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INTEGRATING SERVICE LEARNING IN ENGINEERING EDUCATION BASED ON THE UTCB EXPERIENCE IN THE GIRLS PROJECT

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Abstract. This article presents the integration of Service Learning (SL) into engineering education at the Technical University of Civil Engineering Bucharest (UTCB) within the framework of the Erasmus+ GIRLS project (Generation for Innovation, Resilience, Leadership and Sustainability). Service Learning connects academic content with real-life societal needs, empowering students to apply their knowledge in ways that benefit local communities. The article focuses on the development and implementation of the project "Illuminating Sustainable Futures – Solar Empower, Energize Tomorrow," which engaged high school students and university staff in activities promoting sustainable energy access. The initiative included energy efficiency workshops, a public showcase of a solar-powered prototype house, awareness campaigns, and collaborative educational sessions with local schools. Additionally, the project model was successfully transferred and adapted during a preparatory phase held at the University of Ruse (Bulgaria), establishing a foundation for future regional SL initiatives. Building on this experience, UTCB further expanded the use of Service Learning in core curriculum subjects, including Numerical Analysis, Operational Research, and Probability and Statistics. Case studies and student-led projects demonstrated how real-world contexts, such as optimizing transportation logistics or modeling energy consumption, enhance conceptual understanding and foster critical thinking, civic responsibility, and interdisciplinary collaboration. The article highlights how Service Learning has transformed the teaching process from passive knowledge transmission into active, purpose-driven learning, while aligning with the United Nations Sustainable Development Goals, particularly SDG 7. The UTCB experience confirms the potential of SL to generate both academic and social impact, inspiring a more engaged and competent generation of civil engineers prepared to address contemporary sustainability challenges.

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1. Introduction: Service Learning in Engineering Education

In recent years, engineering education has undergone a significant transformation, shifting from traditional lecture-based instruction toward more interactive, socially engaged, and context-driven methodologies. Among these approaches, Service Learning (SL) has emerged

as a powerful pedagogical model that bridges academic learning with real-world application. Rooted in experiential education, Service Learning combines rigorous academic instruction with structured community service activities, enabling students to apply theoretical knowledge to address concrete societal needs.

In the context of engineering programs, this methodology offers unique opportunities to enhance both technical and transversal competencies. While conventional curricula often focus on mathematical modeling, problem-solving, and system optimization in controlled or abstract settings, Service Learning introduces complexity, unpredictability, and ethical considerations found in real-world environments. Engineering students become active participants in projects that impact local communities, from optimizing energy use and improving infrastructure to addressing environmental sustainability.

Service Learning not only supports the development of professional and civic responsibility but also aligns closely with the goals of sustainable development. By engaging students in projects that tackle pressing societal challenges—such as energy access, climate change mitigation, or urban mobility—SL fosters interdisciplinary collaboration, critical thinking, and reflective practice. Moreover, it transforms the role of the instructor from a lecturer to a facilitator of learning experiences that are both meaningful and socially relevant.

In this context, the Technical University of Civil Engineering Bucharest (UTCB) has actively explored the potential of Service Learning in engineering education. Through its participation in the Erasmus+ project GIRLS – Generation for Innovation, Resilience, Leadership and Sustainability, UTCB has implemented and expanded SL practices across various disciplines, including numerical analysis, operational research, and statistics. This article documents and analyzes this institutional experience, demonstrating how Service Learning contributes to the formation of socially aware and technically competent civil engineers.

At the heart of this transformation stands the Erasmus+ GIRLS project – Generation for Innovation, Resilience, Leadership and Sustainability, which promotes the integration of socially responsible, inclusive, and innovative educational practices within higher education institutions. GIRLS is a strategic partnership project that brings together universities from several European countries, aiming to reshape engineering and STEM education through gender-inclusive strategies, active learning methodologies, and community-based engagement. One of the central pillars of the GIRLS project is the promotion of Service Learning as a structured framework for enhancing the relevance, inclusivity, and social impact of technical education.

The philosophy underpinning the GIRLS project is grounded in the belief that future engineers and scientists must be equipped not only with analytical and technical skills but also with empathy, ethical awareness, and a commitment to societal well-being. Traditional pedagogical approaches often overlook these dimensions, focusing primarily on cognitive learning outcomes. GIRLS addresses this gap by encouraging institutions to integrate teaching strategies that are both participatory and transformative.

In particular, the project supports methodologies that allow students to actively contribute to sustainable development goals (SDGs) through their academic activities. By engaging students in real-life projects that intersect with environmental, social, and economic challenges, GIRLS encourages a redefinition of success in engineering education—not just in terms of academic performance, but also in the capacity to generate positive change in society. Service Learning becomes, in this context, more than a teaching method; it is a vehicle for empowerment, leadership development, and civic engagement, especially among underrepresented groups in STEM fields.

As an institutional partner, UTCB has embraced the GIRLS project as an opportunity to operationalize these values within its own educational framework, leading to the implementation of multiple Service Learning initiatives that combine technical rigor with social relevance.

2. Institutionalizing Service Learning for Sustainable Energy Access in Local and International Contexts

After outlining the theoretical background and the relevance of Service Learning (SL) for engineering education, the next step is to illustrate how this pedagogical approach was institutionalized within the Erasmus+ GIRLS project framework. In order to move beyond conceptual advocacy, UTCB undertook a series of structured actions aimed at embedding SL in both extracurricular and curricular activities, with a strong emphasis on sustainability and community impact.

The institutionalization process at UTCB followed a multi-layered trajectory: first, by raising awareness among students and faculty about the social relevance of engineering knowledge; second, by engaging local stakeholders such as schools, municipal actors, and professional associations; and third, by linking academic tasks to real-world challenges connected to Sustainable Development Goal 7 (Affordable and Clean Energy). These stages ensured that SL was not only tested as an isolated experiment but was progressively anchored in the university's educational culture.

A key milestone in this process was the development of the "Solar Empower House" prototype, designed and demonstrated together with high-school partners in Romania. This initiative became a flagship activity for the GIRLS project, enabling both hands-on learning and public engagement. The prototype served as a tangible demonstration of how engineering students can transform theoretical knowledge into solutions addressing community needs while developing transversal skills such as teamwork, communication, and project management.

Building on the momentum generated at UTCB, the project was subsequently expanded internationally through collaboration with "Angel Kanchev" University of Ruse in Bulgaria. The transfer of methodology and experiences allowed for adaptation to a different institutional and cultural context, while preserving the same guiding principles of civic engagement and sustainable energy awareness. This cross-border dimension not only reinforced the European scope of the GIRLS project but also validated the replicability of SL-based approaches in technical universities.

Consequently, the following two subsections describe in detail: (i) the implementation process at UTCB, highlighting the local partnerships, activities, and curricular integration, and (ii) the extension to the University of Ruse, focusing on the adaptation strategies, dissemination events, and evaluation results that confirmed the added value of scaling SL beyond national boundaries.

Implementation at UTCB

The implementation of Service Learning (SL) at the Technical University of Civil Engineering Bucharest (UTCB) was anchored in the Erasmus+ GIRLS project through the initiative titled "Illuminating Sustainable Futures – Solar Empower, Energize Tomorrow: Service-Learning for Sustainable Energy Access." The project aimed to bridge academic knowledge with community needs by empowering high school students to understand and apply sustainable energy solutions, with a particular focus on solar power.

The initiative began at UTCB in April 2024, where a comprehensive series of activities were carried out in partnership with "Sfântul Sava" National College (Bucharest) and the Forestry

Technological High School (Râmnicu Vâlcea). These activities included: Energy efficiency workshops, introducing high school students to practical conservation strategies; A community awareness campaign, involving seminars and poster exhibitions on renewable energy;

- A public showcase of a prototype energy-independent solar house, designed and presented by university students;
- Hands-on workshops on solar technologies, including basic installation concepts and experiments with photovoltaic panels;
- Reflection and evaluation sessions, where students assessed the social and technical impacts of their work;
- A needs assessment survey, identifying energy challenges in the local school context;
- The creation of educational materials and collaboration with high school teachers to integrate SL elements into the curriculum.

The approach combined educational workshops, hands-on activities, and public outreach, ensuring that learning outcomes were both academically rigorous and socially relevant. By addressing the theme of energy access—one of the central pillars of Sustainable Development Goal 7—the project provided students with opportunities to connect theoretical concepts from engineering and physics with real-world challenges.

A central component of the project was the design and demonstration of a prototype solar-powered house. Developed in collaboration between UTCB students and high school learners, the prototype served as a tangible showcase of how renewable energy can be harnessed in practice. The activity allowed participants to gain practical experience in sustainable construction methods, solar panel installation, and energy efficiency design, while simultaneously raising awareness in the wider community.

The project also integrated a series of thematic workshops. Sessions on energy efficiency and conservation introduced practical strategies for reducing energy consumption and emphasized the role of civil engineers in promoting sustainable practices. Complementary activities included introductory lectures on renewable energy, hands-on experiments with solar panels, and discussions on global energy challenges. These were coupled with needs-assessment surveys and reflection exercises, enabling participants to contextualize knowledge and critically assess their community's energy practices.

Community engagement was another key dimension of the UTCB implementation. Awareness campaigns, poster sessions, and public events created opportunities for dialogue between students, teachers, parents, and local stakeholders. The prototype solar house was exhibited during a dedicated showcase event, offering guided tours, interactive presentations, and demonstrations that inspired environmentally conscious behaviors beyond the academic setting.

Finally, the project emphasized the importance of reflection and knowledge transfer. Feedback sessions and evaluation workshops encouraged both university and high school students to articulate their learning outcomes, identify challenges, and propose improvements. The documentation of activities in reports, videos, and educational resources ensured that the project's impact extended beyond the immediate participants and created a basis for curriculum integration.

Through this holistic approach—combining theory, practice, and civic engagement—UTCB demonstrated that service-learning can effectively prepare students to become both competent engineers and socially responsible citizens. The Solar Empower initiative thus established a replicable model of how higher education institutions can contribute to sustainable energy awareness while strengthening community-university partnerships.

Extension to "Angel Kanchev" University of Ruse

Following its successful implementation at UTCB, the Service Learning (SL) model was transferred to "Angel Kanchev" University of Ruse (Bulgaria), within the framework of the Erasmus+ GIRLS project. This extension sought to validate the adaptability of the UTCB experience in a different national and institutional context, while preserving the overarching aim of fostering sustainable energy awareness and student engagement.

The collaboration between UTCB and the University of Ruse was designed as a structured knowledge transfer process. Materials, methodologies, and outcomes from the Romanian activities were shared with academic staff in Ruse, enabling them to adapt the approach to their own curricula and community needs. Particular emphasis was placed on integrating renewable energy themes into engineering courses, thereby aligning technical education with social responsibility and environmental sustainability.

To replicate the UTCB model, the University of Ruse organized a set of workshops, seminars, and community-oriented activities. These focused on introducing students to the principles of renewable energy, emphasizing solar solutions, and highlighting the societal implications of sustainable energy practices. The events also encouraged high school and university students to work together, fostering intergenerational collaboration and enhancing civic engagement.

The first phase focused on establishing institutional alignment and developing a contextualized educational framework tailored to the Bulgarian academic and community environment. This groundwork included identifying relevant stakeholders, co-designing educational content, and exploring opportunities for transdisciplinary engagement.

The second phase transitioned into hands-on implementation, involving students and faculty in interdisciplinary activities that promoted the understanding and application of sustainable energy concepts. Through workshops, group projects, and collaborative reflection, participants explored the social, environmental, and technical dimensions of energy access and community empowerment.

The third phase deepened community engagement and strengthened the educational impact through interactive, awareness-raising initiatives. A variety of participatory formats were employed to address diverse learner needs and to stimulate local interest in renewable energy practices, with an emphasis on solar-based solutions and climate-conscious behaviors.

This multi-phase implementation in Ruse served to adapt and validate the Service-Learning for Sustainable Energy Access: Illuminating Sustainable Futures – Solar Empower, Energize Tomorrow model in an international setting. The next step of the initiative involves participation in the final phase of the GIRLS project—evaluation and dissemination—aimed at consolidating results and promoting sustainable integration of Service Learning in higher education. This final stage will take place at the University of Ruse and will provide a platform for institutional reflection, cross-country comparison of outcomes, and the formulation of long-term strategies for embedding Service Learning into the academic culture.

Public dissemination played an important role in the Ruse extension. Drawing inspiration from the solar house prototype developed at UTCB, the Bulgarian team organized interactive sessions and demonstration activities to raise awareness among students, teachers, and local stakeholders. The outreach dimension helped to bridge the academic setting with the broader community, ensuring that the project impact extended beyond the classroom.

As part of the adaptation process, the University of Ruse incorporated reflection and evaluation sessions into the activities. These allowed students to critically assess both the technical and social aspects of their learning, identify local challenges in energy access, and explore ways

in which engineering knowledge could contribute to addressing them. Documentation of the process, including teaching materials and project reports, was developed to facilitate future integration into the curriculum.

The extension to Ruse confirmed that the SL approach developed at UTCB is not only contextually relevant but also transferable across borders. By adapting the solar energy initiative to its own educational environment, the University of Ruse demonstrated the flexibility of the model and its potential for wider European application. This cross-border collaboration strengthened institutional partnerships, enriched the educational experiences of students in both countries, and showcased the role of technical universities in advancing sustainable development goals through service-oriented education.

The implementation of Service Learning at UTCB and its subsequent extension to "Angel Kanchev" University of Ruse demonstrate how locally developed educational innovations can be effectively scaled and adapted across borders. At UTCB, the Solar Empower initiative established a replicable framework that combined workshops, prototype development, community engagement, and reflection. Its transfer to Ruse confirmed both the flexibility of the model and its capacity to inspire civic responsibility and sustainable practices in diverse contexts. Together, these experiences underline the transformative potential of Service Learning when embedded in engineering education, preparing the ground for its systematic integration into the curriculum. The following chapter explores how this integration was achieved at UTCB, highlighting concrete examples from mathematics and engineering courses where SL principles were translated into classroom practice.

3. Integrating Service Learning into the UTCB Curriculum

Building on the experience gained through the Solar Empower initiative and its international extension, UTCB advanced the institutionalization of Service Learning (SL) by embedding it directly into core mathematics and engineering courses. While extracurricular projects provided visibility and immediate community impact, the long-term sustainability of SL required curricular integration. This step ensured that future generations of students would experience SL not as an optional activity, but as an integral component of their academic formation.

The curricular implementation followed two guiding principles. First, academic rigor was preserved, with mathematical and engineering concepts remaining central to each activity. Second, these concepts were systematically linked to real-life problems relevant for local communities, thereby fostering both technical competence and civic responsibility. By addressing authentic challenges in sustainability, mobility, and logistics, students were encouraged to perceive theoretical knowledge as a tool for societal transformation.

At UTCB, three courses were selected as pilot contexts for embedding SL: Numerical Analysis, Operational Research, and Probability and Statistics. Each course adopted a case-based approach in which students applied theoretical methods to problems with clear social and environmental dimensions. For example, regression methods were used to study route alignments, optimization techniques supported decision-making in sustainable transport logistics, and statistical modeling provided insights into campus mobility.

The following subsections describe these three implementations in detail, highlighting how abstract mathematical tools were transformed into meaningful solutions for the community.

3.1. **Numerical Analysis: Sustainability through the Least Squares Method.**

In the Numerical Analysis course, Service Learning was applied through a case study involving the least

squares method for linear regression, contextualized within a sustainability challenge relevant to civil engineering. Rather than introducing the algorithm as a purely computational tool, students were invited to engage with a real-world problem involving sustainable energy access and spatial planning.

The proposed task focused on determining the optimal alignment of a gas pipeline (or solar energy infrastructure route) such that it would pass as close as possible to several rural or suburban communities. Students were provided with the coordinates of the towns, which served as data points, and asked to compute the best-fit line minimizing the sum of squared distances. The mathematical core of the project involved:

- Formulating the linear model using the method of least squares;
- Implementing the algorithm and interpreting the slope and intercept within the geographic context;
- Visualizing results using plotting tools and evaluating the solution's proximity to each community.

Beyond the computation, the project was structured around Service Learning principles:

- Students reflected on the broader implications of infrastructure placement in terms of cost, accessibility, and environmental impact;
- They presented their findings in the form of a short technical report and infographic, simulating communication with local authorities or community groups;
- Peer feedback and collaborative discussion were included to enhance critical evaluation and communication skills.

This approach allowed students to understand the mathematical method in depth, while simultaneously recognizing its power in solving socially relevant challenges. It also reinforced the value of using mathematics not as an abstract exercise, but as a tool for creating sustainable and equitable engineering solutions.

3.2. **Operational Research: Optimizing Transport Logistics through Real-World Service Learning Projects.** The course of Operational Research (OR) at UTCB offers fertile ground for integrating Service Learning into the technical curriculum, particularly through its focus on decision-making, resource optimization, and mathematical modeling. In traditional teaching settings, OR often relies on abstract transportation problems or textbook datasets. By incorporating Service Learning, the UTCB teaching team introduced authentic, community-relevant scenarios that required students to apply linear programming techniques to address real logistical challenges faced by construction companies.

A representative case study involved a collaboration with a local concrete supplier and construction contractor. The scenario simulated the transportation of ready-mix concrete from multiple batching plants to various construction sites across Bucharest, with constraints related to capacity, delivery windows, and production costs. The objective: minimize the total transportation cost while satisfying demand and operational constraints.

Students were guided to:

- Define decision variables and construct the linear programming model;
- Input real or simulated company data (distances, capacities, unit costs) into the model;
- Use optimization software (such as Excel Solver or Python-based tools) to compute the optimal transport plan;
- Analyze the solution in terms of cost savings, resource efficiency, and environmental impact (e.g., fuel consumption reduction).

In line with the Service Learning framework, the project also emphasized:

- Stakeholder communication: students prepared executive summaries and visual dashboards, assuming the role of consultants reporting to industry partners;
- Reflection: students discussed the trade-offs in real-world optimization, such as the tension between economic efficiency and sustainability;
- Collaboration: tasks were completed in small interdisciplinary teams, mimicking professional practice in engineering consultancy.

Through this project, students developed a deeper appreciation for the complex interplay between mathematical optimization and societal needs. They did not merely solve an algorithmic problem—they engaged with logistics as a system embedded in economic, environmental, and social dimensions. The Service Learning format transformed a technical exercise into an opportunity for students to practice civic-minded engineering, develop consulting skills, and understand the impact of operational decisions on communities and the environment.

This example demonstrates the potential of Service Learning to move beyond passive knowledge acquisition, encouraging students to think holistically and ethically about the problems they are trained to solve.

3.3. **Probability and Statistics: Traffic Flow Analysis as a Service Learning Project.** In the course of Probability and Statistics, Service Learning was introduced through an applied research project focused on traffic flow analysis, responding to an identified need within the Faculty of Railways, Roads, and Bridges at UTCB. As the campus expanded and student commuting patterns evolved, both faculty members and student representatives expressed concerns regarding congestion near key entrances, inefficient pedestrian crossings, and limited data to support infrastructure improvement proposals. This context provided an ideal opportunity to transform a theoretical course into a socially engaged, data-driven project with real-world relevance.

Under the Service Learning framework, students were invited to act as urban data analysts, tasked with evaluating traffic and pedestrian movement patterns around the faculty's main building. The overarching goal was to provide actionable insights for improving safety, accessibility, and mobility within the university's immediate surroundings.

The project unfolded in multiple stages:

- Data collection: Students designed and implemented structured observation protocols, manually recording vehicle counts, pedestrian frequency, and peak-time congestion intervals. Complementary data was gathered via short surveys distributed to students and staff regarding commuting habits.
- Statistical modeling: Using concepts taught in the course—such as frequency distributions, central tendency, confidence intervals, and hypothesis testing—students processed the collected data to identify trends and statistically significant findings.
- Correlation and regression analysis: Linear regression was employed to explore relationships between traffic intensity and variables such as class start times or proximity to bus and metro stations.
- Visualization and interpretation: Results were presented through histograms, time-series graphs, and GIS-based maps, making the findings accessible to both academic and administrative audiences.

In keeping with Service Learning principles, the project emphasized stakeholder engagement and social relevance:

- Students held a discussion session with administrative staff and safety officers from the faculty, where they presented their findings and proposed interventions (e.g., retiming crosswalk signals, installing signage, redesigning access routes).
- The reflection phase allowed students to consider how statistical tools can directly inform policy, design, and user-centered infrastructure.
- Several student teams extended their reports into final-year projects, and the data was archived to serve as a baseline for future mobility studies on campus.

This extended Service Learning project achieved multiple educational objectives. Technically, it reinforced statistical analysis skills, data interpretation, and research methodology. Socially, it connected students with their own institutional environment and empowered them to become agents of change within it. Pedagogically, it demonstrated how mathematics and statistics—often perceived as abstract or disconnected—can be powerful instruments for understanding and improving the spaces we inhabit.

Furthermore, the experience fostered a culture of responsibility and initiative, as students recognized the broader impacts of their work on campus planning, safety, and sustainability. In doing so, the project exemplified the core mission of Service Learning: to create meaningful intersections between academic knowledge and community engagement.

4. Conclusions and Future Perspectives

The successful implementation of Service Learning (SL) at UTCB not only required innovative curricular design but also a systematic evaluation of its educational impact. Assessing how students perceived these activities was essential for understanding whether SL truly enhanced their learning, motivation, and preparedness for professional practice. This chapter therefore presents the evaluation process and its outcomes.

The analysis was carried out through a structured questionnaire and reflection sessions, designed to capture both quantitative and qualitative evidence. The evaluation focused on three key aspects: the extent to which SL made theoretical knowledge more applicable, its influence on student motivation, and its contribution to professional readiness. By combining numerical data with student feedback, the results provide a comprehensive picture of the benefits and challenges of introducing SL into engineering education at UTCB.

To evaluate the impact of the Service Learning (SL) approach, a structured questionnaire was administered to second-year civil engineering students at UTCB after completing mathematics modules that integrated SL activities. The aim of the evaluation was to capture students' perceptions of the educational value of SL, particularly regarding the applicability of theoretical knowledge, their motivation to learn, and their preparedness for professional practice.

The questionnaire combined Likert-scale items (ranging from strongly disagree to strongly agree) with a few open-ended prompts to allow students to elaborate on their experiences. It was designed around three main dimensions:

- Relevance and applicability of theory – to assess whether mathematical concepts became clearer when linked to real-world cases.
- Student motivation – to explore whether SL activities enhanced engagement and interest.
- Professional preparedness – to determine the extent to which students felt ready to apply knowledge in practical contexts.

The survey contained the following items:

- Q1. The integration of real-world problems helped me better understand the theoretical concepts taught in the course.
- Q2. Working on community-relevant projects improved my ability to apply mathematical methods to practical situations.
- Q3. The Service Learning activities increased my motivation to engage with the subject.
- Q4. I found the collaboration with external partners (e.g., schools, local stakeholders) valuable for my learning.
- Q5. The SL experience improved my teamwork and communication skills.
- Q6. I feel better prepared for my future professional career because of the SL activities.
- Q7. Overall, I consider Service Learning to be a valuable complement to traditional teaching methods.

Responses were collected anonymously to encourage honest and critical feedback. In addition, short reflection sessions were organized in small groups, where students could discuss their experiences openly. This provided complementary qualitative data to enrich the quantitative results of the survey.

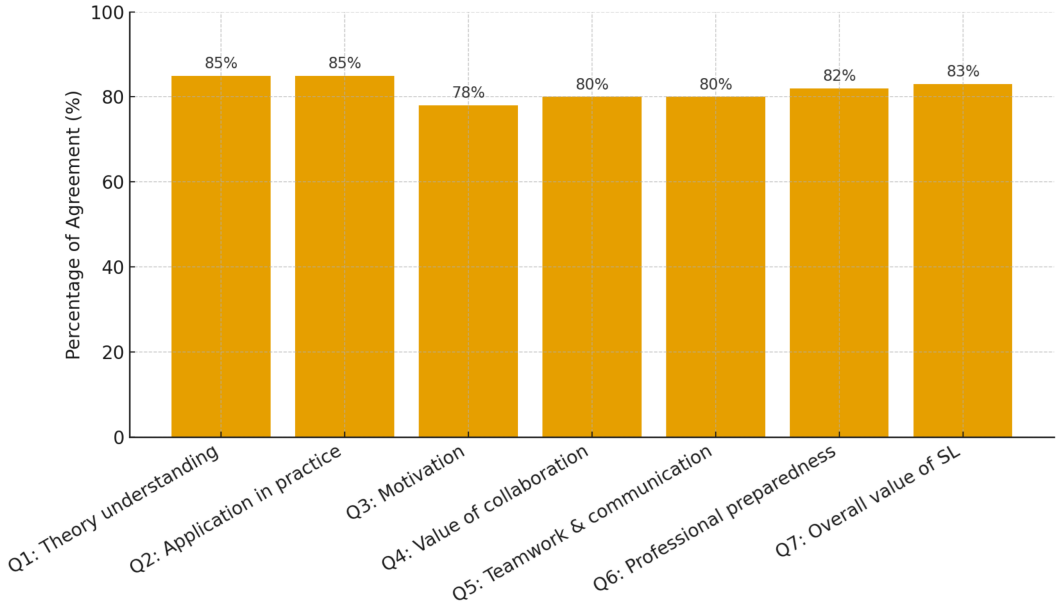

FIGURE 1. Student Responses to Q1 – Q7 on Service Learning Experience at UTCB

The questionnaire results provide a clear indication that the integration of Service Learning (SL) into mathematics courses at UTCB had a positive impact on students' perceptions of their learning experience.

Overall, the responses revealed strong agreement with the majority of the items:

- For Q1 and Q2 (applicability of theory), more than 85% of respondents agreed that real-world projects made mathematical concepts clearer and improved their ability to apply theory in practice.
- For Q3 (motivation), approximately 78% of students reported that SL increased their engagement and interest compared to traditional approaches.

- For Q6 (professional preparedness), 82% of students indicated that the SL activities enhanced their confidence in applying knowledge to professional challenges.
- Items Q4 and Q5 (collaboration and transversal skills) also received high levels of agreement, with many students emphasizing the added value of teamwork, communication, and interaction with external partners.
- Q7 (overall value of SL) confirmed that students considered the approach a beneficial complement to traditional teaching, with the majority expressing support for its continuation and expansion.

Qualitative feedback reinforced these results. Students highlighted that working on authentic problems gave them a sense of purpose and responsibility, while the opportunity to collaborate with peers and community stakeholders made the learning process more engaging. Several respondents noted that the prototype-based activities and community presentations helped them to connect academic knowledge with societal needs in a meaningful way.

The results of the evaluation confirm that Service Learning (SL) can play a transformative role in engineering education when carefully integrated into the curriculum. Students consistently reported that the connection between abstract theory and real-world applications enhanced their understanding of mathematical concepts. This aligns with the primary aim of the GIRLS project: to demonstrate that technical knowledge gains relevance and depth when it is placed in the context of societal challenges.

The increase in motivation highlighted by the survey is particularly significant. Many students indicated that they felt more engaged because the learning activities were not only academic exercises but also contributed to addressing authentic community needs. By situating mathematics in the context of sustainability and renewable energy, SL shifted students' perception of the discipline from being purely theoretical to being a tool for problem-solving with tangible impact.

Another important aspect emerging from the feedback is the strengthening of transversal skills. Collaboration with peers and external partners fostered teamwork, communication, and project management competences, which are increasingly valued in the professional world. The ability to work in interdisciplinary and intergenerational teams was repeatedly mentioned as a benefit of the SL experience.

At the same time, some students pointed out challenges such as the additional time and effort required, or the difficulty of balancing technical rigor with community engagement. These observations underline the importance of continuous adaptation and support from instructors in order to maintain the balance between academic standards and service outcomes.

Overall, the discussion indicates that SL not only supports the acquisition of technical knowledge but also enhances personal growth, civic responsibility, and professional readiness. It validates the approach as a meaningful complement to traditional teaching, capable of preparing students for the complex demands of contemporary engineering practice.

The evaluation of Service Learning (SL) at UTCB highlights its positive contribution to both academic and personal development. Students reported clearer understanding of theoretical concepts, stronger motivation, and greater preparedness for professional challenges. The findings confirm that SL is an effective complement to traditional teaching methods, especially when aligned with sustainability goals and community engagement.

Looking ahead, several directions for further development have been identified:

Curricular expansion – extend SL activities to additional mathematics and engineering courses to reach a broader student population.

Deeper community partnerships – strengthen collaborations with schools, municipalities, and non-governmental organizations to ensure the societal relevance of student projects.

Digital resources – develop a repository of case studies, reports, and teaching materials that can be shared across institutions and reused in future cohorts.

Cross-border collaboration – build on the successful transfer to the University of Ruse by exploring partnerships with other European universities.

Longitudinal evaluation – implement multi-year studies to track how SL influences student learning outcomes, professional trajectories, and civic engagement over time.

In conclusion, Service Learning has proven to be a valuable methodology for transforming technical courses into purpose-driven learning experiences. By combining academic rigor with social responsibility, UTCB has laid the foundation for a model that is both replicable and adaptable, contributing to the advancement of sustainable engineering education.

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