25TH INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
7-8 SEPTEMBER 2023, ELISAVA UNIVERSITY SCHOOL OF DESIGN AND ENGINEERING, BARCELONA, SPAIN

UNDERSTANDING AND CHALLENGING CLIMATE SKEPTIC ATTITUDES AMONG ENGINEERING STUDENTS THROUGH INTERACTIVE PEDAGOGY

Marthe Elden WILHELMSEN, Reyn O'BORN, Anette HEIMDAL and Alexander RUSER
University of Agder, Norway

ABSTRACT
This paper investigates the prevalence of climate scepticism among 3rd year engineering students and seeks to understand how pedagogical interventions can be used to challenge climate sceptic views. This contribution follows a two-pronged approach to estimate the proportion of climate sceptic attitudes in the classroom, understand their root cause and, most importantly, develop pedagogical tools to challenge such views. The first part involved conducting two statement-based surveys to identify the prevalence of climate scepticism before and after pedagogical interventions. The second part discusses the effect of the use of interactive pedagogical methods to challenge climate scepticism and reduce potential conflict in the classroom. The goal of this research is to determine which pedagogical methods can contribute to changing attitudes towards climate scepticism among engineering students. Two surveys were given to 275 engineering students before and after several hours of lectures on sustainability theory and an interactive class exercise to challenge climate sceptical views. The results of the surveys showed that climate scepticism among our group of engineering students was higher than the Norwegian general population average and that the chosen pedagogical intervention showed mixed results in changing these attitudes. The results of the study can be used to understand how engineers perceive the challenge of climate change and to what extent engineering students are sceptical of climate change science. The results will also be useful for educators in understanding how topics of climate change can be discussed and how climate scepticism can be dealt with in the classroom through effective pedagogical methods.

Keywords: Climate scepticism, engineer students, interactive pedagogical methods

1 INTRODUCTION
Engineers play an important role in the sustainable transformation of societies and the development of technological capacities to address human caused climate change. It is therefore no surprise that modern engineering education is increasingly focusing on sustainable design and technical solutions for environmental problems. Engineering disciplines have an outsized influence on sustainable technological development, which means that an understanding and belief in climate science is critical to understanding how technology should work to reduce climate change impacts. It is therefore paramount for educators to understand which gaps in climate science knowledge exist, how prevalent climate scepticism is, and what pedagogical tools can be implemented to combat change scepticism. Educators need to understand the scale of the problem of climate scepticism among engineering students by understanding how their students perceive issues around the scientific foundation of climate science. This study seeks to discover the scale of climate scepticism among engineering students and takes a first step in developing a pedagogical intervention for changing attitudes towards more scientific based understanding of climate change. The study combines a survey approach with interactive pedagogical intervention. Drawing on research that tries to understand the impact of pedagogical interventions on students' attitudes towards science in general [1], this study utilized in-classroom interventions for undergraduate students in engineering at the University of Agder in Norway.

2 CLIMATE CHANGE SKEPTICISM IN EDUCATION
Even though there is a general consensus on the science behind anthropogenic climate change [2], climate sceptic attitudes are significantly high in western societies [3]. Within a broad political consensus, Norway aims to be an international climate leader, while at the same time paradoxically

continuing to produce petroleum as the largest economic sector [4]. Climate change denial is not common in Norway; however, it is relatively common to hold sceptical views of the seriousness and impacts of climate change [5]. There is, however, not much data available on the attitudes of climate scepticism among engineering students in Norway, but a small body of research from engineering educators in the United States has also shown climate scepticism to be surprisingly prevalent there, especially among civil engineers [6, 7]. A similar study has shown that up to 30% of engineering students misunderstand the mechanisms behind climate change, but that the general belief in climate change science is higher than the average population in United States [8]. These studies, however, are geographically limited and do not reflect the attitudes of engineering students in Norway, or Europe in general.

As a topic for educators, addressing climate change poses two main challenges: First, the term is only vaguely defined and tends to lump together anti-scientific and anti-elitist sentiments with distinct normative and political convictions such as an aversion against regulative politics or distinct national(ist) views on international relations [12]. Second, since climate change sceptics often have a distanced relationship with "authorities" and proponents of "mainstream views" top-down attempts to "educate them" might reinforce their worldviews as opposed to changing them. Literature on Education for Sustainable Development [9] in schools suggests that there is a need to develop new holistic pedagogical strategies which we believe should also include teaching at universities. An interdisciplinary approach in teaching sustainability issues (in line with the UN Sustainable Development Goals) is needed for successful and holistic sustainable development to occur, but students must believe that these environmental and sustainability issues exist to foster change. It is therefore important to not only look at the students' technical understanding of the issues, but at how these issues relate to their attitudes and beliefs for understanding the complexities of their climate sceptical views. It is also important to avoid what can be perceived as a more "authoritarian" top-down lecture approach to combatting climate sceptic views, which can reinforce their climate sceptical views, especially when the lecturer is not perceived as a trusted figure.

3 METHODS

3.1 Test group

The course ING200 at the University of Agder, Norway, is a 3rd year course that is taken by all engineering students in the final semester of their bachelor's degree. The course is designed to help engineering students think in terms of systems and evaluate technology based on a foundation of ethics and sustainability, as learned in the course. The main course modules focus on systems thinking, scientific knowledge theory, ethics, sustainability, circular economy, and life cycle thinking for engineers. The class size is approximately 275 students per year and is a mix of engineering students who are studying degrees in construction, mechatronics, electronics, renewable energy, and information and communications technology (ICT).

3.2 Survey design and data collection

Two exploratory surveys were given to the ING200 students. The first survey was given early in the semester, before any sustainability theory was taught, to determine baseline attitudes towards sustainability, and more specifically climate scepticism. The exploratory survey was designed to map out the attitudes of the engineering students' beliefs and attitudes towards climate science. The survey presented statements regarding attitudes and trust towards climate science, policies, and the media which the students had to select their level of agreement with these statements. Questions about their basic demographics, motivation for studying engineering, and general beliefs about sustainability were also included. Following six hours of sustainability lectures and an active session in the classroom on climate scepticism, the students were again asked their overall opinion on sustainability issues and views on climate scepticism, including questions regarding which sessions they participated in in the classroom and if they believe their opinion has changed, how and why.

3.3 Pedagogical intervention

After the initial survey had confirmed the existence of climate change sceptic attitudes among the students, an in-class 45 minutes session was dedicated to exposing them to scientific information and accompanying explanation that addressed selected major talking points of dissenters of the (alleged)

climate change "mainstream". This session aimed to include interactive, participatory elements that give the students a say while respecting their (potentially dissenting) views. The session was aimed at starting a dialogue rather than enforcing specific interpretations of available information. Participating students were given the opportunity to reflect on the topics, give anonymous feedback and voice their opinion to their peers. This pedagogical intervention took place after the lectures on sustainability and were attended by approximately 65 students. Students were asked to work in small groups to engage with and discuss selected questions and materials covering three core reasons for disagreement on climate change: (1) the validity of climate science, (2) belief in a consensus on climate research and (3) media coverage of climate change. They were confronted with common climate sceptical statements such as (1) "*Climate science is not responsible. We simply do not know if the climate is changing*", (2) "*there is no consensus on climate change amongst scientists*" and (3) "*traditional media doesn't tell the truth about climate change*". They worked with this step-by-step, getting one statement at time followed by curated information presenting different views, memes, news articles, opinion pieces and scientific sources on the validity of related research and opinions. The students discussed in groups with the researchers available for questions and listening in on discussions. After some group discussions, they answered questions anonymously in an online Mentimeter survey in the classroom before they started on the next statement. The responses came in as word clouds, ranking and open-ended responses, and these were used as data in this paper, in addition to the surveys prior and after the intervention. The intervention was thus dialogue based between the students themselves, and between the students and the researchers. They had the opportunity to write in anonymous individual answers in Mentimeter.

4 RESULTS AND DISCUSSION

4.1 Results from the first survey

The first survey had 82 respondents who completed the survey, with 83% being male, and 17% female. The majority of the students (38%) were enrolled in mechatronics, followed by ICT/IT (26%), construction and civil engineering (20%), and the rest (12%) were pursuing a degree in renewable energy.

The first survey established a "base line" by mapping the attitudes of the participants prior to any pedagogical intervention. When asked whether we are currently experiencing an environmental crisis (see Figure 1), the majority (68%) agreed or strongly agreed with only a small minority (2%) disagreed strongly or disagreed (9%), while 24% were neutral. However, the picture is less clear regarding trust in climate science: 11% of the students agreed or strongly agreed with the notion that there is no scientific consensus, 66% disagreed or strongly disagreed, while 23% were neutral.

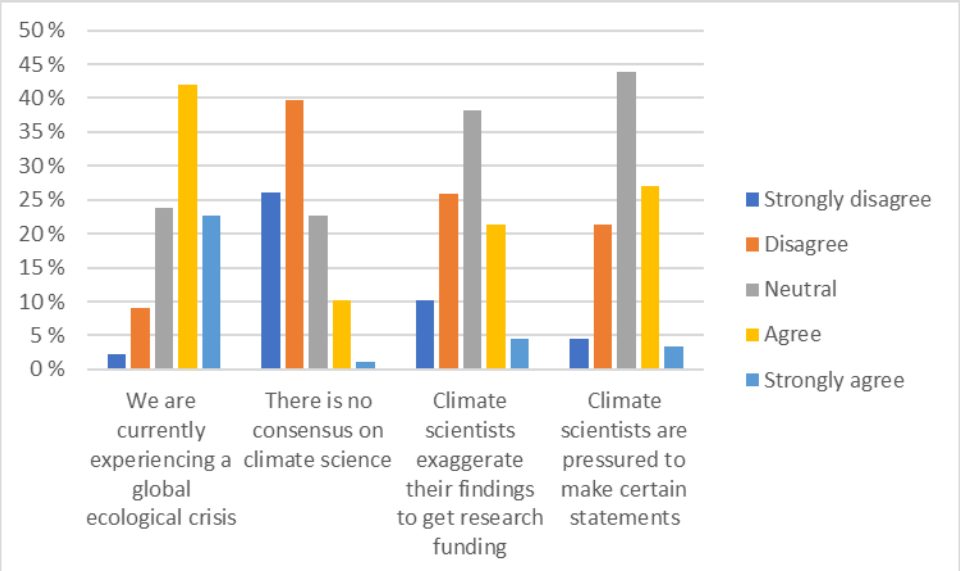

Figure 1. Regarding attitudes towards climate change and climate science

More than one third (36%) either strongly agree or agree with the statement that climate scientists exaggerate their findings to get more funding, and 25% agreed or strongly agreed that climate scientists are pressured to make certain statements demonstrating a more complex picture of the reasons why some of the respondents don't trust climate science. Despite a considerable reservation against climate science, it was surprising to learn that "sustainability" as a topic was overwhelmingly seen as important for the students and their personal lives as well (Figure 2). This suggests that climate scepticism attitudes and concern for the environment are not always mutually exclusive for this group of engineering students.

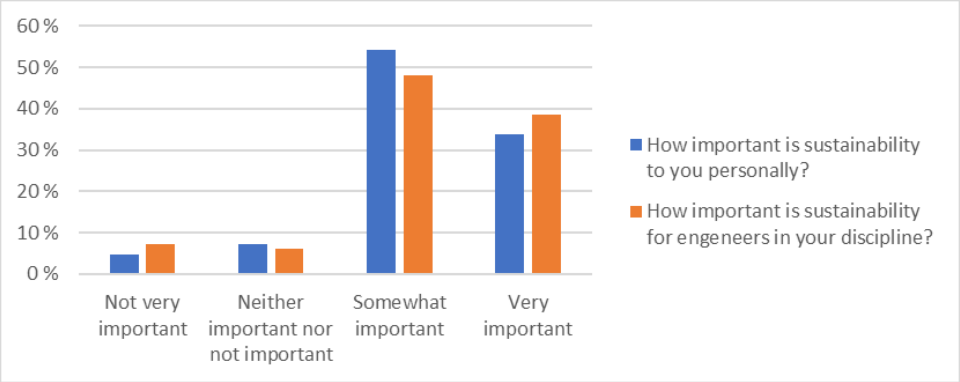

Figure 2. Importance of sustainability from the first survey

4.2 Pedagogical Intervention

The pedagogical intervention mainly aimed at questioning the students' beliefs on climate change. As a viable proxy for assessing the impact of the intervention, the students were asked whether they believed that they "know enough about climate change" before and after being exposed to carefully curated material in the in-class session that addressed the three main talking points of climate change deniers (as described in the methods section). As displayed below (Figure 3), confidence in personal knowledge *declined.* Since the pedagogical material did not include any information that justifies or amplifies climate science or climate policy scepticism the results are likely indicate the beginning of a questioning of climate sceptic views.

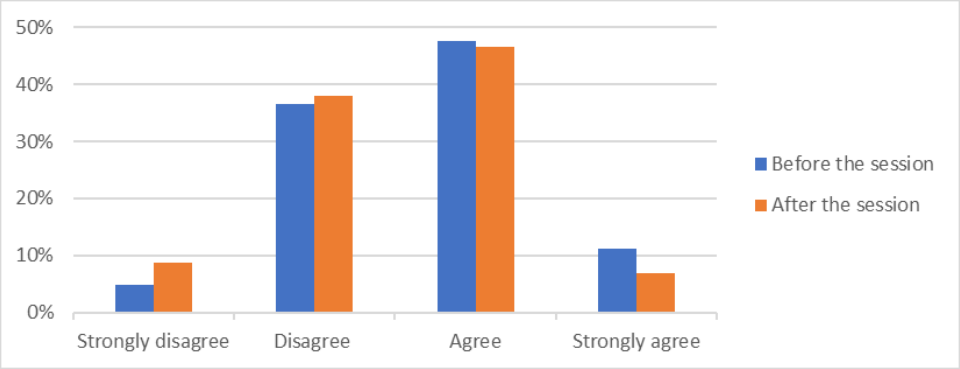

Figure 3. Response to question "I know enough about climate change" before and after in-class intervention

Figure 4 shows the average of the class from 1 (strongly disagree) to 4 (strongly agree), meaning 2,5 is the "medium" in this specific ranking exercise. The average was all around the "medium" or "neutral". When contrasted with the findings from the online survey, these findings paint a differentiated picture showing not only *that* a considerable share of students reject the consensus on climate *science* but *why.*

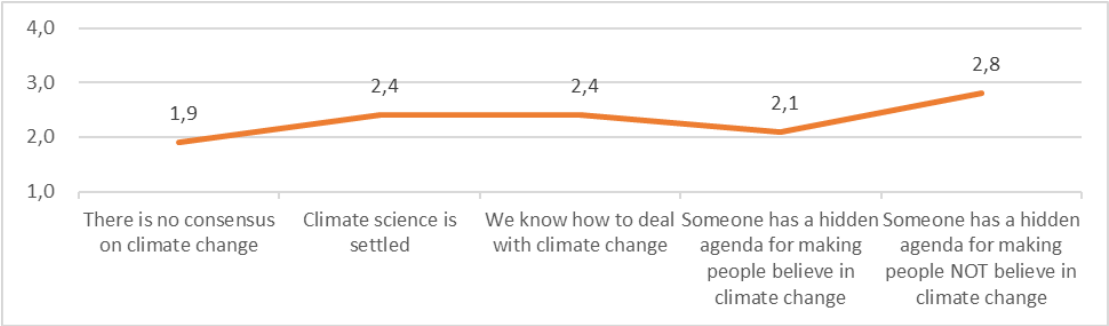

Figure 4. Regarding beliefs in climate science. The figure presents the average in the class

4.3 Results from second survey (post-intervention)

The second survey had 58 respondents who completed the survey, with 79% being male, and 21% female. The majority of the students (40%) were enrolled in mechatronics, followed by ICT/IT (28%), construction and civil engineering (22%), and the rest (5%) were pursuing a degree in renewable energy, which is a slightly different mix of students than the first survey. The second survey was given after the in-class session and revealed a more mixed impact from the chosen pedagogical intervention. While 12 per cent of the students stated they had become less sceptical because of the materials and explanations they were confronted with in the course, an almost similar share (11%) reported that their reservations to accept climate science had increased, while another 9% of previously sceptic students had unchanged beliefs. These findings could be explained by research in increasingly disconnected "counter publics" [10] which are increasingly unwilling to accept information that challenge their normative convictions and knowledge about climate change [11]. This could also be that the respondent groups were not identical between the first and second surveys.

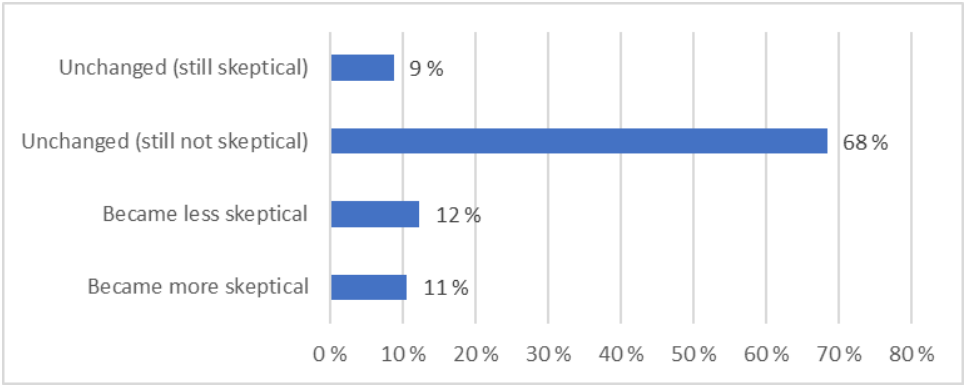

Figure 5. from the second survey, on the effects of the pedagogical intervention

There was also an issue that some respondents wrote unserious replies during the didactical intervention. This also seems be the case with the second survey, as some answered how the pedagogical session influenced them, even though many of them did not participate in the session. The respondents from the first and second survey are not necessarily the same people, and the validity of especially Figure 5 needs to be researched further. To tackle these challenges, future research would include sending the survey to other institutions, looking at different disciplines for a comparative study and trying out different pedagogical interventions. The study was also limited by the time available for the intervention, with only 45 minutes for the in-class session, and a few weeks between the first and the second survey. A longer period between the surveys or longer time in the classroom would potentially provide more conclusive results.

5 CONCLUSIONS

The results of this study show that a considerable share of engineering students hold climate science sceptic views, above the Norwegian national average. When given the opportunity to engage in a guided debate about climate change and when confronted with selected materials on the scientific research, decision making and communication about human made climate change, students begin to question

whether they “know enough” thus indicating a possible opening for pedagogical interventions to tackle climate sceptic views. The subsequent second survey, however, points to the limits of classical pedagogical approaches which focus on the dissemination of information and the provision of explanation. While the didactive intervention produced mixes results, this study not only shows that climate sceptic opinions are endemic among engineering students but that challenging them requires active, participatory, and inclusive learning techniques that refrain from top-down lecturing and attempts to simply disprove students who hold dissenting views. The results of this study show that there is a need for further intervention among educators for guiding engineers towards a sustainable future. To expand the research, more time and more sessions would be beneficial. We suggest that varied and interactive approaches to both learn about climate change and facilitate an arena where the students’ opinions can be explored and challenged can contribute to this complex issue, and that more research using different pedagogical approaches is needed.

REFERENCES

[1] Aguilera D. and Perales-Palacios F. J. "What Effects Do Didactic Interventions Have on Students’ Attitudes Towards Science? A Meta-Analysis," *Research in Science Education,* vol. 50, no. 2, pp. 573-597, 2020/04/01 2020, doi: 10.1007/s11165-018-9702-2.

[2] Cook J. *et al.*, "Consensus on consensus: a synthesis of consensus estimates on human-caused global warming," *Environmental research letters,* vol. 11, no. 4, p. 048002, 2016.

[3] Capstick S., Whitmarsh L., Poortinga W., Pidgeon N. and Upham P. "International trends in public perceptions of climate change over the past quarter century," *Wiley Interdisciplinary Reviews: Climate Change,* vol. 6, no. 1, pp. 35-61, 2015.

[4] Eckersley R. "National identities, international roles, and the legitimation of climate leadership: Germany and Norway compared," *Environmental Politics,* vol. 25, no. 1, pp. 180-201, 2016/01/02 2016, doi: 10.1080/09644016.2015.1076278.

[5] Austgulen M. H. and Stø E. "Norsk skepsis og usikkerhet om klimaendringer," *Tidsskrift for samfunnsforskning,* vol. 54, no. 2, pp. 124-150, 2013.

[6] Milovanovic J., Shealy T. and Godwin A. "Senior engineering students in the USA carry misconceptions about climate change: Implications for engineering education," *Journal of Cleaner Production,* vol. 345, p. 131129, 2022/04/15/ 2022, doi: https://doi.org/10.1016/j.jclepro.2022.131129.

[7] Grubert E. "Civil engineering’s internal skepticism on climate change," *Journal of Professional Issues in Engineering Education and Practice,* vol. 144, no. 3, p. 02518003, 2018.

[8] Shealy T., Katz A., Godwin A. and Bell M. "Civil Engineering Students’ Beliefs about Global Warming and Misconceptions about Climate Science," *Journal of Civil Engineering Education,* vol. 147, no. 4, p. 04021011, 2021.

[9] Sinnes A. T. and Straume I. "Bærekraftig utvikling, tverrfaglighet og dybdelæring: fra big ideas til store spørsmål," *Acta didactica Norge-tidsskrift for fagdidaktisk forsknings-og utviklingsarbeid i Norge,* vol. 11, no. 3, 2017.

[10] Kaiser J. and Puschmann C. "Alliance of antagonism: Counterpublics and polarization in online climate change communication," *Communication and the Public,* vol. 2, no. 4, pp. 371-387, 2017, doi: 10.1177/2057047317732350.

[11] Ruser A. "A Mission for MARS: The Success of Climate Change Skeptic Rhetoric in the US," *"Res Rhetorica",* vol. 7, no. 2, 07/06 2020, doi: 10.29107/rr2020.2.4.

[12] Ruser A. (2022). “The Skeptic Who Came in from the Cold? The Formation of a Climate-Skeptic Alliance in Germany”. In: Hoelscher, M., List, R.A., Ruser, A., Toepler, S. (eds) *Civil Society: Concepts, Challenges, Contexts. Nonprofit and Civil Society Studies*. Springer, Cham. https://doi.org/10.1007/978-3-030-98008-5_24.