Exploring the Impact of Service-Learning Internships on Professional Skills Development in Engineering Students: A Scoping Review

Javier E. Bermúdez
ESPOL Polytechnic University
Guayaquil, Ecuador
jbermude@espol.edu.ec

Katherine Chiluiza
ESPOL Polytechnic University
Guayaquil, Ecuador
kchilui@espol.edu.ec

Tammy Schellens
Ghent University
Ghent, Belgium
Tammy.Schellens@UGent.be

Martin Valcke
Ghent University
Ghent, Belgium
martin.valcke@ugent.be

***Abstract*—This research full paper presents a literature review that seeks to answer: What is the role of Service-Learning Internships (SLI) in developing professional skills in students as future engineers? This is because SLI has been pervasively included in the formation of engineering students. More specifically, this review aims to answer: What is the theoretical base of service-learning (SL) experiences? How are internships organized within the engineering programs? What kind of activities are performed? What are the more common learning outcomes and how are they assessed? Where are the SLI activities performed? and; Which are stakeholders for SLI?**

The articles reviewed in this study were selected from the Web of Science Database. The PRISMA methodology was used to identify, screen, evaluate eligibility, and include the relevant articles for the review. A total of 2969 journal articles and proceeding papers, in English and Spanish, from 2000 to 2023, were screened with the inclusion and exclusion criteria, resulting in 18 articles that were analyzed.

The studies analyzed reveal that the main role of SLI is to train students to address and solve real-world problems, applying their technical knowledge, and as a result, students tend to improve their critical thinking and analytical skills, their social responsibility, and citizen engagement, among other benefits. This is considered important since it relates to their readiness for competent professional practice in a constantly changing labor market. The studies connect the improvement of skills to Robert Bringle's SL experiences, Kolb's experiential learning and John Dewey's experimentalism. The characteristics of the practices and the activities performed differ according to the specific areas of the engineering programs. SL experiences are usually integrated into the programs' curricula, but not always as internships. Regarding location, SLIs are conducted in diverse settings, including university campuses, schools, online platforms, and mostly in community-based environments. The learning outcomes differ from knowledge areas and half of the experiences and the assessment methods vary, with self-assessment via questionnaires being the most prevalent, followed by content assessment and instructor evaluation through written reports. The stakeholders include schools and high schools, non-government organizations, and different spaces from society such as farms, museums or recreation parks.

This review contributes to recognizing the role of SLI in fostering professional skills. It provides valuable insights into the perception of students, lecturers and community stakeholders regarding the university's involvement in addressing real-world challenges. The results establish the necessity of refining assessment methods for professional skills since most of them rely on self-assessment and activity reports, and also offer the opportunity to explore the correlation between instructor-evaluated skill development and the practical application of technical knowledge in real-world settings.

Keywords*—*engineering curriculum, service learning, professional skill

I. Introduction

The labor markets are under structural changes due to globalization. This affects labor's flexibility, mobility, and internationalization [1], [2]. In a rapidly evolving job market, the demand for highly skilled professionals has never been greater [3]. Universities must prepare students with the knowledge and skills necessary to confront such circumstances [4].

Concerning the transformation of knowledge, skills, and values, since 1996 the Accreditation Board for Engineering and Technology (ABET) established the Engineering Criteria which became the minimum learning outcomes requirements for engineering baccalaureate programs to be accredited [5]. Such criteria included six outcomes related to professional skills. Employers increasingly highlighted that achieving success as an engineer demanded more than possessing strong technical competencies. Additionally, engineers were expected to demonstrate proficiency in communication and persuasion, the capacity to lead and collaborate effectively within a team, and a comprehensive understanding of the non-technical factors influencing engineering decisions, to become skilled citizens capable of adapting and evolving in response to rapid societal changes [5], [6], [7]. These skills are related to engaging actively with communities, understanding global issues and societal contexts, and designing engineering solutions with people's needs in mind [8]. This is where Service-Learning (SL) takes an important role for engineering students. Several definitions exist for SL, for instance, Chrispeels et al. [9] define it as "a pedagogical method that integrates community service with required course activities to enhance student attainment of course-specific learning objectives while simultaneously meeting the needs of community partners". Whereas Vilca et al. [10]., defines pre-professional internships as "training process that permanently transforms knowledge, skills and values", it is not common to find a specific definition for service-learning internships. SLI was called service-learning programs by Corey [11], and the same was done by Snell et al [12]. Therefore, since there is no prevalent definition for SLI, we may refer to SLI as internships performed through SL experiences. Being practices where students may acquire experience before graduation, they make them confront how their future professions are relevant. However, there is a debate of whether SL is included as part of the curricula in specific courses or integrated into the curricula along the courses or other approaches.

According to Mitchell [13], community service serves as a call to action for higher education students, generating the concurrence of skills and information from community work with the theories and practices from lectures, making it possible to create new knowledge for them. This makes SL to be used by universities to urge learning for students. This concurs with Salam et al inferences that SL may improve students' capacities such as "increased student learning and practical experience; civic engagement, reciprocal relationship between campus and community; enhanced institutional satisfaction and civic literacy; enhanced social responsibility and civic leadership among students; a deeper understanding of course contents; improving community life by imparting awareness and problem-solving skills" [14].

This study aims to provide a comprehensive review of recent literature on service-learning in engineering education. It seeks to update approaches, content, and trends in service-learning to align with industry demands, emphasizing the professional skills essential for engineers and their societal responsibilities.

II. METHOD

To pursue a thorough investigation, this literature review adhered to Arksey and O'Malley's five-stage framework [15], encompassing: (1) identifying the research questions, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the results concerning the influence of service-learning internships on engineering students' professional skill development.

A. *Identifying the research questions*

To guide our research, we chose to investigate the essential elements of the SL experiences within the context of higher education. To gather relevant literature, we formulated six research questions:

Q1: What is the theoretical base of SL experiences?

Q2: How are internships organized within the engineering programs?

Q3: What kind of activities are performed?

Q4: What are the more common learning outcomes and how are they assessed?

Q5: Where are the SLI activities performed?

Q6: Who are the stakeholders for SLI?

B. *Identifying relevant studies*

The Web of Science (WOS) database was used to identify peer-reviewed articles and conference proceedings in English and Spanish, employing the search terms 'service learning' OR 'service-learning' OR 'community internships' OR 'community service learning' either in the topic or in the title. The search timeframe was extended from 2000 to July 2023. The publications included journal articles and proceeding papers, in English and Spanish. The inclusion and exclusion criteria used to screen the studies are presented in Table 1.

C. *Studies selection*

Using the search criteria outlined in the previous section, 2.969 articles were identified. After applying the inclusion and exclusion criteria, abstracts of the identified studies were examined, and only 18 studies met the inclusion criteria. The article selection process followed the Preferred Reporting of Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement [16]. Figure 1 illustrates this process.

Of the excluded studies, 2.624 were excluded because they did not meet the inclusion criteria regarding the topics addressed. This indicates that most of the articles were related to other knowledge areas rather than engineering. The 18 selected studies dealt with experiences from twelve universities from North America, three from Asia, two from Europe, and one from South America.

D. *Charting the data*

At this stage, all included articles were screened to extract data to answer the research questions. The chart is available upon request to authors.

E. *Collating, summarizing, and reporting the results.ntas*

The final stage of the framework reports the findings which are summarized in Section III.

III. RESULTS

As previously mentioned, this scoping review identified eighteen studies that met the inclusion criteria outlined in Table 1. The main findings from these studies address the research questions defined previously.

A. *What is the theoretical base of service-learning experiences?*

Pruett and Weigel[17], and Chrispeels et al [9] connected the SL experiences specifically to Bringle and Hatcher's description of service-learning, which includes organizing the activities, acting on community needs, reflecting on the activities, and granting curricular credits for it [18].

Kulesza et al [19] linked the SL experiences to Kolb's experiential learning about the four stages of concrete experiences, reflective observations, abstract conceptualization, and active experimentation [20].

Phang et al [21] associated the SL experiences with Dewey's experimentalism which declares that education must be rooted in experience, specifically the real-life experiences of individuals to achieve its goals for both the individual and society [22].

The narrative of eleven studies engaged with experiential learning, therefore, connecting with Kolb's and Dewey's theories, concerning the two main factors of hands-on activities and the relationship with communities to address their needs [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33].

TABLE I. INCLUSION AND EXCLUSION CRITERIA

Criterion	Inclusion	Exclusion
Topic addressed	Articles related to service-learning internships where technical skills from engineering programs are applied to real-life scenarios.	Articles where volunteering is proposed or discussed as relationship with a community.
Study setting	Higher education, engineering programs. Experiences performed with according to planned activities for application of previously acquired knowledges/skills.	Other settings or non-engineering programs. Experiences with no application of previously acquired knowledges/skills.
Study focus	Empirical work related to service-learning internships and their effect on students' skills.	Articles that mention service-learning internships with no empirical work about their effect on students' skills.
Study sample	Undergraduate students from engineering higher education programs.	Students not from undergraduate levels of study, or non-engineering programs.
Other	Not applicable	Not available, repeated studies, incomplete.

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Healey [29] and Cannon et al. [34] established high-impact practice (HIP) as the basis of the SL experiences in their studies. This is because HIP's essential elements involve practically applying classroom knowledge in real-world scenarios and reflective discussions about these experiences with classmates and teachers. Also, they indicate that HIP significantly enhances students' understanding of course material, develops their skills, and fosters critical thinking. According to Kuh [35], SL is a type of HIP that provides students with firsthand experience related to the topics they are studying in their courses and involves them in ongoing community problem-solving efforts. Kuh explains that HIP is a field-based experiential learning where students apply their knowledge to such efforts.

B. *How are internships organized within the engineering programs?*

The SL experiences from all the reviewed studies concurred in (1) having a plan before the execution of the activities, (2) arranging tutoring or supervision by academic staff, (3) including some assessment or evaluation, and (4) grouping students for their activities and interaction with different stakeholders. Although Bringle and Hatcher [18] specify that reflection is a fundamental aspect of SL [10], only 11 out of the 18 studies specified such a process [17], [21], [23], [27], [29], [30], [31], [32], [34], [36], [37].

Of the reviewed studies, twelve corresponded to courses and three to projects with activities concerning the preparation of material and giving support to students from schools. The courses lasted for a university's academic semester. Concerning the general organization of the experiences, twelve corresponded to fieldwork and laboratory experiences [9], [17], [19], [21], [26], [29], [30], [31], [32], [33], [34], [37], and six to on-line interactions [23], [24], [25], [27], [28], [36].

C. *What kind of activities are performed?*

All the interventions reviewed required engineering students to fulfill hands-on activities that depend on the specific engineering area. Such actions include preparing material, designing experiences, laboratory activities, sampling, data collection, and teaching to school students. They also require certain training before the SL experience.

The revision revealed thirteen studies included presentations from students after their experiences, from which five correspond to written reports [17], [21], [26], [29], [37], two matches up to a poster exhibition [19], [32], and six resemble on presentations of different kinds like posters, oral presentation of results, pitching ideas to an organization, or videoconferences [23], [27], [28], [30], [33], [36].

D. *What are the more common learning outcomes and how are they assessed?*

The learning outcomes concerned in the studies analyze professional skills and technical skills for each intervention.

Regarding professional skills, one study referred in general to professional skills [26], ten studies engaged in communication skills [19], [27], [28], [29], [30], [32], [33], [34], [36], [37], five concerned problem-solving capabilities [19], [23], [24], [27], [32], five referred to teamwork and collaboration [21], [27], [28], [29], [34], two involved ethical considerations [24], [27], and seven implied personal qualities or the capability of students to make connections with communities or between their classmates and teachers [19], [23], [25], [27], [30], [36], [37].

All the studies discussed the expected outcomes related to knowledge or skills specific to different knowledge areas. Six dealt with biology content within engineering and science programs [9], [17], [19], [31], [32], [37], five with multidisciplinary experiences without predominance of one program [21], [25], [26], [28], [29], two with industrial engineering [27], [34], and others analyses were one for agricultural engineering [23], one for civil engineering [36], one for chemical engineering [30], one for computer engineering [24], and one for mechanical engineering [33]. Ten studies, even though they corresponded to engineering students, reported interventions where students from more than one undergraduate program collaborated in the SL experience [9], [19], [21], [23], [24], [25], [26], [27], [28], [29].

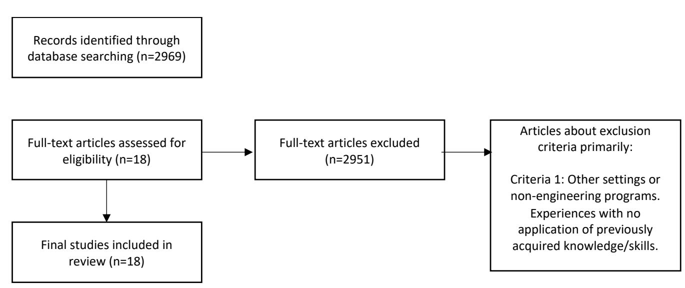

Fig. 1. PRISMA flow diagram for article selection

Four of the reviewed publications discussed the exposure of students to deep thinking and knowledge breadth, depth, and complexity, establishing a broader, thoroughly understood knowledge that could be used to explore and work with the intricate and multifaceted concepts of their engineering areas [17], [19], [30], [34].

Related to the studies' approach to assessment, two forms were identified: self-assessments and assessments by tutors or teachers. Eleven of the publications included surveys or questionnaires that asked the students to self-assess their activities [19], [24], [25], [26], [27], [28], [30], [31], [34], [36], [37]. Seven studies contained written reports, reflections, and concept maps that also matched students' self-assessments [17], [21], [29], [32], [34], [36], [37]. Two publications involved interactions (an interview and a discussion) with students about their perceptions [23], [24]. Seven of the studies included in their design more than one assessment method: questionnaires and content evaluation [27], [28], [31], [34]; questionnaires and reports [36], [37]; questionnaires and discussion [24].

The SL experiences included six studies where technical content was evaluated [9], [27], [28], [31], [33], [34].

E. Where are the SL Internships activities performed?

Despite the need for interaction between students and communities in SL internships, not all experiences involved students' visits outside their universities. Ten studies implicated visits to the stakeholders including high schools [9], [29], [30], [33], non-governmental organizations and institutions [17], [26], [31], and members of society such as farmers [19], [32], [34]. Two studies establish the interaction between students and their local community as in-campus experiences [21], [37]. Six studies determine such interaction in online scenarios, using varied types of platforms for communication, reporting, and assessing [23], [24], [25], [27], [28], [36]. The motivation to experiment with online SL was the pandemic of Covid-19, except in the case of Mou et al [25].

F. Who are the stakeholders for SLI?

As it has been declared repeatedly, SLI intends to support society while impelling undergraduates' education. This is possible, in some way, due to the interaction of students, their teachers or tutors, and the universities, with a variety of stakeholders. Even though some articles did not specify the interacting stakeholders [19], [24], [25], [37], from the reviewed studies we may classify the stakeholders into the community itself – or some members of it; non-government organizations or institutions with specific interests; and other education institution such as schools and high schools. The benefited community may include diverse actors such as families, farmers, or ethnic minorities whose specific problems are addressed in the SLI [21], [23], [34], [36]. Meanwhile, several institutions might cooperate in such projects concerning ecological issues [17], [31] or educational requirements [26], [28]. This contrasts with the projects related to teaching school and high school students on subjects such as physics or biology [9], [23], [27], [29], [30], [33][9], [23], [27], [29], [30], [33].

IV. DISCUSSION AND CONCLUSIONS

This study aimed to shed light to the area of SL in engineering by means of several research questions. The first question that arose concerned the theoretical base for such SL internships in engineering education. The studies revealed a link of SL Internships to Robert Bringle's SL experiences, Kolb's experiential learning and John Dewey's experimentalism. Despite several studies does not mentioning explicitly the referred authors, they do refer to experiential learning. Based on this we may state that different theoretical bases have been used to explain SL, however, mostly Dewey's, Bringle's and Kolb's are the more common among them.

The characteristics of the SL experiences from the studies were compared. As mentioned in the introduction section, there is no concrete definition for SLI, which leads to the first conclusion that none of them refer to SLI specifically, but they consider SL activities among courses or projects. Even though the reference is not exact, we may indicate that they share organizational patterns. Therefore, while the categorization is not specific, the previous activities planning, tutoring required, assessment and evaluation, and student grouping, match the definition of internships by Vilca et al [10]. The second conclusion is that the activities are dependent on the engineering area, however, they share the emphasis on applying their technical knowledge to solving real-life problems concerning stakeholders from their societies.

The SL experiences may take place in scenarios outside of universities, on-campus, and at online set-ups. The last had an important boost after the COVID-19 pandemic which started in 2020. However, the central issue is the challenge of keeping the interaction between students and the SL stakeholders. Such stakeholders are varied and span from NGOs, individuals, or students from other institutions. Exceeding the need to state a stakeholder to interact with, their importance relies on the support they bring to the experience by promoting the solution of real-life problems.

Examining the learning outcomes of the SL is the key aspect of analyzing their impact. More than half of the studies sought to develop communication skills; a third of them aimed the enhance problem-solving capabilities, and another third were related to teamwork. This is consistent with Mitchell stating that "in any service learning project, students are an active participant, and with their active involvement they gain vital skills, such as communication skills, ability to work independently, teamwork, critical thinking, problem-solving skills, social awareness and sense of civic responsibility" [13]. Furthermore, this concurs with the National Foundation for Educational Research report on professional skills that determine that problem-solving, communication and teamwork are three out of the five most demanded skills [38]. The other two are critical thinking/analysis and creativity/innovation.

Concerning the technical skills, we may denote that the learning outcomes depend on the engineering area and program.

Regarding the assessment and evaluation of the SL experiences, we may indicate that self-assessment is the predominant way of evaluating the professional skills. This is done, in the studies reviewed, mostly by questionnaires. In the case of technical skills, there are more cases for tutors' evaluation. In this sense, and under Bringle and Hatcher, we can conclude that the studies did not follow the premise that "service-learning grades should be based on learning, not service. Therefore, instructors would need to implement a means for assessing learning which may include, or even be limited to, traditional measures of mastery of the course content [39]. This opens the opportunity to work on the evaluation of professional skills beyond the students' self-assessment.

Reviewing the information about the learning theories for SL, the characteristics of the experiences, the stakeholders of the process, the learning outcomes and their assessment, and other features, we may denote the complexity of their analysis.

We may conclude that there is a reasonable consensus about the theoretical base for such experiences, attributed to Kolb's experiential learning. Therefore, their organization must follow the cycle of concrete experiences, reflective observations, abstract conceptualization, and active experimentation. To fulfill the cycle, a clear problem and its stakeholders must be defined for the planning of activities, interactions, technical knowledge required, and professional skills to be challenged and developed. It is feasible to resolve that the activities for SL may be as varied as the problem that needs to be addressed due to the variety of possible stakeholders. A contemplation is that the planning includes the compliance that a single visit lacking technical involvement does not correspond to an SLI.

Another important consideration is that engineering programs are usually not considered, as might be seen in Salam et al analysis where 2% of the studies for their review correspond to this knowledge area [14]. The number of studies relevant to this review was approximately 0.6% of the publications extracted from the database. These data clarify the need to continue the research of SL experiences for engineering programs.

Considering that the main aspects of SL experiences are commonly accepted, there is a lot of discussion yet about the results of such experiences and how to assess them. This surrenders the two main aspects to be considered for further research.

In the first place, a clear research path would be to change the assessment methods for professional skills from students' self-assessments to concrete and formal assessments from tutors or teachers. It is important to design and validate appropriate instruments for teachers to assess professional skills, separating it from the evaluation of activities or technical competencies required for the SLI.

The other research area to be explored is the process of reflection during the experiential cycle. Even though most of the reviewed publications included student reflections, 40% of the studies did not incorporate them. It is important to analyze how the cycle phases are experienced by engineering students, especially during the stages of concrete experience and reflective observation when the students must be open-minded, adaptative, and allow themselves to observe critically and not follow immediate action. These will help to understand how engineering students apply and develop their professional skills which are extremely important in such phases.

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