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SCOPE

This document summarizes the innovative pedagogical practices in different partners countries.

AUDIENCE OF THIS DOCUMENT

Project partners

ACRONYMS AND DEFINITIONS

ACRONYMS	DEFINITION
BOKU	University of Natural Resources and Life Sciences, Wien
CEZ/BN	Zootechnic and animal science training centre/National sheep centre of Rambouillet
DESD	Decade of Education for Sustainable Development
EducLocalFOOD	Acronym of the project "Teaching local and sustainable food systems"
ERM Center	International Centre for Ecoremediation
ESD	Education for Sustainable Development
LSFS	Local and Sustainable Food Systems
OEP	Osservatorio Europeo del Paesaggio (European Landscape Observatory)
UL	University of Lisboa
UM	University of Maribor

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ABSTRACT

Modern environmental and social challenges such as climate change, loss of biodiversity, endangered food security and growing consumerism, urgently require a shift in the mindset and lifestyle of young people, who are future growers, processors, decision makers and consumers. Holistic approaches to education, which connect different scientific and non-scientific disciplines, can contribute to the mindset shift, thus assisting to the development of knowledge, skills and values in young people, so that they will work actively towards finding sustainable solutions for environmental, economic and social issues of the modern era.

Since these challenges are faced by our society for the first time on a global scale, the vocational education system in the fields of agriculture, environmental protection and related disciplines requires different innovative, mostly practical approaches. Such approaches can provide learners with an in-depth and holistic understanding of complex systems, such as local and sustainable food systems (hereinafter: LSFS), which interconnect co-natural production, safe processing and a fair consumption of quality food and services in the local environment. In this way, it is possible to change the lives of students, both professionally and privately, with emphasis on a rational use of natural resources, and a redirection from consumerism towards self-supply.

The report provides an overview of some of the features of innovative pedagogy, which are the starting point for the conception of an innovative pedagogical tool for teaching LSFS. The first chapter describes education and training for sustainable development as an example of a global program, in which students developed skills and competences for a sustainable professional and private life. This part of the report has been created mainly on the basis of documents from the *United Nations.*

In the second part of the synthesis report, the partner countries' key findings on innovative pedagogical practices are highlighted, with a particular focus on defining the notion of 'pedagogical innovation'. The partners in this project understand the term 'pedagogical innovation' as changes, improvements, or innovations in methods or tools, which enable the transmission and acquisition of new knowledge or skills in a more efficient way.

The third chapter presents the common features of innovative pedagogical approaches and tools, as identified by the partners in their respective countries. The beginning of this section presents innovative

pedagogical approaches which are understood by the partners as a theoretical foundation for the planning and implementation of education. In the second part of chapter 3, pedagogical tools are described, which the partners understand as the means for teachers to communicate information and guide learning (digital tools, field work, case studies and project work). The described pedagogical approaches and tools are not necessarily innovative in themselves, what is crucial is the manner in which they are applied, and therefore in this report they represent only the starting point for the conception and implementation of an innovative education programme.

Chapter four presents selected examples from partner countries, with descriptions of innovative uses of pedagogical approaches and tools.

The report was prepared by project partners from France, Austria, Italy, Portugal and Slovenia as part of the Erasmus+ project *Teaching Local and Sustainable Food Systems.* The main purpose of the project is to apply an innovative use of pedagogical approaches and tools to encourage young people to actively identify and confront contemporary challenges in the society, and to search for effective solutions in the field of nutrition and natural resource management.

The pedagogical innovation described in the report can be understood as a support to vocational education teachers in the fields of agriculture, life sciences and related disciplines, which will help them in the design and implementation of innovative, attractive and relevant education programmes. The report does not reflect the actual state of innovative pedagogical practices, but provides a general overview of the situation by partner countries, with a synthesis of their findings. The results were mainly created by reviewing literature and through the implementation of focus groups.

EDUCATION FOR SUSTAINABLE DEVELOPMENT

The following section provides a presentation of education for sustainable development, because this was identified by the project partners as an important starting point for the development and strengthening of innovative approaches to education and training in the fields of agriculture, life sciences, and in kindred disciplines.

An example of education for sustainable development is the United Nations' *Decade of Education for Sustainable Development* (DESD), which lasted between 2005 and 2015 (UNESCO Roadmap, 2019). The overall purpose of the program was to "... empower learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity" (UNESCO Roadmap, 2014, 12).

Education and training (hereinafter: ETR) included lifelong and holistic learning with an emphasis on learning content, learning environments and learning outcomes (UNESCO Roadmap, 2014):

- learning content: integrating critical issues, such as climate change, biodiversity, disaster risk reduction (DRR), and sustainable consumption and production (SCP), into the curriculum,
- learning environments: interactivity, learner-centred approaches, exploratory and action-oriented learning and transformative learning. Including physical as well as virtual and online learning environments, and non-formal and informal forms of learning,
- learning outcomes: skills such as critical and systemic thinking, collaborative decision-making, and taking responsibility.

Following the conclusion of the programme, UNESCO assesses the DESD as a successful programme, which has achieved changes with regard to raising awareness about the importance of ETR, the promotion of activity of various stakeholders, international networking, policy making and the creation of development documents, and the planning of successful educational and training events. Some limitations have also been identified, such as the short-term nature of the measures within the programme's timeline, poor connections between ETR policies and practices, and insufficient inclusion of ETR in educational and development documents (UNESCO Roadmap, 2014).

Due to the programme's success and to eliminate the mentioned shortcomings of the DESD programme, in 2013 members of UNESCO adopted a new programme called *Global Action Programme on Education for Sustainable Development* (GAP), so that after the completion of the DESD, ideas continued to spread and concrete actions of ETR were further implemented (UNESCO Roadmap, 2014). Here is a description of three out of five Priority Action Areas that are important for LSFS and the EduLocalFood project (UNESCO Roadmap, 2019):

Priority Action Area 2

Actions, which enable ETR and the transfer of this kind of knowledge into one's own daily life. These actions require the involvement of the entire institution and local stakeholders. It is not just about transferring knowledge, but also about implementing sustainable development in the community. Examples are eco-schools and green campuses.

Priority Action Area 3

Actions to enhance the knowledge and skills of teachers, their values and attitudes. Examples include accreditation and certification within pre-service and in-service training institutions, national technical and vocational education and training institutions, and higher and university education institutions.

Priority Action Area 4

Actions to raise awareness about the impact of young people aged 15-24, their integration into sustainable development and their international integration and cooperation. Examples include online classrooms, mobile learning, platforms for sharing experiences, social networks, applications with information and examples for ETR and sustainable lifestyles, youth organizations, and participation in development institutions.

These priority action areas can contribute to the development of key competences, which students should master for a sustainable future. The competencies include the cognitive, socio-emotional and behavioural dimensions (UNESCO Learning Objectives, 2017, 10):

- systems thinking competency: the ability to recognize and understand connections and relationships; to analyse complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty;

- anticipatory competency: the ability to understand and evaluate multiple futures – possible, probable and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes;
- normative competency: the ability to understand and reflect on the norms and values that underlie one's actions; to understand others' values; to coordinate with others;
- strategic competency: the ability to collectively develop and implement innovative actions that further sustainability at the local level and further afield;
- collaboration competency: the ability to learn from others; to understand and respect the needs, perspectives and actions of others (empathy); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving;
- critical thinking competency: the ability to question norms, practices and opinions; to reflect on own one's values, perceptions and actions; and to defend one's own opinion;
- self-awareness competency: the ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires;
- integrated problem-solving competency: the overarching ability to apply different problem-solving frameworks to complex problems and develop viable, inclusive and equitable solution options, integrating the above-mentioned competencies.

The described abilities should contribute to social transformation, as learners become empowered for developing a green economy, a sustainable lifestyle and a participatory global citizenship (UNESCO Roadmap, 2014).

PEDAGOGICAL INNOVATIONS IN PARTNER COUNTRIES

The following is a brief introduction to the vocational education system and the concept of pedagogical innovation in the partner countries. This chapter is based on national reports.

France

The French partners have found that innovation is mostly related to science and technology, but that it also includes a social dimension (Euro-EducATES report, 2018). According to them, innovation is a change enabled by the community and the society, which introduces new elements into an already established system (POLLEN, 2014).

The report points out that French pedagogy was created under the influence of positivism, which usually consists of one type of definite objective knowledge, which is academic in nature. Knowledge is transmitted by the *transmitter-receiver* model, whereby the teacher, as the carrier of knowledge, transmits knowledge to a passive student/recipient (Astolfi, 1992). Towards the end of the 20th century, relativism develops, in which truth and knowledge depend on spatial-temporal circumstances (Larrère, Larrère, 1994).

The three key components of the pedagogical process are illustrated by means of the *pedagogical triangle* model, which includes a teacher, a student and the content of teaching, i.e., knowledge, with one component always excluded (Jean Houssaye, 1988):

1. teaching form: strong teacher-knowledge relationship; the student is excluded because he/she passively receives information, or disturbs other students (positivism),
2. animation form: strong teacher-student relationship; knowledge is excluded, as no new knowledge is created, rather, the focus is on the student's potentials,

3. learning form: strong student-knowledge relationship, whereby the student actively creates and uses knowledge through repetition (behaviourism) or problem-solving (constructivism).

In the past, agricultural education was focused on productivity, which includes specialization, mechanization and chemicalization of food production. With the break of the millennium, a change is visible through the introduction of sustainability in agriculture and agricultural education. Thus, the Law on Agricultural Orientation was adopted, which does not promote techno-economic, but rather agro-ecological farming. The latter includes multidisciplinarity, comprehensiveness, diversity and multifunctionality, and preparedness for uncertainty (Griffon, 2006; ONEA, 2013).

In addition to the law, agricultural education is another thing that can contribute to a sustainable agricultural system, by connecting farms and vocational schools, and by teaching about different ways of production, the latter requiring different (innovative) teaching. For this reason, the strategic plan of the *General Department of Agricultural Education and Research* includes, among others, the reshaping of curricula and pedagogical practices, and education of school staff and experts (Euro-EducATES report, 2018).

The Ministry also published a manual, *Teaching About Different Ways of Food Production*, in which a lack of unique learning practices that would encourage creativity and flexibility is identified. One of these forms of teaching is field work, as well as other forms of experiential learning, through which students learn about various agricultural practices, which they can use themselves. In addition to experiential learning, the importance of digital learning is also accentuated (Peltier, 2019).

Innovations can be introduced in the area of wicked (fuzzy complex) problems, which can be understood as the starting point for societal debates, a cause for scientific research, and also a pedagogic tool for promoting discussion in the classroom. In this context it is important to maintain the distinction between opinion and knowledge. Wicked problems provide students with the opportunity to assume the role of a researcher, who needs to identify the problem, find ways to solve it, and ultimately, solve the problem. Thus, students are the authors of knowledge, who, in addition to physically performing the work, also reflect on the work they're doing (Fabre et al., 2014).

In wicked problems, concepts of multidisciplinarity and transdisciplinarity are useful, which became established through the environmental movement of the 1970s. In the report, the partners point out a variety of skills such as scientific, practical, informative and conceptual knowledge, and their

interconnection. Initially, it is appropriate to create different kinds of knowledge through a collaboration between teachers and students, and later on, activities which allow the application of this knowledge in solving a problem. In creating knowledge, however, the ability to create questions is crucial, and more important than evaluating and using ready-made answers (Peltier, 2019).

Austria

Austrian partners found the distinction between product innovation, when educational organisations introduce improved or new teaching materials and more commonly used business process innovation, when schools introduce new or significantly changed processes for delivering their services, new ways of organising their activities and new marketing and external relations techniques. They also emphasised the measurement of innovation at a "system level as a significant change in selected key educational practices" (Vincent-Lancrin et al., 2019, 17).

In Austria, vocational education and training for agriculture is taught at secondary level, i.e., to students between 14 and 18 years of age. Students can attend a *secondary vocational education school* or a *vocational school with a shortened programme,* which takes place primarily at a specific workplace. The curricula and their implementation in schools are the responsibility of the state, with the support of the *University College for Agrarian and Environmental Pedagogy* in Vienna (Das Österreichische Bildungssystem, 2019).

The *WG Transdisciplinary Systems Research*, which operates at the U*niversity of Natural Resources and Life Sciences* (BOKU) within the *Department of Organic Farming* is actively involved in teaching and curricula development for sustainable agriculture since several years. In both, teaching and curriculum development, the main objective is to offer didactical methods and approaches to revise and improve current traditional and sustainable agricultural teaching and curricula in higher education, with a special focus on the integration of the systemic perspective. Different approaches – compatible to the AG´s conceptual framework and pedagogical foundation – have been identified supporting the integration of the systemic perspective. These key pedagogical approaches are (among others) Service learning, Case-study learning, Action-learning, Experiential/Reflective learning and Phenomenon-based education/learning with are supported with methods, such as Qualitative interviews, Focus group

(discussions), workshops and Participatory observation and others. Through these approaches, students are able to acquire the knowledge and skills required for making informed decisions (Dietrich and Freyer, 2019).

In 2009, the Bonn Declaration of the UNESCO World Conference on Education for Sustainable Development (ESD) called for introducing pedagogical approaches into all levels of formal and informal education entailing "creative and critical approaches, long-term thinking, innovation and empowerment for dealing with uncertainty, and for solving complex [real world] problems" (Tilbury, Mulà, 2009, 2).

Following this attitude when teaching sustainable food systems, the Austrian partner see a need to initiate a change from the passive reception of information by students to an active role in the classroom and also in real world contexts. Active involvement, critical reflection and systemic, non-linear, inter- and transdisciplinary thinking are essential to understand complex systems. They suggest calling it a systemic pedagogy, a broad range of teaching methods including stakeholders, and focus on a student's role in their system both during the education process and after graduation (Dietrich and Freyer, 2019).

As a version of systemic pedagogy, the *University College for Agrarian and Environmental Pedagogy* is developing 'green pedagogy', which comprises (Wogowitsch, Pfäffli-Tanner, 2016):

- active exploration of one's own living environment, rather than memorization or repetition of data and *objective* truths,
- learning without a previously and precisely determined path or goal, but rather with flexible contents and methods,
- interdisciplinarity, connecting different disciplines and different aspects,
- an integrated approach, taking into account cultural specifics,
- process learning with different methods,
- the use of knowledge in practice and the acquisition of useful skills.

Image 1: Humus-Balance-Trend-Scale by Marie-Luise Wohlmuth (https://humustrendwaage.wordpress.com/) as a learning tool for systemic teaching about the balance of inputs/outputs from the soil.

To sum up, in the framework of green pedagogy, connections are formed between scientific concepts, practical application and motives for personal and collective action in the field of agriculture and the environment. Methods such as problem-based learning, connecting excursions, experiments, interactive learning with new media, life cycle analysis, case studies, thematic relationships, text interpretation, metaphor analysis, and reflexive team work are used (Wogowitsch & Pfäffli-Tanner, 2016).

Italy

Italian partners point out that innovative pedagogy strives towards interdisciplinarity and cross-curricular connection between biology, chemistry, physics, ecology, agricultural sciences, economics, tourism, rural sociology and similar areas (Basile, Nicoletti, Paladino and Addesso, 2019).

According to the Italian partners, the quality of vocational schools in Italy is improving especially through the strengthening of the relationship between schools and companies, where students can work as interns, and through the expansion of tertiary education, which also works in connection with

businesses. In addition to forming connections with businesses, educational institutions have increased the number of educational programs that include eco-sustainable management of the agro-food chain and wine & gastronomy traditions (Basile, Nicoletti, Paladino and Addesso, 2019).

In vocational schools for agriculture, students are presented with the basic dimensions of a territorial approach to nutrition, which includes production (ecological, biodynamic, permaculture, agroecological, traditional), the environment (biodiversity, landscape protection, efficient use of water and energy), economy (circular economy, green public procurement, shared use of the soil), culture (cultural heritage, local tradition, rural culture) and society (food self-sufficiency and food safety, healthy diet, social control over production) (Basile, Nicoletti, Paladino and Addesso, 2019).

Some of the approaches applied include: forms of experiential learning, case studies, field and laboratory research methods, learning by doing, learning locally, project work, business game, role playing, e-learning, blended learning, teaching in nature, systemic approach, service learning (Basile, Nicoletti, Paladino and Addesso, 2019).

In terms of pedagogical tools, vocational schools for agriculture most often use best practices catalogues, media, e-modules, ICT devices, interactive PC software tools, laboratory equipment and small farming tools (Basile, Nicoletti, Paladino and Addesso, 2019).

Image 2: Various workshops for experiential learning (Soil Museum) (Source: Italian partners).

Portugal

The Portuguese partners point out that agriculture in Portugal is mostly an activity performed by the older generation and those with lower levels of formal education, i.e., that agriculture is not an attractive lifestyle for young people. Individuals who decide for education in agriculture mostly receive an education based on a straight-line approach, a cause-and-effect relationship. This includes especially the profitability of the land, the input of nutrients, and the return of investments. Such a simplified approach excludes holism, which would encompass the environment, the economy and the society (Dias Sardinha and Rodrigo, 2019).

Students in vocational education are between 18 and 20(21) years old. Vocational education in Portugal focuses heavily on practical training and integration with the local labour market, so students dedicate less time to general and scientific contents, and more time to technical and implementation activities (Alves et al., 2016; Rodrigues et al., 2018).

According to the Portuguese partners pedagogical innovations include the changing and renovation or improvement of relationships, culture, perspectives, models and teaching practices. Thus, for example, a film can be used in an innovative way for reflexive and collaborative watching and commenting on what has been seen. Innovation requires commitment and long-term planning. The Portuguese partners also emphasize that innovation depends on the circumstances. Innovativeness in pedagogy and in agricultural education in Portugal is not institutionalized (Gonçalves, Oliveira, 2011).

In terms of 'innovations in the development of the education system', the Portuguese partners point out the systematic approach, problem-based approach, student-centred teaching, connecting departments in educational institutions, and connecting educational institutions to farming facilities (Wals, 2014).

Teacher interviews revealed that innovative pedagogy should include practical work, experiential learning, student-centred learning and multidisciplinarity. Concrete innovative approaches at selected Portuguese school include: videos, case studies, problem solving, group work, group discussions, working on concrete cases of conversion to organic farming, field work and visits to existing farms. Skills, to be acquired by the students, include: independent learning (knowledge and skills for changing and adapting as part of lifelong learning), effective communication (listening, written and oral

communication), and systemic thinking (holism, complexity and multifunctionality). The implementation of these approaches depends largely on the teachers, their skills and motivation. Universities also play an important role, as they can be a model or paragon for a sustainable functioning of institutions (Dias Sardinha and Rodrigo, 2019).

Portuguese partners highlight the fact that compartmentalization is an obstacle to education on sustainable development and sustainable agriculture. A greater emphasis should be placed on interdisciplinary collaboration and the different relationships between teachers and departments. In this respect, the so-called hidden curriculum is also important, which includes implicit or hidden contents regarding appropriate actions or decision-making (Blasco, 2012; Wals, 2014).

Slovenia

Slovenian partners conclude that pedagogical innovation is a new way or tool, which enables the transmission and acquisition of new knowledge or skills in a more efficient way (faster, cheaper, more explicit, more lasting, more interesting, more attractive, more useful, etc.). Innovation can be subjective if it is new to individuals, or objective, if it is new to most people. Despite a great need for innovation, these are not a permanent part of teaching for all teachers. One of the limitations is tradition, i.e., persisting in established patterns, which require less energy for thinking, planning, and adapting. Moreover, in introducing innovations, there are no guarantees that they will be effective and successful, which is why teachers resort to already established working methods. Other obstacles include costs, time constraints, lack of trust in innovative practice, lack of understanding and support on behalf of management, lack of knowledge and practical experience, lack of interest in innovation, avoiding the unknown and potential problems, lack of knowledge about the long-term positive effects, and the inability of adapting to new situations (Valenčič-Zuljan, Kalin, 2007).

The Slovenian partners have established that the teacher plays a vital role in integrating innovation. Teachers have to possess the ability and motivation for a quality performance of teaching and management of other activities, for adapting to different circumstances, and for mastering numerous competences. The teacher's role is above all that of a mentor, which implies a greater activity of the student, who learns about the content independently, under the teacher's guidance. In this way, the

teacher creates stimulating and relaxed learning environments for independent work, and guides and encourages the potentials of students, their abilities, skills, thinking, imagination, creativity, commitment and responsibility. The transfer of knowledge is no longer at the centre of the teacher's work, but rather their support to students during learning (Valenčič-Zuljan, Kalin, 2007).

Another important aspect is to increase the involvement and activity of students, who are gradually taking on an increasing part of responsibility for their own process of knowledge acquisition and personal development, and are thus being trained for a lifelong learning (Valenčič-Zuljan, Kalin, 2007).

With the focus group, the Slovene partners found that teachers use some innovative pedagogical approaches for teaching cross-curricular topics, especially in subjects from the fields of nature conservation, environmental protection, and technical subjects (different ways of producing and processing food). Teachers achieve an active involvement of students by carrying out research, project work and group learning with cross-curricular connections. Through such approaches, the teachers seek to strengthen especially the skills of critical thinking and the ability to apply knowledge in practice, which enables young people to effectively address challenges both in the workplace and in everyday life. They point out that it is crucial to connect different scientific and expert fields and actors, so that students can get to know the nutrition system in a holistic way (Lužnik, Davidović and Vovk Korže, 2019).

Image 3: Part of teachers and students at focus group workshop (Source: Slovene partners).

Approaches and methods used in innovative ways in Slovenia are: problem-based learning, project work, teamwork and collaborative learning, guided discovery, solving real-life problems, integrating technology, self-reflection, critical and systemic thinking, learning by doing, research, learning in nature, connecting with local actors, discussions, role play, and asking questions (Lužnik, Davidović and Vovk Korže, 2019).

Pedagogical innovation

By reviewing national reports, in which pedagogical innovations in partner countries are presented, it has been noted that innovation refers to changes, improvements or novelties in products or processes. Dependence on circumstances is an important aspect of innovation, which is why there are subjective innovations, which are new to individuals or a limited group of people, and objective innovations, which are new to most people.

In the field of agriculture and nutrition, partners find that innovation mainly refers to agro-ecological food supply, or to a sustainable management of the food chain and gastronomic traditions.

In the field of pedagogy, innovation includes the changing and renovation or improvement of relationships, culture, perspectives, models and teaching practices. Pedagogical innovation can be defined as a new way or tool that enables the transmission and acquisition of new knowledge or skills in a more effective way.

The concrete innovative pedagogical approaches used in partner countries are:

- transdisciplinarity, which involves learning about different aspects of a phenomenon, cross-curricular integration, connections between different scientific and expert areas, cooperation between teachers and departments, connecting educational institutions with local actors,
- systems thinking or holistic thinking about inter- and transdisciplinary contents,
- active learning by changing the students from passive receivers of information, to students with an active role in the classroom, who are able to apply knowledge in real-life situations,

• experiential learning, which includes learning in nature and in other real environments, and forming connections between theory and practice,

• problem-based learning, especially in the form of group learning with student participation and group discussions.

Concrete pedagogical tools that can be used in innovative ways are especially the following:

• digital tools, interactive learning with new media, e-learning, interactive computer software tools, videos and other audio and graphic records,

• field work and other forms of experiential learning, connecting excursions, learning locally, learning in nature, and visits to existing farms,

• studies or research of concrete examples, integration wicked problems and analysis of the life cycle,

• project work, working on a specific case of a concrete farm, and solving real-life problems.

The key skills acquired and reinforced by the students through innovative pedagogy are especially: asking good questions; identifying problems and finding solutions to these problems; acquiring scientific, practical and other forms of knowledge; critical thinking; independent and lifelong learning; effective communication; imagination and creativity; responsibility and self-reflection.

In the following section, these innovative pedagogical approaches and tools are presented in more detail.

COMMON APPROACHES OF INNOVATIVE PEDAGOGY

The following section presents the pedagogical approaches and tools used in the partner countries in the conception of innovative educational programs and contents. Although approaches and tools are presented separately, there are no strict boundaries between them. Their effectiveness may be even greater, when several different approaches and tools are used interconnectively, for example, the use of personal portable devices or drones for field work. The source of information for their presentation is international scientific and technical literature.

Pedagogical approaches

The project partners understand pedagogic approaches as a theoretical basis for the planning and implementation of education. The following section presents pedagogical approaches, on the basis of which teachers in the partner countries perform innovative forms of education.

Transdisciplinarity

Transdisciplinarity emerged as a response to the inadequate separation of disciplines in the curricula of universities in the 1970s, i.e., as a vision of universities of the future, which would include interrelated research and education for the promotion of innovation (Hillel Bernstein, 2015). The term itself was first used by the Swiss psychologist Piaget during a seminar on interdisciplinarity in universities, which was organized in France by the OECD and the French Ministry of Education. Initially, transdisciplinarity was defined as a condition which "… would not only cover interactions or reciprocities between specialised research projects, but would place these relationships within a total system without any firm boundaries between disciplines" (Piaget, 1972, 138 in Hillel Bernstein, 2015).

At the same event, Austrian astrophysicist Jantsch, who understands sciences as the groundwork for innovation, defines transdisciplinarity as "…the co-ordination of all disciplines and interdisciplines in the education innovation system on the basis of a generalized axiomatics…" (Jantsch, 1972, 106 v Hillel Bernstein, 2015).

In the 1990s, transdisciplinarity becomes an important contribution to the management of society and to solving complex global problems such as climate change, unsustainability, social issues, non-integrational education, and socially irresponsible science (Hillel Bernstein, 2015). The second important event for transdisciplinarity entitled *The First World Congress of Transdisciplinarity* was carried out in 1994 in Portugal. At the event, the *Charter of Transdisciplinarity* was adopted, which summarizes the essence of the term in 15 articles (Hillel Bernstein, 2015).

Today transdisciplinarity refers to the highest degree of synthesis of disciplines, whereby (Hillel Bernstein, 2015):

• multidisciplinarity refers to the collaboration between various disciplines without deeper connections and coordination (collected findings from various disciplines without synthesis),

• Interdisciplinarity refers to the cooperation of various disciplines with a generally accepted system of research or educational assumptions (collected findings from various disciplines with synthesis),

• transdisciplinarity refers to the close collaboration between different knowledge systems (academic, indigenous, experiential etc.) with a generally accepted system of research or educational assumptions - collected findings with an in-depth synthesis, without division into disciplines.

The main feature of transdisciplinarity is the recognition of a complex reality, which is noticeable in learning about a phenomenon from different aspects and dimensions (Hillel Bernstein, 2015). Part of the reality are wicked problems that can not be accurately defined by dissecting them into individual components, such as hunger, poverty, climate change, extinction of species, depletion of natural resources and the destruction of ecosystems. These complex problems have so-called emergent properties that arise by combining parts into a whole, but are not the sum of parts of the whole (the liquidity of water is not found in the individual hydrogen and oxygen atoms, but rather in their combination). By the same token, with the transdisciplinary approach, new knowledge emerges, and is not the sum of different kinds of knowledge from different disciplines (Hillel Bernstein, 2015). Due to their complexity, wicked problems cannot be fully defined or eliminated by means of well-established procedures, and therefore new ones are required.

Transdisciplinary approaches can be performed independently or collectively, what is crucial is the merging of the findings from different disciplines, and the involvement of different stakeholders. Some collective approaches, which involve the division of labour between individual participants, are joint meetings, group discussions on findings, and group brainstorming (Hillel Bernstein, 2015). In the implementation of a transdisciplinary approach, imagination and innovation are also of key importance, as they enable new solutions to problems and also identify new factors that need to be taken into account. Characteristics of persons involved in transdisciplinary projects are the ability to think in a complex and interconnected way, accepting the complexity of the work outside the comfort of their own discipline, openness to new ways of thinking and concrete implementation or action (Augsburg, 2014, 240 in Hillel Bernstein, 2015).

As mentioned, it is important to include different disciplines, i.e., their methods. In addition to natural science methods, it is crucial to integrate methods from social sciences, such as surveys, interviews, focus groups and participatory observation (Francis et al., 2011, 227). In addition to scientific methods, humanities and the arts are also important, as they are able to introduce new perspectives and methods (Hillel Bernstein, 2015). "Transdisciplinarity is as much about the liberal arts, and about cultural symbolisms, as it is about the so-called social and natural sciences, or professions like medicine, engineering, or law." (Macdonald, 2000, 244 in Hillel Bernstein, 2015).

By including different stakeholders as well as theoretical and practical knowledge, emotions, ethics, spirituality and aesthetics, changes that are important to sustainability can be achieved. One of the disciplines for achieving sustainability which connects the environmental, economic, social, political and ethical dimensions of food systems, as well as non-food goods and services, is agroecology (Francis et al., 2011, 229). Due to its diverse content and methods, agroecology is a suitable discipline for recognizing and solving modern global problems. Agroecology is also suitable for innovative pedagogic programs, since they go beyond any kind of specialization and include knowledge of natural resources, agricultural practices, economics, environmental protection, as well as knowledge about people and the society (Francis et al., 2011, 229).

System approach

A system can be defined as a whole made up of interrelated parts, which can be biological, infrastructural, organizational, agricultural, etc., and these parts are characterized by having interactions and effects (Cabrera et al., 2008). Two key characteristics of systems are non-linearity and the existence of numerous relationships, while in researching or teaching systems, terms such as structure, patterns, cycles or loops, are used (Riess and Mischo, 2010).

Systems consist of subsystems and are also part of a larger supersystem, which means that learning through the system approach involves learning on three related levels, which are: the system, the sub-system, and the super-system (Jordan, et al., 2005 in Francis et al., 2011, 235). In this way, the topic can be studied or taught in a holistic way, enabling students to gain the ability to deal with complexity and uncertainty (Francis et al., 2011, 228).

The systems theory is also useful with respect to our way of thinking. Such systems thinking includes concepts and tools for learning about the world, and for the analysis and design of sustainable settings (Schiere et al., 2004). Systems thinking in education is based on the assumption that students can be actively involved in sustainable development only if they are able to recognize and understand complex systems (Riess and Mischo, 2010). Therefore, students are encouraged to strengthen their ability to identify, describe and model complex parts of reality, which are systems, and, in addition, to identify the components of systems and their relationships (Riess and Mischo, 2010). More specifically, systems thinking comprises four key interrelated dimensions (Ossimitz, 2000, 532 in Riess and Mischo, 2010, 706):

- thinking about networks of connections between the elements of a system and feedback loops,
- thinking about the dynamics or development of the system over time,
- thinking about models or simplified representations for prognosis,
- thinking about customized system management.

Systems thinking is not a single skill but a set of skills (Klieme and Maichle, 1994, 62 in Riess and Mischo, 2010, 707). Factors that influence the success of systems thinking are memory, expertise, motivation, and intelligence (Beckmann and Guthke, 1995 in Riess and Mischo, 2010, 707).

Based on an understanding of systems and the skills needed for their research, systems thinking is divided into (Schiere et al., 2004):

1. Hard systems thinking

Systems are seen as closed, static units which can be controlled by a person, but the context is ignored. Quantitative methodology, i.e., measurements of quantities are carried out in order to facilitate the monitoring of systems. Typical features are objectivity, reductionism, materialism and technicism. The emphasis is on one genuine external reality, without the inclusion of different views. The main emphasis is on an engineering approach to production, primarily to increase yields.

2. Soft systems thinking

Systems do not have clear, unambiguous boundaries, i.e., the boundaries are variable, since they are determined by a human being, who can also be a part of the system. A system can not be fully controlled, so it is important to be able to accept uncertainty. In addition to the boundaries, the purpose of the system can also be changed over time. Typical features are inclusion of subjectivity, intellect and ethics. The emphasis is on the diverse perception and interpretation of reality, and therefore there is no complete objectivity. In addition to quantitative, qualitative data are also included.

In addition to the two types of systems thinking, some also define the third type – complex systems thinking. It is distinguished from the other two mainly by a reinforced holistic approach which combines the material and the mental, lifelong learning and the observance of circumstances (Schiere et al., 2004).

No systems thinking approach is either better or worse, because all forms have their own advantages and disadvantages. Hard systems thinking can be useful as well, but it is important to integrate the findings into the whole system (Francis et al., 2011, 227).

Active learning

The teacher is traditionally seen as a source of information, which he transmits to students by means of the transmittal model, which works according to the principle of transmittal-reception of information and of already formed knowledge. In this model, the teacher has the role of the knowledge carrier, and students often play the role of note-takers. This traditional approach is both cost- and time-effective, as one teacher teaches a larger number of students, which is one of the reasons for the prevalence of this approach (Higgs and McCarthy, 2005).

The traditional, also called frontal or lecturing approach is often criticized, but is not necessarily bad because it is suitable for transmitting information and providing guidance for activities. The use of the traditional approach is even recommended, but necessarily in combination with other methods (Bligh, 1998 in Higgs and McCarthy, 2005, 47). A greater efficiency of the traditional approach can be achieved by allowing students greater freedom in asking relevant questions, in doubting and discussing the transmitted information, in forming counterarguments, and working together in smaller groups (Higgs and McCarthy, 2005).

Despite the applicability of the traditional approach in cognitive sciences, it has been established that students find it hard to understand, internalize or apply knowledge if they are not actively involved in the learning process, or, "...that knowledge gained through activity is more useful than knowledge gained through memorisation" (Moran 1997 in Higgs and McCarthy, 2005, 47). This is why in contemporary times, a new role of the teacher is promoted, who should be an expert in the provision of learning conditions, which will act as a catalyst for learning and reflections on worldviews. Thus, teachers are supposed to " ...change the classroom into an active learning environment... " (Higgs and McCarthy, 2005, 43).

The word mentor is often used to describe the new teacher role. The word derives from the Greek *Odyssey*, in which Mentor is the name of Odyssey's friend, who raises and teaches his son Telemachus. Today, a mentor is a person who guides and directs apprentices or students, s that they can develop their personal and professional abilities and their own beliefs, without copying those of the teacher (Vierstraete, 2005).

The teacher-mentor is no longer a transmitter of created knowledge, but a facilitator of independent learning, which means that in this way the students can be more independent and active in the acquisition and development of knowledge. In this sense learning is no longer a passive reception and memorization of information, but rather, active knowledge creation and thinking about and evaluating the acquired knowledge with the support of a teacher (Barth, 2015 in UNESCO Learning Objectives, 2017, 55).

Increasing the active role of a learner involves a shift from teaching to learning (Barr and Tagg, 1995 in O'Neill and McMahon, 2005). Thus, the role of the teacher is the learning of learning, or, the strengthening the learners' ability to learn, which includes metacognition, i.e., the understanding of one's own way of understanding (Higgs and McCarthy, 2005). In addition to knowing one's own way of understanding, learning to learn is crucial in order for the teacher-mentor to train students to ask relevant questions and to independently search for answers. The latter is more important than the delivery of answers, which is at the heart of the traditional approach (Higgs and McCarthy, 2005).

In order for a teacher-mentor to successfully train learners for learning, it is advisable to get to know the views and existing knowledge of students on the subject in question, because this is the only way they can adjust the topic and make it relevant for the students (Higgs and McCarthy, 2005). In this way, it can

be assured that " ... knowledge is built up by learners and that the teacher is a learning guide more than a data representative " (O'Neill and McMahon, 2005, 28) "... that knowledge is constructed by students and that the lecturer is a facilitator of learning rather than a presenter of information" (O'Neill and McMahon, 2005, 28).

Active involvement of students can mean either that they have a choice, or that they carry out their own activities, or both (O'Neill and McMahon, 2005). If they have a choice, then "... students might not only choose what to study, but how and why that topic might be an interesting one to study..." (Burnard, 1999, 244 in O'Neill and McMahon, 2005, 28). Thus, students are involved in designing and implementing the educational program, which is the basis for further reflection on learning and personal development. It is important that students can make choices based on their ideas, values and current knowledge. The possibility of choice can be ensured by means of optional modules, problem-based learning, discussions, role playing, etc.

The concept of active learning is partly consistent with the concept of student-centred learning. In curricula, a student-centred approach can be identified by quoting the knowledge and skills the learner acquires (e.g., at the end of the program, the student will be able to...), rather than listing the contents presented by the teacher (e.g., the program covers...). There is a greater emphasis on the process and skills than on the content (Gibbs, 1995 in O'Neill and McMahon, 2005, 30).

Research has shown that student-centred learning is effective, as students learning in this way have understood the subject better, however, it took them more time to do this (Lonka and Ahola, 1995 in O'Neill and McMahon, 2005, 33). In addition to success, an advantage of this type of approach is its popularity among students, because it boosts their self-esteem and is more exciting than the traditional approach (Lea et al., 2003 in O'Neill and McMahon, 2005, 33).

Active learning can include several forms, such as: computer simulations, collaborative group work, case studies, keeping a journal, video learning, flipped classroom, laboratory work, etc. (Teff-Seker, Portman and Keren Kaplan-Mintz, 2019). One form of active or student-centred learning is personalized learning, in which content and teaching methods are tailored to each student. The starting point for personalized learning is the student's knowledge and the circumstances in which he lives, in other words, this kind of learning means taking into account "... the specific learning needs, interests, aspirations, or cultural

backgrounds of individual students…" (NMC, 2015, 26 in Garrick et al., 2016, 33). In this kind of learning, it is vital that learning becomes a personal activity.

An interesting form of active learning is peer teaching, in which students share knowledge among themselves, so that those who understand explain things to others who do not understand it (Tobin, 2004 in Higgs and McCarthy, 2005, 40). It is sensible to connect learning as a social or group activity, and as a personal or independent activity. With this kind of group learning, students are able to receive feedback from peers (Higgs and McCarthy, 2005).

Some other innovative methods that promote teachers' mentorship approach, or the active approach of learners are (Francis et al., 2013):

• Open-ended case study: the involvement of students, teachers, experts and clients in solving a real problem, without knowing the solution in advance. The solution is shaped through the process itself, as it depends on natural resources, economic characteristics, the persons involved, and the community and their worldview.

• Adventure learning: a teacher-mentor or participants travel to unknown places and learn about nutrition, social problems, or the state of nature in a specific area (it is possible that only one person travels and passes observations onto others through the internet),

• communicative learning: participants work closely together and explain their findings and thoughts to each others, thereby contributing to understanding different opinions, creating good relationships, successful collaboration and developing communication skills.

The transition to the role of a mentor, i.e., to active learning, may be unpleasant both for teachers and students. For the first, because in this way they give up power and control, and for the second, becasue they take great responsibility for their own learning. In addition to the inconvenience that can make teachers and students insist on the traditional approach, the limitations of this kind of learning are also classroom size, time, financial resources, the beliefs of some teachers and students, and the possibility of excluding some students (Higgs and McCarthy, 2005).

Experiential learning

Experiential learning is a special form of the active approach to learning. Experiential learning is a holistic approach to learning which involves thinking, feeling, and perceiving, for an understanding of the world. This theory includes concrete experience and the abstract conceptualization of what has been experienced (Teff-Seker, Portman, and Keren Kaplan-Mintz, 2019).

One of the most famous theories of experiential learning is Kolb's theory, in which students form new knowledge that they can use in different circumstances. The theory consists of four stages, however, it does not matter where the level of learning begins, but it is important that students go through all four stages. Usually, students start with a concrete experience, on the basis of which they perform observation and reflection, then generalize the formation of abstract concepts, and finally use abstract concepts in new experiences or situations (Kolb, 1984, UNESCO Learning objectives, 2017, 55). This kind of learning strengthens the acquisition of knowledge and the development of skills and values. More specifically, Kolb's theory of experiential learning comprises (Figure 1) (Wageningen University, 2012):

1. feeling: students are faced with new, direct experience, doing, performing,
2. inner observation: students consider and evaluate ,
3. thinking: students' thinking encourages abstraction, conceptualization, forming conclusions, ideas,
4. doing: students experiment with the new idea on a new experience.

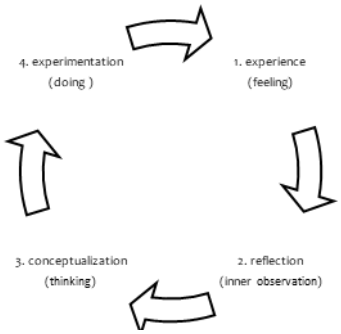

Image 3: Stages of Kolb's theory.

Experiential learning can be based on the already mentioned personalized approach. Complete personalization or adaptation of content and teaching methods to all children is difficult to implement, therefore a compromise can be made in the form of personalization based on learning styles. A learning style is the specific way of learning of an individual and as such has a great influence on the learning process itself. If students have a distinctive learning style, then they may have learning difficulties if the teaching style is not adapted to the learning style. Students who are taught on the basis of their learning style achieve better results.

One of the classifications consists of four types of learning styles that are developed in a combination of two ways of approaching a task (doing and observing) and two ways of responding to a task (thinking and feeling). On the basis of approaching and responding to the task, four styles of learning have been developed according to the adapted Kolb's theory, which can be used as a starting point for the personalization of pedagogical methods (Honey, Mumford, 1986 in Wageningen University, 2012):

1. Activist: learning by doing and feeling. Appropriate pedagogical methods: brainstorming, problem solving, group debates, puzzles, competitions, role playing.

2. Reflector: learning by watching and feeling. Appropriate pedagogical methods: models, statistics, stories, quotes, general background information.

3. Theorist: learning by watching and thinking. Appropriate pedagogical methods: thinking about the use of theories in reality, problem solving, discussion.

4. Pragmatist: learning by doing and thinking. Appropriate pedagogical methods: pair discussions, self-assessment, personality tests, training, interviews.

Experiential education can be carried out in the form of projects, internships, workshops, fairs, campaigns, excursions, hikes, etc. A special form of experiential learning is outdoor learning, which involves learning about natural and social processes outside the classroom.

One of the examples of innovative implementation of experiential outdoor learning is the use of the *hand model*, which was developed in the framework of the European Real World Learning project (RWL), and provides a holistic approach to perception, planning and reflection for a deeper learning experience in the real world.

The hand model includes five key areas of learning for holistic outdoor learning, as there are five fingers on the human hand. It is based on the "Hand-Heart-Head" approach (Real World Learning, 2013):

1. understanding: involvement of scientific concepts of life concepts (circulation, changes, balance, energy flow, etc.).

2. transferability: inclusion of different areas of life (connection with the natural and the social environment, with oneself, etc.),

3. experience: learners are in touch with an outdoor setting (learning for and in nature),

4. empowerment: development and strengthening of competences for shaping a sustainable future (cooperation, critical thinking, reflection),

5. values: development and promotion of self-transcendence values (respect for nature, equal opportunities for all, respect for future generations).

It is a holistic approach that enables young people, through learning by doing, exploring and their own experience in real-life situations, to develop lasting and useful knowledge for identifying and understanding processes that take place in nature and the environment, for evaluating and making decisions in favour of sustainable development, for an easier formulation of visions and alternative proposals to address the numerous environmental problems and develop a responsible attitude towards the environment and society. The main characteristic of the approach is interdisciplinarity, practical approaches, direct inclusion, and greater motivation of young people to actively experience nature and their own creativity and permanence of knowledge (Real World Leraning, 2013).

Problem-based learning

Problem-based learning is a learning process in which students try to understand the problem and its solution (Barrows and Tamblyn, 1980 in Barrett, 2005, 56). Problem-based thus involves "... problems that demand from the learner the acquisition of critical knowledge, problem-solving proficiency, self – directed learning strategies and team participation skills" (Barrett, 2005, 59). In this way, students can learn about a "... systematic approach to resolving problems or meeting challenges that are encountered in life and career" (Maricopa Community College v Barrett, 2005, 59).

A problem is usually a real-life obstacle, which students are not able to resolve with their existing knowledge or way of thinking (Barrett, 2005). The problem has to be interesting and challenging for students to encourage them to explore possible solutions. These can be in the form of scenarios, puzzles, diagrams, dialogues, quotes, cartoons, emails, songs, videos, material objects, etc. (Barrett, 2005).

In line with the already mentioned shift from teaching to learning, problem-based learning is a form of active learning and is an example of a student-centred approach. The teacher or mentor is not focused on traditional contents and methods of teaching, but rather observes, encourages and challenges student to learn. In addition to learning skills, students also adopt research and communication skills (Barrett, 2005).

Problem-based learning is suitable for implementation in a small group of learners (usually 5-8), who learn together about a problem that is not exactly defined, and search for a solution (Barrett, 2005). Usually, students in the group divide areas and roles, such as leader, note-taker, etc., and in this way also enhance their sense of transdisciplinary cooperation. Transdisciplinarity is also involved in various sources and school subjects, from which information is obtained for solving the problem. In this regard, the teacher-mentor is not teaching or providing information, but encouraging the students' thinking about the problem and providing advice on how to solve it (Barrett, 2005). Stages of problem-based learning can include (Barrett, 2005):

1. Students are faced with a problem, i.e., the problem is presented to the students.

2. Students discuss the problem in smaller groups, define it precisely, identify the state of existing knowledge about the problem, and the need for new knowledge which they need acquire in order to solve the problem and ultimately plan an action plan to address the problem.

3. Students independently acquire new knowledge to solve the problem using materials from the library, databases and from the internet.

4. Students present new knowledge to other members of a small group and discuss possible solutions to the problem.

5. Students present and perfect the solution to the problem.

6. Students reflect on the knowledge they have acquired through the process of solving the problem. In the end, the teacher and other members of the group evaluate the contributions of individual members and the whole process.

A study performed on medical students has shown that through problem-based learning they were able to preserve more information in their memory, over a longer period of time, and that they have

reinforced the transfer of theoretical concepts into real-life situations. The same study has shown that students gained more knowledge of basic science when exposed to traditional teaching. Therefore, it makes sense to design hybrid curricula, which combine problem-based learning with traditional forms of teaching and other approaches (Barrett, 2005).

In addition to the effectiveness of problem-based learning, one of its advantages is its popularity among students, who describe it as a fun, challenging and creative way of learning. Thus, problem-based learning can encourage students to acquire new knowledge and skills because of the desire to solve an interesting problem, whereas in the opposite case, learning often does not make sense (Barrett, 2005).

One of the major disadvantages of the problem-based approach to learning is a thorough and prolonged training for teacher-mentors who are going to implement this type of approach, because a short educational seminar is not enough. In addition to teachers, students, too, need to be informed about problem-based learning before they start to use it. School management may also be an obstacle, if it does not provide sufficient support, or if it maintains a strict division into departments (Barrett, 2005).

Pedagogical tools

Pedagogical tools can be understood as means through which teachers transmit information and guide learning. Innovative pedagogical tools used by teachers in the partner countries are presented below.

Digital tools

Educational technology can be defined as a set of tools and aids for improving teaching, learning and research through the use of information and communication technologies. The introduction of digital technologies into pedagogy represents a great potential if executed in a suitable manner.

Digital pedagogy can be used for student-centred learning, so it is necessary to know the students' characteristics. Some of these are general characteristics of a generation. Modern-day students belong mainly to the generation of Millennials and to the Generation Z. Some of their general features include a good knowledge of information and communication technologies, fast searching and processing of

information, less popularity of traditional lectures and more popularity of active learning. Members of the two generations expect that especially technology and teamwork will be involved in education (Kennedy et al., 2009 in Flogie, 2016, 36).

It is important that while learning, members of these two generations still expect a first-person contact with the teacher, i.e., they understand that the teacher is a key figure in the education process. From the teachers, especially instructions and feedback are expected (Kennedy et al., 2009 in Flogie, 2016, 36).

Four new pedagogical orientations or shifts from traditional pedagogy to a new kind, which are suitable for digital learning, are described below (Blewett, 2016):

• from using content to creating content: traditional pedagogy encourages the memorization of facts or focuses on the use of already created content, so that the learner receives the material that must be learned, and later that knowledge has to be demonstrated on the test. Digital pedagogy, in addition to using already created content, enables the creation of new content, so students become active co-creators, rather than passive users of the teacher's content.

• from content to conversation: in traditional pedagogy, teaching was initially conducted by means of the so-called Socratic method. Later on, the major role was given to written texts for reading, memorizing and repeating the contents. Digital pedagogy allows learning through conversation, this is the so-called Socratic Method 2.0, in which content can be divided into subsets that are more manageable for students.

• from correct to correction: traditional pedagogy focuses on one final correct answer. Digital pedagogy promotes the process of correction, in which the content is constantly created through the participation of individuals who complement, improve and correct each other.

• from control to chaos: traditional pedagogy focuses on order, sequences and teacher's control in determining the content and method of teaching. Digital pedagogy allows the teacher to create a useful unfamiliar chaos, so that learners are given the opportunity to identify patterns and posiibilities for solving the problem on their own (this requires more time than a simple use of an equation).

Learning with digital tools can be conceived through a personalized learning approach based on learning styles, which makes learning more effective, as it reduces the effort that a learner has to invest (Graf et al., 2010 in Garrick, 2016, 39). The Felder-Silverman model is one of the most commonly used

learning style classifications in digital pedagogy and includes the sensing/intuitive, visual/verbal, active/reflective, and sequential/global styles. The advantage of the model is that it does not place learners into strictly separate categories, but comes in the form of a continuum which suggests an inclination towards a particular style. An important aspect is that students can use different styles in different situations (Graf et al., 2007).

Based on these learning styles, web pages and similar user-tailored tools have been developed. For students who prefer visual learning, the image occupies the central and largest part of the screen, with the text underneath the image, while for students who prefer global learning a transparent indexing table with content summaries is formed, and for sequential learning, scrolling between pages with a smaller amount of information is more appropriate (Pukkhem and Vatanawood, 2011).

Some concrete examples of approaches in digital pedagogy are (Garrick, 2016):

• bring your own device: students use their own devices such as laptops, tablets and smartphones in their classes,

• flipped classroom: students use videos with instructions provided by the teacher to be watched at home, then students use technologies to apply the knowledge in class,

• makerspaces: spaces for planning, designing and manufacturing products or designing solutions and solving real-life problems using technologies such as 3D printers,

• wearable technology: use of watches, jewellery, glasses and clothing with smart features that can store data, monitor activity, sleep and location, access the internet and social networks, or alert about events, threats, etc.,

• Internet of Things: connecting and synchronizing different objects from the material world with the digital world through the Internet.

One of the most well-known types of digital teaching tools in the modern world are massive open online courses, or MOOC. MOOC is a type of digital online education that falls under the general concept of open education. It is intended for large groups of learners who can participate in a course as part of their classes, or independently outside the school programme. Courses can take several weeks, and students themselves allocate their learning time, as the topic is divided into a series of materials and

learning objects (movies, quizzes, graphs, images, sound recordings, videoconferences). The forum is another key feature, through which participants communicate with each other and with their mentors. In the end, students can obtain a certificate or badge on course completion. The content is usually prepared by universities, which interested students can access through various providers such as Coursera, edX, Udacity, etc.

There is an increase in the use of social networks and personal portable teaching devices, which is called m-learning (m from mobile; m-learning). This kind of education is particularly popular among younger students (Generation Z), which is characterized by their reluctance to use purely traditional teaching approaches (Garrick, 2016). Another interesting study has confirmed the positive effect of SMS messages, received by the learners as a learning stimulus, which also served to strengthen their self-monitoring of learning (Goh et al., 2011 in Garrick, 2016, 41).

The rapid development of technology can also result in a rapid development of pedagogy, provided that the technology is suitably integrated into the education process. In this sense, there is great potential in the development of technologies such as virtual reality tools, 3D maps, holograms and smartboards.

Field work

Field work is part of the active approach to teaching in which students learn from experience by participating in the construction, testing and improvement of mental models (Michael and Modell, 2003 in Arrowsmith, Counihan and McGreevy, 2005, 42). Field learning can allow students to place themselves in real-life situations, like the ones in which they will eventually have to function (Arrowsmith, Counihan and McGreevy, 2005). Some forms of field work include excursions, trips, visits to museums, astronomical observatories, parks, farms, learning trails, outdoor classrooms, etc.

The suitability of field work is evident from the fact that it enhances knowledge and an appropriate attitude towards the subject in question (Knapp and Barrie, 2001). Performing only a single field work activity positively affects the ability to memorize and learn (Falk and Balling, 1982 in Knapp and Barrie, 2001). It is important to emphasize that field work alone does not necessarily constitute active experiential learning. Even in the field, a teacher can use a frontal approach to transmit pre-prepared

content, while students are passive listeners, which means that field work may be nothing more than a *lecture in the field* (Higgs and McCarthy, 2005).

A key method of field work is, above all, observation. The ability to observe changes with increasing theoretical knowledge: the more technical terms and processes the students are familiar with, the more accurately they can describe the observed phenomenon. The change in the vocabulary, or "the conceptual-linguistic shift" (Hodson, 1998 in Higgs and McCarthy, 2005, 42) can be tested at the end of the field work and can therefore be a good indicator of the knowledge acquired (Higgs and McCarthy, 2005).

The purpose of field work is to enable students to use the knowledge they have acquired in the classroom. Also, field work is an opportunity for students to get a sense of different technical professions. Because real experts observe, discuss, convince, negotiate, etc., students should do it, too. Since experts also occasionally disagree about the explanation of the same phenomenon, delivering one correct answer should be a less important goal of teaching (Higgs and McCarthy, 2005).

Planning is important for an efficient execution of field work. A properly conducted field work may increase the internalisation of a story told by the teacher in the field. There is a difference between making the story available to students (the teacher provides data with a frontal approach) and having individual students make sense of the story (Vygotsky, 1978 in Higgs and McCarthy, 2005, 41). In order for students to understand and internalise the story, field work should be based on their existing knowledge and active involvement in the form of observation and measurement, forming hypotheses and testing them, and presenting the findings to peers and group discussions. It is also crucial that students mentally modify new information based on their own experience, knowledge and values (Higgs and McCarthy, 2005), so that they are able to "…produce long-lasting, positive memories…" (Falk, 1983, 141 in Knapp and Barrie, 2001).

When planning field work, the most important factor according to teachers is the price and transportation (Falk and Balling, 1979 in Anderson and Zhang, 2003, 6). Important factors are also time needed for planning, compliance with the number of classroom hours and the curriculum, and the support of school management (Orion, 1993 in Anderson and Zhang, 2003, 6). A teacher survey has found that planning field work is not only their responsibility, but also a responsibility of the institution which they plan to visit (Anderson and Zhang, 2003, 7). In addition to the program, teachers especially

appreciate teaching materials they receive from the institution prior to the implementation of field work (Anderson and Zhang, 2003, 11).

In connection to digital technologies, virtual field trips on computers and the internet can also be used, using maps, texts, photos, videos, and interactive 3D representations. Virtual field trips can stimulate thinking and solving real-life problems (Arrowsmith, Counihan and McGreevy, 2005). Virtual field trips can also be a suitable pre-preparation for field work, as preliminary information about the place where the field work is going to be carried out will increase chances of acquiring new content on the location itself (Counihan, 2005 in Arrowsmith, Counihan and McGreevy, 2005).

Case studies

Case studies can be defined as in-depth comprehensive research of real-life phenomena in their natural circumstances. The phenomenon may be a person, institution or event in a given time and space. In addition to a detailed understanding of individual cases, the purpose of a case study is also to induce or to formulate a broader or general principle. For this reason, this method is suitable especially for students who induce (generalize from individual cases) more easily than they deduce (derive from general principles) (Burns, 2017).

From a pedagogic point of view, case studies can help to learn about numerous factors which influence the emergence of the case studied (Yin, 1987 in Burns, 2017). Case studies are also useful for learning about best practices or for forming hypotheses which can be further statistically tested by the learners (Burns, 2017).

Research has shown that case studies strengthen skills of critical thinking, acquisition of knowledge, forming connections between different fields, understanding of different perspectives, identification of problems and key stakeholders (Burns, 2017). This kind of pedagogical tool also strengthens the basic cognitive skills, which are listed below from the least complex to the most complex (The Economics Network, 2018):

- *Knowledge* involves the skill of memorizing or remembering, not necessarily understanding the meaning; a case study in combination with a frontal approach can enhance knowledge.

• *Comprehension* involves the skill of recognizing meaning, interpretation and extrapolation; a case study based on real-life cases strengthens the understanding of knowledge.

• *Application* involves the skill of implementing concepts, methods, principles and theories on a new concrete case; a case study allows learning about the application of principles in the real world.

• *Analysis* involves the skill of deconstructing a phenomenon into its components; a case study is a type of analysis, since the studied phenomenon is initially analysed in order to identify its components and the relations between them.

• *Synthesis* involves the skill of combining components into a new whole; a case study encourages students to recognize important information, summarize that information into core concepts, and present it in the form of a new whole.

• *Evaluation* involves the skill of assessing or attributing value according to a particular purpose; a case study allows learners to evaluate a specific case and suggest better solutions.

Case studies can be simple or complex, in physical or in digital form (Singh, 2017), and all of them are characterized by having the form of a story. This format of a story is what ensures success, because people are naturally receptive to stories. In addition to the above, the success of case studies is ensured by the active involvement of students and the understanding of the practical applicability of concepts, rather than their memorization (Singh, 2017).

Case studies are a good source of facts, i.e., numerical or descriptive data, which the students can use to solve real-life or imagined problems, but there is no single correct solution. A case study is similar to problem-based learning, but unlike problem-based learning, case studies do not pinpoint the problem in detail (The Economics Network, 2018).

An interesting form of a case study for LSFS is the so-called *foodshed analysis*. Foodshed is a geographical area where food is produced and processed for further consumption, i.e., it includes the places of production, processing, supply and consumption of food. In the same way a watershed comprises water flows within a limited area, a foodshed comprises food flows within a specific region. The western modern-day food system involves a foodshed covering the entire planet. Foodshed analysis can be a useful tool for understanding food systems, or the flow of food from production to consumption in a given area (Peters et al., 2008).

Another example of using the case study approach is a *life-cycle analysis*, in which the path from the beginning to the end of a product is learned, as well as *forensic analysis*, which involves identifying factors that have caused damage in the past.

Project work

Project work or project-based learning can be an individual or group activity that takes place over a long period of time. The purpose of project work is usually a product or solution to a particular problem (Donnelly and Fitzmaurice, 2005). Although the final product (service, presentation, etc.) is the driving force behind project work, the knowledge and skills that students acquire and develop during the project are more important (Donnelly and Fitzmaurice, 2005).

Project work can be an example of a transdisciplinary approach to developing knowledge and skills by tackling real-life problems or creating products. Problems are usually presented to students in a less structured form, such as imaginary scenarios or case studies (Donnelly and Fitzmaurice, 2005).

Project work has some common features with other innovative forms of teaching, such as problem-based learning. In both, students receive introductory guidelines for dealing with real-life tasks, and then independently use different data sources to identify and develop solutions. In this way, they imitate a real professional situation, which they may face at the end of the education program. Since project work and problem-based learning are similar, they are often even joined and, in terms of research, treated together. (Donnelly in Fitzmaurice, 2005).

The difference between them is that project work focuses primarily on finding a solution or developing a product, while problem-based learning is more focused on getting to know the characteristics of the problem. In addition, project work is more systematically planned, while problem-based learning is more open (Teff-Seker, Portman, and Keren Kaplan-Mintz, 2019). Both types are suitable for learning especially because students develop skills for solving transdisciplinary real-life problems involving politics, society and the bio-physical environment (Teff-Seker, Portman and Keren Kaplan-Mintz, 2019; Wiek et al., Teff-Seker, Portman and Keren Kaplan-Mintz, 2019, 2).

Project work usually begins with a vision of the finished product, followed by a definition of the knowledge and skills required for the realization of this product. The realization itself usually consists of

several problems which students can solve gradually (Donnelly and Fitzmaurice, 2005). Key steps prior to the start of project work include a detailed understanding of the project topic, a discussion about the topic in the project team, a distribution of activities among group members, and research of the topic by means of various sources of information (Donnelly and Fitzmaurice, 2005).

The role of the teacher in project learning is to provide advice on sources of information, directing group work, encouraging or motivating, whereby the teacher takes on the role of a peer and does not criticize students. The teacher is thus more concerned with the learning process itself than with the content of learning (Donnelly and Fitzmaurice, 2005).

The benefits of project work for learning are self-initiative and self-monitoring of learners and the strengthening of their sense of innovation. Disadvantages of project work may include a lack of motivation and poor ability of students to organize their own work. For the teachers, obstacles may come in the form of time constraints, a greater amount of planning and preparation, and assuring more financial resources (Donnelly and Fitzmaurice, 2005).

BEST EXAMPLES OF INNOVATIVE PEDAGOGY IN AVET

In accordance with the proposed guidelines for innovative teaching from national reports on innovative pedagogical practices, the project partners selected one case from each partner country. Individual cases were selected according to the findings from the previous chapter.

France

As the most innovative pedagogical practice the French partners highlighted a project on teaching from the point of view of local issues among the examples presented at the national level: *The Collective Production of Alfalfa Within the CASDAR Luz'Co - Cibeins school*. The selected example is based on project work, problem-based learning, the involvement of local actors and learning from real-life situations for a deeper understanding of the local issue of producing fodder legumes (Peltier, 2019). Students are actively involved in a 40-hour process, where in close cooperation with teachers, local actors and experts they develop new knowledge. Through different learning stages and situations, students, using

different learning tools for first-hand information gathering (interviews) and in-depth analysis, reinforce the overall understanding of the development and implementation of a joint project at the local level, look for suitable solutions and provide well-founded initiatives for identified problems, upgrade their knowledge of sustainable approaches to the production of fodder legumes, and reinforce communication skills to present their own findings and new ideas (Peltier, 2019).

Problems faced by teachers in the implementation of the presented project approach are, in particular, the lack of motivation of other teachers for participation in the project work, lack of time, lack of expertise in the subject area, failure to achieve the set learning objectives, recognition (institutionalization) of acquired knowledge at the end of the activity (Peltier, 2019).

In accordance with the defined guidelines for teaching cross-curricular topics developed by the project partners within the project, we can conclude that the French case consistently includes all the criteria for innovative teaching, as shown in Table 1.

Austria

As the most contemporary pedagogical approach to teaching and understanding sustainable and complex systems in the field of agricultural education and training, the Austrian partners have highlighted an example of teaching the topic "from producing to marketing local apples", which connects various items from different areas such as gardening, food processing, healthy diets, marketing and ICT. Learning takes place through the learning-by-doing approach and own experience, whereby students develop, both in theory and in practice, skills and new knowledge about cultivating and processing local apple products, the importance of a healthy diet and marketing. Through the learning process, which is largely taking place in the field, students, in cooperation with teachers, experts or farmers, learn about traditional local species and varieties of apple trees, sustainable production approaches, processing of various traditional apple products from juice, jam, dried products, and culinary products, to innovative approaches to direct local sales on the farm. The final products are also tested and evaluated (Dietrich and Freyer, 2019).

As can be seen from Table 1, the Austrian example includes the criteria for innovative approaches to teaching cross-curricular subjects, since learning activities can also be carried out in the form of project

work, not just in the form of regular lessons. A case study, through which students learn, analyze the system of functioning of the local food chain in the case of apple products, and propose improvements to the existing system, can be used effectively as a learning tool.

Italy

As a holistic approach to teaching about local and sustainable food systems, the project partners highlight the innovative example of the *Istituto Comprensivo Santa Marina - Policastro Bussentino*, which has developed a sustainable concept of a 'green school' to boost its own self-sufficiency in food production, food processing, sustainable waste management and composting. To this end, workshops have also been established in the local environment to revitalize local tradition and traditional knowledge. Through the implementation of the green school concept, which is based on cooperation with local actors, an active participation of students in diverse activities with an emphasis on learning-by-doing, laboratory research methods and experiential learning, young people reinforce understanding and develop skills and new knowledge in the field of management of local and sustainable food systems, gastronomic traditions, healthy lifestyles, responsible attitudes towards tradition and the rural environment, biodiversity, and nature (Basile, Nicoletti, Paladino and Addesso, 2019).

We can conclude that the selected Italian example of innovative pedagogical practice includes the criteria for innovative teaching, as can be seen from Table 1, since the learning process is also based on project work, where young people develop new knowledge from the inital idea, to a new product. Also, in the learning process, the learning tool of case study can be successfully used to enable students to explore the functioning of concrete local food chain cases, rural development, nature protection, etc., compare them with each other, and search for new proposals for a further development of the green school concept.

Portugal

As an example of innovative pedagogical practice, the Portuguese partners have highlighted the learning strategies implemented at the Agrarian Superior School of Coimbra as part of the subject Soil and Fertility. When transferring theoretical knowledge into practice, a classical learning tool, such as a video recording, is used in an innovative way to promote reflection and collaborative learning among

students. Emphasis is placed on student-centred learning strategies, for example, problem-based lessons and group work. Students diagnose the presented real-life problems and with the support of the teacher, look for suitable and justified diverse solutions to specific problems in a discussion. Through the learning process, students deepen their existing knowledge and understanding of the topic under discussion, enhance the skill of critical thinking, responsibility for their work and the ability to transfer theoretical knowledge into practice (Dias Sardinha and Rodrigo, 2019).

In the Portuguese case, we can find all the criteria of innovative teaching approaches. Only the use of two tools, field work and project-based work, is less pronounced, however, it can also be carried out if the classes take place at a school estate or a local farm, especially in cooperation with local actors, farmers, and experts.

Slovenia

Project partners from Slovenia have selected, as the most innovative national-level pedagogical practice, an all-school project called *Food Waste Handling at the Education Centre Piramida Maribor*.

The practice is recognized as innovative primarily because of the holistic and systemic integration of food waste issues into the general study program of all directions, as well as in the organization of our own kitchen and bakery shop, and the active involvement of high school and university students since the beginning of the project, as many new ideas and solutions arise precisely out of the analysis of food waste management, which was carried out among the students of the institution. The approach contributes to more a effective awareness-raising of young people about the subject and sustainable approaches to food production and food processing, as well as to finding new ideas and solutions to reduce food waste and develop better-quality food products (Lužnik, Davidović and Vovk Korže, 2019).

The learning practice is based on experiential education, learning by doing, project work, integration of external experts, independent student group work, and the use of various learning tools such as ICT technologies, healthy food preparation tools, the school garden, best practice visits, excursions, etc. Through various activities in the classroom and in the field, young people develop skills and deepen their knowledge about innovative solutions for recycling and re-using food, the importance of locally produced and processed food, a healthy lifestyle, sustainable approaches to preparing and processing food and packaging, reducing environmental pressures, etc. In the future, the institution plans to

develop new recycled products from locally grown organic raw materials prepared according to traditional local recipes, and strive towards an integrated transition to an environmentally-friendly packaging of sales products (Lužnik, Davidović and Vovk Korže, 2019).

Difficulties reported by the teachers regarding the implementation of the presented activities include a lack of students' motivation for testing new recipes with recycled foods and the need to upgrade ICT technologies for a more efficient implementation of learning contents (Lužnik, Davidović and Vovk Korže, 2019).

In the Slovene case of innovative pedagogical practices, we recognize all the criteria of innovative teaching of cross-curricular subjects, as can be seen from Table 1.

Tabel 1: Selected cases of innovative pedagogical practices for teaching cross-curricular subjects according to the criteria of innovative teaching approaches (the notion of innovation is redundant here because this refers to current and past practices)

		Austria **Integrated teaching from producing to marketing apple products**	France **Teaching from the point of view of a local issue: production of fodder legumes**	Italy **Territorial approach to teaching on the example of a green school**	Portugal **Student-centred teaching in the Soil and fertility subject**	Slovenia **Food waste handling at the EC Piramida**
Innovative pedagogical approaches	Transdisciplinarity	Connecting different sciences, expert areas and topics (horticulture, production, processing, ICT, dietetics, marketing). Cooperation with local actors and experts	Connecting different sciences, expert areas and topics (agroecology, farm business, functioning of agro-ecosystems, managing biotechnical systems, common management of the production of fodder lucerne, etc). Cooperation with local actors and experts	Connecting different sciences, expert areas and topics (production, environment, economy, culture and society). Cooperation with the family, local actors and experts	Connecting different sciences, expert areas and topics ((production, environment, economy, culture and society). Cooperation with local actors and experts	Connecting different sciences, expert areas and topics (production, environment, economy, culture and society). Cooperation with the family, local actors and experts
	Systems thinking	Understanding the functioning of agricultural chains, local food chains.	Understanding the functioning of different types of systems at different levels (farm, local community, region, etc.). Development of new ideas and sustainable solutions.	Understanding the functioning of the local agricultural food chain, the system of re-use, the concept of zero waste, the development of new products. Development of new ideas and sustainable solutions.	Understanding the functioning of natural processes, nutrient cycling, the effect of humans on the natural environment, etc.	Understanding systems of nutrient cycling, re-use, the concept of a circular economy. Development of new ideas and sustainable solutions.
	Active learning	Teacher-mentor (Support, guidance, coordination between external experts and students to transfer knowledge from theory into practice. Active involvement of students in the learning process.)	Support, guidance, coordination between external experts and students to transfer knowledge from theory into practice. Active involvement of students in the learning process.	Support, guidance, coordination between external experts and students to transfer knowledge from theory into practice. Active involvement of students in the learning process.	Support, guidance, coordination between external experts and students to transfer knowledge from theory into practice. Active involvement of students in the learning process.	Support, guidance, coordination between external experts and students to transfer knowledge from theory into practice. Active involvement of students in the learning process.
	Experiential and problem-based learning	Learning-by-doing from the field of production, processing, the lawfulness of marketing, development of new products in real-life circumstances	Researching, analyzing, prognosis of a local problem	The development of ideas for new local products, sustainable production and processing	Analysis of case studies and finding sustainable solutions.	Development of new recipes and products, testing new products, presentation of work results

		Austria **Integrated teaching from producing to marketing apple products**	France **Teaching from the point of view of a local issue: production of fodder legumes**	Italy **Territorial approach to teaching on the example of a green school**	Portugal **Student-centred teaching in the Soil and fertility subject**	Slovenia **Food waste handling at the EC Piramida**
Innovative pedagogical tools	Digital tools	Use of software for collecting and processing data, preparing reports, presenting results, etc.	Use of software for collecting and processing data, preparing reports, presenting results, etc.	Using digital tools for collecting information, preparing presentations	Using digital tools (video) for collecting information, analysing the state of the concrete problem, preparing presentations	Using digital tools for collecting information, preparing presentations
	Field work	Work in the school garden and the possibility of working in other service facilities such as drying room, wine cellar, school kitchen etc.	Work in the local environment, visiting a farm, meetings with local actors, etc.	Work in the school garden, work in a school canteen, visit a local laboratory for rural development and re-use, etc.	Unknown – possibility of researching in the field, visiting a farm, discussions with local actors, etc.	Work in the school shop, school garden, school canteen
	Case studies	Unknown – possibility of researching a local case	Analysis of the concrete example from the project on the production of fodder legumes, search for solutions and development of new initiatives	Unknown – possibility of researching a local case	Analysis of concrete examples with practical problems, search for various sustainable solutions and initiatives.	Analysis of food waste management among students of EC Piramida (survey). Research into best practice examples, developing new sustainable solutions and initiatives.
	Project work	Unknown – possibility of implementation in the form of a project from crop to product, start-up of own company for marketing products, etc.	Working with local actors on a concrete project	Phase implementation of activities: school garden, school canteen, composting, eco-snacks, re-use, rural development	Unknown – possibility of performing project activities in cooperation with local actors, experts, etc.	All-school project lasts for a longer period of time, involvement of different teachers, implementation in several project phases, public presentation of work results
Problems faced by teachers or students		No problems detected	Teachers' lack of motivation to participate in the project, lack of expertise on the topic discussed, providing the attainment of the set learning goals, problem of institutionalization of knowledge after the completion of the activity	No problems detected	No problems detected	Lack of motivation in teachers and students for cooperation, lack of motivation in students to test new products, need to develop new ICT materials

GENERAL CONCLUSION

Due to contemporary challenges faced by the society, the partners find that it is necessary to improve the existing education and training systems in the field of agriculture and biotechnology and related fields. The key to this is the strengthening of the design and introduction of innovative forms of teaching and learning, therefore this Synthesis Report summarizes the state of innovative approaches to learning and understanding complex sustainable systems in partner countries.

The first part of the Synthesis Report presents the state of use of innovative approaches in vocational education in partner countries. Pedagogical innovation has been found to include the integration of new or renewed programs and resources for more effective education, with innovation being objective or subjective. Thus, the pedagogical innovations described in the report are not objective innovations or innovations for all, but represent a starting point or guideline for the conception of objective innovations in education.

In the second part, innovative pedagogical approaches are presented, which include cross-curricular interdisciplinary thinking, active involvement of students, and the implementation of practical and experiential education. Among the innovative pedagogical tools, there is great emphasis on the use of digital technologies, which in contemporary times are an important component of the acquisition of knowledge and skills. In addition to technologies, other tools such as field work, case studies and project work are also important, and their integration and complementarity is especially recommended.

In the last chapter, one selected example of pedagogical practice from each partner country is presented, which, according to the selected criteria and scientific and technical literature, is recognized as the most innovative one. Examples point out the characteristics of pedagogical approaches and tools which are used in an innovative way.

With this Synthesis Report, the partners are presenting approaches which enable the development of new transdisciplinary skills in a holistic way for a successful integration of different fields from natural sciences, social sciences, humanities and diverse practices. The pedagogical approaches and tools presented, if well considered, can contribute to the protection of natural resources and biodiversity, while ensuring good quality food safety for the growing world population. Vocational education teachers can use the presented approaches to design new innovative programs which will motivate and activate young people more effectively, to become the bearers and creators of new and useful skills

already during the learning process. Apart from learning about the importance of food-related topics, through the use of innovative pedagogical approaches and tools, the students can respond effectively, critically and responsibly to the challenges of contemporary society, strengthen the values of coexistence with nature, while taking into account the limitations of natural resources and recognizing the opportunities for creating their own green jobs.

The findings in this report are also a starting point for the design of a learning tool for the development of lasting and useful knowledge and skills in the field of LSFS, both in the professional as well as in the everyday life of young people. Based on the findings from the report, it makes sense to develop a new pedagogical tool on the following principles:

- practical and experiential education,
- active participation in solving real-life environmental and societal challenges,
- networking of different stakeholders in and outside educational institutions,
- strengthening genuine contact with nature and communities,
- well-considered use of digital technologies, and

identifying examples of best practices and upgrading them.

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