management (Wright, 2005). Additionally, publications on education for sustainable development (ESD) have been increasing in the last three decades. Such increase is partly due to research and practitioners' publications on ESD, covering its learning principles, integration, pedagogy, students' perspectives, capacity building, and campus management. Likewise the social and political sense of urgency to address sustainability problems has increased, as for instanced exemplified by the United Nations Sustainable Development Goals (United Nations, 2015) and the Paris Climate Accords (United Nations, 2018).. As a consequence, more universities reflect what it takes for a university to integrate ESD at a systemic level.

Staff training programmes are part of a comprehensive strategy to implement ESD in higher education. The integration of ESD and the institutional processes that can enable a systemic, transformative and deep-rooted integration of sustainability depends largely on its staff, their willingness and capabilities to support such processes. It is through staff training programmes that in-service teachers are able to gain an understanding of sustainability by acquiring knowledge and developing competences to re-design their courses for ESD . Such programmes present the possibility for institutions to 'use' their staff as starting points to bring change from a bottom level (Barth & Rieckmann, 2012).

In engineering education, staff training seems to be inadequate, ineffective and does not reflect the demands on engineering educators regarding ESD, including its conceptualisation, integration, learning outcomes and teaching and learning activities (Barth & Rieckmann, 2012; Roberts & Roberts, 2008). Furthermore, designing appropriate learning activities for staff training should follow an approach similar to the one taken in developing the students' curriculum. Additionally, according to Sharpe (2004, cited by Roberts & Roberts, 2008) staff training activities should:

- *Allow for knowledge construction both individually and in collaboration*;
- *Encourage knowledge to be applied effectively within professional roles allowing the '**knowing that**' to be updated;*
- *Encourage learners to interrogate and engage with their developing knowledge in order to externalize and make explicit the '**knowing how**', so that it can be shared and learnt from, to the benefit of both the individual and the organization; and*
- *Incorporate the values and ethical practice of the profession to reaffirm **how knowledge is used in practice***

Staff training activities should not merely be a platform for knowledge construction and development of new communities of practices; it should also create opportunities for different, progressive, levels of engagement and learning in engineering education for sustainable development (EESD). Additionally, the staff training activities should be transferable, with immediate application in practice. This should include activities that can be applied in teaching practices and facilitate students' learning for sustainability.

This best-practice paper presents an initiative to support staff in engineering and science to integrate sustainability in their educational practice. The initiative concerns an open online course for staff and has been developed as and for a problem based learning approach. Problem-based learning (PBL) is one of most suitable learning approaches to educate for sustainability, as learning principles that characterise both PBL and ESD overlap, including learning principles such as problem orientation, exemplary learning, contextual learning, experiential learning, interdisciplinarity, and collaboration (Guerra, 2014). PBL is a

process-oriented and student-centred approach, where students have ownership of the learning process and are primarily responsible for the decision making process (Guerra, 2017).

In the following sections, the overall conceptual design (section two) and the on-line material (section three) will be presented, followed by concluding remarks (section four).

2 Developing a framework to design an online course – becoming aware, knowing more, doing more

The overall aims of the course is to support staff in: i) helping students to become aware of the sustainability challenges in relation to their study domain, ii) providing students with an entry point to know more about sustainability, and finally, yet importantly iii) empower students to do more and take action in their projects, to contribute to a more sustainable development.

To fulfil the aforementioned aims, we propose a framework to design an online course organised in three levels of ambition: '*becoming aware*', '*knowing more*', and '*doing more*' (see figure 1).

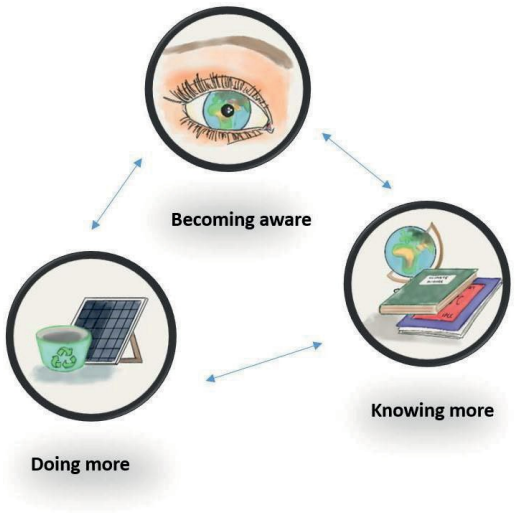

Figure 1: The interplay of the three dimensions in the on-line resources: getting aware, knowing more and doing more.

The framework and the three levels of ambition emerge from our experiences and reflections as lecturers and supervisors at Aalborg University, a PBL environment at the system level. For several years, we have been developing and delivering courses, workshops, seminars and supervising students' projects with, and for sustainability. The overall goal has been to educate AAU engineering students for sustainability. However, the different learning activities have been addressing different learning objectives and levels of development for ESD. For example, in the B.Sc. on Media technology, 1st and 2nd semesters, sustainability has been integrated into the project's sub-theme. In other programmes, seminars and workshops took place to create awareness and basic knowledge about how sustainability topics can be related to disciplinary fields. Nevertheless, we soon recognised that the learning activities for sustainability as well as the learning objectives needed to be organised and reflect progression in educating for sustainability.

We consider that the three levels of ambitions that compose the framework created to design the online course address the aforementioned needs that emerge from our practice and reflections. '***Becoming aware***' aims to create awareness of the role that engineers have in addressing the sustainability challenge. As a first step, there is a need to recognise why engineers, in general and within the expertise of study, can contribute to a sustainable society. After such a recognition, there is a needed to expand and qualify student knowledge about sustainability. This is the target of '***knowing more***', where sustainability, its complexity and principles, needs to be conceptualised and understood before it can be integrated into practice. In this dimension, it is not expected that students will develop expertise in sustainability sciences, but rather a '*know what*': understanding how sustainability is defined within existing frameworks and knowledge domains. Having established a knowledge base, students can start to re-construct and refine their knowledge about sustainability to address real life sustainability problems, i.e. '*know-how*' and the knowledge thereby internalised might even become a platform for identity development, i.e. '*know how to*

become'. With this ambition, '***doing more***' implies that students engage in formulating and solving sustainability problems in a competent way. They become agents for sustainability.

Even though the framework to design the online course emerge from authors' practice and reflections, they relate with existent theoretical and empirical literature on ESD.

For example, a recently study published by Servant-Miklos et al (2020) "*presents different patterns of change for students' development of sustainability awareness and interest during the process of acclimatisation within their engineering studies*", highlighting the interplay between affective, cognitive and action-oriented dimensions of learning. Using a qualitative longitudinal study involving 16 students from four different engineering programmes, four categories emerged from the study: (1) no interest/ little awareness, (2) little interest/ basic awareness, (3) basic interest/ basic awareness + advanced domain specific awareness, and (4) active interest/ advanced (systemic) awareness. In this context, awareness is defined as "k*nowledge and understanding of the sustainability crises",* and interest as*" the propensity to seek out information about the sustainability crises*".

Furthermore, Sterling (2005) refers to three levels of learning towards sustainability, which are seen as consecutive and progressive. They are:

- Basic learning, implying "doing things better" i.e. trying optimise technological sub-systems from within a disciplinary knowledge domain. One can say technology is perceived as the solution and remains within "disciplinary silos". This can be related to becoming aware of the sustainability impacts from specific types of technology.
- Meta-learning, implies "doing better things", i.e. requires stepping out and recognising the relations between different knowledge domains within a wider social-technological perspective. Students then have to become aware of how different stakeholder interests play a role in the way technology is developed, understood and used.
- Epistemic learning, can be interpreted as "doing things differently". Sterling relates epistemic learning to a "helicopter view", i.e. seeing things differently by reconstructing knowledge domains, establishing new community of practices, and recognising the existence of alternative paradigms. It is about re-thinking societies in what Mills (1959) termed sociological imagination, where students need to create a "*vivid awareness of the relationship between experience and wider society*" (Mills, 1959).

These three levels underline the action-oriented approach (different levels of 'doing') of our course framework, but it also underlines the progression in knowledge from disciplinary to interdisciplinary knowledge; from silo thinking to embedded contextual awareness. This is emphazised in the on-line resources by helping staff to facilitate students in rethinking their discipline from a sustainability perspective. We do this first of all by making them aware of the inter-connectively between their discipline and sustainability. Secondly, by using a case approach as a platform to further study and get to know more about existing interrelations. Finally, we use a project oriented approach to get students actively doing more in order to propose new interrelations and thereby new potentials for sustainable developments. 'Knowing more' without 'doing more' would lead to a weak response to the sustainability crisis, but at the same time the consecutive nature of Sterling's three levels of learning underlines that actions for sustainability should build on a solid knowledge base.

The problem-oriented and project-organised learning approach includes the 'know why', which is needed in order to actually consider and validate that the paths taken are actually for the better or is actually making a difference. The 'know why' is deeply related to the problem design approach in PBL (see Holgaard et al., 2017). The problem identification and analysis which is a part of the problem design process requires the

learner to reflect on both the personal and the context-dependent motivations to address the problem. In that way, the learner doesn't just construct or reconstruct their own knowledge – it is a triple loop learning process, where 'triple loop learning is learning that opens inquiry into underlying *whys*' (Isaacs, 1993).

3 Presentation of the online material

The online course on PBL and Sustainability we present in the following section is for staff who want to integrate sustainability in engineering programmes or courses and want to learn more about how PBL and sustainability can be interrelated in curriculum design and practice. The course is both for teachers in engineering programmes and curriculum designers in a PBL environment who want to integrate sustainability in the curriculum. The course is however not to be mistaken for a course introducing staff to sustainability science (or to problem based learning, for that matter). It is strongly recommended that such courses supplement this course. In this course, the aim is therefore to help staff to combine PBL and sustainability, rather than to teach about the domains as such. The team behind the course included engineers, sustainability scientists, education philosophers, as well as PBL researchers in order to address this crosscutting challenge.

The online material for staff on PBL and sustainability introduces different types of resources, including:

- Video materials to share ideas and experiences with education for sustainability.
- Recommended literature and links to share materials that have been beneficial for teachers as well as students for self-study
- Examples of best practices - to inspire educational designs and the facilitation of activities in a problem-based learning approach.
- Facilitating questions in order to initiate further reflections on PBL and sustainability.

In the next section, we elaborate on the online resources prepared for each of the three phases: becoming aware, knowing more and doing more.

Becoming aware

The first process in educating engineering students for sustainability is to facilitate student awareness with regards to the role of their future profession in addressing sustainability challenges. Although sustainability is a discipline in itself, it is also an embedded part of engineering. At least in the professional sphere, students to some extent see faculty as a role models. Therefore, it is crucial that faculty can argue *why* an engineer, in general and within a specific domain, has an important role to play in creating more sustainable societies. To support faculty in their argumentation, the online resources include a video providing an example of such an argument for engineers for sustainability – in general and exemplified in relation to specific domains. Furthermore, faculty can find links to recommended literature on Education for Sustainable Development (ESD).

In a problem-based learning environment the ambition is however not only for faculty to present arguments and express their own awareness about the interrelation between sustainability and particular disciplines – it is just as much a matter of getting students to construct their own argumentations and become aware of their personal role as engineering students and future engineering professional. In the online resources, discussions about the role of sustainability are facilitated by providing a structure and an example of how to facilitate this inquiry process (see example box 1). The idea of the inquiry process is first of all to create reflection on the interlinkages of sustainability and engineering, which creates the baseline for students themselves to point to potential knowledge gaps

To maintain the momentum of interlinking sustainability and disciplinary perspectives, questions for further reflection are provided, with core questions like:

1. What would you like to learn more about in studying the relation between your field of study and sustainability?
2. Do you think you will solve sustainability problems in the future with the help of your profession – and if so, how will you make sure that new solutions are more sustainable than the previous?
3. What obstacles do you see when working with sustainability in relation to your specific field of study?

BOX 1:

The workshop "Nanotechnology and Sustainability" was held for first year's students at the Bachelor programme Nanotechnology at Aalborg University. Approximately 25 students attained the workshop, which is part of the course "Problem-based learning in Science, Technology and Society".

The workshop consisted of two parts. In the first introductory part, students were asked to reflect on why they chose to study nanotechnology and what they expect to work with when they finish their education. In the second and main part of the workshop, focus was on sustainability: how do the students define sustainability and to what extent do they think sustainability is relevant for a nanotechnologist.

In order to structure the discussion on why students had chosen to study nanotechnology, Socrative (socrative.com) was used. Socrative is an online tool to get instant feedback from students on questions asked. With permission from the students, the answers where shown in class, which gave the possibility to elaborate upon the answers given. Some of the answers could also be used in the second part of the workshop, when it was discussed whether or not a nanotechnologist should work with sustainability.

In the workshop, the students had not been introduced to the concept of sustainability. Their input was therefore based on their prior knowledge and understanding of the concept. The students were asked to form small groups with 3 students in each group. Each group had to write their definition(s) of sustainability on a poster. Afterwards, the groups had to present their definition of sustainability in plenary. For most groups, environmental sustainability was most dominant in their sustainability mindset, which was also reflected in the examples they gave: they could work on optimising the utilisation of solar panels, help improving water purification technologies and so on. It was difficult for them to relate to economic and social sustainability.

Knowing more

What Sterling (2005) calls education *about* sustainability implies that students expand their knowledge base in terms of sustainability. The strategy has in many situations been to integrate courses on sustainability in engineering programmes to introduce students to sustainability science. Such courses however, need to consider that the target group is not comprised of sustainability specialists. So, before moving into conceptual frameworks from sustainability science on how to *deal with* the sustainability challenge in specific situations – it is recommended to foster an overall understand of the complexity of the sustainability challenges as such. In the online resources we provide a specific example of a video introduction to the grand sustainability challenge, which was recorded in partnership with Erasmus University Rotterdam. The angle taken in this video sits at the intersection of ecology and political

economy, bearing in mind a target audience of non-specialists. The video targets the sweet spot of the *sociological imagination*, at the point where the personal (e.g. recycling your own trash) becomes the social (i.e. the global plastic crisis). It is also possible to use videos for students' preparation. Furthermore, students can be encouraged to read and look up literature and film productions on the overall sustainability challenge based on examples provided in the online resources; books such as Klein's *This Changes Everything* (2014), or Wallace-Wells' *The Uninhabitable Earth* (2017), and films such as Al Gore's *An Inconvenient Truth,* Di Caprio's *Before the Flood*, and *A Plastic Ocean*.

When the students have obtained knowledge about the overall challenges of sustainability, they have the overview to contextualise sustainability to their particular domain of study. In the problem-based learning environment at Aalborg University, teachers have experienced that the use of cases is effective to motivate students to learn more about sustainability and study how sustainability relates to their particular discipline of study. The cases are designed to stress the relevance of sustainability for the specific programme. The approach has been to facilitate case-work on sustainability in specific disciplines, and in example box 2 there is a concrete example of how students were facilitated to interlink nanotechnology and sustainability, together with reflections from the facilitator.

Another way of using cases is to mirror real life engineering practice and challenge students to face the same dilemmas and challenges as in a real life sustainability project. We provide an online case mirroring a sustainability project, the so-called *Shanzu case* (UCPBL, 2020). The Shanzu case follows a project where the challenge is to improve the water and energy supply system for a school for disabled women in Shanzu, Kenya. The students are faced with the same challenges as in real life at different stages of the project. It can be used as a source of inspiration to create cases simulating the challenges of managing a sustainability projects in progress.

BOX 2:

After the students nanotechnology had had the possibility to define the concept of sustainability themselves (see box 1), the workshop changed focus. The teacher took over and presented, based on literature, different ways to define sustainability. The students were introduced to the three pillars of sustainability: the social, environmental and economic pillar. Throughout discussions subsequently, the students realised that their examples also had an economic and social impact. These were discussed in plenary.

After these discussions on defining the concept of sustainability, it had become time for the students to apply their newly acquired theoretical knowledge on concrete societal problems. On the basis of five concrete societal problems (water pollution, air pollution, energy efficiency, transport and health) students worked in groups of five students each to explore how nanotechnology can contribute to sustainable development within these fields. Relevant literature with regard to these societal problems was made available online beforehand. Students had though the opportunity to collect more literature. Each group was allocated one of the societal problems. They had to discuss two questions: 1) what are the causes and consequences of the problem and 2) how can nanotechnology contribute to solve the problem. The students had to make a short PowerPoint presentation to present their results. During the group work, the teacher had discussions with the groups and asked them various reflective questions. After the presentation the other groups had the opportunity to come with their comments and reflections to the other groups. In the last part of the workshop, the teacher presented causes and consequences of the societal problems and showed some YouTube movies that explained for example how to purify water by using nanotechnology. After these presentations it was discussed whether or not the solutions presented in the YouTube movies were sustainable or not.

Doing more

When students can move from the specific to the general, to capture and interrelate the complexity and the specifics, the students have created a knowledge-base to address real life sustainability problems. It then becomes more than just a matter of knowing more, as the students will in fact be ready to *do more* to foster sustainable development in a competent way.

A problem-based learning environment using real life problems creates a framework to push education from education *about* sustainability to education *for* sustainability. In this latter perspective, students actually make technological inventions, products, systems and environments for a more sustainable development. Projects are furthermore an opportunity to challenge disciplinary boundaries and this can be organised into more interdisciplinary projects such as for example mega-projects, where several student groups from different disciplines work on a real life wicked problem. (Holgaard et al, 2019).

BOX 3:

Students in the Bachelor programme Nanotechnology at Aalborg University are not obliged to apply the knowledge on sustainability acquired in the workshop in their project work. However, some groups have been triggered by the discussions they had on sustainability in the workshop, so they also integrated sustainability issues in the problem analysis of their project.

For example a group that wrote a project about the fabrication of aligned zinc oxide nanofibers via electrospinning. The introduce their project as follows: "*Environmental sustainability is an increasingly prominent issue, as global warming is approaching an irreversible state and energy sources like oil and natural gas are being depleted quickly. Thus, it is of interest to combat the threat of climate change and find a new form of energy production that can replace fossil fuels (…). Solar energy is of great interest as a renewable energy source (…). One promising type of solar cell is the thin film solar cell. Multiple thin film layers are deposited on a substrate to form an electrode. Nanotechnology is of great interest in this field, because when materials approach the nanoscale, the properties of said material change*." (Westerkam, Kristensen, Christiansen & Jensen, 2018: page 1-2).

On this project, the group had two supervisors: a main supervisor who is responsible for nanotechnology in the project and a co-supervisor who is responsible for putting the project's problem in a societal context, in this case a sustainable context. The co-supervisor was also the teacher of the sustainability workshop. It has been a huge advantage, that there was good cooperation between both supervisors. During supervision meetings with the group, in which both supervisors participated, the expertise of both supervisors was used to help students to integrate sustainability into their project. An additional advantage of this approach was that both supervisors got a better idea of the other's research competences.

However, to make such sustainable innovations, a careful identification and analysis of the problem to be addressed is needed in order to provide targeted solutions, and a comprehensive assessment of new solutions is needed in order not to create new (and maybe even more severe) sustainability problems. In other words, the process of identifying, analysing, formulating, solving a problem and then assessing the provided solutions in a comprehensive way creates the setting for integrating sustainability in engineering programmes.

When a PBL and Sustainability project unfolds, sustainability knowledge, skills and competences blend in with disciplinary competences to solve a real life problem – a problem that matters. In box 3 there is an example of how students from Nano-technology at Aalborg University integrated sustainability in their project work. In the on-line material, this and other examples are included for inspiration.

4 Final remarks

In this practice paper, we present an initiative to support staff in engineering and science to integrate sustainability in their educational practice.

The examples from Aalborg University show that the effort to foster education for sustainable development can re-enforce student engagement for sustainability. The intention is that such an engagement will follow students in future projects as an embedded way of thinking engineering. The strategy leads to an interdisciplinary problem-based and project-organised approach supported by active as well as reflective learning activities in courses.

It is important to note that this strategy is not limited to a one-project approach which could lead to students developing a tunnel vision and a reductionist sustainability approach. In other words, becoming aware and knowing more is not a one-time process – it is a continuous process of getting a conceptual understanding of the complexity of the sustainability discourse. The UN sustainability goals for one thing underlines this complexity. Another condition is that students are able to transfer their experiences to other situations, and providing students with a conceptual understanding of sustainability is needed just as well. It is the combination of theory and practice which qualifies the problem solving process, and quality solutions are crucial tackling the urgency of the sustainability challenge.

5 References

Barth, M., & Rieckmann, M. (2012). Academic staff development as a catalyst for curriculum change towards education for sustainable development: an output perspective. *Journal of Cleaner Production*, *26*, 28–36. https://doi.org/10.1016/J.JCLEPRO.2011.12.011

Servant-Miklos, V., Holgaard, J.E. & Kolmos, A. (2020). A "PBL effect"? A longitudinal qualitative study of sustainability awareness and interest in PBL engineering student. Proceedings for the IRSPBL, 2020 (forthcoming).

Guerra, A. (2017). Integration of sustainability in engineering education: Why is PBL an answer? *International Journal of Sustainability in Higher Education*, *18*(3). https://doi.org/10.1108/IJSHE-02-2016-0022

Isaacs, W. N. (1993) Taking flight: Dialogue, collective thinking, and organizational learning. Organizational Dynamics 22(2): 24-39.

Klein, N. (2014) *This changes everything: capitalism versus the climate*. Simon & Schuster.

Mills, C. W. (1959). *The Sociological Imagination*. Retrieved from https://books.google.dk/books?id=zJtpAgAAQBAJ&printsec=frontcover#v=onepage&q&f=false

Roberts, C., & Roberts, J. (2008). Starting with the staff: how swapshops can develop ESD and empower practitioners. *Environmental Education Research*, *14*(4), 423–434. https://doi.org/10.1080/13504620802318278

Sharpe, R. (2004). How do professionals learn and develop? Implications for staff and educational developers. In D. B. P. Kahn (Ed.), *Enhancing Staff and Educational Development* (pp. 132–153). https://doi.org/10.4324/9780203416228_chapter_8

Sterling, S. (1996). Education in Change. In John Huckle & Stephen Sterling (Eds.), *Education for Sustainability* (pp. 18–39). Earthscan.

Sterling, S. (2005). Higher Education, Sustainability, and the Role of Systemic Learning. In *Higher Education and the Challenge of Sustainability* (pp. 49–70). https://doi.org/10.1007/0-306-48515-x_5

United Nations. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Retrieved February 4, 2019, from Transforming our world: the 2030 Agenda for Sustainable Development website: https://sustainabledevelopment.un.org/post2015/transformingourworld

United Nations. (2018). The Paris Agreement | UNFCCC. *United Nations Framework Convention on Climate Change*. Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Wallace-Wells, D. (2017). The uninhabitable Earth: life after warming. Penguin Random House.

Westerkam, A.M., Kirstensen, F.I.L.R, Christiansen, O.P. & Jensen, R.Z. (2018), Fabrication of aligned zinc oxide nanofibers via electrospinning. An analysis of the effect of zinc acetate content in a polymer solution on fibre porphology. Nanotechnology, Student report, 2. Semester, Department of Materials and Production, Aalborg University

Wright, T. (2005). The Evolution of Sustainability Declarations in Higher Education. In *Higher Education and the Challenge of Sustainability* (pp. 7–19). https://doi.org/10.1007/0-306-48515-x_2