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Educating Future Change Agents: Research Instruments applied in Case Studies on Teacher Education for Sustainable Development

Jan-Ole Brandt, Lina Bürgener, Aaron Redman, Matthias Barth

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Educating Future Change Agents

Research instruments applied in case studies on Teacher Education for Sustainable Development

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Editorial

This document provides additional information about the design of the different instruments (assessment tools, focus group guides, and code books) applied in case studies on Teacher Education for Sustainable Development – on the micro level (course-level) of the research project **"Educating Future Change Agents (EFCA)."** Its main objective is to enhance transparency about how the research was conducted with regards to learning processes and outcomes in individual sustainability courses of teacher education programs at Leuphana and Arizona State University (ASU). This is to enable actual reproducibility, which usually exceeds the scope of regular journal articles. Fellow researchers, scholars, and practitioners are invited to comment, discuss, and contribute their thoughts and experiences.

Related journal articles and published material:

Brandt, J.-O.; Bürgener, L.; Barth, M.; Redman, A. (2019): Becoming a competent teacher in education for sustainable development. In: International Journal of Sustainability in Higher Education, 20 (4), 630-653. https://doi.org/10.1108/IJSHE-10-2018-0183

Brandt, J.-O.; Barth, M.; Merritt, E.; Hale, A. (under review): A matter of connection: The 4 Cs of learning in pre-service teacher education for sustainability. In: Journal of Cleaner Production.

Brandt, J.-O.; Barth M. (2020): Case description - Competence development in teacher education for sustainable development at Leuphana University and Arizona State University. In: Working Papers in Higher Education for Sustainable Development. (No. 1/2020) Leuphana University Lüneburg. Center for Global Sustainability and Cultural Transformation.

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Table of Contents

1 Student survey

The student survey was conducted at the beginning and at the end of the semester (pre-post course design) and consisted of two parts. Part 1 was to provide demographics and background information about the students participating in the courses under investigation. It asked about students' previous work experience, extra-curricular activities, and their motivation for becoming a teacher (open item). Part 2 included an open question asking for students' understanding of the term *sustainability* and used existing scales for their world-views, the perceived relevance of education for sustainable development (ESD), and their self-efficacy for a t-test based pre-post comparison.

Below, you can see the student survey as it was conducted at Arizona State University (ASU) in August and November with students of the SCN 400 course, Sustainability Science for Teachers (SSfT) – in the fall semester of 2018:

Preface: By participating in this survey, you agree that the results may be used for research purposes after being anonymized. In this survey, we will confront you with various scenarios and questions for decisions in the context of sustainability. Thereby, we will evaluate your understanding of sustainability in different application contexts as well as your knowledge about specific concepts from the field of education for sustainable development.

Please use the table below to create your personal code. This will ensure the anonymization and allocation of data in the future. Please put a recognizable cross in the corresponding square.

(In case you made a mistake, fully color the wrong square and put a cross in the correct one.)

A	B	C	D	E	F		A	B	C	D	E	F		0	1	2	3	4	5		0	1	2	3	4	5
G	H	I	J	K	L		G	H	I	J	K	L		6	7	8	9				6	7	8	9		
M	N	O	P	Q	R		M	N	O	P	Q	R													
S	T	U	V	W	X		S	T	U	V	W	X													
Y	Z	Ä	Ö	Ü			Y	Z	Ä	Ö	Ü														
1. letter of your first name							**2. letter of your last name**							**2. number in your date of birth**							**4. number in your date of birth**					

Example: **J**ohn D**o**e, born 1**4**.0**7**.1990 = **JO47**

Please transfer your code in the correct order and in capital letters/numbers to the following line:

_____

PART 1 – PERSONAL INFORMATION

1. **Please enter your age (in years).** ☐

2. **Please specify your gender.**

   ◯ female

   ◯ male

   ◯ other ☐

3. **What did you do before you started your current study program?**

   ◯ started a vocational training

   ◯ completed a vocational training

   ◯ started a different study program

   ◯ completed a different study program

   ◯ completed an internship of min. 6 months

   ◯ other professional activity for min. 6 months

   ◯ completed a social year

   ◯ completed an ecological year

   ◯ none of the above

4. **What is your personal motivation to become a teacher?** (open item)

5. What hobbies do you have besides your studies? (extra-curricular activities)

- ◯ care service / nursing
- ◯ education / courses / certificates
- ◯ organization / planning
- ◯ consulting
- ◯ sports
- ◯ sustainability
- ◯ music / art / creative work
- ◯ health / Yoga / meditation
- ◯ gardening
- ◯ IT / computers
- ◯ none of the above

PART 2 – PERSPECTIVES ON SUSTAINABILTY, ESD & SELF-EFFICACY

6. How would you define the term *sustainability*? (open item)

7. How much do you agree or disagree with the statements below?

(NEP scale, by Dunlap, van Liere, Mertig, and Jones (2000))

	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
We are approaching the limit of the number of people the Earth can support	○	○	○	○	○
Humans have the right to modify the natural environment to suit their needs **(recode)**	○	○	○	○	○
When humans interfere with nature it often produces disastrous consequences	○	○	○	○	○
Human ingenuity will insure that we do not make the Earth unlivable **(recode)**	○	○	○	○	○
Humans are seriously abusing the environment	○	○	○	○	○
The Earth has plenty of natural resources if we just learn how to develop them **(recode)**	○	○	○	○	○
Plants and animals have as much right as humans to exist	○	○	○	○	○
The balance of nature is strong enough to cope with the impacts of modern industrial nations **(recode)**	○	○	○	○	○
Despite our special abilities, humans are still subject to the laws of nature	○	○	○	○	○
The so-called "ecological crisis" facing humankind has been greatly exaggerated **(recode)**	○	○	○	○	○
The Earth is like a spaceship with very limited room and resources	○	○	○	○	○
Humans were meant to rule over the rest of nature **(recode)**	○	○	○	○	○
The balance of nature is very delicate and easily upset	○	○	○	○	○
Humans will eventually learn enough about how nature works to be able to control it **(recode)**	○	○	○	○	○
If things continue on their present course, we will soon experience a major ecological catastrophe	○	○	○	○	○

8. Please indicate how much agree with the following statements.
(Perceived relevance of ESD scale, by Tomas, Girgenti, and Jackson (2015))

	Strongly disagree	Disagree	Agree	Strongly agree
Teachers can play an important role in solving social and environmental problems through education.	○	○	○	○
It is important to include education for sustainability in my future classroom practice.	○	○	○	○
It is important to teach environmental education to school students from an early age.	○	○	○	○
Education for sustainability is a fad that will pass in time.	○	○	○	○
It is important to include education for sustainability in pre-service teacher education programs	○	○	○	○
The inclusion of education for sustainability in my pre-service teacher education program will directly benefit my ability to teach students about sustainability.	○	○	○	○

9. How easy would it be for you to perform the following tasks on your own?
(ESD-related self-efficacy scale, by Tomas et al. (2015) – supplemented by Bertschy, Künzli, and Lehmann (2013))

	I couldn't do this	I would struggle to do this on my own	I could do this with a bit of effort	I could do this easily
Identify the science that underlies a newspaper report on an environmental issue.	○	○	○	○
Explain the formation of acid rain.	○	○	○	○
Describe how human activities can impact the environment	○	○	○	○
Predict how changes to an environment will affect the survival of certain species.	○	○	○	○
Interpret the scientific information provided on a government website about climate change.	○	○	○	○
Educate others about sustainability issues.	○	○	○	○

Bring about an improvement in the environment, even if only in a small way, through my own skills and knowledge.	○	○	○	○
To choose possible teaching topics and evaluate their suitability for education for sustainability.	○	○	○	○
To make economic, ecological, social and cultural perspectives within a chosen topic graspable and accessible, by means of questions as well as the formulation of problems and tasks.	○	○	○	○
To appropriately introduce learners to conflicting goals and interests and to enable and guide their attempts at constructively coping with them.	○	○	○	○
To develop and provide efficient learning opportunities concerning the qualification for participation.	○	○	○	○

10. Please indicate how much you agree with the statements below:

(Innovation-related self-efficacy scale, by Emmrich (2009))

	Strongly disagree	Disagree	Agree	Strongly agree
I am confident that I can develop creative ideas that help to change unfavorable teaching and learning structures.	○	○	○	○
I am confident that I can motivate students to engage in new projects.	○	○	○	○
I can make innovative change happen, even when confronted with skeptical colleagues.	○	○	○	○
I know that I can introduce pedagogical innovations, even under problematic circumstances.	○	○	○	○
Even if I encounter barriers when implementing new ideas for teaching and learning, I find ways and means of getting them through.	○	○	○	○
Even if I try very hard, I will not be able to establish new teaching and learning methods in my teaching practice.	○	○	○	○
I feel secure and confident, even when implementing big and innovative projects and reforms.	○	○	○	○

1.1 Code book – students' motivation to become a teacher

To analyze students' *motivation to become a teacher* (Item 4), we used the following code book, inspired by the FIT-choice scale by Watt et al. (2012). However, whereas the original scale included the category or code of *social utility value*, we distinguished between a focus on the individual level (motivation to contribute to the development of children) and the societal level (motivation to contribute to the development of, for instance, the educational sector or entire generations). Furthermore, we added the code *other*, to account for replies that could not be assigned to any of the previously defined categories.

Code	**Rules for coding/*example quotes***
Social influence (A)	Statements on others' encouragement to undertake teaching: - *My family/friends/colleagues think I should become a teacher*
Prior teaching and learning experiences (B)	Statements on prior teaching and learning experiences: - *I had positive experiences when learning/going to school* - *I have had some inspiring teachers that serve as my role models* - *I had bad experiences with teachers and want to do it better myself*
Task demands (C)	Statements on expected difficulties and required expertise: - *The job of a teacher is emotionally demanding* - *The job of a teacher requires a high degree of content and expert knowledge* - *Teachers have to work hard, and I like to be challenged*
Task returns (D)	Statements on expected returns such as high status, reputation, and salary: - *The job as a teacher comes with a high reputation and status* - *Teaching is a respected profession* - *Teachers are highly valued/appreciated by society* - *The gratitude/gratefulness of students and their parents*
Teaching ability (E)	Statements on the perceptions of their own teaching abilities: - *I am good at teaching* - *I have the skills a teacher needs* - *The profession of being a teacher fits my skills/competencies*
Intrinsic career values (F)	Statements on the intrinsic value of teaching and the desire to work with children: - *I like teaching* - *I am interested in the profession of being a teacher* - *I would like to have a job where I can work with kids/children* - *I feel comfortable working at school* - *Being a teacher is a multi-faceted/diversified job* - *I want to make learning fun and effective* <u>Also included:</u> - *I want to see children grow* (implies less active input from the teacher)

Personal utility values (G)	Statements on expected job security, secure income, time for family and job transferability: - *I want a secure job* - *Teachers have a high income* - *As a teacher, I have comparably flexible hours and can combine job and family* - *I will have the ability to travel and teach English internationally*
Social utility values – focus on children (H)	Statements on the desire to shape the values of children and contribute to their development at a more individual level: - *I want to teach/guide/challenge/promote the children* - *I want to be a role model for the children* - *I want to be part of the children's development process* - *I want to prepare children for their future* - *As a teacher, I can convey certain values* - *I want to encourage disadvantaged children so that they can achieve more* - *I want to make children enthusiastic about learning* - *As a teacher, I want and can make an impact* (student-related) Excluded: - *I want to see children grow* (implies a less active input from the teacher)
Social utility values – focus on society (I)	Statements on the desire to shape society, contribute to the development of the educational sector, and impact entire generations: - *As a teacher, I can influence the next generation* - *I want to do something for the socially deprived* - *I want to do something useful for society* - *I want to give something back to society* - *I want to help change the educational system* - *Children are our future* - *As a teacher, I want, and I can make an impact* (society and generation related) Also included: - *I want to make a difference/a valuable contribution* (general statements)
Other (J)	Statements that could not be assigned to any category listed above: - *I don't want to become a teacher* - *I don't know yet*

1.2 Code book – sustainability definitions

To make students' *sustainability definitions* (Item 6) available for quantitative analysis, we created a code book, considering the two variables of *future orientation* (0–3 Pts.) and *sustainability dimensions* (0–2 Pts.), so that overall scores ranging from 0 to 5 Pts. can be used in a pre-post comparison (paired t-tests).

Variable: *Future orientation*

No future orientation (0 Pts.)	Statements with no concrete reference to the future
Future orientation (1 Pt.)	Statements with a concrete reference to the future (such as developments, effects, and/or consequences: - Ideas/conceptions of *"not running out of resources,"*; *"systems staying diverse," "making things last," "keeping Earth healthy," "saving the planet," "using renewable recourses,"* etc. - Further, verbal indications of future orientation, like: *"maintain/maintenance," "preserving/preservation," "progress/progression,"* etc.
Intergenerational justice (2 Pts.)	Statements with a concrete reference to *"future generations"*: - for instance, "*ensuring future generations the same (or a better) lifestyle, access to resources,"* etc.
Inter- and Intra-generational justice (3 Pts.)	Statements with explicit reference to both today's and future generations: - for instance: *"meeting the needs of the present without compromising the ability of future generations to meet their own needs,"* etc.

Variable: *Sustainability dimensions*

No dimension (0 Pts.)	Statements with no concrete reference to any of the sustainability dimensions
Ecological dimension (1 Pt.)	Statements referring to the ecological dimension of sustainability: - *Environmental protection* - *Living in harmony with nature* - *Environmental consciousness* - *Preservation of biological systems* - *Reducing waste and pollution* - References to the *"world/planet/Earth as our environment,"* etc. <u>Also included:</u> - the idea of "*going green*"
Social dimension (1 pt.)	Statements referring to the social dimension of sustainability: - *Societal needs* - *Sustainable lifestyle* - *Fighting poverty, hunger, etc.* - *Social justice*

Economic dimension (Resource orientation) (1Pt.)	Statements on the economic dimension of sustainability: - References to economic concepts like "Productivity" and "Efficiency" - Sustainable consumption <u>Also included:</u> - Preservation/conservation/protection of (natural) resource conservation and protection with regards to availability
Multi-dimensional understanding (2 Pts.)	Mentioning of at least **two** sustainability dimensions (ecological, social, and economic (resource orientation)), as well as taking different perspectives and/or referring to the interplay of the different dimensions

2 Competence assessment: ESD-related pedagogical content knowledge

To assess students' pedagogical content knowledge (PCK) we measured their capability to decide how well the ESD-specific learning principles of *vision orientation*, *connected learning,* and *participatory orientation* (Künzli & Bertschy, 2008) can be put into practice in selected case studies (Plesse, 2007).[1] Ratings were based on two scores: First, we determined how closely the students' rating of whether the learning principles could be applied in each case study matched a rating by experts. This expert rating was determined by having every case study evaluated by four experts from the field of ESD in teacher education and averaging their scores. The difference between the experts' rating and the students' scores (an absolute number) was deducted from the potential maximum of four points, leading to a final score ranging from 0 to 4,* which was again used for pre-post comparisons (paired t-tests). Second, the researchers rated the students' rationales for their ratings (codes ranged from 0 to 2). All coding was conducted by at least two researchers to achieve inter-coder reliability (ICR). In the case of different scores, the researchers jointly re-examined the raw data to come to an agreement.

* Calculating the rating score:

Student rates "can hardly be put into practice": **2**
Expert rates "can be put into practice to a large extent": **4**
Difference between student and expert: **4 – 2 = 2**

Rating Score = Max Score – |Difference (Student vs. Expert)| = 4 – 2 = 2

Preface: Below, you will find different cases of classroom scenarios. Please read them carefully and answer the associated questions.

[1] The original case studies can be found under:
http://www.institutfutur.de/transfer-21/daten/materialien/gs4/HTML/archiv/teil_02.pdf
http://www.institutfutur.de/transfer-21/daten/materialien/gs4/HTML/archiv/teil_03.pdf

Case study 1: Who makes chocolate (un)happy – teaching unit on the topic of chocolate (Plesse, 2007, pp. 149–156)

A 12-week-long teaching unit for all class levels in elementary schools (as well as across levels) on the topic of chocolate

Learning objectives:
The children know the different stakeholders along the production process of chocolate as well as their individual interests and can identify interactions between them. They can critically reflect on their own role regarding the consumption of chocolate and differentiate and justify criteria for consumer decisions. They recognize the possible effects of their own actions on the stakeholders and understand that there are various alternative options for action, each of which leads to different outcomes. They can take a variety of the stakeholders' viewpoints and seek solutions according to their respective demands.

Process:
To begin the unit, the children think about what it would be like if chocolate did not cost anything. Afterward, they learn about some of the stakeholders within the field of chocolate and discuss the impact that free chocolate could have. During a trip to the supermarket and subsequent taste testing, they learn about various products, prices, labels, and the interests of the consumers. During the class, the children learn about the production process of chocolate: From the cocoa bean on the plantation to the chocolate in the supermarket. In addition, they talk about the countries growing the beans, the conditions under which they are cultivated, and the cocoa trade. By means of role-playing games, the children reflect on the demands of the different stakeholders as well as the impact of changing conditions. The class closes with a renewed debate on the initial question.

Task:
How well can the following didactical principles be put into practice in the given example?
Please tick one box each and give a brief explanation for your choice.

Vision orientation

The lesson is aimed at a desired plan for the development of society and not a disaster scenario.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Connected learning

Interconnectedness in the fields "local – global", "environment – economy – socio-culture" and "present-day – future" is implemented in class in a clear and instructive way.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Participatory orientation

Pupils take part in selected decisions which concern the child alone or the class as a whole, and they share the consequence of these decisions.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Case study 2: The herb, spice, and aromatic plant garden – a new place of learning

(Plesse, 2007, pp. 189–192)

An ongoing project as part of the school garden for all age groups in elementary school on the topic of herbs, spices, and aromatic plants

Learning objectives:

The children take on responsibility for the school garden and learn to care for it. They are aware of the possible uses of herbs, spices, medicinal and aromatic plants. They find out about the different applications of these plants in their cultured and wild forms. They are capable of cultivating the plants themselves. They can present their knowledge to others.

Process:

In class, during the project, the children are introduced to a wide variety of plants, as well as the conditions under which they grow. On school trips, they learn about the different ways in which these plants are sold (e.g., frozen, fresh, processed) and how much they cost. In the school garden, the children can experience the cultivation of the plants for themselves – starting with the preparation of the beds, continuing with the planting and sowing, and, finally, the harvest. Here, they can participate directly in the decision on which plants should be cultivated. The children are taught the different ways of processing the plants (e.g., dry, pickle, freeze) and try out a variety of recipes. At a school fair, the children prepare their own samples to smell and taste and present the knowledge they acquired through the project on display boards.

Task:

How well can the following didactical principles be put into practice in the given example?
Please tick one box each and give a brief explanation for your choice.

Vision orientation

The lesson is aimed at a desired plan for the development of society and not a disaster scenario.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Connected learning

Interconnectedness in the fields "local – global", "environment – economy – socio-culture" and "present-day – future" is implemented in class in a clear and instructive way.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Participatory orientation

Pupils take part in selected decisions which concern the child alone or the class as a whole, and they share the consequence of these decisions.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Case study 3: Children explore the world – partner program with a school in Africa

(Plesse, 2007, pp. 85–90)

A typical example of a school sponsorship of a German elementary school for an elementary school in Rwanda is developed into a partnership on equal terms, through which the children can exchange information about the different cultures by writing pictogram letters.

Learning objectives:

Through the continuous exchange with the partner school in Rwanda, the children learn about a culture that has, up to then, been completely foreign to them. They can identify particularities about their own culture and represent them graphically. Through the exchange with the partner school, the children can name differences and similarities between the cultures and learn to take on various perspectives. They develop empathy and solidarity for the children of another culture and can respect and appreciate differences.

Process:

First, a typical school sponsorship is put in place, in which fund-raising events at a German elementary school to collect money for a partner school in Rwanda. Pen pals are established between the children in the two schools, thereby fostering a real exchange. In their letters, the children describe their own daily life through pictograms. This allows them to exchange information on their family situation, day-to-day experiences, and their surroundings. Through this exchange, the children gain insight into a heretofore unknown world and can draw comparisons with their own situation. At a school fair, the children present an African market that reflects the topics of their letters, and, for example, build home-made Rwandan musical instruments, display traditional clothing, or describe the different ways children get to school.

Task:

How well can the following didactical principles be put into practice in the given example?
Please tick one box each and give a brief explanation for your choice.

Vision orientation

The lesson is aimed at a desired plan for the development of society and not a disaster scenario.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Connected learning

Interconnectedness in the fields "local – global", "environment – economy – socio-culture" and "present-day – future" is implemented in class in a clear and instructive way.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Participatory orientation

Pupils take part in selected decisions which concern the child alone or the class as a whole, and they share the consequence of these decisions.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Case study 4: Handling recyclable resources – sustainable protection of resources

(Plesse, 2007, pp. 131–136)

In the Environmental Study Group (Umwelt-AG) of an elementary school, a project is conducted on the topic of waste, culminating in a project week for the entire school.

Learning objectives:

The children know the production process of paper as well as the different paper types and labels. They can reflect on their own consumer behavior and derive options for their own actions. The children can analyze the school's paper consumption, identify the potential for optimization, and develop and implement proposals for solutions. They can present their knowledge to others.

Process:

At the start of the projects, the children choose the topic of how they, themselves, would recycle paper. The children learn about the production process of paper, its uses, and the different paper labels. They research the offers at local retailers and reflect on their own paper consumption, at home and in school, as regards the amount and type of paper. They design informational posters for the school buildings to motivate classmates, teachers, and parents to save resources by monitoring their paper consumption. In the posters, they also raise awareness of ecological labels. Additionally, the children undertake the selling of recycled paper at the school, where they themselves are responsible for selecting, ordering, and financing the paper. In the final week of the project, all the children in the school can address the topic of "paper": making paper by hand, collecting, sorting, and disposing of trash, making crafts from garbage, or reflecting on the waste situation in their own school and developing a waste separation concept, which will then be implemented school-wide.

Task:

How well can the following didactical principles be put into practice in the given example?
Please tick one box each and give a brief explanation for your choice.

Vision orientation

The lesson is aimed at a desired plan for the development of society and not a disaster scenario.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Connected learning

Interconnectedness in the fields "local – global", "environment – economy – socio-culture" and "present-day – future" is implemented in class in a clear and instructive way.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

Participatory orientation

Pupils take part in selected decisions which concern the child alone or the class as a whole, and they share the consequence of these decisions.

- ◯ Can be put into practice to a large extent
- ◯ Can partly be put into practice
- ◯ Can hardly be put into practice
- ◯ Cannot be put into practice at all
- ◯ Not clear from the information available

Please give a brief explanation of your evaluation (where appropriate based on a concrete example)

3 Competence assessment: ESD-related content knowledge

To assess students' sustainability-related content knowledge we developed closed response questions which align with the key competencies in sustainability as described by Wiek, Withycombe, and Redman (2011). In total fourteen items were included, and data was collected from the students pre and post. The students were scored based on the percentage of correct responses. This allowed paired t-tests of the scores for a pre-post comparison.

1. **Efforts to increase recycling rates are typically justified for helping to resolve environmental problems. Of those listed here, check the ways in which recycling helps to resolve social problems (if it does at all).** (More than one answer is correct)

- ◯ Mining for rare earth minerals which comes with health-threatening working conditions, may be reduced. (**correct**)
- ◯ Has a meaningful impact on land area available for conservation by reducing new landfill construction.
- ◯ Recycling is mostly just about helping the environment.
- ◯ Creates "blue-collar" jobs. (**correct**)
- ◯ Keeps plastic out of the ocean.
- ◯ Reduces costs for litter collection by local governments.

2. **You are asked to share an example of a positive feedback loop that might make climate change worse. You decide to give an example using air conditioners. Which of the following do you think would be the best to share (both in accuracy and representing a positive feedback loop)?** (Only 1 answer is correct)

- ◯ Technology for air conditioning continues to improve so even as temperatures increase and amount of air conditioners which are used increases, the electricity used does not and therefore the greenhouse gases emitted do not increase.
- ◯ Increased temperatures cause households to move to colder climates which reduces the amount of air conditioners needed, which uses less electricity which generates fewer greenhouse gases, which causes temperatures to increase less.
- ◯ Increased temperatures cause households to run their air conditioners more which uses more electricity, which generates more greenhouse gases, which increases temperatures more. (**correct**)
- ◯ Paris agreement causes nations to limit the sales of air conditioners, which makes them more expensive, which causes only the rich to be able to afford to keep their homes cool.

3. **You are reading a report which describes a vision of three years in the future with a zero-carbon energy grid. Currently 15% of the electricity on the grid in question is from renewable resources. You would evaluate this vision as being:** (Only 1 answer is correct)

- ○ Desirable but not probable or plausible. (**correct**)
- ○ Both probable and plausible.
- ○ Based on a strong understanding of technological deployment.
- ○ Not a vision because visions have to be at least 10 years in the future.

4. **Your team's vision is being attacked as "unrealistic" and utopian because it includes a 100% renewable society. You respond by saying…** (Only 1 answer is correct)

- ○ Maybe that was a mistake and the vision should just include 90% renewable.
- ○ Visions are meant for inspiration not to have any grounding in reality.
- ○ The vision is actually realistic because we could do this tomorrow if we wanted.
- ○ Visions are not meant to be realistic, rather they must be plausible. (**correct**)

5. **After you presented the assessment results, the CEO complains that "this is not a value-free assessment". You respond:** (Only 1 answer is correct)

- ○ I agree and will start over with my work.
- ○ Sustainability assessments are inherently value-laden, yet scientific. I have articulated the values on which the assessment is based and have made value trade-offs transparent. (**correct**)
- ○ Unfortunately, sustainability assessment is more of an art than a science and there is no way to provide a rigorous assessment.
- ○ The assessment might not be value-free, but I picked the right values.

6. **Economists often use something called Kaldor-Hicks criteria to judge whether an intervention should be carried out or not. Essentially, it gives the go-ahead as long as the net benefits are larger than the costs, regardless of the distribution of costs and benefits. Why is this criterion insufficient for choosing sustainability interventions?**
   (Only 1 answer is correct)

- ○ There have to be no net costs to any individual for it to be a sustainability intervention.
- ○ Economists don't take the environmental or social aspects into account, so it is not sustainability.
- ○ The distribution of who bears the costs and who benefits matters as sustainability interventions seek to improve fairness. (**correct**)
- ○ It is actually sufficient in a practical sense even if it is not the ideal method.

7. **The city has developed a plan to create a new, sustainable fire station. They have identified drivers and barriers and developed an evidence-supported set of instructions for how they will achieve the vision which they developed internally. Select two of the following elements which appear to still be missing from their strategy.**
   (More than one answer is correct)

- ○ Process for inclusion of community stakeholders in development and implementation. (**correct**)
- ○ Clarity between their strategy and their vision for the fire station.
- ○ Rainwater harvesting and xeriscaping landscaping.
- ○ Explicit tactics for managing the politics and power dynamics surrounding the fire station. (**correct**)
- ○ Enough evidence from the expert internal resources at the city's disposal.
- ○ Clear financial cost benefit analysis which shows it doesn't harm the taxpayers' interest.

8. **As a sustainability expert you have been asked by the local government to evaluate a set of strategies which have been proposed by a private consulting firm for a new urban development project. You had previously worked with the local government to develop a systems understanding of the problem and with community members to craft a vision. How would you plan to go about your strategy evaluation?** (Only 1 answer is correct)

○ Work exclusively from the strategies to develop a list of pros and cons for each and from there create a recommendation for the government.

○ Try to calculate the environmental, social and economic costs and benefits and provide a single 'net number' for each strategy.

○ Ignore the strategies already developed by the consultants and use the work your students had done to develop a new strategy.

○ Establish a set of sustainability criteria and analyze how the system changes when each strategy is carried out and how that would play out into the future against those criteria. (**correct**)

9. **A new CEO is looking to re-make her widget manufacturing company into a transformational sustainability business. She has brought you on and asks for a brief overview of how you intend to solve the problem she has of running an unsustainable company. You explain that:** (Only 1 answer is correct)

○ First, you'll develop a systems understanding, collaborate with her employees and others on future scenarios and a vision and then craft strategies designed to achieve the vision. (**correct**)

○ You'll begin by researching all the other companies which are most similar to hers and identifying all the sustainability initiatives they have and cull the best of those to implement.

○ Rebranding themselves as the Sustainable Widget company will cause their employees and customers to think of themselves as sustainability leaders and will therefore be the key driver in transforming the company towards sustainability.

○ You will first identify several relevant sustainability accounting frameworks such as ecological footprinting and then work to apply those to the company to achieve a suite of sustainability certificates of excellence.

10. **A large national grocery chain has brought you on to implement a pilot project focused on incentivizing customers to bring their own bags. You have been brought on to implement a pilot project in a handful of their stores. When you mention this project to a former colleague she asks if the pilot will provide sufficient evidence for a national roll-out of the intervention or whether an experiment was necessary. You respond:** (Only 1 answer is correct)

- ○ Yes of course. If it works at the scale of a couple stores than we can be confident that it will work in all of our stores.
- ○ I don't think the company is really serious about rolling this out nationally and so it is not worth any extra effort to make the pilot project generalizable.
- ○ With a few tweaks, such as establishing a baseline and careful monitoring and evaluation, we can convert this pilot into a solid experiment. (**correct**)
- ○ A pilot project is by definition an experiment and therefore is sufficient.

11. **At the behest of major philanthropist, you brought together a team of experts to develop a strategy for a local food economy. You want to be sure that the team can work well together. Some members want to divide up the project and each work individually, integrating at the end. To make the case for why the team should work more closely together than that, which two arguments are the most relevant for the sustainability context?** (More than one answer is correct)

- ○ Collaborative teams develop more innovative solutions because they take time understand how to unleash the creative potential of team members. (**correct**)
- ○ Teamwork is inherent to sustainability and therefore experts in this area are well practiced in it; teamwork thus will not require extra time and attention.
- ○ Although it is a slower process than everyone working individual, teams generally develop better solutions.
- ○ If you bring together experts with a shared goal of tackling a sustainability problem, teamwork will be easy and require little facilitation and planning.
- ○ Teamwork is beneficial because continually through the process we challenge each other's ideas, ultimately making the solutions more robust. (**correct**)
- ○ Effective teamwork assigns each individual a set of tasks, the results of which only need to be brought together infrequently.

12. **The company you worked for has agreed to launch a large sustainability initiative, and you are the lead designer. Company leadership was very excited about the vision articulated in the plan but not the implementation strategy described. Instead they are planning to follow the project management approach the company has always used for corporate initiatives. You make the following argument in response:** (Only 1 answer is correct)

- ○ Sustainability projects require that projects be managed by sustainability experts with knowledge of the environmental, economic, and social aspects of the field.
- ○ As long as the project team stays true to the original sustainability vision, how the plan is implemented is not materially important for its success.
- ○ As the leader of the planning team, it is critical that I be the one to also lead implementation. Sustainability necessitates continuity from planning through implementation.
- ○ Sustainability projects require different approaches to project management in order to cope with the uncertainty, complexity, dynamically changing situations, and transdisciplinary nature of implementing sustainability solutions. (**correct**)

13. **You have worked for three years to collaboratively develop a sustainability based re-development plan for a city neighborhood largely viewed as in decline. After finally receiving the go ahead from council, your office receives an unexpected flood of complaints from residents. As a result, city council demands you speak publicly about the plan at the next meeting. What would be the best approach to effectively communicating at this venue?** (Only 1 answer is correct)

- ○ Tell the compelling vision story for the neighborhood and how it was collaboratively developed with stakeholders; leaving time to address specific concerns in a Q & A afterwards. (**correct**)
- ○ Create a presentation which clearly lays out the case for the project backed up by the extensive data and analysis which your team put together during their years of work.
- ○ Describe how the extensive stakeholder engagement process which your team carried out went well beyond what was required by law, pointing out how the current plan already was adjusted based on resident concerns.
- ○ Hire consultant to quickly put together a compelling short film on the project as this medium is most likely to engage the concerned residents and address specific concerns in a Q &A afterwards.

14. The city you work for has received special funding from city council to plant 10,000 trees but has only one year to complete the project. As the project leader, you are under significant pressure to begin planting them immediately. Should you make the case that a community consultation process is first needed, why or why not? (Only 1 answer is correct)

○ Yes, stakeholder engagement is a necessary part of any sustainability project both by law and from an ethical perspective. The focus should be on informing the community about the project plans.

○ No, there is too little time to honestly engage with the affected communities and complete the project in the time required by the funders; stakeholder engagement that is done poorly does more harm than good.

○ Yes, for sustainability projects such as this, engaging with stakeholders will improve the project plan, bring more supportive parties on board, and enhance the actual implementation. (**correct**)

○ No, tree plantings are always in demand by residents and other stakeholders as it serves as climate change adaptation measure, and so nobody is going to object to more of them being planted in their neighborhoods.

4 Focus group and interview guides

To provide information about the learning process as well as perceived learning outcomes from the students' perspective, we conducted focus groups (4–7 participants) at the end of the semester. In 2017, the focus group guide asked students for a general reflection on their learning process with regards to the different teaching and learning formats as well as the achievement of the explicit learning objectives of the course. However, the 2018 version was enriched by a photovoice activity and remained more open in terms of students' learning outcomes. In the later version, the students were further asked to trace back their competence development (one competence each) and reflect upon drivers and barriers to their learning. The photovoice method, originally introduced by Wang and Burris (1994), was intended to support students' reflection processes. In using this method, the students took pictures of personal key learning moments over the semester, which then served as anchor points during the group reflections. Semi-structured instructor interviews were conducted to gain further insights about the teaching and learning environment as well as the learning processes and outcomes from the instructors' perspective.

4.1 Focus group guide 2017

Course: Sustainability Science for teachers – SCN 400
Location: ASU
Variables to cover: Competence development; Learning process; Teaching and Learning (T&L) environment; Participants; Context
Pre-discussion Tasks: Print consent form; Check recording device; Have a watch ready; Posters or slides (timeline of the course and its separate learning units + learning objectives); Whiteboard and markers for collecting results of final question (recommendations)

Preface: The project "Educating Future Change Agents" investigates which key sustainability competencies enable change agents to promote the transition toward sustainability. While we also interview future sustainability professionals and entrepreneurs, here we focus on teacher education. The ultimate goal of the project is to provide evidence on promising pedagogical approaches to convey key sustainability competencies in different study programs. We would like to record this interview digitally. The data will be analyzed anonymously and used for academic reasons only. Is that okay with you? Furthermore, I would like to emphasize that your participation here is voluntary, and you have the right to leave at any time. Do you have any questions before we start? (A short round of introductions can help to identify the voices during the process of transcription.)

Introduction – Looking back at the SSfT course (T&L environment / Learning process)

Question:

Now that you have almost completed the SCN 400 course, I would be interested in your opinion on your learning process in the SSfT course. How did you perceive both the actual activities and face to face meetings in class and the online sessions, including videos, quizzes, and assignments?

Contextual aspects	Maintenance questions	Follow-up questions
- General conclusion - Feedback on the structure of the module	- Could you name a concrete example of that? - What exactly were the difficulties? - What helped you? - What was missing?	- How did you deal with the tasks and challenges? - How was the spirit among your students? - What did you like about the course? - How did you organize yourselves to complete the different tasks? - How was the project work for you?

Concrete learning effect through the SSfT course (SCN 400)
(Learning process / Competence development)

Question:

In the course syllabus, the ability to develop and communicate an understanding of sustainability concepts and their application, and being able to apply the WOT (Ways of Thinking) to explain sustainability concepts are the explicit learning objectives. To what extent did you actually achieve these learning objectives during this course?

Contextual aspects	Maintenance questions	Follow-up questions
- Learning objectives - Teaching and learning formats - Competence development	- What helped you particularly in this regard? - What would be an indicator of that? - Could you name concrete examples for that? - What would it have been helpful to have?	- How do you convey that? - Do you think that you could transfer the new knowledge and skills to other contexts, courses, and the working practice as a teacher? - What else did you learn during the SSfT course (something you were not able to do before the course, but can now)?

Beneficial factors and challenges of the course work in SCN 400
(T&L environment / Learning process)

Question:

Finally, I would like to ask each of you to formulate a short list of recommendations regarding the future of the SSfT course. The goal is to further develop the course with your help. Therefore, please summarize what was helpful to your personal learning process and say what you would change about the course, if you could?

Contextual aspects	Maintenance questions	Follow-up questions
- Conditions for competence development - Self-evaluation - Chances and obstacles to the collaboration	- Could you name concrete examples of that? - What exactly were the difficulties, obstacles, or disruptive factors? - Could you describe such a situation?	- How could you have been better supported? - How would you evaluate your engagement and motivation in this course? - To what extent could you bring in your personal strengths? - To what extent could others play out their individual strengths?

Thank you for participating in this focus group and for your hard work during the semester.

4.2 Photovoice-Focus group guide 2018:

Course: Sustainability Science for teachers – SCN 400

Location: ASU

Research question:

What teaching and learning processes enable student-teachers to develop the key competencies required to implement education for sustainability at the school level?

Goal:

To answer the questions

1. What competencies did the students develop over the semester? (key competencies)
2. How did the students learn in this course? (T&L processes)
3. What causal links are there between the different T&L processes and the development of key competencies?

Material:

- Print-Outs (timeline, photos, texts, individual skill tracing hand-out)
- Table and chairs
- Blank sheets and pens
- Sticky notes
- Recording devices
- Flipchart and markers

Time	Activity	Description/Questions	Rationale
30 min	Preparation	- Preparation of pictures in chronological order (*NUMBERING of pictures) - Timeline of the course * so that statements can be traced back to the respective picture	
[PV] Introduction (total: 10 min)			
10 min	Welcome and first impressions regarding key moments of learning	*"Welcome to this photovoice activity. In front of you, you see all the pictures I received over the semester, and that are meant to represent different key moments of your learning processes in this course. Please take a couple of minutes to look at them. Then pick one that resonates most with you or best represents your learning process (it doesn't have to be one of your own pictures) and explain what you see in the picture and why and to what extent it represents your personal learning process."* *Follow-Up Questions:* - *Where did you experience similar moments?* - *Have the others had different experiences?*	Reflection of the semester, exchange of experiences Share first impressions
[FG] "WHAT" - part (total: 15 min)			
8 min	Learning	*"As you know, I am interested in WHAT you have learned in this course,*	Learning outcomes /

	outcomes	*and HOW you have learned it. Let's start with: What do you think you have learned in this course and what competencies do you think you developed over the semester. Take a few minutes to think about it and write it on the sticky notes. [after 2min] Let's share now …"*	Key competencies
7 min	Future applicability of learning outcomes; Self-Assessment of skills and competencies	*"To what extent do you think that this course has prepared you for your future job as a teacher and for implementing education for sustainability at school level?"* *Follow-Up Questions:* - *"What are you now capable of doing that you could not do a semester ago?"* - *"Can you imagine yourself implementing EfS at school level in the future? Why/Why not? Please elaborate"* - *"Are there aspects or components that are relevant to implementing EfS that were missing in this course? "*	Relevance and applicability of learning outcomes from the perspective of students
[FG] "HOW" - part (total: 20 min)			
13 min	Individual HOW Activity: Process Tracing	*"I am also interested in HOW you learned what you said you learned. So:* 1. *Please select the one competence or skill you think you developed or strengthened most in this course.* 2. *Track your learning process by identifying WHEN and HOW the skill was developed.* 3. *Write the competence/skill on one card and use the other cards to write down everything that has contributed to your learning process with regards to the specific competence.* 4. *Put the competence at the end of the timeline and try to sort the other cards chronologically where they fit on the timeline."*	T&L processes, activities and interactions, causal links between learning processes and outcomes; decrypting the black box of WHEN and HOW
7 min	Under-standing of different roles in the T&L process	If not mentioned by the students, follow-up questions: *"What role did …* - *The instructors* - *Your peers* - *Previous experiences* *play in this teaching and learning process?"* *"From your perspective, what were the drivers and barriers to your learning process?"*	T&L processes, interactions, T&L environment, competence of instructors, *Enabling Context*: Stakeholders
[PV] Collective Meaning Making & Concluding Part (total: 5min)			
5min	Wrap-up using pictures	*"Are there any concluding remarks you would like to make? Could you put the pictures in chronological order on the timeline?"*	
Thank you for participating in this focus group and for your hard work during the semester.			

4.3 Instructor interview guide 2017:

Course: Sustainability Science for teachers – SCN 400
Location: ASU
Variables to cover: Competence development; Learning process; T&L environment; Participants; Context
Pre-discussion Tasks: Print consent form; Check recording device; Have watch ready

Preface: The project "Educating Future Change Agents" investigates how learning in sustainability-related university courses takes place and ultimately leads to the development of key sustainability competencies that enable change agents to promote the transition toward sustainability. While we also interview future sustainability professionals and entrepreneurs, here we focus on teacher education. The ultimate goal of the project is to provide evidence on promising pedagogical approaches to conveying key sustainability competencies in different study programs. I would like to record this interview digitally. The data will be analyzed anonymously and used for academic reasons only. Is that okay with you?

Questions:	
1 Please, tell me a little bit about your career and background (academic and non-academic) as well as your experience as a teacher. • (**Follow-up**) Did you have formal or informal training as a teacher? • (**Follow-up**) How did you become an instructor on the SCN 400 course?	**T&L environment** (Instructor profile, academic background, non-academic background, teaching experience, teaching competence)
2 How would you describe your individual approach to teaching and learning in general and to this course in particular? (tradition, preferred T&L formats) • (**Follow-up**) How do you personally relate to the WOT?	**T&L environment/ Learning process** (Instructor profile; actual activities, interactions, teaching and learning approaches)
3 To what extent are you satisfied with how the different activities worked out in class? • **(Follow-up)** Did situations develop differently than expected? If so, in what way and what were the consequences?	**Learning process/T&L environment** (planned activities, actual activities)
4 How would you describe the learning process of your class this semester up until now? • (**Follow-up**) Were there any special situations or moments over the semester that stuck with you? What was special about it/them?	**Learning process** (actual activities, pivotal moments of learning)
5 How would you describe how you interact with your students? • (**Follow-up**) Formal or informal? Is there a written code of conduct? • (**Follow-up**) Could you give an example of that? • (**Follow-up**) Did that change over the semester?	**Learning process** (Interactions)
6 How would you describe how the students interact with each other? • (**Follow-up**) Is there a written code of conduct? • (**Follow-up**) Could you give an example of that? • (**Follow-up**) Did that change over the semester?	**Learning process** (Interactions)
7 To what extent would you say that the students achieved the course-specific learning	**Competence development** (learning objectives, competence level)

objectives? – or to what extent are they about to achieve them? • (**Follow-up**) How do you convey that?	

Demographic information (separate from the actual interview)

a) Age?
b) Gender?
c) Duration of employment as teacher/instructor?
d) Education?

4.4 Code book for qualitative analysis

The qualitative analysis of focus group and interview transcripts was oriented toward an understanding and reconstruction of the learning processes and outcomes, inspired by the coding paradigm of grounded theory, applying the method of constant comparison (Corbin & Strauss, 2015).

However, we generally followed a two-step process of deductive and inductive coding. On the one hand, regarding the learning processes, as deductive codes, we considered the *context* – outside and within the university as an institution – as well as the *teaching and learning environment* – including the different teaching and learning formats applied in the individual courses. Here we distinguished between the *pro*s (advantages) and *con*s (disadvantages) of each format as well as the specific *role* a format plays in the context of the overall learning process – for instance, in relation to the other formats. However, it is important to note that statements referring to the *role* of a teaching and learning format were often connected to those talking about its *pro*s. Concerning the learning outcomes, we oriented toward the concept of ESD-specific professional action competence for teachers, introduced by Bertschy et al. (2013), using content knowledge (CK), pedagogical content knowledge (PCK) and motivation and attitude as deductive codes. On the other hand, we constantly allowed for inductive-codes to emerge within these deductive ones. We added, for instance, learning outcomes like *raised awareness* and *behavior change* as well as *group work/discussions* and *informal learning* to the teaching and learning formats (environment). The latter two, however, were only mentioned with regards to their advantages (*pros*) and their *role* in the overall learning. In the code book below, we only present teaching and learning formats applied in the SSfT course at ASU. The formats applied in the ESD at Leuphana University as the German case of the overall study, such as lectures (flipped classroom), tutorials, seminar sessions, and the practical implementation of an ESD unit with a partner school were coded following the same approach.

With a special focus on understanding the learning process in the courses, three researchers applied open coding to four focus groups to ensure the ICR of the code book encompassing inductive in-vivo codes. In search of significant factors impacting students' learning (drivers and barriers), first emerging categories, such as "course structure," "practical application," "exchange with others," "personal interest" and "preconceptions about science and sustainability," were discussed with the broader research team to allow for different perspectives and interpretations. Through several iterations of axial coding, "connection" was identified as a core category spanning across the other phenomena found in the data. Finally, we included personal connection, professional connection, social connection, structural connection as well as real-world connection as (deductive) selective concepts with several sub-codes – still open for the inductive emergence of new facets.

DEDUCTIVE CODES				
Category	**Code**	**Sub-code**	**Definition**	**Example and/or Lit Cite**
Context	**Broader context**	-	Statements on the broader context – outside of the university as an institution – and its impact on the learning processes and outcomes.	*"(…) the fact that nothing is being done or like strengthened is discouraging, because how are we as teachers expected to go above and beyond it and include sustainability when we're not being supported by the system?"* (S1_361)
	Institutional context	-	Statements on the institutional context of the university – outside of the individual course under investigation (e.g., the overall workload in the program and its impact on learning in the course)	*"Yeah, for me, because like I have to agree, I would just speed up the videos and that's it and I get off topic, I can't just sit there and do homework and then, at least for me I'm here* (at the university) *all day and I stay till late doing homework to like eleven o'clock, so like by the time I hit the videos, I'm already tired, I just want to kick this is and."* (S1_300)
Teaching and learning environment (Mode of delivery/ teaching and learning formats)	**Hybrid course format**	**Pro**	Statements on the advantages of the hybrid course format	*"I really like how the whole thing was set up. I like having the videos to be able to watch it at home and kind of like have that as the lesson and come like rewind your options and you can understand. And then you can come to class and like come with questions and supplement what you watched in the videos with the activities that we did in class."* (S1_329)
		Contra	Statements on the disadvantages of the hybrid course format	*"Hybrid classes just make me feel like there is two separate classes going on. I don't know. I feel like the online portion is a different class than the in-person one just because of like the environment how you're learning and it doesn't feel the same for me, so, I don't know."* (S1_301)
	Online learning	**Role**	Statements on the role or meaning of the online portion for the overall learning process in the course	*"Yeah, I think, I feel like the online work was helpful for the information (…)"* (S1_397)
		Pro	Statements on the advantages of the online portion with regards to the learning process in the course	*"(…) every video and like the quizzes help and the like link she gives us, those all help, like learn it more."* S1_381
		Contra	Statements on the disadvantages of the online portion with regards to the learning process in the course	*"I would change the online portion. The online just didn't help my learning, it's difficult to keep track online and like when you're in class, it's really easy to stay focused, so."* (S1_395)
	Videos	**Role**	Statements on the role or meaning of the videos for the overall learning process in the course	*"And then just having the videos every single week, they're really time consuming and we all know that we're just doing it to answer the quiz questions (…)"* (S1_317)
		Pro	Statements on the advantages of the videos with regards to the learning process in the course	*"I personally, loved the videos, I felt like I learned the most through them (…)"* (S1_352)
		Contra	Statements on the disadvantages of the videos with regards to the learning process in the course	*"(…) the videos I feel like it was just too much information which is part of one of my anxieties, is like when too much information is being like thrown at me, I don't really know how to sort through it very well"* (S1_346)

	Quizzes	**Role**	Statements on the role or meaning of the quizzes for the overall learning process in the course	*"I hadn't thought about that, because I always say the quizzes are to make sure we're watching the videos and like we're getting the information (…)"* (S1_387)
		Pro	Statements on the advantages of the quizzes with regards to the learning process in the course	*"Well, the quizzes were like based on what we learned in the videos but I liked that they were short and sweet and it was able to like sum up what we saw on the videos."* (S1_416)
		Contra	Statements on the disadvantages of the quizzes with regards to the learning process in the course	*"I think the videos or quizzes is not always the best way to go, because like in, I think the disposal or the production, I think that was my favorite, like favorite videos to watch, but I was having a hard time like really pay attention, because I was like worrying about the questions that I needed to answer"* (S1_348)
	Assignments	**Role**	Statements on the role or meaning of the assignments for the overall learning process in the course	*"The assignments where we had like research a clothing store that we all go to like what was there, like how do they apply it that like made us think and relate it to ourselves."* (S1_405)
		Pro	Statements on the advantages of the assignments with regards to the learning process in the course	*"(…) the other parts of the assignments were like your own opinions, like you watch, like you read an article and then you talk about your opinion on it, which I think I really learned a lot from that."* (S1_387)
		Contra	Statements on the disadvantages of the assignments with regards to the learning process in the course	*"Sometimes the secondary activities in the lessons, kind of felt disconnected. Like, there would be the video and it would be all cool and sometimes we would have this, you know, portion we had to like write, you know, some short answers on stuff and sometimes those felt like they didn't connect to it."* (S1_330)
	In-class activities	**Role**	Statements on the role or meaning of the in-class activities for the overall learning process in the course	*"I would definitely agree with that. Being able to articulate how you would show that in a classroom setting, I think you definitely get with the face-to-face, but like understanding the concept I got with videos."* (S1_311)
		Pro	Statements on the advantages of the in-class activities with regards to the learning process in the course	*"I think the best part where I learned is like, we had all these videos and our articles we had to read, but I like that when we came to class the next day or the next time we met, he* (the intructor) *kind of went over them and then he didn't just talk about it or just class discussion, we did activities, like the landfill, we also did the other one where, I think about the water system and then there was like, you had to do a poem, a song and like that was fun."* (S1_364)
		Contra	Statements on the disadvantages of the in-class activities with regards to the learning process in the course	*"when we came to class, the activities, it was kind of like, we were supposed to know or assume what like thinking we were doing and applying, I think there need to just be more emphasize like and like instruction within the classroom, like what thinking we're using and why applying."* (S1_364)

	Group work and discussions	**Role**	Statements on the role or meaning of group work and/or discussions for the overall learning process in the course	*"I thought we were just going to discuss it as a group but writing the letter didn't help me see like that's the point of view rather when like, when we sat in our groups, talking about it, it helped me understand better like what we're doing and like why we all feel the way we do about the topic."* (S1_300)
		Pro	Statements on the advantages of group work and/or discussions with regards to the learning process in the course	*"The in-class assignments and the in-class discussions, I think were a big part of it, too. The videos were great, but like getting to collaborate with our cohort and talk about it with each other was great also."* (S1_337)
	Informal learning	**Role**	Statements on the role or meaning of informal learning for the overall learning process in the course	*"When I was at the beach I just was thinking about all the sustainability things we had learned about throughout the semester and how, like, we need to be proactive about keeping things clean and plastic waste and basically everything. I was like 'Wow, it's right there' because I was there, so."* (S2_378)
		Pro	Statements on the advantages of informal learning with regards to the learning process in the course	*"When I was at the beach I just was thinking about all the sustainability things we had learned about throughout the semester and how, like, we need to be proactive about keeping things clean and plastic waste and basically everything. I was like 'Wow, it's right there' because I was there, so."* (S2_378)
Learning outcomes	**CK – content knowledge**	**-**	Statements on (not) having gained knowledge about sustainability concepts and/or related factual information	*"You know, like I think a lot of it was ignorance, we didn't know and now we know a lot more about sustainability."* (S1_416)
	PCK – pedagogical content knowledge	**-**	Statements on having developed skills to implement ESD at the school level, like the ability to create specific lesson plans, breaking down complex sustainability topics for children, etc.	*"I feel like I always was trying to make those connections and it helped me remember and I feel like I could teach it to children or infuse into a curriculum as a result of the instruction."* (S1_346)
	Motivation – attitude	**motivation to contribute to sustainability/ societal change**	Statements on the (lack of) motivation to contribute to sustainability in general and/or societal change	*"So, I think that is the, yeah, that is the whole point of this class. Like do not overwhelm yourself because, sure, you by yourself you cannot change the world but you can do something to be better."* (S1_413)
		motivation to implement ESD at the school level	Statements on the (lack of) motivation/willingness to implement ESD at the school level	*"Yeah. A lot of these topics though like aren't in our standards. So that kind of freaks me out because I want to teach this but it's not in the standards that we're supposed to teach, so that's kind of concerning to me because to address a lot of these, but I just kind of have to fit it in where you can, I guess."* (S1_422)
		motivation to learn more about sustainability	Statements on the (lack of) motivation to become more educated on sustainability	*"This was also one of my favorite courses. I started looking at graduate degrees in sustainability yesterday."* (S1_398)

	raised awareness	-	Statements on the (lack of) raised awareness (cognitive perception) about sustainability issues and/or solutions, such as realizing non-sustainable actions or noticing sustainable solutions, such as renewable energy devices, etc.	*"I feel like everywhere and anywhere I go I see the signs or like the talk about sustainability, like I see solar panels and I'm like "That's awesome, they use solar panels." Like I don't know, I just, I never thought about things like that ever before and like she said we like walked out, we were walking around Campus, we're like, that's so not sustainable, like we're just so interested in it now and I've never, I've never thought about it before."* (S1_387)
	behavior change	-	Statements on (the lack of) actual changes in individual action patterns toward more sustainable behavior, such as consuming less meat, using public transportation more or recycling more, etc.	*"I think the biggest thing for me that I have noticed throughout the semester is that I don't leave anything plugged in anymore and that was like one of the first things that, no, maybe not one of the first things but something that I remembered early on in the classes, that like don't leave anything plugged in because if it's plugged in, it's wasting energy. And now, no matter what I'm doing, I'm always unplugging my, you know, whether it's the TV that's in my room that I use once a week or, you know my laptop charger, my phone charger (...)"* (S1_408)
	Other/unspecified	-	Statements on learning outcomes that could not be assigned to any of the previously defined codes.	*"I definitely learned a lot"* (S1_379)

SELECTIVE CODES

Category	Code	Sub-code	Definition	Example and/or Lit Cite
Personal connection	**Personal connection**	-	Statements on how the (lack of) personal connection to the topics fostered or hindered learning (e.g., increased the motivation to learn).	*"Yeah, I think making a personal connection with each of the modules or lessons was really good for me and just to know that it won't be as hard to do that for the students, it was a good thing to learn."* (S1_383)
		Relatability	Statements referring to the (lack of) individual interest and the applicability of course content to private life and/or the relation to personal thoughts and actions.	*"Yeah, I agree with that. The knowledge that we gained from the videos didn't have a direct impact in your life until we had group discussions and we all connected together how this really influences our day to day life."* (S1_371)
		Emotions	Statements referring to emotions being triggered by course content and/or specific teaching and learning formats, such as anger, joy, excitement, surprise.	*"I just feel like all in all, like, this class really made me, like, fall in love with sustainability, like, I literally told T_010 that I was thinking about changing my major to Sustainability."* (S2_400)
		Personal engagement	Statements on the (lack of) personal engagement in the learning process, such as during hands-on activities.	*"I think the group activities and the actual projects that we did, that's where a lot of my learning and understanding came from, because those were just hands-on, really fun activities"* (S1_353)

		Agency	Statements referring to the (lack of) opportunity to decide on the WHEN, WHERE, WHAT, and HOW of learning.	*"You got to do it yourself and you could go at whatever pace you needed to understand it"* (S1_377)
Professional connection	**Professional connection**	**Applicability in future classroom**	Statements referring to the (lack of) applicability of course content in future classrooms and/or practical examples of how to implement ESD at the school level.	*"So, I guess the way that our learning took place was we did like modules online and then on Thursdays we came to class and she supported our learning by like doing hands-on activities and showing us ways that we could like incorporate it into our classrooms (...)"* (S1_388)
		Taking a teachers perspective	Statements referring to students taking the perspective of and/or being treated as teachers in the learning process.	*"I feel like this is just more like a professional development, meaning where I'm like, I already feel like a teacher and oh, I'm going to go implement this in my classroom."* (S1_308)
Social connection	**Social connection**	**Exchange with others**	Statements referring to the exchange of thoughts and perspectives with others (instructor, fellow students, friends, and family) and how that has impacted the learning process.	*"What I loved about the course was in-class discussion, I really loved being able to hear the people's opinions respectfully and to have a respectful debating and I feel like that helps with our learning because we're able to see, use values thinking to see different point of views. [...] discussion is huge"* (S1_368)
		Instructor's feedback and guidance	Statements referring to feedback and guidance the instructor provided during the semester and how that has impacted the learning process.	*"When we did the reflections on the videos, that would help me, because the I could go back and look at everything and then she would also give us comments of like if we were on the right track of what we learned from the video"* (S1_328)
		Role models	Statements referring to others being sustainable or passionate about (teaching sustainability) and how that has impacted the learning process.	*"Having a helpful teacher who's passionate the whole time helped, at least it helped most of those I've talked to in class. [...] her passion would make me interested in learning about the topic."* (S1_300)
Structural connection	**Structural connection**	**-**	Statements referring to the explicit or implicit (lack of) connection between individual teaching and learning formats and related content and how that has impacted the learning process.	*"If you didn't do the online work, you wouldn't have been successful in the actual classroom or been able to discuss it."* (S1_340)
Real-world connection	**Real-world connection**	**Helps to understand**	Statements on how real-world connection supports the development of understanding sustainability issues and solutions and thereby works as a driver to learning	*"I think the thing about sustainability is facts and statistics and all these big numbers doesn't really give you an understanding of what's going on, you know what I mean? It's kind of hard to apply that to your real life, you know, exactly what kind of sheets or stats and have absolutely no idea what it means (...)"* (S1_389)

		Helps motivation	Statements on how real-world connection drives the motivation to learn or implement ESD	*"I think a big part is that it's like actually, like real world problems, like it's actually happening whereas it's just like in elementary schools like science that was like how far can your paper plane go and so like it's more interesting and it like drives you to want to keep learning and maybe eventually make a change when incorporating it into your classroom."* (S1_365)
		Helps to create a personal connection to the topics	Statements on how real-world connection helps to create a personal connection to sustainability topics and thereby works as a driver to learning	*"When we used like real world applications (S1_385: Yeah) is when I felt like I could relate more to the topics."* (S1_395)

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