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Developing Competences of Pre-Service Teachers through STE(A)M-based Renewable Energy Curriculum

# {RENEWTEACH}

**PR3**

## Development of Assessment Tool for Preservice Teachers

2021-1-TR01-KA220-HED-000027614

# ABOUT

## Overview

RENEWTEACH is an ERASMUS+ project with the title "Developing Competences of Pre-Service Teachers through STE(A)M-based Renewable Energy Curriculum" and project number 2021-1-TR01-KA220-HED-000027614. This document is designed to introduce PR3, one of the project results developed within the RENEWTEACH project.

## What is the PR3?

PR3 includes a self assessment tool consisting of "Achievement Test for Renewable Energy Field", "Risk Perception Scale on the Use of Renewable Energy Resources", "Intention Scale for the Use of Renewable Energy Sources" and "Scale of STE(A)M Based Thinking" prepared to determine the achievements of pre-service teachers towards renewable energy and STE(A)M.

## Aim of PR3

The aim of this project result is to determine the knowledge, skills, attitudes and values of pre-service teachers in the target group of the project about renewable energy and STE(A)M.

## Implementation

The developed assessment tools make it possible to monitor the knowledge, skills, attitudes and values of the pre-service teachers participating in the project regarding renewable energy and STE(A)M before, during and after the project. In addition, the developed assessment tools are expected to be used by external users (academics, teachers, NGOs, etc.).

## How to Access?

You can access the PR1 content via the RENEWTEACH project website (https://renewteach.org/) or by registering and logging in to the online learning platform developed within the RENEWTEACH project (https://guzemxonline.gazi.edu.tr/).

# Importance Of Assessment Tool

Erasmus+ projects are designed to promote international cooperation, cultural exchange, and personal development. These projects enable participants to interact with different cultures, gain new skills, and gain international experiences. Self-assessment tools help participants of these projects understand their experiences more deeply and guide their learning processes. Therefore, it is very important to develop a self-assessment tool so that participants can benefit from the project outcomes as much as possible.

In teacher education studies, reflective thinking of teachers was deemed very important in terms of their professional development. It was necessary to ascertain to what extent the pre-service teachers' cognitive, affective, and skill gains achieved in the project were obtained by the self-assessment tool. The data provided not only indicated the need to follow the developmental levels of the participants but also offered insights for the project outcomes. In this way, researchers would meet the need to revise project results if necessary.

Therefore, it was required that participants of this project, which considered STE(A)M and RE context as transdisciplinary, should make self-evaluation. Consequently, a measuring tool was needed. Finally, as per the partners' own institutional needs, it was necessary to conduct pre and post-test evaluations for the preservice teachers participating in the project and the LTTA event. For this reason, PR3 was developed, targeting elementary and science preservice teachers for this project. The indirect target groups included secondary school teachers and their students, as well as LTTA participants. Elements of innovation included the use of this tool as an assessment tool to measure and monitor preservice teachers' knowledge, skills, attitudes, and values related to RE. This evaluation tool would also contribute to reflective writing. Reflective writing was also important in terms of evaluating the pre and post-project views of the target group.

Additionally, the self-assessment tool included STE(A)M -based thinking and interdisciplinary questions related to RE. The self-assessment tools developed in the project were innovative because they were unique to the nature of that project. The expected impact included monitoring the target group of the project, which would be followed by accurately determining the knowledge, skills, attitudes, and values of preservice teachers related to RE. This tool is also expected to be used by external

users (academics, teachers, preservice teachers). The items created to be used in the assessment tool were translated into different languages (the languages of the partner countries) and were made available to EU countries. Different stakeholders (trainees, educators, etc.) would have the opportunity to measure their level of knowledge, skills, attitudes, and values related to RE.

## Development of Self-Assessment Tools

The self-assessment tool was developed in three steps: Literature Review, Expert Opinion, Reliability and Validity Analysis. All partners took part in these processes and contributed to the development of PR3. The UM/ERM center was the leader of PR3. UM, GU, UniBuc partners provided support at academic points such as data analysis. All partners were involved in piloting and feedback.

Overall, the self-assessment tool is comprised of the following four sections: Achievement Test for the Renewable Energy Field, Risk Perception Scale on the Use of Renewable Energy Resources, Intention Scale for the Use of Renewable Energy Resources, and Scale of STE(A)M Based Thinking.

**Tasks for the Development of Achievement Test:** Within the scope of the Renewteach project, students' academic success levels are monitored with "academic achievement test" and "end of the unit questions". The academic achievement test is used to compare the academic success levels of the participants before and after the project. On the other hand, end-of-unit evaluation questions allow learners to check their learning regarding the relevant unit after the completion of each unit.

In order to develop the academic achievement test; UM experts wrote question items in accordance with the conducted research, and Maribor shared the questionnaire items with other partners. Each partner translated written questions into their own language, and the questionnaire items were shared with 4 academicians working with RE in science and engineering science. Academicians evaluated the questionnaire items and offered extra items and general feedback. UM finalized the questionnaire in light of feedback from partners and experts.

Similarly, all partners are involved in the development of end-of-unit evaluation questions. In this process, unit-specific question pools were created with the participation of all partners. After each partner wrote and contributed to the question pool related to the unit they were assigned to, they provided feedback to the end-of-unit evaluation questions written by the other partners. Therefore, all partners participated in both item writing and evaluation processes. End-of-unit evaluation questions were shaped as a result of partners' feedback on the question pool and expert opinions.

**Tasks for the Development of the Questionnaire on Attitudes and Values:** In order to determine to what extent the project can achieve the planned goals, measurement tools that include attitudes and values as well as knowledge and skills related to RE need to be developed. In this context, measurement tools based on the "Theory of Planned Behavior" and risk perceptions towards renewable energy sources have been developed in order to determine the participants' decision mechanisms regarding renewable energy.

*Risk Perception Scale on the Use of Renewable Energy Resources:*

One of the most popular concepts in the decision-making mechanism of individuals over the last half century is risk. According to risk theorists, risk perceptions are defined as the possibility of there being unwanted events such as accidents (Howard, 2011; Rohrmann & Renn, 2000). Risk perceptions include subjective evaluations of individuals regarding the possibility of there being a specific situation, such as the occurrence of an accident. Besides an evaluation of its probability, perception of the risk also includes its negative consequences (Sjöberg et al., 2004). Furthermore, risk perceptions are related to a specific attitude formed by individuals towards a specific object (a potential hazard) and are intertwined with other psychological factors (Frewer et al., 2004). Examining the studies on risk perceptions and RE, it is observed that risk perceptions are closely related to attitudes, use behavior and knowledge (Eltham et al., 2008; Pongiglione, 2011; Upreti & van der Horst, 2004).

Risk perception includes risk-related factors such as dread, voluntary risk, catastrophic potential, control, severity of consequences, etc. In many studies, these factors are gathered by researchers under the headings of “dread” and the “unknown” (Kılınc et al., 2016; Slovic et al., 1982). “Dread” is characterized by a lack of control over the risk, the potential for catastrophic or fatal consequences, and the degree to which distribution of the risk is inequitable. The "unknown" is characterized by the newness of the hazard, the degree to which its dangers are unobservable, and the delay mechanism of the harm (Sohn et al., 2001).

Within the scope of the Renewteach project, in order to determine the risk perceptions of the participants towards renewable energy, the "Risk Perception Scale" (Demirbag, and Yilmaz, 2020), which was developed by a researcher in the Project (from BUU), was used after taking the feedback of all partners and being adapted in line with expert opinions. The adapted scale consists of two dimensions:

"dread" and "unknown". The scale has a total of 16 items, 8 in the "dread" dimension and 8 in the "unknown" dimension.

*Intention Scale for the Use of Renewable Energy Resources*

Another measurement tool developed within the scope of the project is "Intention Scale for the Use of Renewable Energy Resources", which is based on The Theory of Planned Behavior (TPB). The Theory of Planned Behavior (TPB) is one of the most important theories that have pioneered the understanding of human behavior. The Theory of Planned Behavior (TPB) states that individuals' own wishes and desires direct their behavior, but external factors and barriers affect individuals' behavior.

The TPB attempts to explain the factors that guide behavior by centering on individual and social judgements such as belief and attitude (Ajzen, 1991; Halder et al., 2016). In this context, the TPB is established on the trio of "Attitude" (AT), which include individuals' positive and negative judgements regarding behavior, "Subjective Norms" (SN), which include the effect of other people's discourses and attitudes on behavior, and "Perceived Behavioral Control" (PBC), which includes individuals' perceptions of their control over the external factors that make their behaviors easier or more difficult. TPB assumes that these factors together form the basis of behavioral intention (I) (Ajzen, 1991).

Within the scope of the Renewteach project, to determine the intentions of the participants towards renewable energy, the "Intention Scale for Renewable Energy " (Demirbag, and Yilmaz, 2020), which was developed by a researcher in the Project (from BUU), was used after taking the feedback of all partners and being adapted in line with expert opinions. Adapted "Intention Scale for the Use of Renewable Energy Resources" consists of four dimensions in total: the "Intention" dimension (4 items), which directly aims to determine individuals' intentions towards the use of renewable energy resources, and the "Attitude" (8 items), "Subjective Norms" (4 items) and "Perceived Behavioral Control" (8 items) dimensions, which are stated to predict the intention in the context of "TPB".

*Scale Of STE(A)M Based Thinking*

The last component of the self-assessment tool is "Scale Of STE(A)M Based Thinking". The scale aims to measure individuals' awareness levels regarding STE(A)M integration in the field of renewable energy. The scale was developed by

BUU by taking the feedback of all partners and the opinions of experts. The scale consists of 5 multiple choice (Likert type) and 4 open-ended questions. In the final open-ended question, participants are asked to design a renewable energy event based on crosscut concepts. In this sense, the scale allows participants to perform reflective writing activities.

Following the completion of the development and adaptation processes for all measurement tools, the self-assessment tool (PR3) was given its final form and PR3 was transferred to the online learning environment (PR4). As a result, it has become possible to make a comprehensive evaluation of project outcomes thanks

## Result

Theory of Planned Behavior (TPB), which forms the basis of the self-assessment tools developed within the scope of the Renewteach project, is a widely accepted and studied theory that covers a wide range of subject areas. In this sense, it is possible to adapt the measurement tools developed within the scope of the project for different contexts and target groups. It is envisaged that the measurement tools developed in this way can serve as a reference for other projects and academic studies in the literature.

Thanks to the developed self-assessment tool, the target group of the project was monitored and their knowledge, skills, attitudes and values regarding RE were determined. Transferability of questions generated for use in the assessment tool were translated into partner' languages so that this tool would be open to partners and other EU countries. This tool is also expected to be used by external users (academics, teachers, NGOs etc.).

Below you may find the self-assessment tool developed as part of the RENEWTEACH project, which was also used and tested during the LTTA event.

## Achievement Test for the Renewable Energy Field

| | ITEMS | Correct | No Idea | Incorrect |
|---|---|---|---|---|
| 1 | Nuclear energy is considered among renewable energy sources. | | | |
| 2 | Fossil fuels are among the most widely used energy sources today. | | | |
| 3 | Fossil fuels cause global warming. | | | |
| 4 | Renewable energy is continuously available in nature. | | | |
| 5 | Renewable energy is one of the STE(A)M subject areas where science and mathematics come to life through engineering applications. | | | |
| 6 | Post-normal science focuses on complex issues involving uncertainties that concern science and society. STE(A)M is one of these subjects. | | | |
| 7 | The crosscut concepts of science and engineering do not encompass 'patterns' and 'cause-and-effect' relationships. | | | |
| 8 | In the crosscut concepts of science and engineering, 'scale, proportion, and quantity' along with 'structure and function' are included. | | | |
| 9 | Solar energy is used solely for heating buildings, soil, and water. | | | |
| 10 | The substantial energy produced as a result of fusion reaction (the conversion of hydrogen into helium) is referred to as Solar Energy. | | | |
| 11 | The photovoltaic cell is a crucial component of solar energy systems. | | | |
| 12 | Beryllium, copper, iron, and aluminum elements are commonly used in the production of solar cells. | | | |
| 13 | The photoelectric effect can be defined as the liberation of electrons from a metal by light. | | | |

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|---|---|---|---|---|
| 14 | Organic waste has no financial value other than its use in fertilizer production. | | | |
| 15 | Bacteria are utilized in the production of biomass energy. | | | |
| 16 | Mineral rocks are biomass sources. | | | |
| 17 | The type of biomass is determinative in terms of the quantity and efficiency of the produced bioenergy. | | | |
| 18 | Biomass is converted into biofuel through chemosynthesis. | | | |
| 19 | Hydroelectric energy is generated using the potential energy of water. | | | |
| 20 | Hydroelectric power plants have adverse effects on the life in the rivers where they are installed. | | | |
| 21 | Due to its derivation from rivers, the storage of hydroelectric energy is not feasible. | | | |
| 22 | As the accumulated water in dams increases, the hydroelectric energy potential of the power plant also rises. | | | |
| 23 | Hydroelectric power plants generate electricity by the rotation of turbines driven by hot water vapor. | | | |
| 24 | Wind turbines are used to convert wind energy into thermal energy. | | | |
| 25 | Wind energy is one of the consistently available natural energy sources. | | | |
| 26 | The instrument used to measure wind speed is called an Anemometer. | | | |
| 27 | The number of blades in wind turbines affects the maximum amount of energy the turbine can generate. | | | |
| 28 | Wind turbines can generate energy when the wind blows at a certain speed. | | | |
| 29 | The other name for wave energy is tidal energy. | | | |
| 30 | Wave energy generators do not emit carbon during electricity generation. | | | |
| 31 | Wave energy is produced using sea and ocean waves. | | | |
| 32 | Surface devices, which are wave energy generators, use the kinetic energy of waves. | | | |

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|---|---|---|---|---|
| 33 | There are numerous patented designs specifically designed to harness electric power from wave energy. | | | |
| 34 | Geothermal energy is not considered among renewable energy sources. | | | |
| 35 | Geothermal energy is the utilization of the radioactive heat from the magma layer to generate electricity. | | | |
| 36 | In heat pumps, geothermal energy is utilized for heating and cooling purposes. | | | |
| 37 | Dry steam power plants are a type of hydroelectric energy generator. | | | |
| 38 | The increase in temperature as one descends from the Earth's surface towards the magma is referred to as the geothermal gradient. | | | |

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## Risk Perception Scale on the Use of Renewable Energy Resources

| | ITEMS | (1) Strongly Disagree | (2) Disagree | (3) Neutral | (4) Agree | (5) Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | Renewable energy sources may have catastrophic effects on nature. | | | | | |
| 2 | Renewable energy sources may cause environmental (soil, air, water, noise) pollution. | | | | | |
| 3 | Renewable energy sources may have adverse effects on human health. | | | | | |
| 4 | Renewable energy sources may cause mass extinctions, leading to the depletion of generations of living organisms. | | | | | |
| 5 | Renewable energy sources may harm plants and animals. | | | | | |
| 6 | Using renewable energy resources may disrupt natural habitats. | | | | | |
| 7 | The risks associated with the use of renewable energy sources can be managed. | | | | | |
| 8 | The risks of renewable energy sources can be mitigated with precautionary measures taken in advance. | | | | | |
| 9 | Renewable energy sources may indirectly trigger natural disasters. | | | | | |
| 10 | The risks of renewable energy sources may increase over time. | | | | | |
| 11 | Renewable energy sources may carry risks that are not observable today but could emerge in the future. | | | | | |

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|---|---|---|---|---|---|---|
| 12 | Renewable energy sources, even if not directly, can negatively impact nature and living organisms through chain events they may trigger. | | | | | |
| 13 | In areas where renewable energy sources are being established for the first time, there may be community backlash. | | | | | |
| 14 | It is challenging to accurately predict the full extent of the harmful effects that renewable energy sources may have on a wide area. | | | | | |
| 15 | It may be difficult to determine how much the benefits of renewable energy sources outweigh their potential risks. | | | | | |
| 16 | The risks associated with renewable energy sources may be manipulated and hidden from the public. | | | | | |

## Intention Scale for the Use of Renewable Energy Resources

| | ITEMS | (1) Strongly Disagree | (2) Disagree | (3) Neutral | (4) Agree | (5) Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | Renewable energy sources reduce dependence on foreign energy. | | | | | |
| 2 | Renewable energy sources may increase global warming. | | | | | |
| 3 | Renewable energy sources provide sustainable energy as they are replenished over time, rather than being entirely depleted | | | | | |
| 4 | Renewable energy cannot replace fossil fuels. | | | | | |
| 5 | Renewable energy sources are environmentally friendly. | | | | | |
| 6 | Renewable energy sources may not meet the supply-demand balance. | | | | | |
| 7 | Renewable energy sources are used in the fight against climate change. | | | | | |
| 8 | Production and maintenance costs of renewable energy sources may be quite high. | | | | | |
| 9 | I am willing to use renewable energy sources. | | | | | |
| 10 | I plan to use renewable energy sources in the future. | | | | | |
| 11 | I would like to meet my energy needs with the highest possible proportion of renewable energy sources. | | | | | |
| 12 | I support the establishment of renewable energy plants in my region. | | | | | |

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|---|---|---|---|---|---|---|
| 13 | If politicians and government officials encourage the use of renewable energy sources, I will utilize them. | | | | | |
| 14 | If scientists support the use of renewable energy sources, I will use them. | | | | | |
| 15 | If the media and non-governmental organizations support the use of renewable energy resources, I will use them. | | | | | |
| 16 | I will use renewable energy sources even if other people don't. | | | | | |
| 17 | If renewable energy sources can provide my daily energy needs without interruption, I will use them. | | | | | |
| 18 | I will use renewable energy sources even if they are more expensive than fossil fuels. | | | | | |
| 19 | I will use renewable energy sources if they are safe. | | | | | |
| 20 | I will use renewable energy sources if they are made more accessible by providing the necessary infrastructure. | | | | | |
| 21 | If vehicles and tools powered by renewable energy become more economical and widespread, I will use them. | | | | | |
| 22 | If I can use fossil fuels more practically and effectively than renewable energy sources, I will not use renewable energy sources. | | | | | |
| 23 | If I can meet my daily needs as effectively with it as with fossil fuels, I will use renewable energy | | | | | |
| 24 | If there are infrastructural issues, I will not use renewable energy. | | | | | |

## Scale of STE(A)M Based Thinking

| | ITEMS | (1) Strongle Disagree | (2) Disagree | (3) Neutral | (4) Agree | (5) Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | I possess adequate STE(A)M knowledge in the field of Renewable Energy. | | | | | |
| 2 | I can elucidate the relationship between Renewable Energy and STE(A)M . | | | | | |
| 3 | I can utilize STE(A)M knowledge to elucidate topics related to renewable energy. | | | | | |
| 4 | I can explain the relationship between renewable energy concepts and STE(A)M through crosscut concepts (etc, Cause and effect) | | | | | |
| 5 | I can interpret and evaluate current developments in the field of renewable energy using STE(A)M knowledge. | | | | | |

**OPEN ENDEN QUESTIONS**

**1**. Have you previously encountered the concept of 'crosscut concepts' in STE(A)M ? Please enumerate the crosscut concepts of STE(A)M in a list.

**2**. What are your thoughts on the role of crosscut concepts in the integration of STE(A)M into the field of renewable energy?

**3**. Please choose a crosscut concept and provide an example of its application in the field of renewable energy.

**4**. Please design a learning activity on renewable energy in accordance with the crosscut concept you have chosen.

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