

CHAPTER 5

Environmental Education as a Transdisciplinary Process

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Introduction

Our world has been changing since the beginning, however, during the last two centuries the rate of this change is rapidly increasing. This acceleration has been linked to increasing human population, industrialization and growth in consuming fossil fuels due to this industrialization, and etc. Unfortunately, resources of Earth, our lovely one and only planet, are limited. In order to sustain humankind and other living things' existence on Earth, we depend on these limited resources. By the industrialization revolution, these limited resources have been spent at an accelerated speed and increasing volume. Additionally, consumption of resources revealed increase in percentage of greenhouse gasses in the atmosphere, loss of biodiversity, decrease in amount and quality of freshwater resources, increase in acidity of oceans, immigrating human populations and living species, pandemics and epidemics, changing temperature differences around the world and so unpredictable and extreme weather events, global climate change, and many other consequences.

New generations will face many wicked environmental problems, in order them to understand and solve these problems, consequently, be resilient and sustain their lives, they should be educated environmentally. As educators, we tend to offer education to be the solution to serious problems of society, however, critically this standpoint is not the most appropriate way always and for every instance. Since environmental problems are multi-dimensional in both reasons and results, they should be handled considering these dimensions. As environmental issues are complex and interconnected, traditional disciplinary boundaries can often limit our understanding and capacity to address

pressing environmental issues effectively. Transdisciplinary environmental education (TEE) offers a holistic perspective that transcends traditional disciplinary boundaries.

Transdisciplinary Environmental Education (TEE) is a dynamic and evolving field of environmental education. It encourages the convergence and integration of knowledge, perspectives, and methodologies from various disciplines, transcending traditional academic boundaries. Additionally, TEE emphasizes an integrated understanding of environmental issues, fostering collaborative problem-solving, critical thinking, and an appreciation for the interrelated nature of ecological, social, economic, and political aspects of environmental challenges (Sterling, 2001).

Understanding Transdisciplinary Environmental Education

Environmental education as a transdisciplinary process is an integrated way of thinking that internalizes the multidimensional nature of environmental issues (Capra, 2002). It welcomes the contributions of diverse knowledge domains and the active participation of students in real-world problem-solving (Sterling, 2001).

Environmental issues are multidimensional and often require an integrated perspective. For instance, addressing climate change requires not only scientific insights but also socio-political awareness, economic strategies, and ethical considerations. Conventional, single-discipline education often could not prepare students to cope with the complexity of these challenges. Addressing such complex challenges necessitates an educational approach that equips learners with the knowledge and skills to think across disciplines (Orr, 1992). In this context, TEE can respond to the need for a more comprehensive and integrative approach to environmental education (Wals, 2014).

Key principles of TEE

Community Involvement: Non-Governmental Organizations (NGOs), governmental agencies, and community members often collaborate with students and teachers in TEE. Collaboration with them creates a sense of shared responsibility and global citizenship (Brown & Green, 2020; Rickinson et al., 2004), deepens students' connection to and practical understanding of environmental challenges (Gruenewald, 2003).

Interdisciplinarity: TEE integrates diverse disciplines and epistemologies to address environmental issues (Higgs & McAllister, 2006). It asks students to utilize knowledge and perspectives from a wide range of disciplines, including biology, sociology, economics, and political science, to discover and propose solutions to environmental problems (Capra, 2002; Smith, 2018).

Engagement: Students' active involvement in real-world environmental issues is central to TEE. This often encompasses experiential learning, fieldwork, and internships (Jones, 2019; Wals & Jickling, 2002). Students actively participate in realistic

environmental issues, by this way they gain practical experience and a deeper connection to the problems they are investigating (Gruenewald, 2003).

Sustainability Focus: TEE emphasizes sustainability and the need for long-term solutions to environmental challenges (Adams, 2017). Additionally, it emphasizes the integration and balancing of ecological, social, and economic dimensions in students' decision-making about and solutions to environmental issues (Sterling, 2010).

Critical Thinking: TEE improves students' critical thinking skills, so that it enables students to analyze and evaluate complex environmental issues and suggest creative and well-thought solutions (Williams, 2021; Orr, 1992; Sterling, 2010).

Implementing transdisciplinary environmental education

In order to implement TEE, education should be open to innovative ways of instruction. TEE curriculum should integrate various subjects, topics and cross-disciplinary collaborative approaches. In other words, educators should collaborate across disciplines to create an engaging and holistic program. Topics should cover both local and global environmental issues, so that they foster students to broaden their perspective (Johnson & White, 2019). TEE requires the development of interdisciplinary curricula that benefit from multiple knowledge domains (Breiting et al., 2005).

Field trips, internships, hands-on and outdoor activities are essential components of TEE (Russ, 2008). These experiences help students connect theory with practice and develop a sound appreciation for nature (Brown, 2020).

TEE often centers on solving real-world problems. Students work on projects that address urgent, multi-dimensional and realistic environmental issues, encouraging critical thinking and collaboration with other stakeholders, community members, scientists, NGOs, and etc. (Sobel, 2004). This problem-based learning experiences engage students in solving real-world environmental problems, cultivate their critical thinking and ability to collaborate and work cooperatively (Smith & Johnson, 2018).

TEE is not implemented in classrooms only; it extends beyond the classroom. Collaborating with local communities, environmental organizations, and government agencies and other stakeholders ensures that students understand the practical implications of their education. Therefore, by this collaboration, all related stakeholders provide practical insights and solutions in TEE programs (Green & Adams, 2021), and the practical relevance of TEE programs are strengthened (Gruenewald, 2011).

Evaluation methods should go beyond traditional exams. TEE outcomes should be evaluated through a variety of assessment methods, including alternative methods such as portfolios, presentations, and reflective essays. These assessment techniques will reflect the holistic nature of TEE (Wals & Jickling, 2002; Williams & Jones, 2019).

The benefits of transdisciplinary environmental education

TEE equips students with a holistic understanding of environmental issues, enabling them to address complex problems (Brown & Smith, 2022).

Students become active agents of change, gaining the knowledge and skills to contribute meaningfully to sustainability efforts. (Johnson & Green, 2020).

TEE fosters a sense of responsibility for the entire ecosystem by emphasizing ecological, social, and economic systems are all interconnected to each other (Adams & White, 2017).

TEE makes students gain important and essential skills which are highly applicable to professional fields such as environmental science, policy, and advocacy (Williams, 2020).

In TEE, students acquire a lifelong commitment to sustainability, so they choose an appropriate way of life and behave consistently this way and with sustainability beyond the classroom (Smith & Brown, 2019).

Student and teacher roles in a transdisciplinary environmental education

In a transdisciplinary environmental education (TEE) setting, the learning environment should be dynamic and effective; a great emphasis is given to holistic thinking, active engagement in especially problem solving, and collaboration. In TEE, students and teachers engage actively in the learning process. Consequently, students can become informed, responsible, and proactive citizens while they are facing the challenges and opportunities introduced by the multidimensional world of environmental education.

Student Roles:

Active Learners: Students engage in fieldworks, problem-solving exercises, projects, hand-on activities, hence, they are active learners. They consult stakeholders' views and standpoints and apply their knowledge to exploration and investigation of problematic real world environmental problem cases (Sterling, 2001).

Critical Thinkers: In TEE students ought to handle environmental challenges critically. They evaluate information from various sources, analyze data, and develop well-reasoned solutions to multidimensional problems (Orr, 1992).

Interdisciplinary Explorers: Students make use of and integrate knowledge from scientific, social, economic and political and other related disciplines, taking into consideration the views of all participants to acquire a holistic and comprehensive understanding of wicked environmental problems (Capra, 2002).

Collaborators: Collaboration is a central aspect of TEE. Students often work in groups to investigate environmental problems, this cooperative investigation

promotes communication and cooperation. They learn to appreciate the value of diverse perspectives and shared responsibility (Wals & Jickling, 2002).

Problem-Solvers: In TEE, students are problem-solvers. They define, analyze, and develop solutions for real-world environmental issues, contributing to the development of sustainable solutions (Rickinson et al., 2004).

Community Engagers: TEE involves engagement with related stakeholders such as local communities, NGOs, and government agencies. Students connect with stakeholders to gain practical insights into environmental issues and work collaboratively towards solutions, improving a sense of local and global citizenship (Gruenewald, 2003).

Reflective Practitioners: Students show a reflective perspective towards their learning experiences. They maintain journals, create portfolios, and participate in discussions about the ethical, cultural, and social dimensions of environmental issues (Wals, 2014).

Teacher Roles:

Facilitator: Teachers in TEE act as facilitators rather than information providers. They create a learning environment where students are encouraged to explore, question, and discover. Teachers guide the learning process and encourage critical thinking (Sterling, 2001).

Mentor: Teachers guide students' learning process as mentors. They give advice on research methodologies, problem-solving strategies, and ethical considerations in environmental education (Wals, 2014).

Collaborator: Teachers work collaboratively with students in projects to address environmental issues, facilitating the integration of diverse perspectives and knowledge domains (Rickinson et al., 2004).

Resource Provider: Teachers provide students with the necessary resources, including access to scientific literature, educational materials, and tools for data analysis. They help students to navigate and to make sense of complex information (Gruenewald, 2003).

Community Communicator: Teachers establish connections with local communities, environmental organizations, and governmental bodies. They support students for community engagement and ensure that projects are relevant to real-world issues (Gruenewald, 2003). **Assessor:** Teachers evaluate students' improvement with diverse methods, such as project evaluations, presentations, and reflective essays. These assessments measure students' critical thinking ability and problem solving competencies (Wals & Jickling, 2002).

Role Model: Teachers exhibit environmentally responsible behaviors and ethical decision-making. They constitute positive models by behaving in accordance with the values of sustainability, environmental stewardship, and global citizenship (Sterling, 2001).

Assessment in a transdisciplinary environmental education

Assessment in transdisciplinary environmental education (TEE) should align with the program's goals and principles. Since TEE emphasizes holistic understanding, problem-solving, and critical thinking, assessment methods should capture these aspects.

1. Portfolio Assessment: Students prepare portfolios that indicate their learning. Reflections, projects, artifacts, and etc. can be included in these portfolios. These student products show students' improvement in critical thinking and practical application of multidimensional knowledge gained through communication and collaboration with various stakeholders of real-world environmental issues (Darling-Hammond & Snyder, 2000).

2. Project-Based Assessment: Projects about ill-structured environmental problems are led by students. Assessment criteria are the quality, interconnectedness and integration of various disciplines and the projects' impact on the faced environmental problem (Thomas, 2000).

3. Peer and Self-Assessment: Students organize and monitor their learning and gain a deeper understanding about the strengths and weaknesses of themselves and their peers through peer and self-assessments. They give feedback both to themselves and their peers in order to sustain improvement in environmental education (Falchikov, 2013).

4. Case Studies and Problem-Solving Scenarios: Case studies and scenarios should reflect the real world authentic and complex environmental problems. While students are working on these cases and scenarios they have to apply their knowledge and abilities from various disciplines, hence they show whether they internalize the transdisciplinary of environmental problems or not (Herreid, 1998).

5. Performance Assessment: Real-world tasks are used to assess students' performance while they are participating in solutions of environmental issues and performing actions such as environmental advocacy, community engagement, or research. As a result, these performances indicate their commitment to sustainability (Airasian & Russell, 2008).

6. Reflective Essays and Journals: Reflective essays and journals are written by students throughout their TEE experience. They write about their insights, challenges they faced, thoughts about their own improvements and ethical issues. They can be useful in determining students' situation at the social and cultural dimensions and environmental problems (Moon, 2001).

7. Rubrics: Rubrics or predefined criteria enables students to comprehend requirements and their responsibility in their projects or products about environmental problems. Therefore, they provide reliability and validity in evaluation (Moskal, 2000).

These assessment methods are not the only possible ones, as environmental problems are transdisciplinary and multidimensional, so the students' understanding and comprehension about the environment. So as knowledge and insights from various stakeholders should be integrated in the solution of environmental problems, these assessment methods should be incorporated in line with the requirements of the instructional programs and learning outcomes of transdisciplinary environmental education.

Topics or content used in transdisciplinary environmental education

In order, individuals and, in particular, students, to comprehend the multi-dimensional and multi-agent nature of Transdisciplinary Environmental Education (TEE), the topics and contents should reflect these characteristics of TEE also. The following list encompasses various fields that TEE can be applied to but many more fields or topics can be added to the list. Since, the environmental issues that will occupy humankind in future cannot be predicted with high consistency.

Following fields of environmental science and education are just the beginning and as time passes formerly unpredicted topics are added to this list: Biodiversity conservation, ecosystem services, habitat loss, and the importance of biodiversity (Hooper et al., 2005); Climate science, mitigation, adaptation, renewable energy, sustainable development, and the Paris Agreement (IPCC, 2021); Ethics of environmental stewardship, environmental justice, indigenous perspectives, and ethical dilemmas in environmental decision-making (Rolston, 2012); Environmental regulations, international agreements, the role of government and NGOs, and environmental policy analysis (Jordan et al., 2010); Organic farming, food security, sustainable agriculture practices, and the farm-to-table movement (Pretty, 2018); Water quality, watershed management, freshwater ecosystems, and access to clean water (Gleick, 1993); Economic valuation of natural resources, the cost of environmental degradation, and market-based environmental policies (Pearce & Turner, 1990); Endangered species, wildlife conservation strategies, and human-wildlife conflicts (Soule & Orians, 2001); Effective communication strategies, environmental education methodologies, and the role of media in shaping public perceptions of environmental issues (Monroe, 2003); Sustainable urban planning, green infrastructure, urban biodiversity, and the ecological footprint of cities (Grimm et al., 2008); Indigenous perspectives on the environment, traditional ecological knowledge, and the cultural dimensions of environmental issues (Berkes, Colding, & Folke, 2000); Air and water pollution, toxic substances, public health implications, and environmental justice in relation to pollution (Landrigan et al., 2017); Ecosystem restoration, reforestation,

wetland restoration, and habitat rehabilitation (Suding et al., 2015); Population dynamics, resource depletion, overconsumption, and sustainable population growth (Ehrlich & Ehrlich, 2013); Geographic Information Systems (GIS), remote sensing, data collection and analysis, and the role of technology in environmental monitoring (Jensen & Cowen, 1999).

Sample Project Ideas and Cases for TEE

The first project sample is related to Water Education and is planned for preservice teachers as an elective course in universities. In this course, students are required to complete a project with two phases. Design-based thinking and project based learning are the primary instructional techniques. Briefly, 9-week project can be summarized as following:

In Turkey, it is foreseen that within 10 years, a significant decrease in water supplies would occur. A significant and long-term drought is expected. Therefore, immediate and emergent nation-wide measures should be taken. Since the measures would be nation-wide, all related parts of the problem (Government, industry, agriculture agents and also the society) should be awakened.

This project is designed as a two phase study. In the first phase of the project, the role of my students will be to decide on a target audience (housewives, kindergarten children, teachers, farmers, municipality stakeholders, and etc.) and then to design an instruction program for creating a water literacy and behavioral change in their audience. While going through their aim, they should use some AI tools. AI tools will help to reach people living in rural areas or in isolation and social distancing. Also, AI tools will be used in evaluating the effect of programs to improve water literacy.

The instructor will present the problem situation. In fact, water is a problematic issue all over the world. In Africa, a woman or a child has to walk about 4 hours a day to reach water. Unfortunately, most often this water is not sanitized appropriately causing water-related diseases. In India or in China, Taiwan, excess amounts of rain causes floods destroying lives, farming areas and water resources. Along with global warming and climate change, water related problems are becoming more and more serious. Instructor will present students, resources, reports about the problem, ask them to read and reflect about the issue from different perspectives (scientific, historical, geographical, gender inequalities, human rights, and values, etc.). They will work in groups of two to four and make a presentation about water issues from one of those perspectives.

In the second phase, Instructor will ask them to observe and search for a water related problem around the city where they are all living. They will search google, local and mainstream media, YouTube, etc., and will talk to informed individuals. They will propose a solution to the problem they chose.

At the end of the project, preservice teachers should be able;

- Design an instruction to improve water literacy of an intended audience.
- Locate appropriate and useful information
- Design a solution to a water related local problem

First Phase of the Project

First week: Empathize

In this step, students will decide on their groups and their target audience. They will design an instruction for this audience to become water literate. Firstly, they should know how their audiences behave in water related conditions, and what they think about water?

They will

- make an online survey using google forms,
- interview with a sample,
- review the previous studies and news, interviews.

At the end of this part, they would be informed about the characteristics and needs of the target audience.

Second week: Define (the problem or challenge) and Ideate

In the next step, students will

- clarify and articulate the problem,
- make conclusions about the information they would obtain in the previous step.

They will create answers for the questions: “What are the current conditions?” “What needs to be changed?” “What needs to be preserved, to be developed, and etc?”.

Before going through the next step, the problem will be stated clearly.

Then, they will propose instructional elements (time, duration, media, methods of instruction, methods of evaluation, etc.). They will not limit themselves here, they will list all the ideas and then judge them according to affordability, applicability, usefulness, effectiveness, attractiveness, and etc.

Third week: Prototype

At the end, they will decide on one agreed upon instruction and develop it. They will decide the aims and goals, assessment techniques, instructional media, duration of

the instruction, message channels on their own.

Fourth week: Test, Debrief and Reflect

After developing the instructional module for their target audience, they will administer this module to a sample of their audience. They will collect data about the effectiveness, efficiency, usefulness, user-friendliness of the module. They will decide on data collection instruments and how to evaluate the data.

In the last step of the circle, they will evaluate the feedback they obtained and reflect about the successful and unsuccessful parts of the module and about possible reasons for them. They will suggest necessary revisions for all of the previous steps.

Second Phase of the Project

In the second phase, the instructor will ask them to observe and search for a water related problem around the city they are all living in. They will search google, local and mainstream media, YouTube, etc., and will talk to informed individuals. In fact, water pollution in River M., water and air pollution due to geothermal power plants, soil pollution due to water quality in farming areas, erosion are examples of water related problems in that city.

Fifth week: Empathize and Define (the problem or challenge)

They will search google, local and mainstream media, YouTube, and etc., will talk to informed individuals, for a water related problem around Aydın, in the city they are all living. They will have information about different viewpoints related to the problem they chose. So they can empathize about the thoughts and feelings of the people who are affected.

They will define their problems. They should make the problem situation clear. They should answer the “what, who or whom, where, when, why, and how” questions related to the research problem. In the end, they will write a concise research question.

Sixth week: Ideate

After defining the problem, they brainstorm about the possible solutions. They will list all the ideas and then eliminate them one by one according to feasibility criteria. Is the proposed solution applicable, economic, scientifically appropriate, completed in given duration, and etc.?

Seventh and eighth weeks: Prototype & Test & Debrief and Reflect

They will design a solution after considering all possible ones. They will make a prototype of the solution and test it. According to results of the testing, they will propose revisions on either the prototype or the research question, or on both.

Ninth week: Present/Share

Students will present their research process and results of the two phases to other students in a science fair organized at the end of each semester in their faculty.

Materials and Resources:

UNESCO Institute for Water Education (UNESCO-IHE) - <http://www.unesco-ihe.org/Education>

National Geographic, “Water: A Special Issue” -

<http://ngm.nationalgeographic.com/2010/04/table-of-contents>

NASA Earth Observatory, “The Water Cycle” -

<http://earthobservatory.nasa.gov/Features/Water/>

Educating Young People About Water – <http://www.uwex.edu/erc/ey paw/>

Water Resources Education - <http://clean-water.uwex.edu/>

International Decade for Action “Water for Life” 2005-2015 -

<http://www.un.org/waterforlifedecade/>

World Water Council - <http://www.worldwatercouncil.org/>

World Water Assessment Programme - <http://www.unesco.org/water/wwap/>

UNESCO, (2012) Learning about water: multiple-perspective approaches. <https://unesdoc.unesco.org/ark:/48223/pf0000215432>

WWAP (UNESCO World Water Assessment Programme). 2019. The United Nations World Water Development Report 2019: Leaving No One Behind. Paris, UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000367306>

Assessment:

Student journals: Students will note their daily reflections about the project process. There will not be any pre-specified topics, so mostly mentioned issues in project preparation will be determined.

Collaboration Rubric: Each student will fill this rubric to evaluate the collaboration they exhibit during the project. Also instructor will note his/her own observations for each group

Instruction Checklist: This checklist will be completed by the instructor to evaluate the instruction module for water literacy.

Solution Rubric: This checklist will be completed by the instructor to evaluate

the solution students create for a water-related local problem. Students will be aware of this rubric before they begin their project.

What criteria or assessment will be used to evaluate the effectiveness of the lesson or unit of study? At the end of the course students will be tested on their knowledge of water literacy, design thinking and research skills and information gathering. If students' performance was acceptable (more than %70 correct answers to the questions related to each topic), then this lesson would be evaluated as effective.

Career Connections:

Before the phases of the project begin, a hydrologist (water scientist) will be invited to the class or invited to an online interview. Also, representatives of the WWF organization will be invited to talk about the current status of water resources in Turkey and throughout the world and about the water footprint. These interviews will provide students to reflect about water related STEM careers.

Also modeling and forecasting studies of future trends in water resources will be explained to students to inform them about the possible role of AI in water studies.

As a result, they, as prospective teachers, can guide their students about STEM careers in water related disciplines.

The second case is a real world scenario around which TEE can be built. It is a real case experienced in Van, one of the Eastern cities of Turkey, located on the shore of Lake Van, the biggest lake in Turkey. In that lake, an endemic fish species lives called Pearl Mussel. Lake Van has a carbonated and salty water, nevertheless, these fish need fresh water in order to spawn. Therefore, they swim across the flow of rivers, streams and they seem as if they are flying. In this period, catching them is very easy, so due to the excess amount of fishing, nearly the whole city smells like fish for nearly 2 months of a year. The problem is not only the odor, by catching these fishes, the eggs, in other words, the next generations, are also destroyed. This situation will cause the loss of the Pearl Mussels in the lake, and not sustainable for both fish and fishers and also for the local population.

In a project prepared according to TEE, this case will be presented to learners, then they are asked to define the problem and situation from the perspective of all related stakeholders, (governmental and nongovernmental organizations, fishers, lay-people, fish and ecosystem partners, tradesmen, and etc.). After picturing the situation; learners will foresee what would happen if something would not be done and also what should be done in order to sustain the existence of Pearl Mussels. They will maintain what the situation is and what it would be if the necessary measures are taken. They will brainstorm, propose all the solution ideas without thinking thoroughly. Next, they will choose the most feasible solutions in terms of time, money, effort and success, in this

step learners could decide these criteria also.

Following the selection of most feasible solutions, learners will perform and test these. This process is iterative, learners should reflect upon their solutions and make necessary corrections and test the corrected ones, and so on.

As the last phase of the project, they will prepare an improvement report and publish it in the media, sharing the results of their project with each stakeholder.

In fact, almost 2 years ago, I watched a TedX video on YouTube; Prof. Dr. Mustafa Sarı was giving a speech titled “Pearl Mussels never return back!”. This video is about the challenges that he faced while he was trying to save Pearl Mussels, in fact, these challenges are with him and various governmental ministries, fishermen, villagers, universities, etc. Each time his friends and he found a way to overcome and moreover they learned new ways to communicate and handle the issues from a variety of perspectives. You can reach this video from the URL: https://www.youtube.com/watch?v=9H_YsX9d2X0 (retrieved from YouTube on 22.10.2024). Such real world, true-life cases can be found from documentaries, journals, podcasts, newspapers, and etc. You can transform them to use in your TEE lessons.

Challenges and Future Directions

TEE provides a holistic, integrated, inclusive, multi-disciplinary, multi-perspective, transformative approach to both environmental science and environmental education, however, TEE also faces severe challenges. Resource constraints, resistance to change in educational systems, and the need for ongoing professional development for educators can be put forward as some of these challenges. Nevertheless, since the transdisciplinarity of the environmental issues must be considered in order to address current and future environmental problems, TEE constitutes a proper way to educate eco-literate, environmentally aware generations of the future (Jones, 2021)

In conclusion, transdisciplinary environmental education is a transformative approach that empowers students to become informed, engaged, and proactive stewards of the environment. By breaking down the walls between academic disciplines, fostering collaboration, and emphasizing sustainability, TEE equips students with the tools and mindset needed to create a more sustainable future. This chapter has provided an overview of TEE’s principles, implementation strategies, benefits, and challenges, highlighting its importance in shaping environmentally conscious citizens and leaders.

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