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# Service-learning: Innovative Pedagogy for Resolving Environmental Problems – What Have We Learned in the Past Ten Years?

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4<sup>th</sup> ZORH CONVENTION

## Abstract

Service-learning represents an innovative pedagogy that integrates academic learning with community service to address environmental issues based on experiential learning principles. This innovative pedagogy enhances higher education learning outcomes by fostering active engagement, real-world context, interdisciplinary insight, skills development, and civic engagement among students. The merging of service-learning contributes to a profound understanding of the subject matter, its practical applications, and personal and professional growth. This paper provides an overview of the implementation of service-learning in the STEM field, with a primary focus on the decade-long involvement of the Faculty of Chemistry and Technology in environmental protection projects. Through collaboration with the non-governmental organisation Sunce and partners from the University of Split, this initiative, led by environmental experts, has introduced a novel approach to higher education, facilitating knowledge expansion, skill improvement, and expertise development for both students and academic staff. The impact has been substantial, with the University of Split attaining the 21<sup>st</sup> position globally on the “World Universities with Real Impact” list for ethics in 2021, largely attributable to these service-learning projects. Service-learning has been integrated into the SEA-EU initiative, furthering its development at the University of Split, and establishing it as a pioneer in this field. Institutionalising service-learning in higher education requires the establishment of dedicated courses, integration into existing programmes, and the allocation of resources for academic staff, community partners, and students. Successful implementation requires a collaborative, iterative process involving careful planning, preparation, and assessment, ensuring that students benefit from meaningful opportunities to apply course content to real-world challenges while positively impacting the community.

## Keywords

*Service-learning, education theory, curriculum, learning outcomes, Faculty of Chemistry and Technology, University of Split*

## 1 Introduction

A socially conscious and sustainable society must be fostered through community and industrial development that values and protects the environment. Educational institutions are adapting their curricula to better prepare students for a labour market where environmental awareness holds significant importance. In response to this challenging circumstance, the United Nations (UN) General Assembly formulated the 2030 Agenda, outlining 17 Sustainable Development Goals (SDGs) to advance sustainable development. Thus, to provide effective Education for Sustainable Development (ESD) in Science, Technology, Engineering, and Mathematics (STEM), instilling values related to sustainability and environmental concern must be given high priority in the education system.<sup>1</sup> Service-learning, a recognised pedagogical approach, addresses these challeng-

es and contributes to the SDGs by integrating academic learning with community service to tackle environmental issues in the local community.<sup>2</sup> Service-learning contributes extensively to Education for Sustainable Development (ESD).<sup>3</sup>

Recently, service-learning has become a topic of academic and policy concern in the European Higher Education Area (EHEA) as a stand-in for community-engaged teaching and learning methodology in higher education institutions (HEIs).<sup>4</sup> Service-learning, as a form of experiential pedagogy, involves students applying their acquired knowledge to address community problems collaboratively. Learning unfolds through a cycle of action and reflection, allowing students to achieve meaningful goals within university courses designed to address local community issues, fostering a deeper understanding of themselves and the local problems.<sup>2</sup> Recognised as an innovative pedagogy, service-learning encompasses activities benefiting all stakeholders — community members as service recipients, faculty members as facilitators, organisers, and coordinators between academic institutions and the community, and students as both service providers and learners in service-learning experiences.<sup>5–8</sup>

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**Note:** The findings of this study were presented at the 4<sup>th</sup> International Convention of Scientists, Specialist Employees, and Students on the topic of Environmental Protection in the Republic of Croatia (4<sup>th</sup> ZORH Convention), held on April 20–21, 2023, at the Faculty of Chemistry and Technology University of Split, Croatia.

In order to create successful service-learning programmes, instructors, community partners, and students are essential participants. Service-learning offers meaningful service activities that address actual community needs as defined by the community; it is structured around clear learning objectives and is connected to course content. Moreover, it gives students the opportunity to reflect critically on their service experiences.<sup>5</sup> Students engage in projects, tasks, or activities that benefit society in collaboration with civil society organisations, benefiting students, faculty/teachers, and the local community. In addition to realising the learning objectives of specific courses, students contribute to achieving the organisation's goals and vision while acquiring new, specialised knowledge and skills under the guidance of staff members.<sup>2,5</sup>

Although service-learning is a well-known and innovative pedagogy implemented in numerous universities worldwide, it remains relatively new in Croatia. A decade ago, in 2013, the Faculty of Chemistry and Technology (FCT) in Split introduced service-learning implementation, allowing students to engage in projects related to service-learning in the STEM field. The FCT, a higher education institution at the University of Split founded in 1960 to address the growing need for engineers in the field of chemistry and technology sectors due to the development of the chemical industry in the Dalmatia region of Croatia, is one of the oldest components of the University of Split. Today, the FCT stands as a recognised research and educational institution with more than 100 employees and approximately 700 students actively involved in the study process. Its mission is to systematically develop and expand nationally and internationally recognised excellence in education and research, primarily focusing on natural sciences, – the scientific field of chemistry, and technical sciences – the scientific field of chemical engineering, as well as biotechnical sciences – the scientific field of food technology. The environmental issues in the Republic of Croatia, especially along the coast, are numerous, due to intensive tourist activities, inadequate waste management, biodiversity pressures, the impacts of climate changes, and other issues. The Association for Nature, Environment and Sustainable Development Sunce, a non-governmental organisation (NGO) based in Split, Croatia, was established in 1998. Today, it is one of the leading environmental organisations in Croatia, boasting over 300 members and the successful implementation of more than 250 projects, with 65 to 80 % of funding originating from international sources, primarily foundations for nature and environmental protection, and EU funds. Based on its numerous achievements, Sunce has earned national and international recognition as one of the leading organisations for nature and environmental protection in Croatia. The organisation's activities are grounded in current scientific indicators, examples of good practice, expertise, and extensive experience in nature and environmental protection. Since 2005, the NGO Sunce has operated under participatory multi-year strategic plans (the latest covering 2021–2026), enhancing coherence of goals and activities, thereby increasing the potential to achieve anticipated social changes. One of the main educational initiatives of the NGO Sunce is to support behavioural changes in individuals and cultivate their proactive needs. Students actively work on community problems through

educational programmes, considering each issue as an opportunity for engaged individuals to gain hands-on experience and collaborate with their institutions and the local community. The service-learning projects developed and implemented by the NGO Sunce in cooperation with the FCT have proven to be successful tools over a decade of successful collaboration, raising awareness and addressing environmental issues with students in the local community.

This paper provides an overview of service-learning projects and activities conducted over the past decade at the FCT under the leadership of the NGO Sunce. Special attention is given to the skills, knowledge, and experience acquired by the students during the process, contributing to the learning outcomes of the students involved in service-learning implementation, as well as the benefits for the teaching staff and the local community.

## 2 Service – learning: Innovative pedagogy approaches for resolving environmental problems

Service-learning represents an innovative pedagogy offering students specific, measurable, achievable, relevant, and time-bound opportunities to engage in meaningful work in collaboration with civil society organisations while aligning with their academic courses and allowing them to accumulate credits in the ECTS (European Credit Transfer and Accumulation System). This structured approach ensures that service-learning is an effective and goal-oriented form of experiential education. The unique aspect of service-learning is that it focuses on students participating in real work, projects, or activities with clear societal benefits. Such activities have been executed within the framework of civil society or the NGO Sunce. This non-profit organisation addresses the community needs and challenges related to environmental, nature protection, and sustainable development issues. The success of service-learning is measured through acquisition of ECTS credits, a standardised method of quantifying students' academic achievements. These credits are formally awarded within specific courses at the FCT, making the outcomes of service-learning projects quantifiable and measurable. The achievable aspect of service-learning is demonstrated through the collaboration among three key parties: faculties/teachers, students, and civil society organisations (NGOs). This collaboration ensures that students engage in meaningful work within the NGO while fulfilling academic requirements. Interdisciplinary teamwork with students from other faculties involved in the implemented projects provides students with a different perspective on the real-life challenges they may encounter in the job market. Specific learning outcomes and the acquisition of new knowledge and skills are made possible by this model. The relevance of service-learning is evident in its ability to serve the interests of all three parties involved. Civil society organisations benefit from student contributions that help advance their missions and visions. Students gain practical knowledge and skills directly relevant to their academic work. Credit for student participation in the service-learning programme was granted by exempting a portion of the course exam, usually equivalent

to 1–1.5 ECTS credits, from the course whose outcomes are achieved through the service-learning student project. Faculties and teachers find it essential to connect students' experiential learning with the educational objectives of their courses. The projects developed for service-learning are structured within a specific timeframe, usually aligned with the duration of a dedicated course or academic semester at the FCT. Learning outcomes and objectives were planned and achieved within this time-limited framework to ensure that students' efforts were focused and productive.

The experiences and skills acquired are processed and evaluated through guided reflection, a central feature of service-learning. Reflection "plays a decisive role in being able to process, organise, and evaluate the experiences and skills acquired." It serves as "the link between service and learning" and is key to enabling "learning through experience" in service-learning. We employed various methods for reflection with the students, including the Learning Diary, MicroArt Method, Reflection Roundabout, Letter to Myself, and Exchange of Questions.

**Learning Diary:** The students created and maintained a learning diary throughout the service-learning programme, supporting a differentiated examination of their learning. Primarily, it facilitated the observation and recording of the process and their engagement with the topic of the service-learning project. This method unfolds in three phases: A) Before the start of the service-learning programme, B) During the service-learning programme, and C) At the end of the service-learning programme.

Questions that the students have to answer include:

- A) What do I expect from myself? What do I expect from participating in the service-learning programme? What are my (learning) goals? Do I have any questions, or do I need help/support?
- B) What was new? What aroused my interest? What motivated me? Did I miss anything? What learning progress have I made? Would I like to tackle this topic as part of the service-learning programme? Do I have any ideas I would like to continue working on? What would I like to pay particular attention to at the next workshop? Do I need help/support?
- C) What have I learned from working with the NGO Sunce? How will this learning help in continuing your studies or your future work – give a concrete example. What was particularly good? What achievement would you highlight? What should you pass on to the next group of students? What should be done differently? Where do we need help/support? What challenges have arisen?<sup>26</sup>

An overview of reflections from the final workshop with students, professors, and NGO Sunce representatives within the PAZI! Projects framework, is given in the Supplemental section.

In addition, the University of Split applied for the "World Universities with Real Impact" list for "Ethical Values" in 2021 and 2022. Service-learning is particularly highlighted as an example of good practice at the University.<sup>9</sup> The

methodology for the evaluation process and the list of categories can be found on the WURI web page.<sup>10,11</sup>

### 3 Discussion

Higher education institutions (HEIs) aspire to provide their graduates with cutting-edge knowledge and employable skills relevant to the modern world and the job market. Service-learning activities in the STEM field, as implemented at the FCT, have demonstrated promising results that have contributed to the achievement of this crucial goal. According to quality assurance requirements, HEIs should ensure that programmes encourage students to play an active role in sharpening the learning process with assessments reflecting this approach. The innovative service-learning pedagogy applied at the FCT has fully contributed to this goal, elevating the overall quality of education.

In the past decade (2013–2023), the FCT, in collaboration with NGO Sunce and other University members, participated in four major projects funded by the European Commission through the European Social Fund, European Solidarity Forces, and DBU (The Deutsche Bundesstiftung Umwelt), as well as the Sense Foundation Brussels and the SEA-EU Alliance, funded by the European Commission. DBU, a German environmental foundation, is one of Europe's largest foundations supporting innovative environmental projects, and the SEA-EU Alliance is actively involved in these projects. A list of activities and projects designed by the students is detailed in Table 1.

### 4 Students' benefits from service-learning

The service-learning innovative pedagogy can be viewed from the perspective of student-centred learning and teaching, significantly fostering students' motivation, introspection, and participation in the learning process. In this context, service-learning involves thoughtful planning, implementation, and evaluation of service-learning pedagogy activities, with outcomes reflected in student evaluations. Students actively participate in each project involving service-learning innovative pedagogy, thereby acquiring essential skills such as critical thinking, problem-solving, communication, independence, teamwork, social awareness, and a sense of civic responsibility.<sup>5,8</sup> Activities and projects developed as part of service-learning innovative pedagogy at the FCT showed great respect for the diversity of students and their needs, enabling flexible learning. The main activity within the service-learning innovative pedagogy involved developing and implementing projects aiming to address real-life environmental issues in the local community under the leadership of NGO Sunce. To identify the community needs and prospects for providing projects involving service-learning innovative pedagogy in the best interests of community members, faculty members, and students invested considerable effort into needs assessments. The students then developed their projects in environmental protection, demonstrating their ability to solve problems and work in interdisciplinary teams with

other students from the University of Split and the NGO Sunce. Real environmental problems were addressed in these projects, and the work was recognised as part of obtaining ECTS credits in courses related to environmental issues at the FCT. This approach provided students with project-based learning opportunities with a strong impact on the local community. Upon completion of the projects, a public presentation of the results was organised by the students, allowing FCT members, students, and the local community to learn more about the projects and activities developed and implemented. Some projects proved inspiring, leading to thesis development for certain students, and encouraging their future professional development.

The service-learning innovative pedagogy presented students with a unique opportunity to develop transferable skills, including teamwork and interdisciplinary collaboration. Within the service-learning pedagogy, students often worked in groups, which required effective communication. They gained the ability to communicate ideas effectively, listen attentively to others, and adapt their communication style to various stakeholders and team members.

Through service-learning, students were encouraged to cooperate and work as a team to achieve common goals, assigning responsibilities, recognising each other's abilities, and fostering mutual encouragement. Service-learning facilitated the development of conflict resolution skills as students learned to resolve conflicts, reach agreements, and maintain a positive workplace culture. Students gained experience in both leadership and followership roles, developing flexibility and leadership abilities by learning when to take the initiative and when to support others. A multidisciplinary approach is essential to address the multitude of complex real-world issues that are tackled in service-learning innovative pedagogy. Students gain the ability to recognise complex problems, break them down into manageable components, and use information from various academic fields to devise solutions. Interdisciplinary work encouraged critical thinking, as students examined multiple viewpoints, questioned assumptions, and evaluated potential solutions, fostering well-informed decision-making. Real community issues often require imaginative and inventive solutions. Students working in a multidisciplinary environment develop their ability to think creatively by combining concepts from several disciplines to produce original ways of problem-solving. This cross-disciplinary approach equips students with different techniques, languages, and problem-solving approaches, encouraging their flexibility for operation in diverse professional environments. As students learn to understand and respect people from diverse cultural, social, and economic backgrounds, they also gain empathy and cultural competency. Learning effective time management, essential for balancing service-learning pedagogy projects and academic commitments, improved the students' organisational skills.

Reflection aids students in becoming more self-aware. Increased self-awareness can help them develop personally and professionally as it highlights their strengths, weaknesses, and progress. Engaging in service-learning pedagogy projects not only allows students to positively impact their local community but also cultivates important skills that prepare them for future academic and professional suc-

cess. These skills are highly valued in the job market and can lead to versatile, adaptable, and socially aware individuals. Service-learning pedagogy projects have the potential to increase student motivation by making learning more purposeful and relevant. Moreover, they foster entrepreneurship skills, promoting problem-solving, innovation, teamwork, networking, and a risk-taking mindset. Within service-learning pedagogy projects, students experience a sense of autonomy while benefiting from the guidance and support of their academic staff.

Demonstrating all the aforementioned skills, the students engaged in service-learning pedagogy projects moved forward and, together with the academic staff, organised the international meeting "ZORH" that brings together scientists, professionals, and students focused on environmental protection in the Republic of Croatia. The ZORH meeting, held since 2018, with a two-year interruption due to the coronavirus pandemic, gathers students, young engineers, and experts from Croatia and Europe to exchange knowledge, experience, and new achievements in environmental protection. It also contributes to raising awareness of the need to protect the environment and nature in all forms of economic and social activities. A unique aspect of this meeting is that students organise it, while FCT academic staff are members of the Scientific Programme Committee. Since 2021, the organisation of ZORH has expanded internationally. The third ZORH meeting was organised by students from the FCT and the Faculty of Materials, Metallurgy and Recycling of the Technical College in Košice, in cooperation with the Alliance of European Maritime Universities (SEA-EU) and the student section of the Croatian Society of Chemical Engineers and Technologists. The 4<sup>th</sup> ZORH meeting involved students from the Faculty of Maritime Studies from Kotor (Montenegro) in its organisation.<sup>32,33</sup> The ZORH conferences typically attracted around 150 participants from Croatia and other countries such as Slovenia, Slovakia, Czech Republic, Bosnia and Herzegovina, Romania, Moldova, Ukraine, Spain, France, Germany, Poland, and Malta. Presentation topics encompassed current environmental protection issues in Croatia and globally, waste management, wastewater treatment methods, marine pollution, remediation of pesticide-treated soils, air quality, waste as a raw material, endangered species in nature and national parks, new technologies and techniques in environmental protection, microplastics, and the impact of the Covid-19 pandemic on environmental protection. All teaching staff involved in projects with service-learning pedagogy also played a role in preparing the ZORH conference, fostering a sense of autonomy among students while ensuring appropriate guidance and support from academics. This also promoted mutual respect within the student-teacher relationship at the FCT, as the work initiated with service-learning pedagogy projects was now recognised nationally and internationally at a higher level.

In addition, some service-learning pedagogy projects have inspired students to consider social entrepreneurship, with their ventures focused on both financial success and social good. Students have developed waste management devices such as the pilot-scale rotary drum composter and *C-EcoForHome* composter (see the results column in Table 1), and participated in student incubator activities promoting sustainable development goals related to entre-

Table 1 – Overview of performed service-learning projects at the Faculty of Chemistry and Technology  
 Tablica 1 – Pregledi izvedenih projekata društveno-korisnog učenja na Kemijsko tehnološkom fakultetu

Project title Naziv projekta	Funding Financiranje	Timeframe Vremenski okvir	Project partners Projektni partneri	FCT teaching staff Nastavno osoblje KTF	Students involved (number) Uključeni studenti (broj)	Results Rezultati
Students Learn about Civic Engagement through Service-learning in Environmental Protection	Deutsche Gesellschaft für Umwelterziehung	2016–2018	NGO Sunce (leading partner) Faculty of Philosophy Faculty of Economics Faculty of Chemistry and Technology in Split Department of Marine Studies, University of Split	I. Carev M. Buljac N. Vukojević Medvidović L. Vrsalović	4	Capacity building at FCT <sup>12</sup> : 1. <i>Workshops</i> 2013: “Participatory Learning Methods” 2016: “Training – Development of Skills and Methods for Working with Youth” 2. <i>Study visits</i> – University of Erfurt and NaturErlebnisGarten “Fuchsfarm”, Erfurt, Germany – University of Kassel and the Die Kopiloten e.V. Association, Kassel, Germany – University of Duisburg-Essen and UniAktiv, Essen, Germany 3. <i>Developed student projects</i> – Green Recycling Areas on Faculty Grounds – Plastic Detox 4. Lecture for FCT Alumni: “Service-learning in Environmental Protection”, 2016, Split, Croatia.
PAZI!-Practical-Active-Together-Interdisciplinary!	European Social Fund	2018–2021	NGO Sunce (leading partner) Faculty of Philosophy Faculty of Economics Faculty of Chemistry and Technology in Split Faculty of Chemistry and Technology ALUMNI Association	I. Carev M. Buljac N. Vukojević Medvidović L. Vrsalović I. Smoljko M. Marušić	10	Capacity building at FCT <sup>12</sup> : 1. <i>Workshops</i> 2020: “Sustainability Plan for Service-learning” 2019: “Improving Knowledge and Skills for the Implementation of Service-learning” 2. <i>International conferences on service-learning in HEI</i> <sup>13,14</sup> 3. <i>Performed student projects</i> – Watch Out Now – Eco Quiz! – Don’t Be Like an Ostrich – Waste Selection at the University Campus in Split – How to Become an “Eco” Accommodation Provider? – UniCompoST – Creation of Pilot-scale Rotary Drum Composter – Don’t Put Everything into the Same Basket 4. <i>Diploma theses</i> <sup>15,16</sup> 5. <i>Conference initiation and organisation</i> <sup>7,17,18</sup> 6. <i>Conference oral presentations</i> <sup>13,14,19,20,21</sup> 7. <i>Conference poster presentations</i> <sup>22,23</sup> 8. <i>Proceedings</i> <sup>7</sup> 9. <i>Published scientific papers</i> <sup>24,25</sup> 10. <i>Development of life – long learning</i> Summer school “Service-learning for Nature and Environment at University” <sup>26</sup> 11. Established office for service-learning at the University of Split

Table 1 – (continued)

Tablica 1 – (nastavak)

Project title Naziv projekta	Funding Financiranje	Timeframe Vremenski okvir	Project partners Projektni partneri	FCT teaching staff Nastavno osoblje KTF	Students involved (number) Uključeni studenti (broj)	Results Rezultati
Raising Awareness of the Role of Composting	Sense Foundation Brussels	2021–2022	NGO Sunce (leading partner) Faculty of Economics Faculty of Chemistry and Technology in Split University Department of Professional Studies KLIPER institutions for the education of human resources in the maritime industry	M. Buljac N. Vukojević Medvidović	3	The project's goal was to raise awareness in the local community that the separate collection and composting of biodegradable waste is an essential link in an integrated waste management system, a circular economy, and environmental protection. As part of the service-learning programme, employees of educational institutions were educated about the use of the C-EcoForHome composter and the disposal of bio-waste in collaboration with teachers and students from four different faculties.  <i>Finished bachelor and master thesis<sup>27–29</sup></i>
UniCompoST Classroom	European Solidarity Forces - project number 2021-2-HR01-ESC30-SOL-000039113.	2022	ALUMNI Association (Association of former students and friends of the Faculty of Chemistry and Technology (AMACTFS))	M. Buljac N. Vukojević Medvidović L. Vrsalović, M. Marušić, S. Svilović	–	As part of this project, FCT teachers actively served as mentors in creating educational opportunities and imparting certain practical and theoretical aspects and skills for fieldwork in the areas of waste management, composting, recycling of all waste fractions, sustainable development, and environmental protection. They also participated in the testing and trial of a new device that combines biowaste processing with "indoor" gardening at the Faculty, contributing to knowledge and technology transfer in sustainable waste management.
SEA-EU Alliance		2019–today		Members of the platform for service-learning at UNIST: I. Carev M. Buljac N. Vukojević Medvidović L. Vrsalović I. Smoljko M. Marušić		Creation of a platform of experts in service-learning at the University of Split where all teaching staff from FCT are involved.  <i>1. Organised conferences</i> 2022 Split: "Community-engaged University." 2024 Cadiz: "Higher Education in the Service of Society".  <i>2. Conference presentation<sup>31</sup></i>

preneurship. Besides being used in educational activities in the local community, these composting devices were employed for scientific research activities, including the preparation of final and diploma theses, and the publication of scientific papers in a scientific journal (see results column in Table 1).

From the service-learning pedagogy projects at FCT, it is evident that they not only enhanced students' transferable skills, teamwork, and interdisciplinary work but also motivated them by connecting academic learning to real-world impact. Organising international conferences with a topical theme in their professional field fostered entrepreneurship skills, potentially inspiring social entrepreneurship.

## 5 Faculty members' benefits from service-learning

The growing acceptance of service-learning as a pedagogy, together with the need for social responsibility and growing community collaboration has encouraged members of higher education institutions to use innovative service-learning pedagogy as a tool to achieve their academic goals.<sup>5</sup> The FCT's academic teaching staff have also benefited significantly from projects involving service-learning pedagogy in various ways. The academic staff was able to develop and improve their teaching skills by designing, implementing, and leading service-learning pedagogy projects. They learned to create engaging and practical learning experiences for their students and were prepared by participating in workshops and study visits to Germany. The workshops for teachers were organised as part of the project PAZI 2020: "Sustainability Plan for Service-learning"; PAZI 2019: "Improving Knowledge and Skills for the Implementation of Service-learning"; DBU 2013: "Participatory Learning Methods" and DBU 2016: "Training – Development of Skills and Methods for Working with Youth". A study visit to Germany in 2016 for 11 participants of service-learning pedagogy projects and activities was organised as part of the project "Students Learn about Civic Engagement – Service-Learning in the Protection of Nature and the Environment". The participants of the trip were academic staff from the Faculty of Economics, Faculty of Philosophy, FCT, University Department of Marine Studies of the University of Split, and employees of the Sunce association. The aim of the study trip was to visit universities that implementing service-learning pedagogy projects with a focus on environmental issues:

- University of Erfurt and NaturErlebnisGarten "Fuchsfarm", Erfurt, Germany.
- University of Kassel and the Die Kopiloten e.V. Association, Kassel, Germany.
- University of Duisburg-Essen and UniAktiv, Essen, Germany.

Together with the academic staff and the NGO Sunce, certain ideas gained in Germany were implemented for students from four faculties of the University of Split. The handbook produced at the end of the two-year project

presented best practices of service-learning pedagogy projects from Germany and Croatia.<sup>6</sup>

The innovative service-learning pedagogy familiarised academic staff with the students' different learning styles, enabling them to better adapt to the students' individual needs. The projects developed within service-learning pedagogy often involved interdisciplinary collaboration, allowing academic staff to engage in projects spanning multiple fields, resulting in new findings and publications in academic journals. This provided an opportunity for action research, enabling academic staff to evaluate the effectiveness of their teaching methods, curriculum design, and the impact of service-learning pedagogy projects on student learning outcomes.

Academic staff had the chance to build links with community, local, and international partner organisations. Working with the community on service-learning pedagogy projects kept the academic staff in touch with real issues and challenges. This first-hand experience enhanced their teaching and research relevance. These connections led to opportunities for collaborative research, funding, and community engagement, which has enhanced their professional network and professional opportunities, as shown in the list of outcomes in Table 1. Teachers participated in service-learning conferences in HEI organised by international organisations and universities with service-learning experience, held in Madrid, Spain, and Antwerp, Belgium. This was an opportunity for them to share their expertise in service-learning in higher education and to network with other higher education teachers in Europe and worldwide.<sup>14</sup>

Projects that addressed service-learning pedagogy at the FCT contributed to the enhancement of teaching skills by promoting innovative pedagogy. In designing and implementing these projects, teachers experimented with different teaching methods and delivery modes consistent with the experiential nature of service-learning pedagogy. They incorporated real-world experiences, interdisciplinary approaches, and hands-on learning, thereby expanding their pedagogical toolkit. Additionally, service-learning pedagogy projects foster mutual respect within the student-teacher relationship. By engaging with students in community service and addressing real-world societal issues, teachers and students developed a deeper understanding and respect for each other's roles and contributions. This shared experience led to more meaningful and respectful interactions within the academic environment, as exemplified by the organisation of the ZORH conferences.

Another vital conference organised as part of service-learning pedagogy projects, was the 1<sup>st</sup> Conference on service-learning at Universities in 2018. The ESF project PAZI! (Practical-Active-Together-Interdisciplinary! – Service-learning Programmes for Environment and Sustainable Development) served as the umbrella organisation for the conference. The conference aimed to network service-learning actors and programmes in Croatia, exchanging information and experiences on the implementation of innovative service-learning pedagogy. Sixty participants were expected to spend two days discussing the current

state of service-learning programme implementation and the evaluation results of their implementation. They also shared their own success stories. The conference resulted in the production of conference proceedings, available to project users and conference participants in printed (one-hundred copies) and electronic form.<sup>7</sup>

Academic staff played a leading role in planning and implementing service-learning pedagogy projects. This experience fostered their leadership skills and contributed to their credential's involvement in innovative service-learning pedagogy, and inspired academic staff to champion community engagement and experiential learning within their institutions. The result was the inclusion of innovative service-learning pedagogy in the SEA-EU Alliance project, with the University of Split assuming a leadership role in this area within the Alliance, and FCT taking a leading role in STEM. The SEA-EU Alliance, one of the pioneers in the European Commission's European Universities Initiative, is an alliance of nine European coastal universities: Cadiz, West Brittany, Kiel, Gdansk, Split, Malta, Algarve, Naples, and Nord. Since 2019, it has been working together with more than 75 stakeholders, to shape the future of European Higher Education. The SEA-EU Alliance offers a broad range of opportunities for our entire community, uniting students, researchers, and employees at or with a SEA-EU university, providing courses, mobilities, languages, resources, infrastructures, and new joint degrees.

Implementing service-learning as a work package in the SEA-EU Alliance project has elevated this student-centred innovative teaching method to a higher institutional level, promoted the value of innovative service-learning pedagogy, and influenced institutional policy. As a result, a non-formal platform of experts in innovative service-learning pedagogy was formed, providing numerous opportunities for academic staff to get involved in improving their studies at the University of Split. This led to the organisation of the SEA-EU Service-learning Conference "Community-engaged University," held in Split in 2022 and attended by several international participants, including service-learning professionals from the University of Cádiz (Spain), Université de Bretagne Occidentale in Brest (France), University of Kiel (Germany), University of Gdańsk (Poland), University of Split (Croatia), and University of Malta (Malta), which form the SEA-EU Alliance (<https://sea-eu.org/alliance/>), and many others. The next conference on service-learning within the SEA-EU Alliance is scheduled for Cadiz in 2024.

Projects incorporating service-learning pedagogy not only improve teaching skills and learning outcomes but also make topics more relevant, engaging, and impactful for students, ultimately enriching their educational experience. The positive impact of service-learning pedagogy projects on community improvement gives academic staff a renewed sense of purpose in their teaching and research. Witnessing the growth and development of students through service-learning pedagogy was personally fulfilling and motivated academic staff to become even more involved as educators.

Reflection on service-learning pedagogy through projects has led to personal growth and self-improvement for ac-

ademic staff, positively impacting their teaching and research practices. In terms of professional development, engagement in service-learning pedagogy projects, workshops, conferences, publications on educational topics, and awards have contributed significantly to the references required for the professional development of the teaching staff at the FCT.

In summary, academic staff have benefited from service-learning pedagogy projects by applying innovative teaching approaches, improving their teaching skills, engaging in interdisciplinary research, expanding their network, finding personal fulfilment, gaining access to leadership opportunities, and experiencing personal growth. Their involvement in service-learning pedagogy projects can lead to an enriching and effective teaching and research career, and the enhancement of studies in general at the FCT.

## 6 Local community benefits from service-learning pedagogy projects

Projects with innovative service-learning pedagogy should provide solutions to real problems and create benefits for all stakeholders involved. Local people are considered the most critical actors in all service-learning pedagogy projects as they are the beneficiaries of the project.

Service-learning projects directly address the real needs and challenges faced by local communities. Students and the FCT collaborate with local community organisations, the NGO Sunce, to work on environmental issues. These projects provide the local community with additional resources and support. Students, academic staff, and NGO staff donate their time, energy, knowledge, and skills to improve the quality and reach of environmental programmes.

Service-learning pedagogy projects engaged students in solving problems around the University of Split, enabling them to actively address issues in their own community. Service-learning pedagogy projects have raised awareness of community issues among all stakeholders and encouraged civic engagement. This empowerment has fostered a sense of ownership and responsibility, helping community members understand their challenges, and inspired them to take action by involving young people in community service. Such engagement can be valuable in instilling a sense of responsibility and social awareness in the next generation. Our projects involving service-learning pedagogy focus on long-term solutions and sustainable development, as seen in the ZORH conferences organised by FCT students and academic staff, four of which have been planned so far, and will continue. The progress in the organisation of the conferences is also reflected in the increased involvement of more international partners each year, ensuring that communities continue benefiting from the project after its completion. Local communities could gain access to the expertise and skills of students and academic staff, enabling them to tackle future challenges more effectively. Through environmental projects incorporating service-learning pedagogy, communities could experience

a better quality of life, whether through a cleaner environment or expanded educational opportunities.

Projects incorporating service-learning pedagogy generated positive publicity for the community and the organisations involved, leading to additional support, funding, and collaboration for future initiatives. One of the students participated in the student incubator programme to develop a start-up based on the SDGs. Subsequent service-learning pedagogy projects involved Alumni from the FCT and the Kliper organisation, two other NGOs also involved in the local community and academic network. Additionally, the academic staff organised the first conference on service-learning pedagogy projects at universities in Croatia, “Education for the Environment and Sustainable Development in Croatia,” held in Split in 2018. This was followed by the implementation of service-learning as a work package in the SEA-EU Alliance project, leading to the in SEA-EU Service-Learning Conference “Community-engaged University” held in Split in 2022. A book of abstracts or conference proceedings was produced to contribute to environmental protection. The FCT academic staff also developed the curriculum, offering the possibility of a lifelong learning course, “Summer School of Service-learning in Environmental Protection”, for students interested in this topic.

It is worth mentioning that all the projects listed in Table 1 were carried out in cooperation with teachers from the Faculty of Economics, the Faculty of Philosophy, the Faculty of Law, and the University Department of Marine Studies of the University of Split. This collaboration strengthened the partnership among the mentioned organisations and imparted the projects and activities with a crucial element – interdisciplinarity. While both students and teachers from the mentioned faculties were involved in the listed activities, our primary focus in this work is to present the contributions of the FTC teachers and students.

The organisation of a non-formal platform for service-learning at the University of Split has demonstrated that FCT academic staff is leading in the STEM area among those involved in the implementation of the service-learning projects. In 2024, the next conference will be held in Cadiz, Spain, showcasing a promising outlook on service-learning projects and their importance in the European Higher Education Area. The research conducted so far on service-learning can provide communities with valuable information for evidence-based decision-making and policy development. These projects fortify social networks and community ties, leading to stronger professional connections and networks of individuals passionate about environmental protection. Participation in service-learning projects has sparked interest in civic engagement and advocacy, encouraging more active involvement in local government and policy discussions related to environmental protection.

The service-learning pedagogy projects that have been carried out have contributed directly to protecting and restoring a more sustainable environment, providing participants with hands-on learning experiences. They have gained a deeper understanding of environmental issues, ecosystem dynamics, and the importance of protecting the environ-

ment. This knowledge was shared with the wider community, raising environmental awareness through student projects and conferences. The service-learning projects foster a sense of community engagement and belonging, encouraging residents to actively participate in efforts to protect their environment and instilling a sense of ownership. Participants acquire practical skills applicable in their professional lives, enhancing their employment opportunities. A cleaner and healthier environment leads directly to improved public health, with reduced pollution and access to green spaces, enhancing air quality and physical well-being. Hands-on projects offer participants the opportunity to develop a greater sense of responsibility for their environment, potentially leading to long-term, sustainable changes in behaviour and local policies related to environmental protection. Involving young people in these projects makes them more likely to develop a lifelong commitment to environmental stewardship, inspiring future generations to do the same. A clean and well-preserved environment enhances the overall quality of life for community members, providing space for recreation, relaxation, and enjoyment, contributing to the well-being of individuals and families.

Local environmental protection efforts can have a cumulative effect on global problems such as climate change and biodiversity loss. When implemented in multiple communities, small actions can have a significant impact. Projects that incorporate service-learning pedagogy benefit local communities by directly addressing their needs, improving services, empowering residents, creating networks, raising awareness, engaging youth, promoting sustainability, transferring skills and knowledge, improving quality of life, providing positive public relations, providing valuable data, and inspiring community members to take action. We hope that the commitment and dedication of the students and educators in service-learning will encourage community members to get involved and take a more active role in local projects and initiatives. The initiatives have created connections between educational institutions and local organisations, developing valuable networks and resources that benefit the community beyond the project scope.

As valuable recognition for the hard work done as part of the service-learning project, the University of Split was ranked 21<sup>st</sup> in the world in 2021 on the “World Universities with Real Impact” list for ethics, and in 2022 it gained 18<sup>th</sup> position on the same list.<sup>29,39</sup> The NGO Sunce received awards in 2018 and 2019 for its excellent cooperation with the University of Split, becoming an important teaching base for the students of the University of Split. Given the excellent ranking of the University of Split, the FCT teaching staff received a special award for implementation of the service-learning project and exceptional contribution to the excellence of the University of Split.

All the references cited in this paper underscore the significance of projects incorporating service-learning pedagogy in the context of a student-oriented approach with the University of Split and the FCT positioned as leaders in the implementation of projects involving service-learning pedagogy in the STEM area. The spark ignited ten years ago has set in motion numerous activities, initiatives and projects, triggering a positive cascade of events in the fields

of environmental protection and higher education. The FCT has not only solidified its place on the research map but also on the map of projects involving service-learning pedagogy in higher education. As evident, this has had a positive impact on students, academic staff, and the local community, contributing enormously to the SDG goals and enhancing the quality of education in the European Higher Education Area. Table 2 summarises reflections on the performed service-learning within the framework of the PAZI! project.

Table 2 – Overview of reflections on the performed service-learning within PAZI! project framework

Tablica 2 – Pregled refleksija o provedenom društveno-korisnom učenju u okviru projekta PAZI!

	Reflection/Refleksija
student	My competencies have significantly expanded through this programme.
student	I consider this a great preparation for everything that lies ahead.
student	The project has contributed to my overall development, and I believe that every student should engage in such activities.
professor	For me, service-learning represents a new approach, new challenges for course design. It provides the opportunity to collaborate with lecturers from other faculties.
professor	Participating in the service-learning projects has heightened my awareness of the obstacles to applying academic knowledge in practice.
professor	Service-learning is an excellent way to integrate practical learning into the curriculum as it allows students to engage in real life scenarios.
NGO Sunce	Reflection is hardly encouraged in the Croatian educational context, be it in schools or universities. Pupils, teachers, and students are unfamiliar with incorporating reflection as an essential part of the learning process. Consequently, students faced difficulties when prompted to reflect on their learning process for the first time as part of the service-learning programme. While there is significant motivation to integrate reflection processes into pedagogical work, it will take some time before this becomes a matter of course. Only experience in conducting reflection will help teachers and mentors to implement it successfully, be it in the context of service-learning or other educational activities.

## 7 Conclusion

Over the past decade, service-learning has emerged as an innovative and transformative pedagogical approach at the FCT, bridging the gap between academic knowledge and community needs. Our paper summarises the evolution of

service-learning, focusing on three key stakeholder groups that have contributed to its success and impact. By aligning student engagement with real-world societal needs, fostering mutual benefits among stakeholders, and emphasising the connection between knowledge and action through reflection, service-learning has created a unique opportunity for students to learn through experience. All parties benefit mutually from service-learning as it contributes significantly to the overall improvement of the local community. This approach has contributed enormously to the requirements of student-centred learning, where programmes at the FCT are taught in a way that strongly motivates and engages students to participate actively in the learning process. The student assessment reflects this approach.

Beyond the FCT, other academic institutions at the University of Split have also embraced service-learning, with numerous researchers confirming its effectiveness. The FCT has not only positioned itself prominently on the research map but also on the map of service-learning in higher education. Existing policies and quality assurance frameworks have shown shortcomings in integrating service-learning, which emphasises the need to incorporate service-learning into modern academic subjects. This will be addressed in our future projects, as we build upon the success of past service-learning pedagogy projects that have significantly enhanced the quality of studies, student development, and FCT's overall impact on the local community and its real environmental challenges.

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## Authors' contribution

I. C. was responsible for formal analysis, conceptualisation, writing-original draft, supervision, writing, review & editing, N. M. V., M. B., L. V., I. S., M. M., L. V., T. K. R., M. N., M. R., G. M. O. were all responsible for formal analysis, conceptualisation, writing, review & editing.

## Consent for publication

All the authors are agreed to publish the data in this paper.

## SUPPLEMENTAL

*Table 1S* – Overview of reflections from the final workshop with students, professors and NGO Sunce representatives within the framework of the PAZI! project

*Tablica 1S* – Pregled dojmova sa završne radionice sa studentima, profesorima i predstavnicima NGO Sunce u okviru projekta PAZI!

Responses from students only / Odgovori studenata		
What have I learned from working with the NGO Sunce?	<ul style="list-style-type: none"> <li>– respect for other people’s opinions/adaptability</li> <li>– problem solving</li> <li>– organisation of public events</li> <li>– respecting different opinions and accepting other people’s ideas</li> <li>– considering the importance of time management when creating a project (organisational skills)</li> </ul>	<ul style="list-style-type: none"> <li>– any idea can be realised, but only with joint effort</li> <li>– work with the media</li> <li>– what is service learning</li> <li>– the importance of personal engagement in teamwork</li> </ul>
How will this acquired knowledge be useful to you in continuing your studies or future work – give a concrete example?	<ul style="list-style-type: none"> <li>– ideas for implementing sustainable development</li> <li>– organisation of public events</li> <li>– graduation/diploma thesis</li> <li>– communication skills and tricks for organising courses and seminars</li> </ul>	<ul style="list-style-type: none"> <li>– working with a large number of people</li> <li>– better organisation</li> <li>– media and organisational skills</li> <li>– importance of teamwork</li> </ul>
Responses from students, professors, and NGO Sunce Odgovori studenata, profesora i članova NGO Sunce		
What was particularly good?	<ul style="list-style-type: none"> <li>– involvement of professors, volunteers and employees of the NGO Sunce</li> <li>– socialising</li> <li>– lecture content</li> <li>– locations</li> <li>– faculty connection</li> </ul>	<ul style="list-style-type: none"> <li>– connecting students – greater impact on students by spending more time with them</li> <li>– networking</li> <li>– student motivation</li> <li>– workshop structure (examples of theory, practical work)</li> </ul>
What particular achievements would you highlight?	<ul style="list-style-type: none"> <li>– response of the participants to the public events</li> <li>– cooperation between students and faculty representatives</li> <li>– genuinely interested students – capacity building</li> <li>– student creativity</li> </ul>	<ul style="list-style-type: none"> <li>– positive impact on the academic community</li> <li>– well-conducted workshops – not purely lecture-based, interesting, well-conceived</li> <li>– well-conducted organised public events</li> </ul>
What should you pass on to the next group of students?	<ul style="list-style-type: none"> <li>– timely and equal distribution of duties and tasks</li> <li>– workshops with small changes</li> <li>– learning diary</li> </ul>	<ul style="list-style-type: none"> <li>– communication with students</li> <li>– positive practices and experience</li> </ul>
What should be done differently?	<ul style="list-style-type: none"> <li>– increase budget for activities</li> <li>– increase number of students from the same faculty</li> <li>– involve more faculties</li> <li>– better definition of ECTS credits</li> </ul>	<ul style="list-style-type: none"> <li>– create “awards” for better students</li> <li>– short reports after the workshops</li> <li>– consultation between the workshop and the public event</li> </ul>
Where do we need help/support?	<ul style="list-style-type: none"> <li>– professional help</li> <li>– IT support</li> <li>– help with communication with students</li> </ul>	<ul style="list-style-type: none"> <li>– help with certificates – what if some worked more and some less – how to get feedback from students</li> <li>– help from professors</li> </ul>
What challenges have arisen?	<ul style="list-style-type: none"> <li>– seminar preparation</li> <li>– preparation of posters and invitations for workshops</li> <li>– collision of university lectures with workshop dates</li> <li>– cost sheet</li> </ul>	<ul style="list-style-type: none"> <li>– student interest – higher than expected</li> <li>– personal responsibility and adherence to agreements</li> <li>– finding an idea that makes everyone in the group “click”</li> </ul>

### List of abbreviations Popis kratica

DBU – Deutsche Bundesstiftung Umwelt

ECTS – European Credit Transfer and Accumulation System  
– Europski sustav prijenosa i akumulacije bodova

EHEA – European Higher Education Area  
– Europski prostor visokog obrazovanja

ESD – Education for Sustainable Development  
– Obrazovanje za održivi razvoj

ESF – European Social Fund  
– Europski socijalni fond

FCT – Faculty of Chemistry and Technology  
– Kemijsko-tehnološki fakultet

HEI – higher education institution  
– visokoobrazovne institucije

- NGO – non-government organisation or civil society organisations  
– nevladina organizacija ili organizacije civilnog društva (OCD)
- PAZI! – Practical-Active!-Together!-Interdisciplinary!  
– Praktično!-Aktivno!-Zajedno!-Interdisciplinarno!
- RH – Republic of Croatia  
– Republika Hrvatska
- SEA-EU – European University of the Seas – European Union  
– Europsko sveučilište mora – Europska unija
- SDGs – development goals  
– ciljevi održivog razvoja
- STEM – Science, Technology, Engineering, and Mathematics  
– Znanost, tehnologija, inženjerstvo i matematika
- UN – United Nations  
– Ujedinjeni narodi
- ZORH – Environmental Protection in Republic of Croatia  
– Zaštita okoliša u Republici Hrvatskoj

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## SAŽETAK

### Društveno-korisno učenje kao inovativan alat u poučavanju rješavanja okolišnih problema – što smo naučili u 10 godina?

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Društveno-korisno učenje (DKU) je obrazovni pristup koji spaja akademsko učenje s korisnim radom u zajednici da bi se riješili problemi okoliša utemeljeni na principima iskustvenog učenja. Taj inovativni pristup poboljšava ishode učenja u visokom obrazovanju nudeći studentima aktivan angažman, kontekst stvarnog svijeta, interdisciplinarnu uvide, razvoj vještina i uključenost građana. Uključivanje DKU-a potiče dublje razumijevanje materijala kolegija, njegove praktične primjene te osobni i profesionalni rast. Ovaj rad daje pregled implementacije DKU učenja u STEM području, uglavnom se fokusirajući na desetljetnu uključenost Kemijsko-tehnološkog fakulteta u projekte zaštite okoliša. Suradnjom Udruge za zaštitu prirode i okoliša Sunce s partnerima sa Sveučilišta u Splitu, ova inicijativa, koju vode stručnjaci za okoliš, uvela je nov pristup visokom obrazovanju. Omogućila je studentima, nastavnicima i suradnicima da prošire svoja znanja, naprijede svoje vještine i razviju stručnost. Utjecaj je bio znan, a Sveučilište u Splitu zauzelo je 21. mjesto u svijetu na popisu "Svjetska sveučilišta sa stvarnim utjecajem" u kategoriji etike u 2021., uglavnom zahvaljujući DKU projektima. DKU je integriran u inicijativu SEA-EU i nastavlja se razvijati na Sveučilištu u Splitu, postavši predvodnik u tom području. Institucionalizacija DKU-a unutar visokog obrazovanja zahtijeva razvijanje DKU kolegija, integraciju DKU-a u postojeće programe i osiguravanje resursa za nastavno osoblje, partnere u zajednici i studente. Uspješna implementacija zahtijeva kolaborativni, iterativni proces koji uključuje pažljivo planiranje, pripremu i evaluaciju. Taj pristup osigurava studentima smislene prilike za primjenu sadržaja kolegija na izazove iz stvarnog svijeta, a istodobno pozitivno utječu na zajednicu.

#### Ključne riječi

Društveno-korisno učenje, kurikulum, ishodi učenja, Kemijsko-tehnološki fakultet, Sveučilište u Splitu

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