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Teaching sustainability: How to visualize and change CO2 emissions and corresponding habits?

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Abstract

Teaching sustainability presents challenges due to the inherent complexity and required behavioral change. A special pedagogical approach is needed. In this paper, we focus on the research question how students' awareness of sustainability issues can be improved significantly in a brief workshop. The presented workshop let the students autonomously addressing problems and possible solutions in small groups – with no patented recipes given, nor any "finger-pointing" from the outside. The educational basis for this workshop is the concept of discovery learning in combination with sketchnoting. This is especially appropriate to present acquired knowledge in a compact and meaningful way, to show relationships and allow schemas to be developed by the participants. This paper also describes the workshop results from several executions and the lessons learned.

Keywords: *Sustainability; CO2 emission reduction; discovery learning; visualization; sketchnoting.*

1. Introduction

The world is going through numerous ecological crises that will significantly affect the economy and society in the future. Companies can no longer be efficiency-oriented, short-term and reactive, but must solve this situation with proactive, future-oriented and sustainable products and services. The Green Agenda is increasingly challenging companies and politicians, who do not have a sufficient concept (Lema *et al* 2020). Unfortunately, only a part of the students is aware of this situation.

How big is my personal ecological footprint? How much CO2 do I produce per year? And how is this CO2 generated by my current lifestyle? Participants in the uCORE workshop (derived from understand CO2 emissions' Reduction and Elimination) will be able to answer these questions individually after this workshop. But calculating the individual footprint is not the end of the story at this workshop: How can each individual contribute to active environmental and climate protection with very concrete, individual measures? The main objective of the workshop is to encourage participants to address this question.

The workshop was initiated by several professors at the University of Applied Sciences Munich in order to

- to move from a transfer of knowledge by the lecturer to the participants' own examination of the topic and in this way to increase motivation and knowledge,
- to anchor climate change as an important social issue in the minds of the participants,
- to fulfill our educational mandate and the initiatives for a Green Economy,
- to support the efforts of the Munich University of Applied Sciences for an active sustainability initiative.

In this paper, we focus on the research question how students' awareness of sustainability issues can improve significantly in a brief workshop. In the following, we explain the design principles behind the workshop and the pedagogical concept. Then we present results from several executions of the workshop as well as lessons learned and an outlook with future steps.

2. Related work

The authors Scarff & Ceulemans (2017) consider the field of teaching sustainability with a "transformative pedagogy required for learning". For this, on the one hand, awareness of the topic of sustainability must be improved; on the other hand, appropriate pedagogical approaches must be used. Segalàs *et al.* (2012) demand "the reorientation of the pedagogy and the learning processes is a must". Wooltorton (2002) also argues that sustainability requires different learning as transformation becomes necessary. According to Segalàs *et al*.

(2010), the reasons are often that students see little relevance in their social and attitudinal aspects. Therefore, Myers & Beringer (2010) suggests that sustainability should be taught in more community-oriented and constructive, active-learning pedagogical approaches. Segalàs *et al*. (2012) also states that for students the penetration of the complexity of sustainability is often very low. Lourdel, Martin, and Bererd (2006) even write that "students distancing themselves from the problem". Traditional teaching methods are described as inadequate and "leads to low yields in information retention and to decreased student attention" (Scarff & Ceulemans 2017). But alternative approaches are neither new nor undesirable, yet not used widely. However, their use depends on the pedagogical and educational goals and the situation (De Freitas & Oliver 2006).

3. Pedagogical concept

The educational basis for this workshop is the concept of discovery learning in combination with sketchnoting. The idea of discovery learning goes back to the psychologist Jerome Bruner (1961) and is based on the insight that knowledge is built up through the learner's own discovery and activity. According to Gücker *et al*. (2003), in discovery learning, the learner "uses his or her prior knowledge to search for new facts and relationships and to organize them with a view to finding a solution." Discovery learning is usually assigned to constructivist learning theory (Schunk 2014).

The workshop contains a sequence of mini-projects, so-called assignment, which the students work self-paced in teams of three. Each assignment begins with a description of the overall context and then poses specific questions that need to be answered. For this aim, there are defined solution steps, which ask the participants to discuss facts in the group and to search for information on the Internet. As an introduction to the analysis, some websites, e.g., for calculating one's own CO2 consumption are provided directly. Further research to answer the follow up questions is left to the participants themselves. The cooperation within the student teams and the independent research also promotes the active, self-regulated, emotional and social dimension of a constructivist learning approach (Reinmann-Rothmeier *et al*. 2001).

In order to summarize the findings from the discussion and research in the assignments, the participants should create posters by using sketchnoting. The presentation with sketchnotes is particularly appropriate to present acquired knowledge in a compact and meaningful way and to keep it well in mind (Sykula 2019). Notes, drawings, or diagrams are examples of visual representations that can be used to structure information. Visual notes can also show relationships and allow schemas to be developed by participants (Saunders *et al*. 1995) (Fig. 1). During the first execution of the workshop, to enhance the sketchnoting skills of the participants, a guest lecturer specializing in sketchnoting was included. He provided the basic knowledge necessary to develop advanced sketchnotes (see Fig. 1, bottom right).

Figure 1: Impressions from different implementations of the uCORE workshop

After the functional introduction and instructions for visualization, the participants are guided to individual emissions and reduction possibilities. The following details deepen several aspects such as heating resp. cooling buildings or electricity. In the overarching view, the individual perspective is left behind to discuss the level of industry, politics and energy production.

4. Principles of the workshop

The workshop can be used without prior knowledge and with participants from all disciplines to teach environmental and climate topics in a practical and engaging way. No special equipment, facilities or time-consuming preparations are required. The workshop components fulfill exactly these characteristics:

- The workshop is divided into 15 mini-projects (the assignments): Depending on the time budget (between two and six hours), a selection of the assignments can be used.
- The individual assignments are worked on largely independently by student teams of about three participants each, with the help of the documents provided. The teacher assumes the role of a coach without interfering in the team process.
- In addition to teamwork, discussions and internet research, visualization by means of sketchnoting is learned and applied. Even without special painting skills or

previous design knowledge, informative, convincing results are created in the form of posters. In addition, participants receive helpful tips and tricks as well as sketch ideas for various things, such as airplanes, animals, etc. (Fig. 2). After the first successful presentations of the sketchnoting principles in person by the professional visualizer, he recorded his core points into a 15-minute video, which is now used for further workshop executions.

– Lecturers can use the workshop as a "ready-to-use package" (with assignment, etc.). The further development of the workshop takes place within the community.

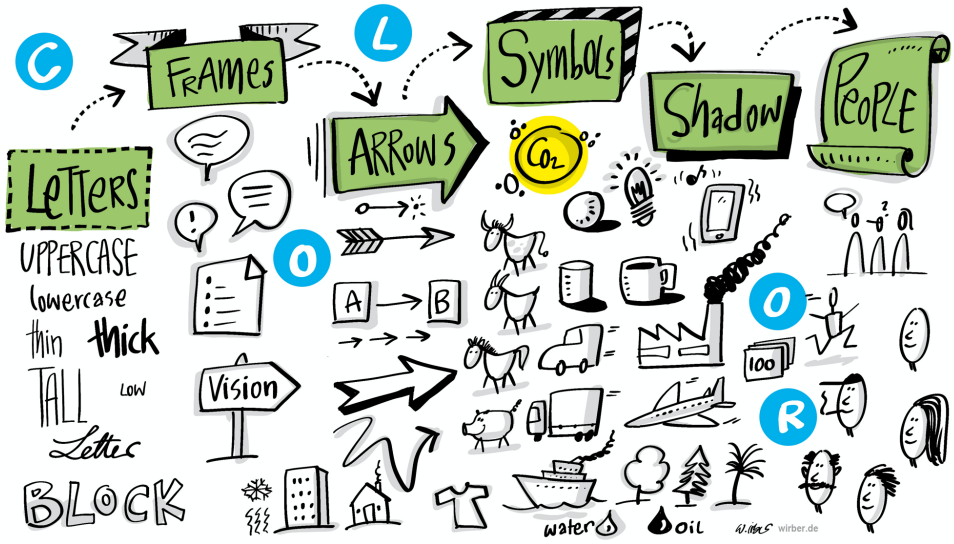

Figure 2: Suggestions for Visualization of Objects for the Participants (created by a Professional Visualizer)

In the course of the workshop, the participants develop an understanding of the CO2 emissions they generate and their effects. In the next step, ideas for solutions to reduce and avoid CO2 emissions are derived and evaluated in terms of impact and feasibility. A particular focus is on ensuring that participants develop an understanding of the relevant orders of magnitude and are thus able to appropriately classify individual challenges and proposed solutions. Rarely participants can relate 5,000 kilometers driven (in a car with an internal combustion engine) to a flight to the USA or heating their home.

By autonomously addressing problems and possible solutions in small groups, no patented recipes are given, nor is there any "finger-pointing" from the outside. By working on the assignments, the participants gain insights, which in turn lead to changing their own habits. In addition to one's own private environment, this topic is also becoming increasingly important in the professional world. For this reason, the workshop will also develop solution ideas for companies as well as the influence that politics can have. Equipped with this

knowledge, participants will not only be able to reduce their ecological footprint in the future, but also to convince others to adopt a more climate-conscious lifestyle.

5. Workshop results

5.1 Integration into a course

The workshop was deliberately designed to be modular and not tailored to one discipline so that it can be used in different application scenarios and for different student groups. The following is an example in the field of business administration of how it can be integrated into a course: Participants in a course on process management and optimization are advised that in addition aiming for "time reduction" and "quality increase", there are also ecological aspects such as "environmental compatibility", e.g. in terms of CO2 emissions, to be considered. For this purpose, a 3-hour version of the workshop is used at the beginning of the semester to increase the sensitivity of the participants with regard to that topic. Later in the semester points from the workshop are deepened. The integration into a course has to be adopted individually by each lecturer so that the participants see the relevance for the respective subject area and do not perceive the workshop as a useless "add-on".

5.2 Perceived benefits

Lecturers benefit from the possibility to integrate directly usable assignments into their courses ("ready to use"). Due to the modular design of the workshop, interested lecturers can vary the length of the workshop with little effort and thus integrate it into their course - a change of the curriculum or the examination regulations is normally not necessary. One lecturer can supervise up to 50 participants (in teams of three to a maximum of five participants) as a coach. Participants do not need any prior knowledge for the assignments. The workshop is interactive; participants can apply what they have learned directly or learn as they apply it. The step-by-step instructions deliberately leave many questions open for the teams to discuss together. In doing so, hurdles towards the topic are reduced ("I can't do anything anyway" or "the others have to start"). In addition to the technical input, other competencies such as teamwork, self-reflection, willingness to change and problem solving are practiced. The necessary equipment is deliberately kept to a minimum (flipchart, pen, computer/smartphone with Internet access), or is brought along by the participants themselves. An existing (flexible) seminar room can be converted into a suitable learning room in a few minutes and the equipment can be prepared. Alternatively, the workshop can be set up online using a communication platform with breakout rooms and a cloud platform for graphical documentation.

5.3 Lessons learned during development and implementation

In the preparation of the workshop, it became clear that the existing sources of information are either very scientifically in-depth and geared to a partial focus or are based on "popular sources" that lack a balanced basis for consideration and must rather be described as polarizing. Also, the "raised finger" for or against behavior change often stands in the way of the possibility of self-knowledge through rational discussion. Recognizing that the complexity, scope and different ways of looking at the issue do not allow for an all-encompassing consideration, the workshop therefore focuses "only" on the CO2 consideration and deliberately excludes other points of view. Nevertheless, it also became apparent during the creation of the workshop that one's own behavior with regard to power generation, power consumption, sensible or senseless journeys or also conference visits should be questioned.

The workshop can be conducted in different variants onsite or virtual and in various durations. Experience has already been gained with several variants. The concept of discovery learning usually leads to an "aha effect" in terms of the content. Due to research and discussion, connections are quickly recognized and new knowledge is built up. The task of graphically processing the findings and presenting them in the form of a sketchnoting poster promotes creativity and cooperation in the group.

In the positive feedback of the participating students the awareness building is explicitly emphasized. Furthermore, the building of the sketchnoting skills - especially in combination with the awareness building, is listed. Finally, enabling interactivity was mentioned. It was also noted as a need for improvement that other tools for CO2 calculation or sketchnoting could be tried out. Furthermore, there was a suggestion that sketchnoting education should be facilitated in advance of the workshop

6. Next steps

The positive response of the participants is to be measured in further rounds by questionnaires, especially with regard to the success of the content. A survey before and directly after the event - in particular on planned behavioral changes - is planned. The existing assignments will also be further developed by the community in terms of content. Interested lecturers or developers for further content can contact us at any time for free access to the documents.

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