Resources, Inequality and Sustainability - integrating language and science teaching in ESD

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ABSTRACT*: The aim of this paper is to investigate to which extent student teachers at a Higher Education Institution (HEI) acquired sustainable competences from attending a course in the SustainComp curriculum in the 2nd semester, 2023 at UCL University College, Denmark. The conceptual framework integrates Klafki's critical constructive theory about the epochal key problems with the UNESCO guidelines for teaching sustainability, the Sustainable Development Goals (SDGs) and the notion of Socio-scientific Issues (SSI). The paper presents results from a case study of a full-scale pilot activity in the SustainComp project. The research question is "How can a course on Resources, Inequality and Sustainability, that is focused on the impact of sandmining, con-tribute to student teachers' development of sustainable competences?" The question was answered via a thematic analysis conducted by teachers and researchers as a Community of Practice (COP). Results indicated that students acquired knowledge about SSI, interdisciplinary approaches to teaching ESD, linguistic skills, intercultural understanding and critical thinking. Implications for research point towards the need for more research in the field.*

KEYWORDS: Socio-Scientific Issues; Inquiry Based; ESD; Interdisciplinarity

The aim of this chapter is to investigate to which extent students acquired sustainable competences from attending a course in the SustainComp curriculum in 2nd semester 2023. The article is a case study of this full-scale pilot activity based on the SustainComp curriculum with a special focus on the module: Resources, Inequality and Sustainability (SustainComp, 2024).

Introduction

In this study, the full-scale pilot represents an educational activity where a newly developed curriculum was applied in teacher education for the fall semester 2023. Anticipating the full-scale pilot for 25 teacher students, a pre-pilot activity was conducted at the Department of Teacher Education at UCL University College, Denmark in April 2023, followed by case study

research (Ruge et al., 2024) In the pre-pilot, selected components in the SustainComp curriculum were tested and adjusted for application in the full-scale pilot that included all four modules: Sustainable Diets, Sustainable Health, Sustainable Consumer Behaviour and Resources, Inequality, and Sustainability.

Our research question in this case study is "How can a course on resources, inequality and sustainability that is focused on the impact of sandmining contribute to student teachers' development of sustainable competences?"

The sustainable competences include the following competences:

- Intercultural competence
- Critical thinking
- Knowledge about socio-scientific approaches
- Linguistic skills
- Interdisciplinary and co-teaching methods
- Cross-curricular teaching methods

These competences correspond with the intended student learning outcomes from participating in SustainComp module Resources, Inequality and Sustainability that was conducted as an interdisciplinary subject in English and natural science. The intended learning outcomes will be applied as themes in the thematic analysis of collected data.

Methods and conceptual framework

Situated in the SustainComp project

The aim of the SustainComp curriculum was to bridge the gap between sector-divided, discipline-embedded national curricula in education. In addition, to address the current need for competence-based, integrated, interdisciplinary, and transformative Higher Education in congruence with the European Council Erasmus+ program and the 21st Century learning goals. A Design Based Research (DBR) approach was adopted for the development of a 10 ECTS SustainComp curriculum, where development, test in practice, and adjustment were conducted both in the pre-pilot in April 2023 and the full-scale pilot in October-December 2023. See Chapter 2. Each of the four partner HEIs developed a 2,5 ECTS module. The objectives were to facilitate students' participation in the developed courses as an attractive supplement and added value to their respective education. This article only concerns the UCL module entitled: Resources, Inequality and Sustainability.

The pedagogical and didactical development took the point of departure in Klafki's critical constructive theory about the epochal key problems (Klafki, 1996) combined with the UNESCO guidelines for teaching sustainability including the SDGs (Rieckmann, 2017) and the notion of Socio-Scientific Issues (SSI) as defined by (Amos and Levinson, 2019). Focus was directed to the cognitive, socio-emotional and behavioural domains for teaching ESD. Also, the process included critical reflections regarding the formative content informed by Vare and Scott (2007) and the theory about ESD1 (learning for sustainable development) and ESD2 (learning as sustainable development). This conceptual framework served as a common ground for the cross-

country, cross-institutional and interdisciplinary efforts to develop a new curriculum for teaching sustainable competences in HEIs.
As stated by Rieckmann and colleagues (Rieckmann, 2024), educators at higher institutions are often missing educational resources and competences for teaching ESD. Rieckmann's conclusion supported results from the SustainComp state-of-the-art report for ESD in University of Agder Norway, Masaryk University the Czech Republic, Ljubljana University, Slovenia and UCL University College, Denmark (Ruge et al., 2022). This study concluded that teaching sustainability at HEIs was mostly conducted as 'part of another topic' and that teachers were struggling to find relevant educational materials. Teachers were also missing colleagues to share knowledge and ideas for interdisciplinary teaching. Based on these results, the SustainComp COP developed an open access, online interdisciplinary 10 ECTS curriculum, consisting of four modules. In addition, the COP developed a teacher-training module for teaching ESD as integrated in other subjects and topics at Higher Education. Please see more about the design-based research collaboration process in Chapter 2.
The SustainComp COP was focused on producing educational materials that could contribute to students' development of sustainable competences. In relation to the module Resources, Inequality and Sustainability the combined main subjects were Natural Science and English at the teacher education. Across these two subjects, the intended learning outcome in the form of sustainable competences were defined as:

- Intercultural competence
- Critical thinking
- Knowledge about socio-scientific approaches
- Linguistic skills
- Interdisciplinary and co-teaching methods
- Cross-curricular teaching methods

The educational activities: Full-scale pilot (2023)

The full-scale pilot was conducted during the fall semester in 2023. Each of the SustainComp modules was conducted as integrated in the ordinary English course for 25 student teachers during their 1st year at the UCL. The module was placed in the weeks 45-46 in November 2023 as the third module out of four. See Figure 1.

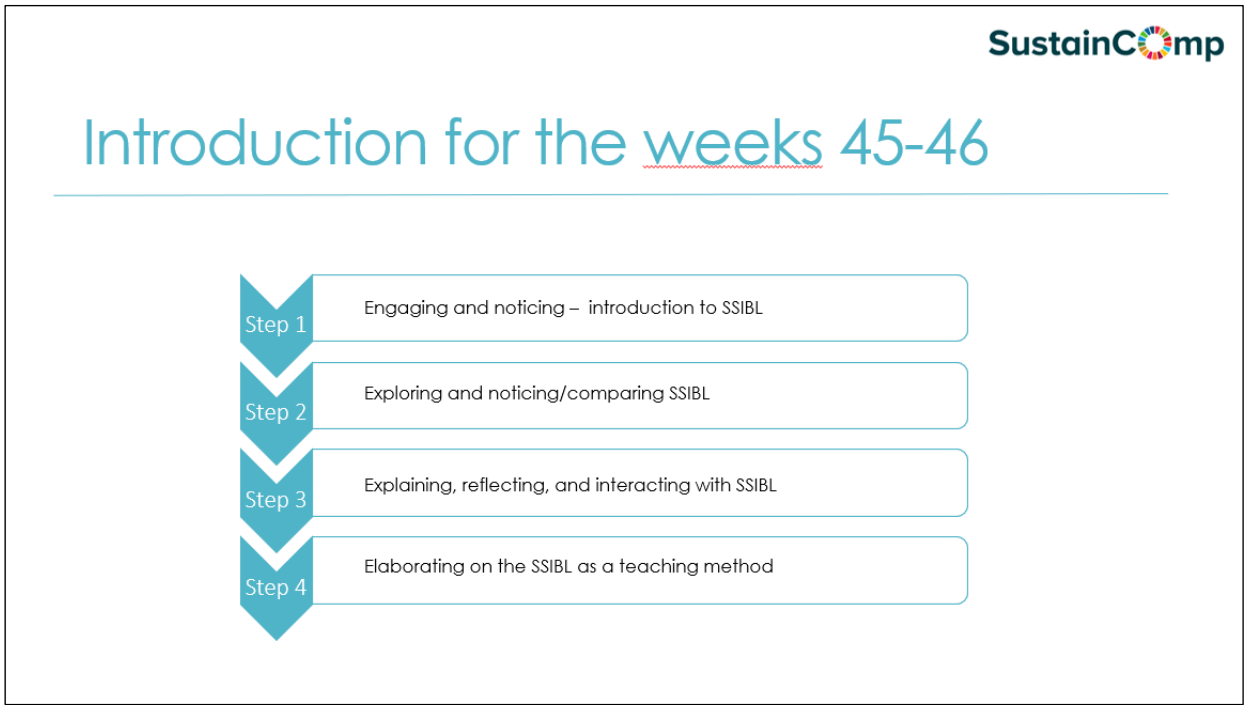
Figure 1. Overview of the SustainComp 'full-scale pilot' (fall semester 2023)

October 2023	November 2023	December 2023
University of Agder (UIA), Norway	**UCL University College (UCL), Denmark**	**University of Ljubljana (UL), Slovenia**
Masaryk University (MUNI), Czech Republic		

Figure 2 illustrates the four steps of the curriculum. The steps are

- Step 1 Engaging and noticing
- Step 2 Exploring and noticing/comparing
- Step 3 Explaining, reflecting, and interacting
- Step 4 Elaborating

Figure 2. Overview of the UCL modules during the full-scale pilot (fall semester 2023)



The English lecturer, Thedchanamoorthy (TH) and ESD lecturer and researcher, Ruge (RU), conducted co-teaching (Friend et. al., 1993) activities throughout the full-scale-pilot of all four modules. During the Resources, Inequality and Sustainability module, the Natural Science lecturer, Rousing Lauridsen (RL) conducted co-teaching together with TH. The interdisciplinary frame of the content took its starting point in the 5E model (Lesley University, n.d.) from Natural Science didactics and the cycle model of intercultural learning (Risager & Svarstad, 2023) from foreign language teaching didactics.

The 5E model (Figure 3) and the cycle model (Figure 4) constituted the didactic foundation since the phases supplemented each other with regard to an inquiry-based learning approach known from Natural Science as well as a learning cycle from English (Risager & Svarstad, 2023).

In Step 1, the first lesson required no prior preparation by the students as the aim was for them to be open-minded and receptive towards an, most likely, unknown and imminent topic. Therefore, the lecturers followed the first phase of the learning cycles: Engaging and noticing by introducing students to the didactic approach for the module. See illustration in Figure 2.

Hereafter, a short video on sand extraction and its implications locally, nationally and globally was presented. Based on dilemmas posed in the video, student teachers were to search for additional information and share with each other in rotating and dynamic group work, thus enhancing the engaging and noticing phase.

In Step 2, the second, third and fourth lesson, students explored, noticed and compared the SSI according to the didactical models. At this stage, RL scaffolded the students' prior knowledge with specialised lectures respectively in geology and intercultural competences in order to demonstrate how examining and discussing a scientific issue could contribute to development of intercultural competences. The student teachers had to stay in the researching and reflecting loop, due to the inquiry-based teaching, so they needed to revisit the unanswered questions from the previous lesson and try to answer them with new insight. Another layer was added to scaffold their ongoing research on sand extraction when they were to watch a recorded interview with leading researcher in geography, Mette Bendixen (Bendixen et al., 2021), read supplementary articles and reflect on how we ought to relate to the world's sand 'shortage'. Finally, their new-found experiences were conveyed in rotating and dynamic groups.

In Step 3 the students explained and reflected collectively as well as interacted with the SSI. Towards the end of Step 4 the student teachers elaborated on the SSI as a teaching method for lesson 5 and 6.

These final lessons also culminated in utilising all four phases in the cycle model of intercultural learning. Due to the target group being future teachers, especially the elaborating and interacting phases required bridging the activities in the module to a practical school setting. The lecturers had to aid a transfer from student teachers' mostly theoretical knowledge and reflections to practical implementation. How were the student teachers going to teach SSIs in their classes – hence establish a double-didactic perspective. Thus, they were obliged to produce a lesson plan, fulfilling criteria such as choosing an SSI related to sustainability and intercultural competences.

Additionally, the students' lesson plan for pupils was meant to draw connections to the SDGs and the 5E model (Figure 3) or the cycle model of intercultural learning (Figure 4). The lecturers' intention was not to make the students reproduce a similar course on sand, but to have them explore other SSIs within the frame of the SDGs. However, struggling students were allowed to be inspired by the lecturers' adaptation. The didactic task was summarised on a poster and finished with group presentations. The posters were later used as a part of the dissemination for a final dissemination event. See Chapter 8.

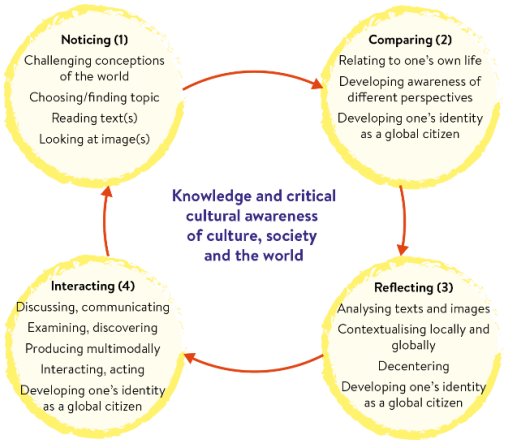
The steps used are illustrated in Figure 3, which shows the 5E model as a circular process.

Figure 3. Overview of the 5E model. Lesley University (n.d.) Empowering Students: The 5E Model Explained. Retrieved June 25, 2024, from https://lesley.edu/article/empowering-students-the 5e- model-explained.

One of the aims of the curriculum was to have the students work interdisciplinarily. Therefore, it was important to be aware of the cycle model which is used when teaching interculturality in English as second language (ESL). See Figure 4. The steps in the cycle model are to some extent like the steps in the 5E model. The steps to obtain knowledge and critical cultural awareness of culture, society and the world are

- Noticing
- Comparing
- Reflecting
- Interacting

Figure 4. Overview of the cycle model of intercultural learning (Risager & Svarstad, 2023).



Figur 2.3. The cycle model of intercultural learning.
Fra: Karen Risager og Lone K. Svarstad: *Verdensborgeren og den interkulturelle læring. Inspiration og nytænkning til sprogfagene og andre fag.*
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By presenting both the Natural Science and the intercultural methods to the students and making them aware of having focus on issues in their tasks, the students were able to work interdisciplinarily.

Case study research methods

In this study we applied case study research methods according to Robert Yin (2014). This means that we used a variety of methods to explore a current, social phenomenon, in this case related to teacher education. We were asking 'Why?' and 'How?' in an open-ended way that applied various forms of sources for data. A way that is sensitive towards the impact from contextual factors, such as human behaviour and changing educational paradigms over time and aims to make social science matter (Flyvbjerg, 2012).

In addition, we applied a Participatory Action Research method (PAR) (Baum, 2006) which implied that we, five female employees at the UCL, have been engaged in an ongoing cycle of critical reflections among us. During the design-based research process we rotated our roles as respectively developer, facilitator, lecturer or teacher, observer and teacher as researcher (MacPhail, 2020). Some of us had special competences, but we tried to work as a COP to reach a shared goal despite the differences and the synergetic collaboration. We have tried to disseminate these processes in a transparent way that might inspire collaboration between lecturers and researchers in the practical arena of education. However, the focus of this chapter is related to students' learning outcomes.

Data collection

Data for getting insight into students' learning outcomes were collected from various sources in the form of:

- Observations
- Survey data (N=25 participants)
- Student products
- Photo

In this chapter the main information comes from survey data and student products. The main codes for thematic analysis correspond with the themes for intended learning outcomes that we focused on. We have applied these codes in the analysis of collected data that we have been conducting during critical reflections in the group of authors.

Analysis and results

In this section the aim is to present answers from the analysis of data from various sources to the research question: "*How can a course on Resources, Inequality and Sustainability that is focused on the impact of sandmining, contribute to student teachers' development of sustainable competences?"*

- Intercultural competence
- Critical thinking
- Knowledge about SSI approaches
- Linguistic skills, co-teaching
- Interdisciplinary teaching methods (lower taxonomic level)
- Cross-curricular teaching methods (Higher taxonomic level)

Observations during the Resources, Inequality and Sustainability module

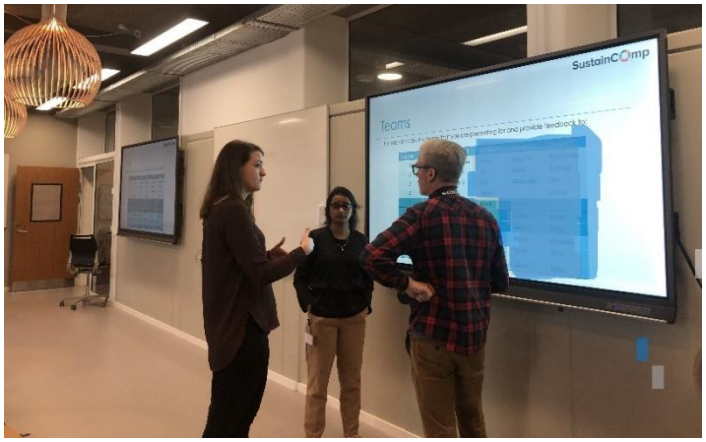
The observations were made over three times during the SustainComp full-scale-pilot. The observer was both participating in the lessons as a teacher and walking around among the students, listening to their communication and asking questions spontaneously to the group members. The groups sat in a room that was designed and convenient for group work. Between some of the groups, there was a shielding screen while others were placed with proper distance to each other. Thus, communication in the groups was not disturbing aside from work noise. See Figure 5.

All groups had a good view of the board which was placed in middle of the front wall of the room. The teacher's computer stood to the right of the board on a small holder with a small table underneath, which might not have been convenient as a workplace.

The relation between teacher and students seemed very good. Students felt confident and eager to ask questions or comment on relevant topics, both in groups when the teacher walked around among the students and in plenum. The atmosphere among the students in the groups was respectful, and the students expressed interest in their task and worked engaged. According to GDPR regulation, photos were taken and videos recorded of students during their group work with the modules[i]. See Figure 5 and 6.

Figure 5. Photo of lecturers and students in typical situation in class, preparing for the lesson and for groupwork.

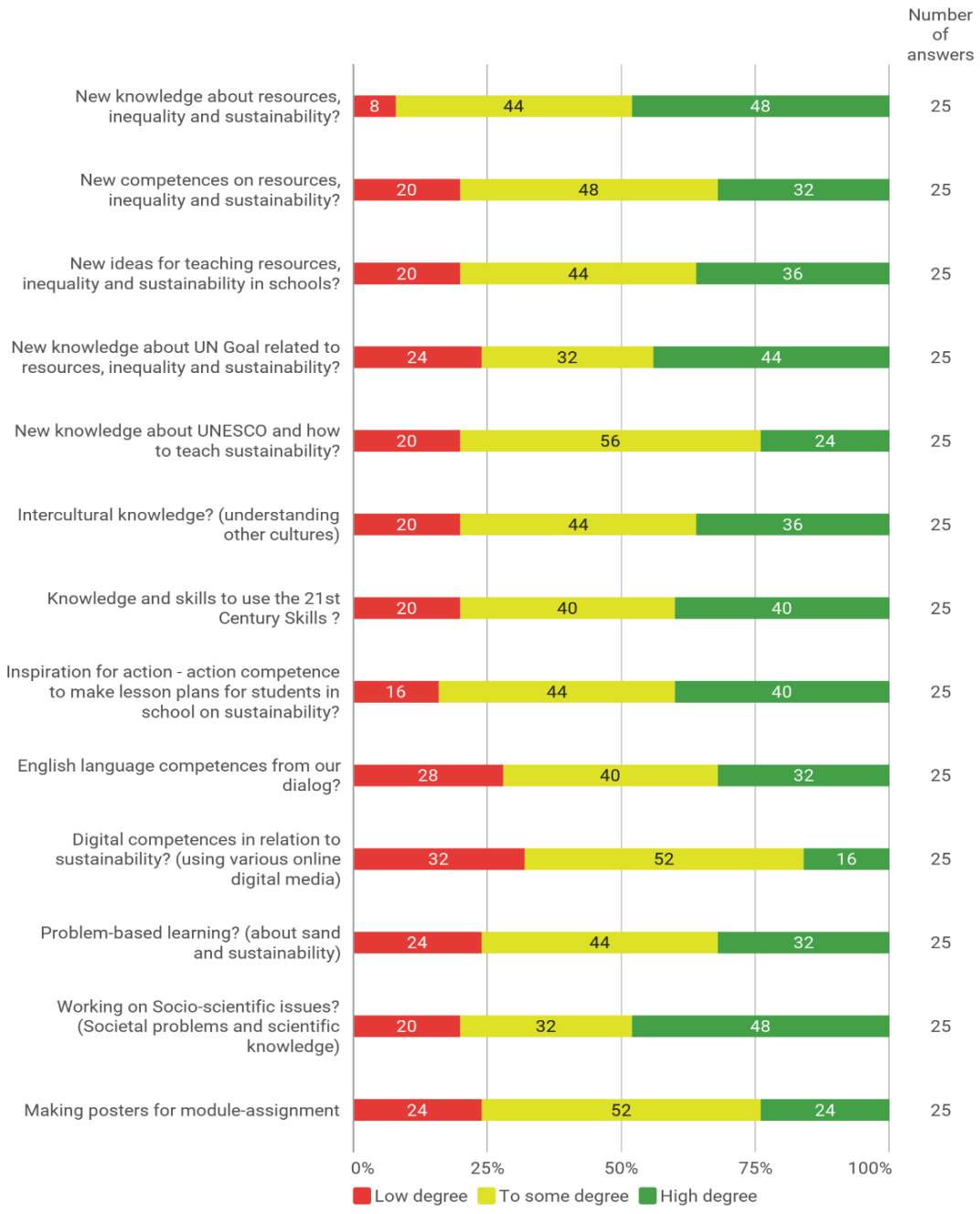
Figure 6. Photo of learning environment.



Survey data

The survey was distributed to the students after the last lesson of the module. Figure 7 illustrates students' self-reported learning regarding the intended learning goals.

Figure 7. Student learning outcome from participating in Resources, Inequality and Sustainability compared to the other three modules. Survey Question: Did you have an outcome from participation regarding:



The results in Figure 7 document that 48% of students had a high degree of learning outcomes regarding new knowledge about resources, inequality, and sustainability. Further, 48% of the students said they had up to a high degree learning outcomes regarding SSI. This result indicates that students had learning outcomes related to interdisciplinary teaching methods and cross-curricular teaching methods. Forty-four percent of the students mentioned that they to a high degree learning outcomes regarding new knowledge about the SDGs related to resources, inequality and sustainability.

Combining the categories of some degree and high degree 80% of students (40%/40%) marked that they had obtained learning outcomes regarding 21st century learning skills and inspiration for action. The acquisition of action competence was related to the lesson plans the students developed during the UCL module. Regarding acquisition of linguistic skills 76% of students (44%/32%) said they had a learning outcome from the interaction during the module.

The least learning outcome was related to digital competences where 32% marked a low degree outcome. This makes sense, as the module was conducted without online presentations or online collaboration (COIL) with students from other universities. Still, the module was conducted in English.

The data in Figure 8 were generated based on answers in 'Open fields' in the survey. The answers support the insights from Figure 7 and provide elaborated insights regarding the obtained learning in the cognitive (knowledge), socio-emotional (emotional engagement), behavioural (action competences) domains.

Figure 8. Survey 'Open Field': Please write in your own words what you learned during the UCL-submodule.

Please write in your own words what you learned during the UCL-submodule on how to teach sustainability in schools	Thematic analysis - learning outcomes
We made a lesson plan and I really think it was relevant	Knowledge about SSI approaches Interdisciplinary teaching methods
Nothing, in the sense that I can't really explain it. it's a little "unstable" what we learn, so it's kind of difficult to describe	Critical thinking
I've learned way more about the different issues we have in our world. For example, the sand shortage.	Knowledge about SSI approaches Interdisciplinary teaching methods Cross-curricular teaching methods
I love the 21st century skills the most, which I did not notice there is such skills before. And I feel that it is very important not only for teaching the students in the future but also value-up ourselves as a better teacher.	Intercultural competence Interdisciplinary teaching methods Cross-curricular teaching methods
We practiced using some different models.	Cross-curricular teaching methods
To better create a lesson plan for the students	Cross-curricular teaching methods

To be open about how this world is currently doing, no hiding facts or not asking.	Intercultural competence Critical thinking Knowledge about SSI approaches
There is a sand crisis, sand is round or angular, which is important for construction. Using teaching aids is helpful, knowing the vocabulary of your own subject is critical, from fellow students that various form of activities is essential.	Intercultural competence Critical thinking Knowledge about SSI approaches Linguistic skills, co-teaching Interdisciplinary teaching methods Cross-curricular teaching methods
It is knowledge that I will bring with me into my class-room in the future.	Interdisciplinary teaching methods Cross-curricular teaching methods
I've learned what is important for kids to possibly learn and what would be interesting and what would not	Interdisciplinary teaching methods Cross-curricular teaching methods
I've learned about the 21st century skills and intercul-tural competences.	Intercultural competence Critical thinking
I sadly haven't been here much but I did learn how sand is the second most used natural resource	Knowledge about SSI approaches
I learned how to be able to teach in different levels because first up we have been taught ourselves and afterwards made a lesson plan for a class of our choice, which we then presented to other groups and gained insight in different levels of learning.	Intercultural competence Critical thinking Knowledge about SSI approaches Linguistic skills, co-teaching Interdisciplinary teaching methods Cross-curricular teaching methods
I learned about a new global issue that I never would have guessed was this big of an issue.	Intercultural competence Critical thinking Knowledge about SSI approaches
I learned a lot about sand and the fact we are run-ning out, I also got an idea of why sand is such a meaningful resource and how there's not a lot of things that can be used instead	Critical thinking Knowledge about SSI approaches
I have learnt about sand in Greenland, sand crisis and how it affects people in the world.	Intercultural competence Critical thinking Knowledge about SSI approaches
I have learned a lot of new things that I will take with me when it is my time to teach. Example making posters about different kinds of sustainability	Knowledge about SSI approaches Interdisciplinary teaching methods Cross-curricular teaching methods

I gained a lot of new knowledge when it comes to the sociocultural issue of the sand crisis	Intercultural competence Critical thinking Knowledge about SSI approaches Interdisciplinary teaching methods Cross-curricular teaching methods
Focus points for the sand crisis that are relevant for various age groups.	Critical thinking Knowledge about SSI approaches Interdisciplinary teaching methods Cross-curricular teaching methods

The results in Figure 8 support the insights about learning outcomes from Figure 7, especially regarding intercultural competences, knowledge about SSI approaches and interdisciplinary teaching methods. Further, it is important to notice how students reflect on how to meet, talk with and educate children and youth about sustainability. In this way they show competences regarding interdisciplinarity and cross-curricular teaching methods:

"*I learned how to be able to teach in different levels because first up we have been taught ourselves and afterwards made a lesson plan for a class of our choice, which we then presented to other groups and gained insight in different levels of learning*"(Answer in Open fields)

Student products

Student products in the form of lesson plans and posters provided a rich source of information about learning outcomes. In this section we have included two representative posters with lesson plans as examples of group assignments. See Figure 9 and 10. The layout has been slightly adjusted by the authors of this paper to anonymise the work. The groups and group members have been anonymised according to GDPR agreement. The module assessment criteria for groups were to 1) Make a poster presentation related to the topic Resources, Inequality and Sustainability 2) Make a lesson plan for a chosen age group with the same topic.

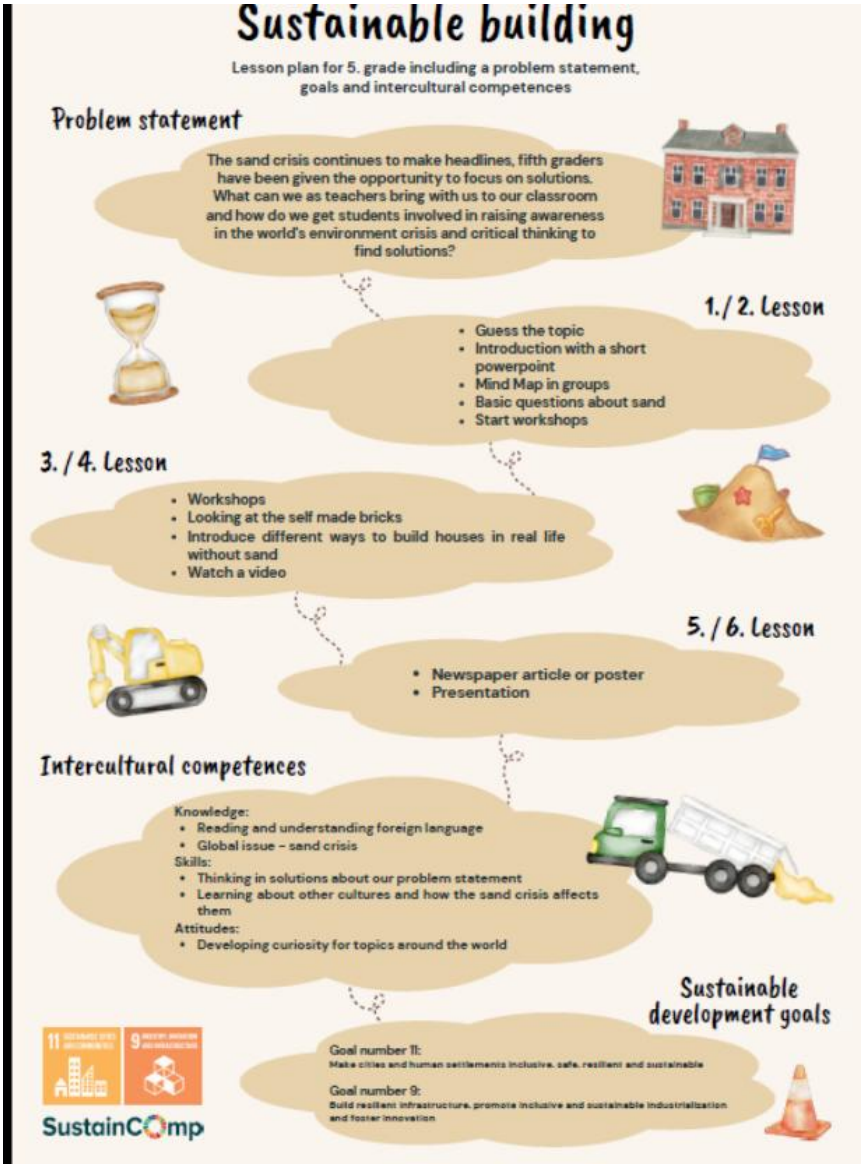
Figure 9. Student product Group A: Poster presentation and lesson plan for 6th grade:

Group A. Lesson Plan

Lesson 1	• **Introduction: What resources are needed?** Talk to your desk mate for 5 minutes. Write their suggestions on the board. Introduce them to the sand crisis. Is it something you have ever heard of? Talk to your desk mate about what you think sand is used for. Video about sand. • **Purpose of lesson on learners' learning**: Give them an insight into the sand crisis. Knowledge about the global sand crisis. Communication Prior knowledge
Lesson 2	• **Introduction**: Different types of sand and their uses and shapes. Why we can't use all types of sand (e.g. Why we can't use desert sand for construction). • **Activity**: Give them a choice between river sand (in use of Lego blocks) and desert sand (in use of marbles) and get them to try to build something with it. • **Activity**: Looking at different types of sand with a microscope. What have you earnt from the activity. • **Purpose for this lesson**: To teach them different sand and which sands can be used to build, and which cannot be used purposefully. Visual learning and creativity.

Lesson 3	• **Introduction**: Introduce their assignment, where they must choose from 5 regions and research and find problems with that region's sand consumption. (E.g. Environmental impacts) Greenland, Mekong River (Vietnam), China, India, Indonesia. The students are then to prepare a 5–7-minute presentation with information they've researched about their assigned region. With provided resources. • **Purpose for this lesson**: To widen their knowledge of the global sand crisis around the world (in different countries) through their own research. Communication between the pupils.
Lesson 4	• The students continue working on the presentations and aim to finish it by the end of this lesson. • To widen their knowledge of the global sand crisis around the world (in different countries) through their own research. • **Purpose for this lesson**: Communication between the pupils.
Lesson 5	• This lesson will be used for the learners to present their findings. With time for questions between each presentation. • Learners will "Learn from each other" through their presentations, so that they learn about the sand crisis in other countries apart from their researched one. • **Purpose of lesson**: Critical thinking
Lesson 6	• **Introduction**: Conclusion and important points from today's lessons. Sand shortage is a finite resource. Talk about the important points from each presentation. The importance of promoting the issue and finding alternatives. If none of the learners have come in on it: talk about what sand mining does to water quality and marine life. • **Purpose of lesson**: To sum up what we've learned today and introduce the class to some of The United Nation's Sustainable Development Goals.

Figure 10. Student Group B: Poster presentation, including lesson plan for 5th grade.



Student groups presented lesson plans and posters to each other in matrix groups on the final day of the module. Additionally, the posters were presented in English at a Seminar in Sustainable Competences in Higher Education, which occurred at UCL on December 6th, 2023. Each group functioned as a matrix group for another group and groups gave each other feedback and feedforward.

The selected poster examples in this chapter indicate how groups worked with both the cognitive, socio-emotional and behavioural aspects of ESD, according to the UNESCO guidelines (Rieckmann, 2017). In addition, student products included SDGs in relation to critical thinking, intercultural understanding and interdisciplinary teaching methods of the two subjects: English and Natural Science.

Concluding results

The research question for this chapter was "*How can a course on Resources, Inequality and Sustainability that is focused on the impact of sandmining, contribute to student teachers' development of sustainable competences?*" The answer to this question is focused on the degree to which the following intended learning outcomes were acquired by student teachers: Intercultural competence, critical thinking, knowledge about socio-scientific approaches, linguistic skills, co-teaching, Interdisciplinary teaching methods, and cross-curricular teaching methods.

From the results we can conclude that students to a medium-high degree have acquired these sustainable competences due to participation in Resources, Inequality and Sustainabilit'. This conclusion is supported, both by students' self-reported learning outcomes and by the student products: the posters and the lesson plans that were assessed by student groups and lecturers – and presented at the final dissemination event in December 2023.

We pay attention to the fact that this module was the only one out of four conducted with physical presence of the two UCL teachers. This may have caused some bias in students' answers being in favour of the UCL module. We also acknowledge that sometimes the Danish student teachers were not so open minded towards being taught by lecturers from the other universities. There were indications that some of the reluctance was related to the linguistic skills by the lecturers as not all lecturers were English teachers and some of the (Danish) students tended to be prejudiced towards other accents than 'Oxford' or 'American' English. In this sense, the full-scale pilot turned out to be a very good exercise in interculturality for all participants.

Discussion

The results seem to provide indications of positive student learning outcomes that correspond with the special focus on learning outcomes. However, the results in relation to ESD should still be discussed critically. The ongoing discussion about ESD1 (learning for sustainability) and ESD 2 (learning as sustainable development) (Vare and Scott, 2007) is highly relevant in relation to the Resources, Inequality and Sustainability module. The title reveals that the module is not an invitation to study whether sand extraction is a crisis. Rather, the decision has already been made that there is an un-sustainable dynamic related to the deployment of planetary

resources. In this perspective, the approach is problem oriented (Klafki, 1996) and inquiry-based teaching for sustainability. This approach differs from the traditional positivistic, Natural Science paradigm focused on measuring and rather refer to the Social-Science paradigm, based on qualitative case study research methods that include contextual factors (Yin, 2014; Flyvbjerg, 2012). In this perspective, it can be argued that the Resources, Inequality and Sustainability module is ESD1 as well as ESD 2, which means dealing both with the knowledge about the facts and the obvious actions - and the critical reflections on causes and implications for humanity – and possible actions for obtaining change. The notion of ESD 3 has been suggested by Garsdal (Garsdal, 2024) as a holistic approach that bridges both the knowledge, skills and formative action components (sustainable development) in relation to sustainability education. This notion might be productive to support and further bridge the very much needed interdisciplinary teaching in Higher Education.

Regarding the theme of sand extraction (Lauridsen, 2022), the notion of SSI - as suggested by Amos & Levinson (2019) and Amos et al. (2020) - was a huge inspiration for the development and teaching activities of this module. It has been bridging the different domains, ontologies and epistemologies of the two subjects: Natural Science and English language in teacher education. Maijala et al., (2023, p.1) suggest that the inclusion of language teachers in ESD is needed to develop a transformative educational approach to ESD that also includes intercultural and linguistic competences. This case study has investigated how this can be done in practice – and the results are promising regarding student learning outcomes.

Overall, the UNESCO publication, Education for sustainable development goals: Learning objectives, (Rieckmann, 2017) was an important and formative publication for the SustainComp partners, providing suggestions for how to teach ESD by including the SDGs. Especially, the notion of cognitive, socio-emotional and behavioural domains in teaching has served as common ground for the lecturers in their cross-national collaborative efforts. Recently, Corres et al. (2024) presented results from a study of ESD in Spain, based on an analytical framework regarding teachers' roles. They conclude that across formal and in-formal teaching settings, competences such as empathy, interdisciplinarity, participation and action are important for teachers' roles in ESD. If we compare these results to the results from our case study of the future teachers, it seems to correspond very well with our focus on interdisciplinarity, interculturality and action-oriented teaching.
Corres et al. (2024) conclude that more research is needed in relation to the socio-emotional dimension of learning in the practical arena. This is also a valuable suggestion that corresponds with the results regarding ESL students' engagement in the implications for humanity, nature and culture of the sand shortage in the world. During the dissemination process from January to September 2024, we had the opportunity to share educational resources with colleagues from other subject areas, such as Visual Arts and Mathematics. A lecturer, Christensen (CH), from Visual Arts at UCL introduced his students to the SustainComp project during their special theme on 'Visual Arts & Sustainability' where they worked with clay to produce tableaus that included the SDGs. One of the groups expressed a special interest in working with the sand extraction theme in relation to 'Resources, Inequality and Sustainability'. During a short briefing via the case description 'The Fisherman's Family', the group developed a tableau that to a high degree engaged the spectators in a socio-emotional way[ii].

This educational activity told us that the inclusion of creative teaching methods is very much a route to socio-emotional engagement and action in relation to ESD, and we decided to include the student products from Visual Arts in the SustainComp curriculum. In another didactical perspective, the Math-group developed a teaching material focusing on an inquiry-based method for using Math didactics to explore the problems related to sand extraction. The results were promising and positive. See more about this interdisciplinary and Science, Technology, Engineering, and Mathematics (STEM) approach in the paper about student engagement in sustainability issues (Toft, Sterup & Hjelmborg, 2024).

Limitations and implications

The main limitation of this study is that it is a single case study with a relatively small number of participants. Therefore, the internal validity is high, and the external validity is low, with reference to Yin (2014). Our intention was to share the activities, the research methods, and the results in a transparent way that offers the reader an option to be inspired or maybe even try to apply the module Resources, Inequality and Sustainability in own teaching activities. With support from Erasmus Plus, the materials are available as Open Access from the SustainComp website.

Regarding the special topic about sand extraction, we as developers, teachers and researchers feel, in retrospect, that we could have put more attention on the 'demand side' of the problem. We are aware that Danish companies may be part of the reason for the massive problems related to sand extraction for construction and other industries. The exploration of these dynamics is to a high degree related to the behavioural and action competences related to working for sustainable development. Scientist Mette Bendixen (Bendixen, 2021) has to a high degree opened our eyes to these complex and complicated matters, by suggesting that massive sand formations that have been revealed due to global warming in Greenland might be an excellent substitute for extracting sand in vulnerable areas in Asia and Africa. Thus, in the scope of the SustainComp project, it was our intention to shed light on a relatively unknown topic to the general population, among which are our own bachelor students in Denmark and in our project partner countries, as well as providing the students and faculty colleagues with a point-of-entry to further explore the topic.

Further, we are aware that the topic of 'inequality' needs to be addressed in a thorough way, compared to our first initiatives that reflect our own privileged situation in Denmark. To improve our work on this important topic we might seek contact among students and teachers in countries where sand extraction is causing problems for the native population. At the SustainComp project's final conference at Masaryk University in the Czech Republic in May 2024, we met students from Southeast Asia, who expressed a strong interest in the module. They told us that the pictures of disappearing sand beaches were exactly the beaches of their childhood, their livelihoods and family homes. Due to sand extraction by companies, the sand beaches had disappeared - and a lot of trash was piling up along the beaches instead. The two students made us aware of other forms of resources that would also be highly relevant to collaborate on in relation to inequality: the water crisis, the energy crisis and the plastic crisis.

Implications for practice

One important implication for practice to which degree other lecturers can integrate this module in the SustainComp curriculum into their own teaching activities. We know from the State-of-the-art report that this is what most teachers prefer: To teach sustainability as part of another topic (Ruge et al., 2022). In respect of this initial finding, the current module and the whole SustainComp curriculum are intended to be used by HEI teachers for their own teaching, co-teaching, COIL, and teacher training activities. The results also have implications for teaching practices at HEIs and we suggest that co-teaching among lecturers is a relevant method for implementing interdisciplinarity at HEI, where more project-oriented approaches can be difficult to conduct. It is an option that new, interdisciplinary contributions from teachers and students can be added to the e-learning platform which is an open resource protected by CC license (SustainComp, 2024).

Implications for research

More research is needed in relation to ESD at HEIs and especially in relation to the problems related to sand extraction in vulnerable habitats, for instance in Asia and Africa. This problem seems to have the potential to stimulate interdisciplinary teaching and interculturality in ways that engage both teacher students and their lecturers. Also, the negative effects on native populations, regarding health, scarcity of resources and risk of immigration caused by sand extraction, should be researched to a higher degree by including the SDGs as a conceptual framework. Maybe in ways that can lead to contact between teacher students in affected countries, and students from western HEIs. Apart from online collaboration, exchange visits could be an obvious associated activity. More research is needed in students' response to these educational activities, and how students can bring these forms of learning with them into their future jobs as teachers. The design-based-research approach has been rewarding, but also a challenge for both lecturers and students. After the adjustments based on evaluation and critical reflections of the full-scale pilot, and the finalising of the modules in spring 2024, it will be very relevant to do a follow-up case study of the final SustainComp curriculum and the affordances in the educational resources on the e-learning platform.

Conclusion

The research question for this case study was: *How can a course on resources, inequality and sustainability that is focused on the impact of sandmining, contribute to student teachers' development of sustainable competences in the form of these learning outcomes*: *Intercultural competence, critical thinking, knowledge about SSI, linguistic skills, co-teaching, Inter-disciplinary teaching methods, cross-curricular teaching methods.* Based on the results we will conclude that students to a medium-high degree have acquired these sustainable competences due to participation in Resources, Inequality and Sustainability. This is supported, both by students' self-reported learning outcomes and in the form of student products: the posters and the lesson plans that were assessed by student groups and lecturers, presented at the final dissemination event in Sustainable Competences in Higher Education, which occurred in December 2023. It can also be concluded that the limitation of the study is that it is a single case

study with a small number of participants. However, we suggest that this example of interdisciplinary teaching of ESD – Natural Science and English – has the potential to inspire other lecturers or teachers to include the topic of Resources, Inequality and Sustainability with a special focus on the un-sustainable aspects of sand extraction for people, animals, and nature in their own teaching.

There are indications that the interdisciplinary SustainComp approach can be integrated in teaching and learning **for** and **as** sustainable development in a wide range of teaching subjects in Higher Education – and that students will acquire sustainable competences from participating. In the module Resources, Inequality and Sustainability in the SustainComp project, we as teachers and researchers aimed at applying the UNESCO guidelines for teaching sustainability in HEIs. In 1996, Klakfi reminded us about the core problems of the modern world and the tasks of education. Klafki concluded:

> If we as adults, and all the more so as educationalists, wish to do justice to our responsibility for the new generation, then I feel we must, both theoretically and practically, deal with the key problems of our historical epoch (Klafki, 1996, page 18)

Almost 30 years later, the question for education and research could be: Has the adult generation still the legitimacy to teach the younger generations how to deal with the key problems and how to act, facing the multiple planetary crises and the tipping points. What is the impact of this for educators? More development and research are needed to both develop and to research critically how to teach ESD1, ESD2 and hopefully also ESD3 to children and young people. The aim of this paper was to investigate to which extent teacher students at a HEI acquired sustainable competences from participation in the Resources, Inequality and Sustainability module. The conceptual framework integrated Klafki´s critical constructive theory about the epochal key problems with the UNESCO guidelines for teaching sustainability, the SDGs and the notion of Socio-Scientific Issues. Through collaboration in our own HEI and across our partner HEIs throughout the SustainComp project, and with focus on strengthening intercultural competences, we feel that our small contribution to the teaching of ESD suggests a solution to tackle the epochal key problems from a HE perspective.

[i] See photo and video recordings from the SustainComp full-scale-pilot at this e-learning website: https://sustaincomp.splet.arnes.si/

[ii] See additional materials from the Visual Arts ESD course at the SustainComp full-scale-pilot at this e-learning website: https://sustaincomp.splet.arnes.si/

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