

A systematic literature review of reciprocity in engineering service-learning/community engagement

David A. Delaine¹  | Sarah Redick¹  | Dhinesh Radhakrishnan²  | Amena Shermadou²  | Mandy McCormick Smith³  | Rohit Kandakatla⁴  | Linjue Wang⁵  | Claudio Freitas⁶  | Casey L. Dalton²  | Lina Dee Dostilio⁷  | Jennifer DeBoer⁸ 

¹Department of Engineering Education, College of Engineering, The Ohio State University, Columbus, Ohio, USA

²School of Engineering Education, College of Engineering, Purdue University, West Lafayette, Indiana, USA

³Guardians of Honor, LLC, Columbus, Ohio, USA

⁴Department of Electronics and Communication Engineering, KG Reddy College of Engineering and Technology, Hyderabad, Telangana, India

⁵Center for Research on Learning and Teaching in Engineering (CRLT-Engin), College of Engineering, University of Michigan, Ann Arbor, Michigan, USA

⁶Department of Electrical and Computer Engineering, Purdue University Fort Wayne, Fort Wayne, Indiana, USA

⁷Office of Engagement and Community Affairs, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

⁸Purdue Applied Research Institute—Global Development and Innovation & School of Engineering Education, Purdue University, West Lafayette, Indiana, USA

Correspondence

David A. Delaine, 3108 Smith Laboratory, Department of Engineering Education, College of Engineering, The Ohio State University, 174 West 18th Avenue, Columbus, OH 43210, USA.
 Email: delaine.4@osu.edu

Abstract

Background: Scholars agree that reciprocity is a cornerstone of service-learning and community engagement (SLCE); however, engagement with this concept varies widely in practice and across disciplines. To enhance the potential of SLCE to fulfill its promise for societal impact, engineering education must understand how reciprocity is achieved, recognize barriers that inhibit its progress, and identify strategies for how it can be strengthened.

Purpose: We performed this review to understand the ways reciprocity is articulated in the engineering SLCE literature. Drawing from these articulations, we examined the extent of engagement with reciprocity toward providing insights into the design and assessment of SLCE efforts for reciprocity.

Scope/Method: We performed a systematic literature review on engineering SLCE at institutes of higher education. Following an established approach to identify and synthesize articles, we developed deductive codes by distilling three well-articulated orientations of reciprocity. We then analyzed the operationalization of reciprocity in the literature.

Results: The literature demonstrated varying degrees of reciprocity. Minimally reciprocal efforts centered university stakeholders. In contrast, highly reciprocal partnerships explicitly addressed the nature of engagement with communities. Findings provide insights into the breadth of practice within reciprocity present in engineering SLCE. Further, analysis suggests that our codes and levels of reciprocity can function as a framework that supports the design and evaluation of reciprocity in SLCE efforts.

Conclusions: Our review suggests that to enact more equitable SLCE, researchers and practitioners must intentionally conceptualize reciprocity, translate it into practice, and make visible the ways in which reciprocity is enacted within their SLCE efforts.

KEY WORDS

community engagement, engineering education, reciprocity, service-learning, systematic review

1 | INTRODUCTION

Reciprocity, an essential cornerstone for practicing ethical and high-quality service-learning/community engagement (SLCE), is the mutuality in a partnership between an educational institution and a community (Bloomgarden, 2013). SLCE efforts achieve reciprocity when all stakeholders agree on and engage with the problems identified, approaches used, and achieved impacts (Drahota et al., 2016; Hammersley, 2012; Henry & Breyfogle, 2006). SLCE grounded in reciprocity provides opportunities for both the educational institution (e.g., university or other academic unit) and the community (e.g., community centers, neighborhoods, non-profits and their supported constituents) to contribute to, benefit from, and evolve within the partnership; it also ensures that SLCE efforts are built on long-term, trusted relationships (Clayton et al., 2010; Cooper & Orrell, 2016; Mitchell, 2013; Nieusma & Riley, 2010). Reciprocity's emphasis on mutuality across SLCE contexts and practices makes it a useful criterion for understanding, evaluating, and advancing equity across SLCE partnerships.

Although reciprocal SLCE partnerships work to ensure mutual benefits for stakeholders, partnerships that omit or pay lip service to the concept of reciprocity fail to achieve their core purpose, and may even harm vulnerable stakeholders, including communities and students (Marullo & Edwards, 2000; Pompa, 2002). Examples of these harms have been documented, including SLCE efforts that reinforce stereotypes and problematic social hierarchies, prioritize university outcomes and needs over those of the community, and produce outcomes misaligned with community needs (Chesler & Scalera, 2000; Conner & Erickson, 2017). When repeated over time, these imbalanced and inequitable partnerships compromise the trust between community members and partner institutions, and genuine community impact cannot be achieved.

In the last 20 years, the articulations of reciprocity in the SLCE literature have highlighted its complexity and elusiveness. Scholars have focused on reciprocity to describe three primary aspects of SLCE efforts where it can manifest: nature of relationships among stakeholders; ways through which needs or problems are addressed; and outcomes that are generated. For example, Henry and Breyfogle (2006) call attention to all three of these aspects in their discussion of the *transactions* between the “service providers” and “service receivers,” as well as the *mutuality* between the needs and outcomes of these stakeholders (Henry & Breyfogle, 2006). Kendall (1990, as cited in Henry & Breyfogle, 2006) focuses on relationships and highlights the role of *exchange* in the relationships, defining reciprocity as the “... giving and receiving between the server and the person or group being served” (p. 27). Janke and Clayton emphasize equity and define the roles of each stakeholder: “[reciprocity is about] recognizing, respecting, and valuing ... the knowledge, perspective, and resources that each partner contributes to the collaboration” (2012, as cited in Davis et al., 2017, p. 36). Caruccio (2013) further deepens our understanding of exchange in reciprocal SLCE efforts by emphasizing equitable distribution of benefits, risk, contribution, and recognition of stakeholder efforts: “[A reciprocal SLCE effort is] one characterized by mutual benefit, shared risk, collaboration, and an acknowledgment that all parties are serving and being served” (p. 3). These different definitions show how researchers and practitioners think about reciprocity in the theory and practice of SLCE.

Following Trainor and Bouchard (2013), our initial exploration of the engineering SLCE literature echoes their conclusion that “reciprocity was not identifiable as a singular, stalwart concept” (p. 999); in addition, we observe that outside of engineering, work on reciprocity has sought to examine its role in advancing equity and justice in the theory and practice of SLCE. In the social sciences, D’Arlach et al. (2009) defined reciprocity from the perspective of both students and community participants, while Mannion (2012) used an intergenerational learning perspective. Other disciplines highlight how reciprocity is enacted through behaviors in learning processes: for example, health practitioners build participatory relationships with their patients (Melby et al., 2016), and preservice teachers mutually learn “with” and “from” community youth (Donahue et al., 2003).

These recent studies suggest that, rather than using a single definition, a systematic and multifaceted approach for understanding reciprocity might better support researchers and practitioners in addressing its complex and varied nature in SLCE. In perhaps the most comprehensive review of this complexity to date, Dostilio et al. (2012) looked across disciplines and knowledge traditions to orient reciprocity in SLCE. Their review connected current

uses of reciprocity to earlier theoretical work exploring social relations (Gould, 1983), the logic of collective action (Olson, 1965), reciprocal determinism (Bandura, 1977), and several indigenous epistemes (e.g., Harris & Wasilewski, 2004; Kovach, 2009). From this synthesis, Dostilio et al.'s (2012) concept analysis of reciprocity characterizes it across three orientations—*exchange* or interchange of actions, benefits, and resources; *influence*, how outcomes of a partnership are influenced by stakeholders' knowledge and actions; and *generativity*, the extent to which stakeholders collaborate to develop something new that does not otherwise exist. These three orientations represent a robust and nuanced conceptual framework for characterizing reciprocity in a given SLCE effort.

Engineering educators interested in reciprocity will note that engineering SLCE literature rarely prioritizes it. This gap was noted by Oakes et al. (2002), who showed that engineering tends to lag most other disciplines in its acceptance of SLCE pedagogies, as evidenced in the uneven distribution and various forms of SLCE used in engineering education. Owing to this uneven distribution, what is known about reciprocity's effects in other disciplines is only partially integrated in engineering. This highlights the need to better understand reciprocity's presence in engineering SLCE. This exploration is especially vital, because focusing on reciprocity in this context may help explain how educators' and practitioners' implicit beliefs—especially those harmful or problematic beliefs—affect community outcomes (Delaine et al., 2021; Delaine & Thompson, 2021) while also supporting engineering alignment with justice and sustainability (Leydens & Lucena, 2017; Lucena et al., 2010).

To address this gap in our understanding of reciprocity in engineering SLCE, we conducted a systematic literature review of SLCE publications in engineering. Our goal was to explore how the various elements of reciprocity have been conceptualized, incorporated into pedagogical design, interpreted, and enacted in the engineering literature. Therefore, this study aimed to answer two research questions (RQs):

RQ1. *In what ways is reciprocity articulated in the literature of engineering SLCE?*

RQ2. *What do articulations of reciprocity (or lack thereof) suggest about the forms and extent to which reciprocity is manifested in engineering SLCE?*

By answering these questions, this systematic review makes two contributions: we characterize articulations of reciprocity across the literature and establish an analytical framework to more effectively enact reciprocity in engineering SLCE. Specifically, we add (i) an emergent analytical framework providing criteria for integrating, evaluating, and disseminating reciprocity in engineering SLCE, and (ii) patterns in reciprocity indicators across eight framework elements and the differing levels to which they appear. This review explores reciprocity's manifestations in engineering to aid practitioners and scholars in investigating, enhancing, and promoting equitable SLCE practice.

2 | CONCEPTUAL FRAMEWORK

Our systematic review is conceptually grounded in Dostilio et al.'s (2012) conception of reciprocity. Scholars have attempted to account for the complex instantiations of reciprocity in SLCE by developing frameworks to understand and characterize it. Although they differ in emphasis—for example, some emphasize the relationships among stakeholders, while others are more concerned with the impacts and outcomes of those relationships—most depend on *comparison* for understanding reciprocity. For example, Jameson et al. (2010) compare SL relationships by introducing a spectrum with poles of “thick” and “thin” reciprocity. On this spectrum, stakeholders in “thinly” reciprocal relationships interact transactionally and focus on technical outcomes. The authors contrast this relationship with those on the other side of the spectrum, where “thickly” reciprocal SL relationships prioritize not just technical outcomes but achieving mutual outcomes through joint project ownership and co-creation of ideas, knowledge, and power. Because these kinds of relationships tend to produce more mutually beneficial and equitable outcomes, Jameson et al. suggest that these “thickly” reciprocal partnerships are more valuable.

While Jameson et al. assign greater value to SLCE relationships on the “thick” side of the spectrum of reciprocity, Enos and Morton's (2003) partnership typology weaves value-laden assumptions into its organizing logic. Enos and Morton's framework assigns different values to “transactional” versus “transformational” relationships. Transactional relationships, where partners engage in transitory exchanges to accomplish a particular task, are valued less than transformational relationships. In transformational relationships, partners engage in open-ended, ongoing exchanges to

collaboratively work and build knowledge. Using this partnership typology, reciprocity in an SLCE effort is assessed by comparing the effort's relationships across their *duration*, *depth*, and *complexity*.

Thompson and Jesiek (2017) build on the Enos and Morton (2003) partner typology to propose a transactional, cooperative, and communal (TCC) model that focuses on partnerships in engineering. In this model, the transitory exchanges characteristic of transactional partnerships are also characterized by the presence of another social dimension, wherein partners perceive or create a “distinct boundary between stakeholders, thereby tending to preserve or enhance a sense of ‘us’ and ‘them’ between the participant groups” (Thompson & Jesiek, 2017, p. 85). Unilateral partnerships, where the perceived distance between participant groups is substantial, can be exploitative; Thompson and Jesiek note that, by definition, transactional-exploitative partnerships are not reciprocal. In contrast to the “us/them” divide established in transaction partnerships, the TCC model describes cooperative relationships, where partners work together as a single team with a “we” mentality. In cooperative relationships, including the needs of both partners is an essential component because the *process* in which the partners work is as important to consider as what the partners produce (Thompson & Jesiek, 2017). Finally, in communal partnerships, boundaries are “permeable and transcend the participating groups to include the community and/or the society as a whole” (Thompson & Jesiek, 2017, p. 85). Thompson and Jesiek, like Enos and Morton, introduce more categories and granularity for identifying and evaluating elements of reciprocity in SLCE, but Thompson and Jesiek also build in logic comparison for identifying reciprocity.

The schemas we have summarized present valuable insight into the various ways reciprocity has been framed in existing SLCE literature. However, they are constrained in that they are largely dependent on comparison—transactional partnerships are different from (and less “good” than) transformational partnerships; cooperative relationships are different from (and less “good” than) communal partnerships. Evaluating an SLCE effort by comparison to an imagined ideal (“transformational”; “communal”) can inhibit a robust understanding of the extent to which reciprocity is present in an SLCE publication.

A concept analysis (Hupcey & Penrod, 2005) of reciprocity conducted by Dostilio et al. (2012), however, positions reciprocity outside of comparative, value-laden formulation; instead of evaluating the extent to which the reciprocity in a given SLCE effort is “ideal” or “authentic,” their *orientations* reveal the “diverse conceptualizations contained in the term” (Hammersley, 2012). In seeking to avoid the limitations of comparison or a priori valuations of particular forms of engagement, Dostilio et al. (2012) contribution is notable in both its scope—reviewing SLCE literature from engineering as well as from other disciplinary perspectives—and comprehensiveness. Their review constitutes a comprehensive review of the relevant scholarship and its applications. To our knowledge, no other concept analysis of reciprocity has been conducted that is germane to the practices of SLCE; consequently, Dostilio et al. (2012) remains an authoritative resource upon which we ground the conceptual framework for our systematic review.

Dostilio et al. (2012) use a concept analysis to provide a comprehensive description of the forms of reciprocity connected to the ways of *relating*, *knowing*, and *being* among stakeholders along three orientations: exchange, influence, and generativity (further articulated in *Appendix*, Table A1). In *Appendix*, Table A1, we provide descriptions and examples of the three orientations to highlight the ways that differences in how partnerships are enacted correspond to the orientation in which reciprocity is manifested in the same engineering SLCE context. By choosing to describe reciprocity using “orientations,” Dostilio et al. break from existing frameworks, which situated reciprocity in partnerships along a spectrum of valuation. The term “orientation,” itself, suggests a descriptive, nonlinear, nonhierarchical approach to the ways in which reciprocity might be enacted in different contexts. At a minimum, the orientations provide interpretive lenses for clarifying what is conveyed when the term “reciprocity” is invoked in a program description or implementation model.

To identify how reciprocity is articulated in engineering SLCE, we operationalized Dostilio et al. (2012) orientations as a conceptual basis for coding and evaluating literature in our systematic review. Our approach to the systematic review and analytical procedures is detailed in the following section.

3 | METHODS

This systematic literature review was conducted following the PRISMA 2020 guidelines and Borrego et al.’s recommendations for reviews in engineering education (2014). The following section provides a description of our review method, including information retrieval, inclusion criteria, selection process, as well as limitations to our approach. The synthesis stage of our systematic literature review process will follow the Methods in a separate Section 4.

3.1 | Literature search strategy

To establish our dataset, first we developed search terms based on (i) our research questions within engineering education and (ii) keywords related to SLCE and reciprocity. Our intent in using these as search terms was to capture the breadth of literature connected to reciprocity. We used Boolean operators to incorporate synonyms and link major terms. The complete search string used was as follows: (engineering education) AND (partnership OR collaboration) AND (“service learning” OR “service-learning” OR “community engag*” OR “civic engag*”) AND (university OR college OR “higher education” OR “post-secondary” OR postsecondary).

To identify the most appropriate databases to conduct our search, we consulted a subject librarian in engineering education and selected the following: (i) Educational Resources Information Center (EBSCO), (ii) Academic Search Complete, (iii) Education Full Text (H.W. Wilson), and (iv) Education Research Complete.

After searching each of these databases, an initial review suggested that we were not capturing conference proceedings. Because conference proceedings and other “gray literature” can be a valuable source of information in engineering education systematic reviews (Borrego et al., 2014), we completed an additional ERIC database search using the publisher limiter “ASEE” to yield relevant results from the annual meeting of the American Society for Engineering Education. Because the majority of ASEE proceedings are evidence-based practice papers, by including these papers we enriched and expanded our dataset for analyzing the form and extent to which reciprocity is present in practice.

Our initial database search retrieved 187 relevant records. After duplicates were removed, 142 articles remained.

3.2 | Inclusion criteria

Our database search criteria included scholarly, peer-reviewed journal articles and ASEE conference proceedings published between 2000 and 2021. We chose our search period (i.e., 2000–2021) to align with the emergence of engineering education as a field (Froyd & Lohmann, 2014). This window of time also corresponds to a phase of increasing interest in engineering SLCE, and includes publications produced both before and after the Engineering Projects in Community Service (EPICS) program was established (EPICS; Coyle et al., 2005). EPICS has been a highly influential engineering service-learning model throughout the last 15 years, and scholarship on its programming has been disseminated widely to a variety of colleges and universities.

To further tighten the scope of our results for our research questions, we required that all articles explicitly include an engineering context rather than a broad inclusion of the STEM fields. Our inclusion criteria also targeted higher education settings, so we excluded articles that focused exclusively on K-12 programs. Because we are interested in reciprocity as it manifests in SLCE, in our review, selection criteria required that an article have one of the following components: service-learning, community-based learning, or a community-engaged, or university–community partnership. In addition, we chose articles where these components follow one or more of the integration models described by Oakes (2004): integration into existing courses; integration with co-curricular components; new SLCE courses; or SLCE programs. Because prior work (e.g., Salam et al., 2019) shows that SLCE frequently includes cross-national experiences as well as domestic partnerships (and that benefits differ across the contexts), we included both domestic and international SLCE. Table 1 summarizes our inclusion criteria.

3.3 | Selection process

To complete the selection process, articles were randomly assigned to teams of reviewers who then screened each by title and abstract by applying the inclusion criteria. Each abstract was evaluated independently by at least two reviewers. If consensus between the initial two reviewers could not be achieved, a third reviewer evaluated the abstract and applied screening criteria to determine inclusion. A total of 65 papers were retained for evaluation for the next stage of the literature review.

After the initial abstract screening, the full text review of each of the 65 remaining papers was then coded independently by two reviewers. From this process, papers were eliminated because criteria for inclusion were not met: SLCE was absent ($n = 11$) and engineering concepts were absent ($n = 2$). Our final stage of the selection process left a total of 52 articles for full study inclusion. Details of the search, screening, and selection process are provided in Figure 1.

TABLE 1 Summary of inclusion criteria.

Category	Inclusion criterion
Time	Published between 2001 and 2021
Context	Addresses engineering concepts SLCE participants from post-secondary and higher education Service-learning Community-based Learning Community-engaged University–community Partnership International Domestic
Integration model	Integration into existing courses Integration with co-curricular components New or existing SLCE courses New or existing SLCE programs

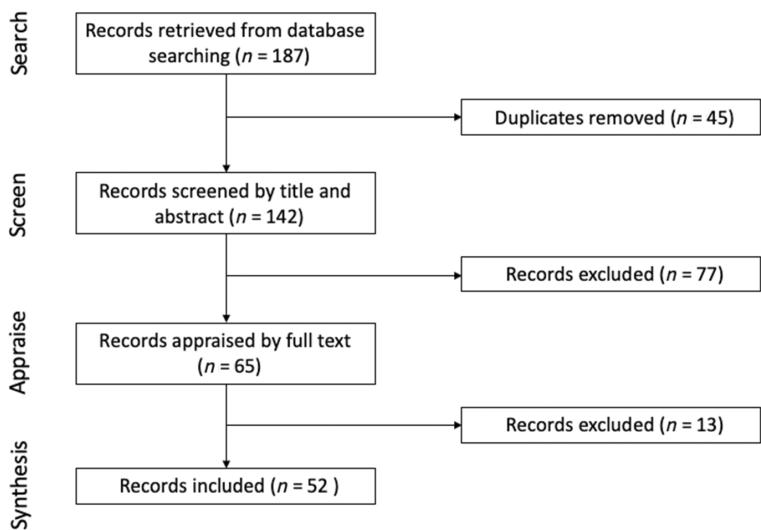


FIGURE 1 Literature search and screening process flowchart.

3.4 | Limitations

There are three main limitations to the methods used. First, we acknowledge that our search terms might not have been broad enough to elicit articles describing the full range and variety of ways that institutions and communities may partner and connect. Various orientations to university–community relationships are reflected in the terminology used in publications. We attempted to capture these diverse approaches through our search terms but, in our focus on SLCE in engineering and higher education, it is possible that we have unintentionally excluded some relevant studies.

Additionally, we narrowed our examination of the literature to engineering-specific efforts. Based on our research questions, a broader consideration of STEM-related SLCE efforts was not included in this review. It is possible that a wider examination of the field of STEM would provide a more comprehensive view of the elements of reciprocity that are currently in practice, but because many of these likely include particular disciplines within STEM (e.g., biology or chemistry), we believe that it would skew our ability to make compelling inferences about engineering, specifically.

4 | ANALYSIS

The synthesis process of our gathered papers was organized in two phases. Phase 1 (Section 4.1) focused on analyzing the articles using deductive codes derived by the core authors from reciprocity orientations. In addition, our Phase 2 analysis (Section 4.2) focused on examining the collaborative memos that were generated during the article analysis. The outcomes of the article and memo analyses revealed a need for further interpretation, particularly around the extent to which the codes alone could provide insights into the extent of reciprocity present within SLCE efforts. Therefore, using the collective findings from our article and memo analyses, we developed a second dimension to interpret the levels of reciprocity in SLCE literature. We used these two dimensions (deductive codes and levels of reciprocity) to establish an emergent analytical framework for evaluating the articulation and extent of reciprocity found in SLCE efforts.

4.1 | Phase 1: Coding

In this section, we present the development and piloting of our codebook, as well as the implementation of deductive codes to analyze the gathered articles.

4.1.1 | Developing codebook using reciprocity orientations

To code the dataset derived through our article selection process, we developed *a priori* codes (Saldaña, 2015) to operationalize Dostilio et al.'s descriptions of the reciprocity orientations. By deconstructing the complex orientations into codes, we were able to methodically analyze our dataset for elements of reciprocity within the SLCE efforts described.

The core author team derived the *a priori* codes through distilling each of Dostilio et al.'s orientations (exchange, influence, generativity) into key observable characteristics, as shown in the "Deductive codes" column in Table 2. Initial codes included "impacts," "knowledge," "approach," "relationship," "context," and "problem identification." For example, under the *exchange* orientation, the description of "give and receive" was interpreted as referring to the impacts and/or benefits received as a result of the engagement. Once the initial set of codes were determined by the core authors, three additional codes were identified during the discussion of the *a priori* codes as implicitly woven into the orientations and as critical components of reciprocity: "definitions," "research methods," and "power, privilege, and oppression." "Definitions" was added to address the various definitions used to define SLCE efforts and the implications each definition had on reciprocity. "Research methods" was added as a code because the research approaches were a core component of peer-reviewed articles, which made observable characteristics of reciprocity accessible through the way methods were enacted, as well as how units of analyses were determined. Finally, "power, privilege, and oppression" emerged in discussions on the implicit and/or explicit nature of these characteristics in the ways reciprocal partnerships are formed and executed.

4.1.2 | Pilot coding session using deductive codes

After we developed the initial deductive codes, the core authors implemented a pilot coding session (Creswell & Creswell, 2017) to systematically align the approach to the analysis across the team. For the pilot coding session, each team member reviewed and analyzed the same sample paper using the deductive codes (Table 3). We also included an additional code, "other," to inductively capture potential emerging codes by the team during the pilot session. Once each member coded the assigned paper, the full team met to discuss and revise the codes before beginning to analyze the full dataset. Our discussion resulted in no major changes or additions to the initial deductive codes. In Table 3, we document the deconstruction of each reciprocity orientation into the deductive codes, justification for inclusion of each code, and guidance for the operationalization of each code in analysis.

4.1.3 | Analysis cycle using deductive codes

The full set of articles were analyzed with the deductive codes documented in Table 3. This coding cycle involved assigning each article to two reviewers, where each reviewer analyzed the article independently using the deductive codes.

TABLE 2 Deductive codes from Dostilio et al.'s orientations to reciprocity.

Orientation to reciprocity	Description of orientations as presented in Dostilio et al. (2012)	Deductive codes
Exchange	“Participants give and receive something from the others that they would not otherwise have. In this orientation, reciprocity is the interchange of benefits, resources, or actions ” (p. 19).	Impacts/benefit
Influence	“The processes and/or outcomes of the collaboration are iteratively changed as a result of being influenced by the participants and their contributed ways of knowing and doing. In this orientation, reciprocity is expressed as a relational connection that is informed by personal, social, and environmental contexts ” (pp. 19–20).	Impacts Knowledge Approach Relationship Context Problem identification
Generativity	“As a function of the collaborative relationship, participants (who have or develop identities as co-creators) become and/or produce something new together that would not otherwise exist. This orientation may involve transformation of individual ways of knowing and being or of the systems of which the relationship is a part . The collaboration may extend beyond the initial focus as outcomes, as ways of knowing, and as systems of belonging evolve ” (p. 20).	Relationship Knowledge Impacts Problem identification

Reviewers employed guiding questions that broke down the concept of each code, enabling them to identify elements of the codes in the articles (guiding questions can be seen in Table 3). Once the coding was complete, each article and the corresponding analysis were discussed by the two reviewers who analyzed them. These discussions were captured in collaborative memos, which then provided the analysis artifacts that served as the foundation for Phase 2 of our analysis.

4.2 | Phase 2: Developing emergent analytical framework for reciprocity

This section presents the analysis of the collaborative memos for each framework element and the levels of reciprocity practice that surfaced from the analysis.

4.2.1 | Analysis of collaborative memos

Once the team of two reviewers completed their independent coding of shared articles in Phase 1, Phase 2 of the analysis included two cycles of exploring the resulting collaborative memos. This was done to capture additional insights from the memo to enrich understanding of how reciprocity was articulated across the articles. The first cycle of analyzing the memos involved developing analytical templates to guide our analysis and to ensure consistency across reviewers. The template included definitions for each of the deductive codes and space for the reviewer to describe characteristics, trends, and exemplars present in the collaborative memos. To allow for flexibility in this cycle of the analysis, reviewers were also asked to capture any emerging analytical observations related to the codes. Each reviewer was assigned a specific code for further analysis (e.g., Author 3 was assigned the “problem identification” code). The authors then analyzed the collaborative memos for their assigned code independently, with the goal of identifying more nuanced insights on the code.

For the second cycle, the authors then met in teams of three to discuss the findings resulting from the first cycle of analyzing the memos. Each team included one member who had performed the analysis of the assigned code and two members who had not. These discussions aimed for consensus on findings and fostered deeper reflection on trends and descriptions.

Throughout the analysis of the memos, the authors identified that the memos presented varying levels of reciprocity depending on the extent of orientation elements being present in the descriptions of the SLCE efforts. From the process of analyzing the articles, we recognized that the deductive codes alone did not capture the breadth of practice related to reciprocity. We explored this idea further by constructing a two-dimensional framework. This framework (a matrix of the codes in Table 3, and levels in Table 4) captures the articulation of reciprocity in SLCE efforts, as well as facilitates identifying the level of reciprocity practice.

TABLE 3 Justification and description of the emergence of each code from Dostilio et al. (2012) orientations of reciprocity alongside guiding questions for analysis.

Code	Dostilio excerpts	Justification of the emergence of each code	Guiding question for analysis
Context	Dostilio et al. (2012) assert that “reciprocity cannot be separated from individuals, families, communities, and generations or the time or place that provide it context and influence it” (p. 24).	Context was derived as an element of our framework based on the importance of situating SL/CE efforts within the particular circumstances of each partnership. The salience of issues related to who, what, when, and where highlight how the students, university, and community enter and maintain relationships. Context is closely related to all other framework elements, as it shapes stakeholder engagement, relationships, and project outcomes. In this case, since SL partnerships involve multiple contexts, we coded for university, community, and student.	<ul style="list-style-type: none"> How is context described? How is student context described? How is university context described? How is community context described?
Approach	Dostilio et al. (2012) argue that a “particular consideration for analysis” is that “reciprocity can be present within a process, an outcome, or both; further, it can actually be a process or an outcome of engagement” (p. 24).	The processes, including the approaches that partners take to initiate and engage in a project, are an important analytic consideration of reciprocity. A closer examination of the steps and actions of the processes involved in approaching a partnership provides a way to understand reciprocal work.	<ul style="list-style-type: none"> What are the steps and actions taken to initiate, engage, and complete the SL/CE effort?
Problem identification	Generativity-oriented reciprocity is characterized by processes “that include the co-definition of issues to be addressed” (Dostilio et al., 2012, p. 26).	SL/CE efforts are initiated when stakeholders problematize an area of focus. Therefore, problem identification was identified as a critical framework element. The way universities, students, and communities are involved and the extent of their involvement in problem identification are reflective of different orientations to reciprocity.	<ul style="list-style-type: none"> How are community needs that are being supported by the SL/CE effort identified?
Impacts	Exchange-oriented reciprocity is implicated, as participants are involved in a straightforward “interchange of benefits, resources, or actions” (Dostilio et al., 2012).	As noted in the Approach framework element, both processes and outcomes are analytic considerations in determining the form and extent to which reciprocity is present in each partnership. The impacts, or outcomes that are achieved, range from the interchange of resources (exchange-based reciprocity) to the transformation of systems (generativity-oriented reciprocity). Impacts were coded at the student, university, and community levels to more closely examine how outcomes affected stakeholders.	<ul style="list-style-type: none"> What are the impacts on stakeholders? What are the impacts on students? What are the impacts on the university? What are the impacts on the community?
Knowledge	Dostilio et al.’s (2012) reference to “ways of knowing” in defining influence- and generativity-oriented reciprocity (pp. 19–20). Additionally, as Dostilio et al. (2012) note, reciprocity “is also relevant to the knowledge products created” (p. 28).	Knowledge was developed as a framework, as it represents a form of currency in reciprocal relationships and includes the ways in which information is generated, exchanged, and shared among stakeholders. Therefore, this framework element also included a consideration of the types of knowledge that were produced through each partnership.	<ul style="list-style-type: none"> How is knowledge created? Who is creating the knowledge? How is knowledge being shared?

(Continues)

TABLE 3 (Continued)

Code	Dostilio excerpts	Justification of the emergence of each code	Guiding question for analysis
Relationship	<p>Dostilio et al. argue that reciprocity in the SL/CE literature is “viewed as relevant in relationships between the full range of individuals and organizations” (p. 20). Further, Dostilio et al. describe the concept of reciprocity from a generativity-oriented perspective as the “interrelatedness of beings and the broader world around them as well as the potential synergies that emerge from their relationships” (p. 24).</p> <p>Partners are embedded in systems that influence differences in identity, privilege, and ways of knowing (Dostilio et al., 2012).</p>	<p>Reciprocity can be expressed through collaboration and relational connections among stakeholders (Dostilio et al., 2012). Therefore, relationship was developed as an element of our framework. These relationships manifest differently depending on the orientation to reciprocity. The way authors report the roles of stakeholders in SL/CE projects and represent their relationships provides insight into how reciprocity is being attempted and enacted.</p>	<p>What is the relationship among stakeholders?</p>
Power, privilege, and oppression		<p>Power, privilege, and oppression was an element that cut across all other framework components. The way stakeholders are positioned, how areas of focus are problematized, and the way relational connections are established and maintained speak to issues of power. The conceptual review on which this framework is based points to the importance of considering reciprocity within systems of power. These elements must be reflected upon in order to provide specificity about the ways reciprocity are expressed in a partnership.</p>	<p>In what ways are power, privilege, and oppression implicitly or explicitly considered?</p>
Research methods	N/A	<p>After an initial mapping of Dostilio’s orientations into operationalized codes, our team met. Our iterative discussions led to an additional framework element, Research Methods. The systematic steps documenting SL/CE projects and outcomes were determined to be an important indicator of reciprocity. Processes regarding the selection and implementation of research methods foregrounds different stakeholders’ interests. For example, community-based learning, community-based participatory research, and other action research approaches have the potential to be generative and transformative, as a result of the fundamental principles that underlie these forms of research. Methodological choices and rigor contribute to the forms of reciprocity that are enacted.</p>	<p>How are research methods described?</p>

TABLE 4 Levels of reciprocity as emerged from systematic review.

Level of reciprocity	Rank	Description of each level
Potentially harmful/ exploitative relationship	-1	Scenarios that show potential for harm, whereby the community partnership was leveraged strictly for the gain/benefit of the university stakeholders.
Not enough information	0	Scenarios in which not enough information was present within the reviewed manuscript to determine the extent of reciprocity present.
Potentially some reciprocity	1	Scenarios in which there is indication of community stakeholders' involvement and benefit, even if it were minimal.
Clear indications of reciprocity	2	Scenarios in which there is evidence of community stakeholders' recognition, participation, and impacts in deliberate ways from a moderate to a high level.
Exemplar demonstration of reciprocity	3	Scenarios in which community stakeholders are well-integrated across the framework components at a very high level in relation to the papers reviewed.

Note: Colors used in table are shown to match the colors of the levels of reciprocity used in the heat map in Figure 2.

4.2.2 | Early stages of analytical framework development

Our analysis in Phase 2 focused on examining the collaborative memos from the lens of understanding how the codes informed the form and extent of reciprocity in engineering SLCE (addressing RQ2). This analysis revealed new perspectives on the wide range of reciprocity practices, and we found that leveraging the deductive codes alongside these levels of practice could function as a framework for understanding, evaluating, and informing the manifestation and extent of reciprocity.

For example, we initially derived the element of “context” based on the centrality of time, place, and the people involved in an SLCE partnership: “reciprocity cannot be separated from individuals, families, communities, and generations or the time or place that provide it context and influence it” (Dostilio et al., 2012; p. 24). The salience of context—who, what, when, and where—highlights circumstances influencing how the students, university, and community enter and maintain relationships. However, through further analysis of the memos, we found that context also informs and connects to all other elements of reciprocity because it shapes stakeholder engagement, relationships, and project outcomes.

During the Phase 2 analysis discussions, we identified that the extent to which reciprocity elements were present in an article was indicative of a level of reciprocity. This observation took shape into a gauge for allowing us to interpret whether a partnership was exploitative or an exemplary demonstration of reciprocity. Table 4 presents the levels that were extracted from the discussions on the Phase 2 analysis, along with a ranking scale that would be used to understand the levels of reciprocity present in the articles we reviewed.

The collaborative memos for each code were evaluated using the ranking system in Table 4, independently by two authors. The authors began by analyzing two memos and then met to check for reliability of their approach to assigning levels of reciprocity. Any text that indicated harmful or negative implications, such as downplaying the community outcomes, in the cell was coded as -1. Any text that either was blank (no data) or mentioned that not enough information was included that would indicate reciprocity was coded as 0. Text that suggested reciprocity was present and/or the community was involved, would benefit, or was impacted/changed to any extent at all, even minimal, was coded as 1. Clear language of reciprocity (shared, involved, collaborative, etc.) was coded as 2. Lastly, in cells where there was an exemplary level of reciprocity with respect to the other papers/framework elements, we coded as 3. In cases where the two coders disagreed, they met to discuss each cell of disagreement, and negotiated a consensus when possible. This ultimately led to an interrater reliability score of 99.2%, where agreement was not possible on only 5 of the total 676 cells. The outcome of this analysis is illustrated in Figure 2 and interpreted in Section 6.

4.2.3 | Authors' note on analysis of articles

Our analyses are based on the language used by the authors of the reviewed articles to report or make claims about what was involved in their SLCE efforts. The authors of this article agreed that a paper with an absence of evidence under a specific code—for example, “knowledge” or “impacts”—does not mean it indicates an absence of knowledge-sharing or mutual benefits in their respective SLCE; rather, it just might mean that it was not reported or emphasized

in the final paper. We acknowledge the prioritization of demonstrating the value systems related to student and university outcomes at institutes of higher education. Because of these values, we therefore further recognized that papers might be limited in presenting evidence of particular themes. For example, Aslam et al. (2014) report that the students and the community co-created knowledge in the SLCE work through appreciating the expertise from both sides. We cannot access the perspectives of participants on all sides of this interaction, but we do know the authors valued the co-creation of knowledge between the students and the community in the relationship because they chose to report it in the article. During the analysis, such value statements are either explicitly described by the authors or are implicit, thus requiring interpretation during the data analysis.

5 | FINDINGS

We operationalized Dostilio et al.'s orientations for understanding reciprocity in SLCE into eight codes. This section presents our findings across each code, in sequence, addressing how each contributes to answering RQ1: *In what ways is reciprocity articulated in the literature of engineering SLCE?* We start by defining the way authors across the engineering SLCE literature articulate content that aligns with each code. After defining the code, we then present the primary characteristics, using examples from each code, while pointing to the trends that were found within each of these emergent characteristics. These findings are summarized in Table 5.

In this paper, it was necessary that we critique the content reported within the engineering SLCE efforts. We recognize reciprocity is a challenge, difficult in practice, and easy to critique. Therefore, we decided to only explicitly cite and name exemplars of reciprocity, while examples of low reciprocity and exploitation are only alluded to in aggregate.

5.1 | Findings: “Context” code

Through our analysis of the articles, data coded within *context* was defined by the conditions of the SLCE effort, including the people, places, time, and environment. We further delineated context into three primary subcodes to align with the SLCE stakeholders: *student context* describes the backgrounds and circumstances of the students; *university context* describes the characteristics of the university and relevant units within it that concern the SLCE efforts; *community context* describes the environment in which the SLCE effort is carried out and the circumstances of the associated community partners.

Across the reviewed articles, we found that there were three main characteristics used by authors when articulating contexts: (i) balance of focus across stakeholders; (ii) depth of description; and (iii) thematic emphasis on history, organizational operations, sites, or people.

Within balance of focus across stakeholders, four categories emerged across the articles (Table 5): (i) an institutional context-focused study (prioritized the university, the university students, and their evolution); (ii) student outcomes and classroom-focused; (iii) community solution/product-focused; (iv) long-term context development/integration-focused.

Studies where the *balance of focus* prioritized the institutional context focused on how the SLCE effort benefited the university, such as the alignment and justification of the course and outcomes with ABET accreditation. Participating universities were often large (and frequently land-grant) public institutions. Descriptions of instructors were often limited to describing the instructors' perspective, their role/lectures, and overall course goals. The curriculum was described alongside a history of SLCE at the university (focusing on justification for the course and procurement of financing). Few studies were part of ongoing courses (those that were, were typically associated with the EPICS program), and these more often had ethics outcomes and the trajectory of the classes described. Again, the course context was typically not a required core course but rather a cornerstone or capstone design course and/or elective. Sustainability of the course was discussed here, as the course may have been designed to meet institutional initiatives (e.g., connecting with an industry/company partner for corporate benefits), the university mission (e.g., Jesuit tradition), and organizational membership. The context referenced the leveraging of institutional commitments, resources, and connections. For long-term SLCE course maintenance, institutional commitments were present (and perhaps required).

TABLE 5 Summary of findings including definition and characteristics of each code.

Code	Definition	Characteristics	Categories
Context (student, university, community)	The specific placement of the SL effort, including the people, places, time, and environment that circumscribe the SL.	Balance of focus	1. An institutional context-focused study (prioritized the university, the university students, and their evolution); 2. Student outcomes and classroom-focused; 3. Community solution/product focused; 4. Long-term context development/integration focused
Research methods	The way in which the systematic steps documenting the SL and its monitoring of success were shared	Type of method	1. Descriptions constrained to one or more of the above foci; 2. Description of partnership
Approach	The steps taken to initiate the collaboration, the process followed to build the partnership, and the milestones on the way to achieve the outcomes intended from the SL efforts	Focus of methods	1. No description of method; 2. Vague description of methods; 3. The Scholarship of Teaching and Learning (SOTL); 4. Mixed/multi-method approaches; 5. Case study; 6. Participatory methods
Impacts	The achieved outcomes described in the reviewed papers	Rigor/quality of application	1. Students; 2. University; 3. Community; 4. Entire SL partnership
Relationship	The way the authors report the roles of stakeholders within the SL efforts	Distribution of impacts/outcomes across stakeholders	1. High-quality Research Methods; 2. Absence of high-quality methods
		Descriptions of relationships within the SLCE	1. Informal and formal integration of SL into the curriculum; 2. Multiple stakeholder involvement in various stages of the SL effort; 3. Efforts taken by university to build international service-learning partnership
		Descriptions of relationships within the SLCE	1. Impacts on students were the most frequently described; 2. University and student impacts were most often the driving factor behind establishing SL partnerships and experiences; 3. Community impacts were often implicit and largely described from the perspective of the authors
		Descriptions of relationships within the SLCE	1. Relationships were reported in a student-centric and task-oriented way; 2. Relationships were facilitated through formal ways of interacting with all stakeholders; 3. Relationships were mutually beneficial, collaborative, and multilateral between multiple stakeholders in CBL/SL efforts

(Continues)

TABLE 5 (Continued)

Code	Definition	Characteristics	Categories
Problem identification	How stakeholders determined the issue, project, or course goals that were addressed by the SL effort	Extent to which multiple stakeholders are authentically involved in identifying problems to be addressed via SL	1. One stakeholder is the primary influence; 2. There is minimal collaboration among the stakeholders; 3. Intermediary organizations support decision making; 4. A systematic, multistakeholder approach is pursued
Knowledge	The ways in which information was identified, exchanged, and generated as a result of university–community engagement and its programs	Types of knowledge	1. Process and product knowledge; 2. Knowledge of community; 3. SL programmatic and theoretical knowledge; 4. SL course/program content and design knowledge
Power, privilege, oppression	The ways in which perceptions of stakeholders, their actions, and ways the language used to describe these indicate privileging or increased authority of one stakeholder over another	Distribution of Power across Stakeholders	1. Knowledge generated and controlled by Faculty and/or students; 2. Community partners as providers of feedback within knowledge generation

Studies with a balance of focus placed on the student context were often nested in the university, where most examples primarily focused on the context of the SLCE course learners. Student leadership was limited (typically not leading the design or decision making of the course). Some were given specific responsibilities (e.g., within a budget), milestones, and requirements for communication with community partners. Assessments for students typically focused on social orientation and satisfaction, but they gave limited descriptions of the students' demographics (e.g., reporting gender, but not race, ethnicity, or ability status). Students often had limited technical experience, and they could take the class to get some practical technical knowledge. Students were often new to service learning, seeing it as an opportunity to volunteer. The student context was isomorphic with the institutional context, in other words, parallel to the aims and behaviors of the institutional context.

The *balance of focus* placed on a community context was reported least frequently of the four categories that emerged, even at times when university and student context were described extensively. The community context was typically introduced with a superficial description of the people but a detailed geographic description. Often these context descriptions were from a deficit perspective, positioning the community as needs-focused, targeting rural poverty infrastructural issues (e.g., food–water–energy nexus). Some studies distinguished the wider community and local partner non-governmental organizations (NGOs). The NGOs were often already working with the communities, which sometimes separated direct communication between the university/students and the community partners. However, when deeply embedded and committed to the community, the NGOs also facilitated reciprocity among all partners. A few of the studies were situated within a domestic context working with community partners in the United States. We found that, more frequently, the SLCE partnerships were cross-national engagements, which can afford the benefits of building global competence and broadening university students' social, political, and cultural understandings of engineering work (Salam et al., 2019). However, this kind of engagement can also position the community partners as "other," flattening understandings of complex social and historical factors, such that students can easily identify inequities in other cultures, but not in their own.

The additional two characteristics used to describe the contexts across articles include the depth of description and the thematic emphasis on history, organizational operations, site, or people. Overall, nearly every article had some description of the context of their work, although a handful focused more on describing the nature of the partnership rather than the partners' contexts. The context description in most articles often situated the SLCE in space, geography, time, goals, and values.

The relationship between the various stakeholder contexts—student, university, community—pointed to how a whole study could be characterized: following Dostilio et al., contexts described in the studies as either *generative* or characterized by a combination of *exchange* and *influence*. Examples of coding for context that were supportive of reciprocity include always mentioning the community site and providing background history and efforts to develop sustainability for the SLCE effort and reciprocal relationship. Elements that were not supportive of reciprocity include superficial descriptions of the community, focus on institutional history/mission, and emphasis on university students. Such elements were "necessarily" often a deficit of focus, seeing reciprocity as a clear exchange. *Generative* reciprocity contexts included descriptions of all relevant resources and motivations across all three stakeholder groups that are very detailed. Participants from the university as well as the community are described in extensive and human detail, explaining their goals and motivations. In contrast, *exchange/influence* reciprocity relations are often aligned with "service" orientations, and the U.S. institutions (whether the student or university units) are described in operational detail. The community is described superficially and as "in need."

5.2 | Findings: "Research methods" code

The reviewed articles articulated "research methods" in ways that led us to develop the following definition: the systematic steps documenting the SLCE effort and the ways of monitoring of success/outcomes/impact. This definition agrees with broad understandings of appropriate program evaluation, learning, and reporting (e.g., USAID, 2022). We recognize that methodological choices in manuscripts can vary significantly, and therefore our analysis focused on the ways authors described their methods, without limiting to a particular methodological approach. In our review, three relevant characteristics emerged: (i) the type of method, (ii) focus of the methods, and (iii) the rigor/quality of the application of the methods.

The most prevalent category of methods types was "no description of research methods", where 12 articles did not explicitly share how they documented, monitored, or made inference about the SLCE effort (see below for further

discussion of gaps in rigor). In the next largest category, 10 articles used a multi-/mixed methods approach, utilizing multiple strategies for gathering information. Scholarship of Teaching and Learning (SOTL) papers and surveys were, respectively, each identified in six articles; methods used but not explicit enough to categorize, as well as qualitative or interview methods were used in five studies; and case study methods were used in four. Given the range of methodological choices we observed in SLCE publications, we discuss in our concluding section the implications for strengthening the investigative approaches within the SLCE space.

Within the focus of the methods category, the unit of analysis within the reviewed articles was most often centered on students, followed closely by the community. We see therefore that the subjects of SLCE in engineering research are most often university students. Further, when a community focus was included as a unit of analysis, these articles still often treated the community like a datapoint, rather than as contributors within a partnership. Very few articles focused on the experiences of the instructors. Some papers focused on describing the structures of the actual SLCE partnership itself (Davis et al., 2014; Kant et al., 2014; Thompson & Jesiek, 2014).

Finally, there was also a range of rigor/quality within the reviewed articles. As we were not evaluating the specific methodological choices themselves, we assessed rigor broadly on the common guidelines for educational research (National Science Foundation, 2013), namely, generating evidence about opportunities for learning or knowledge production. For example, some articles were very rigorous and reported exemplary use of educational research methods (Arcipowski et al., 2017; Stein & Schmalzbauer, 2012). On the other hand, a handful of papers demonstrated little to no methodological quality and/or did not address methods in the article. Papers lacking methodological rigor may have lacked alignment between evidence and design choices or drawn conclusions that involved leaps in reasoning or overinterpretations. Research methods were one of the major gaps identified by our review; the type of method was not always explained, nor was the focus or unit of analysis always explicitly articulated.

Incorporating reciprocity as part of methodological rigor is crucial for equitable SLCE; participatory methods align with reciprocity by involving community partners in the research. The descriptions of a community's participation can indicate whether they were viewed as a data point or full partner. However, SOTL papers frequently do not represent reciprocity because they focus mainly on student teaching and learning, which is oriented toward the university. Therefore, partnership should be considered as part of the methods consideration, including in ethics reviews and peer reviews.

5.3 | Findings: “Approach” code

The “*approach*” across the articles can be defined as the steps taken by the institution and/or the community partner to initiate the collaboration, the process followed to build the partnership, and the milestones on the way to achieve the outcomes intended from the institution–community engagement. Among the articles we reviewed, we captured three main aspects of the approach taken by the three different stakeholders (faculty, students, and community partners) to engage in engineering SLCE activities: (i) informal and formal integration of SLCE into the curriculum; (ii) multiple stakeholder involvement in various stages of the SLCE effort; and (iii) efforts taken by higher education institutions to build international SLCE partnerships as part of a major university initiative or mission.

Most of the reviewed papers focused on SLCE efforts formally integrated into the curriculum. However, the approaches taken to integrate SLCE experiences into undergraduate engineering education differed in terms of the target audience and the types of models for integration. Engineering SLCE courses were offered as one-credit courses (often offered to first-year students), project-based learning elective courses, summer study abroad programs, and senior capstone projects (e.g., Abrahamse et al., 2015; El-Gabry, 2018; Onal et al., 2017; Seay et al., 2016). Most of the SLCE experiences were offered as multidisciplinary courses to students from various disciplines in engineering and technology. Some of the articles reported SLCE experiences integrated as informal extra-curricular activities led by non-profit/student organizations such as Engineering for Sustainable Development and Engineers Without Borders (Chisolm et al., 2014; Florman et al., 2009; Stein & Schmalzbauer, 2012).

Another category that emerged via review of the approach to SLCE was the involvement of multiple stakeholders at various stages of the SLCE efforts such as problem identification, design, development, testing of solutions, and final implementation within the community. Most of the partnerships were initiated by the university, while some were initiated by the community partners themselves. There were also a set of articles that were initiated by nonprofit organizations who acted as intermediate facilitators between the university and community. Few articles showcased a comprehensive multi-stakeholder, participatory approach where the faculty, students, and members from the

community interacted and jointly collaborated throughout different stages of the SLCE effort (Aslam et al., 2014; Dunkel et al., 2011; Kang & Chang, 2019; Reynolds, 2019; Trott et al., 2020).

The last trend observed was the international nature of many of the SLCE efforts, where many included an international component where the problems to be addressed were identified from different countries, especially from lower income nations (Abrahamse et al., 2015; Budny & Gradoville, 2011; Reynolds, 2019; Seay et al., 2016; Simon et al., 2012). Some articles recognized the importance of building cultural awareness among students before visiting international community partners and organized capacity-building sessions to bridge these gaps. For example, Simon et al. (2012) described a direct correlation and impact of improving cultural awareness and constant communication with international partners to the partners' level of ownership and buy-in to the SLCE efforts. Many articles described the logistics and challenges involved in organizing international SLCE efforts where most of the community interaction occurred as part of summer study abroad or a short immersion experience.

Our analysis observed that the extent of reciprocity can be examined via the approach and the extent of stakeholder involvement at various stages of the SLCE effort. Approaches were considered least reciprocal when the students had no interaction with the community partners and worked to solve pre-identified problems provided to them by the faculty. Here, the SLCE efforts were completed within the boundaries of the university and therefore had limited elements of reciprocity within the entire experience. The extent of reciprocity was observed to be more involved in articles where the problems being addressed were identified and provided to the university by the community partner. In this type of approach, the community partner may have had greater, but still limited, involvement in the entire process. Further reciprocity was showcased in SLCE efforts where students actively engaged with community members, contributing to the development of meaningful relationships between the stakeholders. The most thorough form of reciprocity was highlighted in articles that reported following a systematic and/or participatory approach during all the various stages of the SLCE effort. Within these approaches, there appeared to be attempts to build a long-term partnership with the community through frequent face-to-face interactions that can allow the development of trust, respect, and meaningful relationships between the stakeholders.

5.4 | Findings: “Impacts” code

Impacts, defined as the outcomes achieved for each of the stakeholders involved in the SLCE partnership, were observed to cluster across three sets of characteristics, similar to the three sets for *context*. As with the context code, these three areas of impacts—student, university, and community—were further delineated to align with the three stakeholders: *student impacts* describe the outcomes and benefits directed at students; *university impacts* describe the impacts associated with the university and relevant units within it that concern the SLCE; *community impacts* describe the benefits and outcomes directed at community partners. The analysis of the *impacts* explored the implicit and explicit outcomes of the SLCE efforts described by the authors and resulted in three trends across the reviewed papers: (i) impacts most frequently centered students; (ii) university and student impacts were most often the driving factors behind developing SLCE partnerships and experiences; (iii) community impacts were often implicit in the reviewed papers and were generated from the perspective of the authors.

The first trend we observed was that, in describing outcomes of the SLCE effort, impacts most frequently centered the outcomes achieved by the students. The primary areas of impact on students were the technical and professional skills that were developed. In the reviewed papers, impact was evaluated using techniques such as pre and post surveys (e.g., Budny & Gradoville, 2011) and guided reflections (e.g., Florman et al., 2009), which were most often used for the purpose of assessing student learning outcomes. Moreover, the evaluation techniques predominately focused on learning outcomes associated with technical skills (i.e., problem-solving and engineering design), while professional skills (i.e., cultural competency, leadership, communication) were often not explicitly evaluated, but an assumed outcome of the immersive nature (i.e., cultural, geographic) of the SLCE experience.

The second trend that emerged from analyzing the impacts of the reviewed papers suggested that SLCE efforts were developed to fulfill the need of achieving specific outcomes for universities and students. Across the reviewed articles, the primary need identified was to provide experiential learning opportunities for students. Some papers alluded to unassessed long-term university and student impacts, such as graduating students who were giving back to society more broadly. The impacts on the universities varied, but largely focused on increasing access to funding opportunities, positive media and public exposure through curricular advancements, an enhancement to recruitment and retention efforts, and vague or watered down allusions to broader impact that align with societal benefits.

The third trend revealed that there were few instances where community impacts were described, and even fewer where these impacts were centered. Further, when impacts on the community were described, they were written from the authors' perspectives rather than collected from the community perspectives themselves. The most common community outcomes that authors did include tended to make assumptions of positive outcomes for the community by nature of the service students provided (e.g., community will benefit from having a product installed for them), the product of the engineering design project, community being educated on engineering topics broadly or on the specific product or service being provided, or community being empowered to use the installed product. Lastly, impacts on communities were not prioritized by authors when providing a description of the overall SLCE efforts. This outcome could be a result of the value systems at institutes of higher education, as mentioned earlier in the paper. However, this could also be a result of not centering community perspectives when approaching the design of a SLCE effort, particularly the evaluation aspect of the effort. Only two of the articles (Davis et al., 2014; Stein & Schmalzbauer, 2012) intentionally collected feedback from the community partners as evidence for the community impacts that were described in the paper.

When considering the findings of the impacts code through the lens of reciprocity, characteristics of mutuality in the partnerships could be inferred, but not confirmed, in some cases by observing how and in what ways impacts were framed and prioritized in SLCE efforts. For example, when the impacts only focused on student and/or university outcomes, it is possible that community impacts were not considered, or only seen as a byproduct at the conclusion of the student service experience. This inference can indicate an exchange orientation of reciprocity, where student learning is one of the impacts of the service and the community also experiences an impact from the service, resulting in a direct exchange of benefits during the experience. However, when community perspectives are excluded from the evaluation of the impacts of a SLCE effort, there is a risk of actions from students and universities that could produce negative outcomes on the community. These outcomes could undermine reciprocity, resulting in an imbalance in the exchange of resources, inauthentic relationships, and a partnership lacking transformative outcomes for the partner community.

5.5 | Findings: “Relationships” code

In our review, coded data highlighting *relationships* addressed how the authors (from university or community) describe the roles of stakeholders (university, students, faculty, programs, community) and their interactions with each other. For example, we observed the form and frequency of communication between student design teams and users/clients in the partner community site. Three trends emerged in the literature when describing the relationships within SLCE: (i) relationships were reported in a student-centric and task-oriented way; (ii) relationships among all stakeholders were established through organized interactions; and (iii) relationships were mutually beneficial, collaborative, and multilateral between multiple stakeholders in SLCE efforts.

The first category includes articles where the authors reported the relationship in a student-centric and task-oriented way. Here, the content in the articles suggests these relationships were formed to facilitate student learning outcomes. For example, in one case, students were engaged in relationships with beneficiaries who served a supporting role in the student-centric goals of learning a technique, process, or approach. In other studies relationships were often established to exchange the benefits of learning outcomes and to finish projects. Furthermore, the community is often described as a “beneficiary,” indicating a distance and distinction in the relationship between the students and the community as provider and receiver.

The second category lends insight to articles where the authors reported the relationship by mentioning formal ways of facilitating interactions among stakeholders (primarily students and community partners). In these interactions, for example, formality was introduced by generating a list of the stakeholders, roles, or responsibilities involved in the SLCE efforts (e.g., Chisolm et al., 2014). Additionally, a structured approach for fostering relationship-building was implemented through organized meetings, rather than having students engaging with the community in spontaneous ways. For example, Onal et al. (2017) describe formal meetings initiated when the instructor visited the local community organizations where student teams could observe the challenges associated with the projects firsthand and discuss possible solutions with local community leaders. The project teams then continued meeting with the community organizations to share their suggested solutions and implement the agreed-upon revisions. As a result, the project teams and the community developed relational connections, facilitating conversations and promoting deeper relationships through regular communication, and using meetings as formal spaces for interacting.

The third category of articles includes content where the authors report relationships to be mutually beneficial, collaborative, and multilateral between SLCE stakeholders. In this category, the key purpose of such a relationship is to support both university and community goals. These efforts recognize that SLCE cannot exist without community buy-in and collective engagement. For example, Bratton (2014) acknowledges that their global program is only made possible through relationships in which “students learn to see ‘clients’ as ‘partners’ without whose cooperation, the solutions created, no matter how innovative or affordable, would be less likely to succeed in the long-term. The needs of partner organizations must be satisfactorily addressed for the relationship to flourish and the project to advance” (p. 207). The value of understanding such purpose is to facilitate the students’ appreciation of knowledge from the community and enable all stakeholders to feel a part of and contribute to the project.

To summarize, the ways relationships are approached and described may reflect the authors’ intentions to support reciprocity. If the relationship is positioned as student-centric and task-oriented, it can be challenging to determine how reciprocity is present via this framework element. Our analysis suggests that, in addition to investing time and approach, partners may authentically and systematically structure relationships through formal interactions and also invite mutual engagement and increased levels of reciprocity. Similarly, mutually beneficial, collaborative, and multilateral interactions among multiple stakeholders in SLCE efforts embody highly reciprocal relationships (DeBoer et al., 2022; Delaine et al., 2023).

5.6 | Findings: “Problem identification” code

Data coded under *problem identification* led us to define this code as how stakeholders determined the issue, project, or course goals that were addressed/pursued by the SLCE effort. Problem identification existed along a continuum that involved varying degrees of collaboration among stakeholders. Some papers described how projects were selected, yet omitted who was involved in the selection process. These articles provided little insight into how the project’s focus was determined and which stakeholders were involved. In other cases, when problem identification was described, it could be differentiated into four categories.

Through our data analysis, four categories of problem identification emerged: (i) one stakeholder is the primary driver of problem identification; (ii) collaboration among stakeholders to identify problems is evident, but limited; (iii) external stakeholders, such as intermediary organizations, drive problem identification; and (iv) problem identification is derived through a systematic, multi-stakeholder approach.

In the first category, one stakeholder was the primary influencer when determining what problem to address, even if opinions of other stakeholders were solicited. For example, Onal et al. (2017) described a partnership in which either students or the community independently submitted industrial engineering projects ideas to faculty members, who ultimately decided which projects to focus on in the course.

A second category emerged when there was some input from multiple stakeholders in identifying the problem. In these cases, there was community involvement or co-development in the generation and selection of projects. For example, university faculty and engineering students collaborated with middle school principals and students to propose new projects (Anderson, 2005). In a similar effort involving multiple stakeholders, Dewoolkar et al. (2009) involved the community and university faculty in the scoping stages of the project, in which problems were identified to also align with the aims of the course and requirements of the university.

External or additional input, such as the involvement of intermediary organizations or community-based research, represented the third category of problem identification. NGOs connected communities with university partners or provided insight into what local needs the SLCE effort might address. In their work with an Egyptian squatter village, an NGO provided information about which projects might benefit the children in the community (El-Gabry, 2018). Market research and needs analyses also contribute to identifying significant problems for the community. Arcipowski et al. (2017) described the identification of the problem of access to clean water through input from the community and research, which indicated that this issue substantially impacted the community.

The fourth category of problem identification occurred when multiple stakeholders were systematically involved in defining problems and selecting projects for SLCE efforts. Previous partnerships represented one potential way stakeholders worked together to determine which problems were most appropriate for SLCE. For example, in the development of the Bowman Creek Academy, a multi-year partnership was used to identify local environmental concerns (Boukdad et al., 2018). Intentional collaborative listening sessions can also support these methods of problem identification. For example, Dale et al. (2014) prioritized focus group sessions involving the university

team, the village council, partners from a local NGO, and other community stakeholders. Additionally, transnational partnerships such as that between EWB-MSU and the Khwiser community created structures to support collaboration among stakeholders, enabling the project team to better serve the community (Stein & Schmalzbauer, 2012). An advisory board was established with community members to work with students on surveys and send them to local residents. Results from the surveys were then used to determine which schools would benefit from the SLCE efforts. These examples reflect attempts at partnerships that involve the continued and systematic co-generation of projects.

How problems were identified is shown to influence the degree of reciprocity embodied in a partnership. Of the articles reviewed, 13 did not explicitly address who identified the problem, 10 represented one stakeholder as the primary influence in problem identification, and 9 showed systematic, multi-stakeholder involvement. The range of stakeholder involvement reflects how projects are determined, how stakeholders can be involved in the selected projects, and who benefits from the outcomes and relationship. Involvement from the community that is superficial or marginal can result in projects that are not aligned to community needs, that are unworkable or prioritize student coursework over community issues. These patterns pointed to minimally reciprocal relationships. Conversely, the perspectives of multiple stakeholders and their active involvement in identifying problems can increase the relevance of projects to the community and incorporate their core values. Additionally, sustained partnerships may support the development of realistic timelines and achievable goals. These examples illustrate the opportunity for collaborative problem identification to increase reciprocity. Given these trends, we argue that addressing how problems in SLCE are identified provides transparency and supports efforts to create reciprocal partnerships.

Evaluating the approach to problem identification within an SLCE effort provides insight into how reciprocity is supported. Reciprocity may be reflected in *how* problems and needs are identified and *by whom*. Given these trends, addressing how problems in SLCE are identified provides transparency and supports efforts to create reciprocal partnerships.

5.7 | Findings: “Knowledge” code

The coding of the articles for *knowledge* resulted in our defining this as information identified, exchanged, and generated as a result of stakeholder engagement in SLCE efforts. We utilized the term “information” broadly, including data gathered to understand the community and the context, the project-specific information exchanged between the participating stakeholders, and finally, new knowledge generated, or existing knowledge validated through research. We evaluated the articles for what knowledge is gathered/exchanged/generated and who participates in knowledge-related activities. Four forms of knowledge were represented across the articles reviewed. These include (i) process and product knowledge, (ii) knowledge of community, (iii) SLCE programmatic and theoretical knowledge, and (iv) SLCE course/program content and design knowledge. Additionally, embedded within each of these categories is an additional characteristic that promotes understanding of knowledge: loci of control, ownership, and/or creation of knowledge. Two more categories support this understanding: (i) knowledge generated and controlled by faculty and/or students, and (ii) community partners as providers of feedback within knowledge generation.

Process and product knowledge highlighted the engineering design process, problem-solving-related information, and information of products (mostly technical) that were designed. We observed two variations in process and product knowledge: one was observed in the articles that provide dedicated and detailed descriptions of the engineering design process applied in the program. These articles highlight the various ways the steps in the design process were completed by the students participating in the program. In this type of representation, students and faculty are described as predominantly responsible for this knowledge with no representation of the community. The other type of process and product knowledge was observed in descriptions of the community as an end user in the design process. The articles under this type highlight the critical role played by the community during the needs assessment, problem scoping, data gathering, validation of solution and results, and in the other design stages to provide feedback (Bratton, 2014; Brockman et al., 2017). These articles also commonly present the type of their program or process as user-centered or human-centered, or humanitarian engineering (Arcipowski et al., 2017; Florman et al., 2009; Stein & Schmalzbauer, 2012).

The second category of knowledge we observed—knowledge of community—relates to descriptions of community history, demographics, and other contextual information. Similar to process and product knowledge, knowledge of community is also commonly represented in two different ways: In the first type, articles addressed the community’s

geographic and demographic information and highlighted the significance of this knowledge in creating relevant designs and meeting user needs. However, these first type of articles omit reference to how the community knowledge was obtained and integrated into the design of the SLCE effort or project process. In contrast, in the second type, knowledge of community is both acknowledged and applied in the overall collaboration and implementation of the SLCE effort and project process. Here, the processes are commonly highlighted by describing it as “collaborative design,” and “sustainable approach for partnership” (Arcipowski et al., 2017; Florman et al., 2009; Rodriguez et al., 2014; Thelenwood et al., 2020) and the community members as “local experts” (Arcipowski et al., 2017; Stein & Schmalzbauer, 2012). Based on these descriptions, this category might best be described as “knowledge with community.”

The third knowledge category—SLCE program and theoretical knowledge—connected information from the SLCE literature and theories to the conceptualization and approach of the effort. The program and theoretical knowledge are shown as being gathered and communicated by the university members, that is, students and/or faculty participating (Cannon et al., 2016; Duff et al., 2014). Belonging directly to the academic community, faculty and students take on this role to perform the literature reviews relevant to SLCE and the specific nature of their own efforts and draw theoretical connections to support their program and research study. It is difficult to conclude reciprocity in this form of knowledge, as the process of obtaining and adapting this information is not discussed or represented in the articles. Community participation is only highlighted after the faculty and/or students have generated the program and theoretical knowledge.

Finally, the fourth category of knowledge—course/program content and design knowledge—highlighted information on the SLCE effort's structure, format, and design process. Knowledge specific to the program/courses is represented based on the course structure and learning goals: that is, first-year design (Dale et al., 2014), capstone (Cannon et al., 2016), projects as part of a course, or others. This is again presented in two ways. The majority of articles discuss and highlight the role of faculty as a significant contributor to the design of curriculum and course content. Although typically faculty were the key stakeholder in providing this kind of knowledge, NGOs and students were knowledge makers in some of the studies. For example, NGO partners provided feedback on the overall structure and content within which they hold expertise (El-Gabry, 2018).

Two critical themes emerged from our analysis of knowledge and its relationship to reciprocity. First, reciprocity is dependent on the form of knowledge highlighted in the articles—SLCE efforts where knowledge across these four categories involve the community to a greater extent tend to be more reciprocal. Second, the locus of control/responsibility for knowledge among the stakeholders varies based on the form of knowledge, which further demonstrates the nature of the effort's reciprocity. Except for programmatic and theoretical forms of knowledge, all other forms present some community role in the knowledge and, therefore, present elements of reciprocity. It is important to note that articles in which community partners were creators/owners of knowledge were not observed. Foregrounding community knowledge demonstrates increased efforts toward reciprocity.

Furthermore, collaborative and sustainable development may result from positioning community members “as experts in their own history, culture, community challenges, and strengths” (Arcipowski et al., 2017, p. 5). To summarize, the different forms of knowledge presented in the articles demonstrate reciprocity at varying levels based on the participation of the stakeholders in the process. While certain forms are traditionally limited to the involvement of university stakeholders and are more commonly represented, the few articles that did show examples of community inclusion through equitable participation demonstrate reciprocal relationships, which can result in sustainable SLCE efforts.

5.8 | Findings: “Power, privilege, and oppression” code

The *power, privilege, and oppression* code emerged from the data to be defined as the ways in which the language used to describe perceptions of stakeholders and their actions indicate the privileging or asserting of authority of one stakeholder over another. The main characteristics shown to impact this element include (i) who is in control of the SLCE decision making and implementation, (ii) how power is conveyed through language, and (iii) control of and access to resources.

The first characteristic, namely who is in control of the SLCE decision making and implementation, emerged within four categories across the articles. These categories reflect who is empowered and/or to what extent (and how) power is shared as described within the SLCE efforts. The first category reflects articles in which students and/or faculty

held more power. In this category, power dynamics may be problematic, as there is potential for exploiting community partners. Additionally, this category includes cases where power imbalances were discussed as being addressed through the “long game”: Here, authors justified the privileging of students, assuming trickle down to communities over time as these students developed into professionals embracing social responsibility. The second category reflects articles where effort is taken to empower the community. In this category, power dynamics was acknowledged, and attempts made to level power imbalances/efforts taken to empower community partners were presented. (Arcipowski et al., 2017; Aslam et al., 2014; Boukdad et al., 2018; Nieuwsma & Riley, 2010; Stein & Schmalzbauer, 2012). The leveling of power dynamics can be a complex challenge and, in some cases, power imbalances persist in favor of students/faculty despite efforts to level them. The third category reflects SLCE efforts where community members were involved as full partners in the SLCE efforts (Florman et al., 2009; Kang & Chang, 2019). Lastly, the fourth category includes efforts where power is retained by the community (Ing et al., 2012). In this scenario, the community partners held authority over all decision-making processes. Additionally, articles were reviewed in which power dynamics were not addressed or could not be determined.

The second characteristic centers the ways in which language reflects the power dynamics within the SLCE literature, highlighted by three categories. The first category involves instances when subtle language cues disempowered the community partners. Here, language such as “developing world,” “beneficiaries,” and describing the SLCE efforts as “fun” and “a good time” for students reflect ways in which university stakeholders hold more power than community partners. Additionally, deficit language was often used to describe the community context as well as community skills/abilities. In the second category, language cues that indicate an equitable consideration of power were used within the articles. Terminology such as “peers” and the use of descriptors that highlighted assets rather than deficits were shown to center the strength of partners and opportunity within the community. Additionally, the privilege of the students, such as the use of “socioeconomic advantage,” was sometimes declared in meaningful ways that acknowledged the power imbalances and sought to minimize the impact. Lastly within this category, language was used that reflected priorities within the SLCE context. Here, “soft skills” can highlight how professional skills may be considered secondary to technical skills in an engineering context. Additionally, some articles showed a desire to move away from the “service-learning” language, as “service” may connote a more powerful stakeholder serving the other.

The last characteristic to emerge reflected control of and access to resources. This characteristic highlights how resources reflect power and control within SLCE. Here, the ability to obtain, access, and utilize funding was the primary way this characteristic was manifested.

To summarize, funding, decision making, and outcomes were areas that indicated privileging of one stakeholder over another. Overall, the language use provided a direct way to determine how power was distributed or withheld from stakeholders. Ultimately, this element mirrors the essence of reciprocity, as in certain ways reciprocity can be defined as the sharing and/or equitable distribution of power within and across SLCE efforts. With equitable power, a partnership can strongly reflect reciprocity.

Through the coding process and the results of our data analysis, the trends we see suggest an emergent analytical framework. In the next section, we situate the overall trends, explain the analytical framework, and recommend its usage for others.

6 | DISCUSSION

To better understand the form and extent to which engineering enacts or articulates reciprocity in their SLCE efforts, a critical review was necessary. Where our Section 5 provided a direct, summative answer to **RQ1** (*the ways reciprocity is articulated in the literature*), we situate our results in Section 6 by using the emergent analytical framework to answer **RQ2** (*What do articulations of reciprocity (or lack thereof) suggest about the forms and extent to which reciprocity is manifested in engineering SLCE?*). Overall, we observed a wide range in the forms of reciprocity that papers emphasized, as well as varying degrees in the extent to which programs were reciprocal. In this section, we will begin by discussing a wide range of engagements with reciprocity SLCE efforts through visual illustrations of the outcomes of the analytical framework. This will be followed by a synthesis of forms of engagement with reciprocity from our interpretations of the findings, including (i) positive engagement with reciprocity, (ii) limited or exploitative engagement with reciprocity, and (iii) undisclosed or under-articulated engagement with reciprocity. Furthermore, we will examine the qualities of engagement with reciprocity, as well as the challenges and limitations of engagement, all converging toward a primary conclusion regarding the significance of directly articulating reciprocity within engineering SLCE. Our subsequent Section 7 expands on these further.

6.1 | A breadth of engagement with reciprocity across the framework elements

Engagement with reciprocity is shown spanning from exploitative to exemplary. It also provided a variety of entry points for understanding how reciprocity is or is not being actualized. To one extent, there is evidence of singularly beneficial SLCE efforts (actions and benefits of engagement initiated and received by only one group of stakeholders),

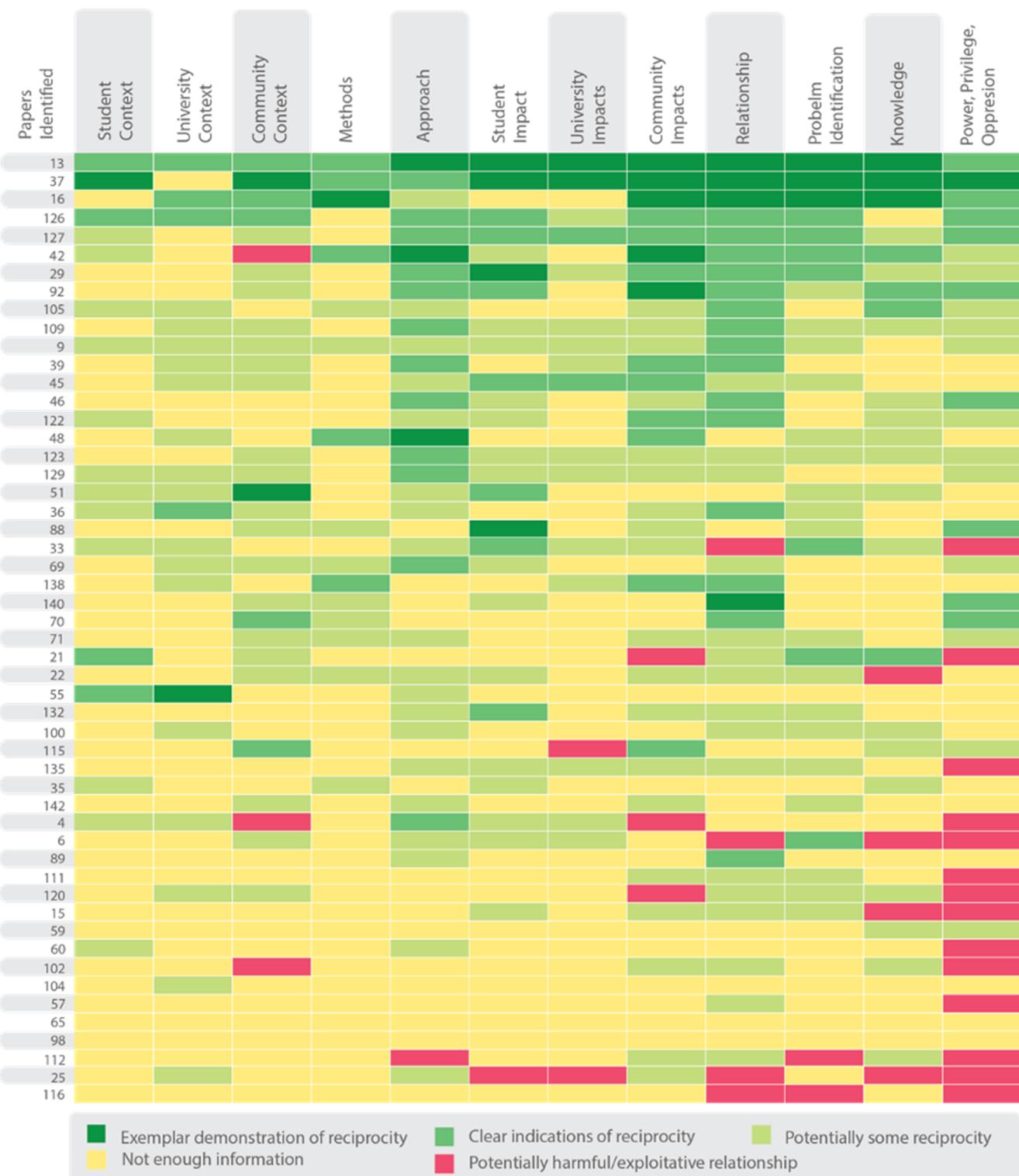


FIGURE 2 Heat map revealing level of reciprocity across the reviewed engineering SLCE literature and framework elements.

which could benefit from more reciprocity. Conversely, SLCE efforts that demonstrated more reciprocal elements were observed to not be singularly beneficial to one stakeholder or performance of a specific service. Rather, they were efforts that were co-generated across stakeholders, collaborative in all phases of development, execution, and sustainable over the longer term.

We show in Table 6 that nearly every cell (framework element *by* level of reciprocity) has an example excerpt from our literature review that exemplifies the breadth of engagement with reciprocity. This breadth also represents a lack of consistency in forms and levels of reciprocity, leaving individuals and institutions to define for themselves what is acceptable, often with few benchmarks. We see some general strength areas (*approach*, with high levels of reciprocity described in the overall program plan, and *student impacts*, in that students take away skills and knowledge about cross-institutional exchanges) as well as some generally exploitative areas (*power relations* implicitly or explicitly described, treatment of *knowledge*, setup of *relationship*, and the elements related to *community*). We see some areas of overwhelming lack of information about reciprocity (*methods*, *student context*, *university impacts*).

To further articulate the breadth of engagement with reciprocity, we created a heat map across a matrix of the 52 reviewed papers and the framework elements, presented in Figure 2. This figure illustrates the extent to which reciprocity is present within the reviewed engineering SLCE literature, using horizontal and vertical dimensions to intersect findings. The horizontal axis represents the framework elements (listed in Table 3), while the vertical axis lists the 52 reviewed papers in a color-coded fashion indicating reciprocity levels. Papers are sorted from least to most reciprocal, with paper 13 being the most reciprocal and paper 116 being the least. This heat map provides a snapshot highlighting the range of highly reciprocal to exploitative practices across studies, the extent to which few studies embodied the same level of reciprocity across elements, and the most consistent trend being a lack of information on specific elements that would clarify the level of reciprocity.

As a synthesis of Figure 2's heat map, we provide an alternative model (Figure 3) to illustrate the extent to which each framework element is present across the reviewed papers. This model shows the attention given to each framework element individually, summing the number of papers that address it at each indicator level. Three aspects are emphasized: vertical axis arranges levels of practice (−1 to 3), horizontal axis lists framework elements, and three shapes represent paper counts for each element's reciprocity indicator. For example, in the first column, out of 52 papers, 35 lacked sufficient student context information, 12 papers showed some reciprocity, while only 5 exhibited clear or exemplary reciprocity levels.

Several discussion points emerge, such as 14 papers demonstrating evidence of harmful community relationships when analyzed with respect to power, privilege, and oppression. Further, many papers do not provide sufficient detail within many of the elements, indicating a need for greater clarity around the extent of engagement with reciprocity. Trends emerge from these figures, illustrating the ways in which SLCE is positively engaging with, struggling to engage with, and neglecting to articulate reciprocity (discussed in more detail below).

Such breadth of engagement with reciprocity complements previous work in this area that demonstrates how relationships in community engagement can operate differently with varied approaches to reciprocity, including conceptualizations of thin and thick reciprocity (Jameson et al., 2010), transactional and transformational partnerships (Enos & Morton, 2003), and transactional, cooperative, and communal models of partnerships (Thompson & Jesiek, 2017). These models acknowledge that inequity and reciprocity cannot coexist in the long term, which aligns with assumptions proposed by the Dostilio et al.'s (2012) framework. Our work complements and expands on existing work by demonstrating the ways reciprocity can exist across multiple levels and forms of engagement at the same time.

6.1.1 | Positive engagement with SLCE reciprocity

Across the reviewed papers, reciprocity characteristics—long-term community partnership, collaborative research approaches, long-term engagement, relevant impacts, multi-lateral, collaborative relationships, and power retained by community—provide a further understanding of elements that support the highest levels of reciprocity. Approaches attending to relationship structures and problem identification by engaging all stakeholders from the beginning ultimately support practitioners in pursuing reciprocal engineering SLCE partnerships. Participatory approaches and research methods actively engage communities, students, and universities in all stages of the relationship (Coughlin et al., 2017). Community-based learning, community-based participatory research, and other action research approaches have the potential to be generative and transformative as a result of the fundamental principles that underlie these forms of research (Radhakrishnan et al., 2022). These are therefore observable indicators of high levels

TABLE 6 Extent of reciprocity and specific levels of reciprocity derived from the framework elements.

Framework element	Potentially harmful relationship	Not enough information	Potentially some reciprocity	Clear indications of reciprocity	Exemplar demonstration of reciprocity
Context	Deficit-language	Institution-focused	Community demographics and participation in the program	Community-centered design	Long-term community partnership
Example excerpts	<i>"the community is one of the poorest in the region and required expert help"</i>	<i>"the paper describes program that involves community engaged work in a university and understands the students' learning"</i>	<i>"students spent time interacting with our community partners"</i>	<i>"students attended multiple lectures by the community leaders throughout the design stages... Community leaders and representatives demonstrated expertise in the adaptation of local technical systems that were different than the ones our students were used to at the university"</i>	<i>"our long-term program established community advisory boards involving community members in the decision-making phases. Over a decade our program established strong ties with not only the community but various private and public organizations working in the community, which allowed us to leverage resources from multiple stakeholders."</i>
Methods	NA	Scholarship of Teaching and Learning	Inclusion of community data	Inclusion of community in research design	Collaborative/participatory research approaches
Example excerpts	NA	<i>"applied mixed-methods to understand the student's experiences in the service learning"</i>	<i>"mid-semester survey captured student and community feedback and was analyzed using qualitative methods"</i>	<i>"the survey and interview protocol was validated and translated by community representatives"</i>	<i>"community representatives were included in the research design process as equal stakeholders to investigate the community outcomes"</i>
Approach	Unstructured and choice-based	NA	Community stakeholder involvement in the process	Community-initiated and community stakeholder led	Collaborative and long-term engagement
Example excerpts	<i>"list of communities and problems were scoped and introduced to the students. Students selected the communities to work"</i>	NA	<i>"team of students worked with a client from a local non-profit organization to develop tools that would fulfill a need of the client."</i>	<i>"The engineering students were given the orientation for the program who then approached the communities to gather project ideas. Students and community members together scoped these projects"</i>	<i>"the program developed at the university drives the development of sustainable community projects. We engaged with the community with daylong brainstorming sessions"</i>
Impacts	Downplaying community outcomes	Student and institutional impacts only	Useful solution to community needs	Mutual benefits	Sustainable impacts for the community and institution
Example excerpts	<i>"Defining success partly through student learning, regardless of final implementation, could be seen as the 'long game'."</i>	NA	<i>"community received high quality technical resource and problem solutions"</i>	<i>"students created successful devices that was tested by the end-users. Students made several comments about realizing the importance of working with the communities and valuing their local knowledge"</i>	<i>"all designs were installed with the collaboration of skilled locals who are able to then maintain the systems. Our program, in addition to the service-learning program, since the collaboration a decade ago have contributed to the infrastructure of the local school, set-up scholarships, and provided healthcare support to local women"</i>
Relationship	Institution-centered and prioritized	Focused only on students	Formal relationship with multiple stakeholders, university-led	University-led, community-integrated	Multi-lateral, long-term, collaborative
Example excerpts	<i>"community partners failed to meet the requirements and expectations of students and faculty"</i>	NA	<i>"University established connections with the local NGO. The NGO provided the orientation for students and students visited the community once."</i>	<i>"The instructor visited the local community multiple times along with the project teams to observe the problems firsthand and discuss possible solutions with community leaders."</i>	<i>"The partners share mutual commitment to each other that has provided the space to develop the partnership organically"</i>
Problem identification	Instructor-led and choice-based	Not disclosed	Third-party organizations and community representatives identified	University-led, and collaboratively identified	Community identified and supported with evidence
Example excerpts	<i>"instructor screened the clients (communities) and made the final selection was made"</i>	NA	<i>"The local NGO identified the problem for the community"</i>	<i>"a community member wrote a proposal to our organization (professional organization in the university) to address his community needs"</i>	<i>"The problem was identified by the community and backed by significant weight of research explaining the issue has substantially impacted the community"</i>
Knowledge	Community solely as receiver of knowledge	Not disclosed	Community as users	Community recognized for valuable knowledge contribution	Collaborative knowledge generation
Example excerpts	<i>"The students believed they had all the knowledge needed to solve the problem. The community children who participated in the program were criticized by the university students for lack of basic knowledge"</i>	NA	<i>"Project teams meet regularly with representatives of their client organizations and client feedback is routinely solicited and integrated into the development of the projects and the conduct of the overall program."</i>	<i>"University professionals valued local community members as experts in their own history, culture, community challenges, and strengths, and demonstrated that respect through joint meetings, listening sessions, and discussions about priorities and community needs."</i>	<i>Not identified in the literature</i>
Power, privilege, and oppression	Deficit-language	Not disclosed	Institution holding power with limited power for community, Apolitical	Efforts demonstrate actions to empower community	Power retained by community
Example excerpts	<i>"the technology is simple to operate, meaning that women can also utilize the processor to increase household standards of living."</i>	NA	<i>"Community stakeholders positioned as partners in identifying needs/content that was addressed through the program."</i>	<i>"The skepticism is not uncommon in communities that have seen Americans descend on them to declare community needs, "do good deeds," and then disappear. Through the Xicotepic Project, Iowa Rotarians, university students, faculty, and staffmembers have shattered this image for people in Xicotepic."</i>	<i>"we experienced a turning point when our members realized the value of local knowledge. It has since been acknowledged that localized solutions, while they may not always seem like the best solutions from the standpoint of development "experts" in the global North, tend to work best in the community. Members now prioritize the harvesting of local knowledge, energy, and expertise through collaboration."</i>

Note: Colors used in table are shown to match the colors of the levels of reciprocity used in the heat map in Figure 2.

of reciprocity, leading to sustainable programs with community-supported reciprocity and, consequently, positive outcomes for all stakeholders.

More specifically, we can recognize areas, such as approach and student impacts, where engineering effectively incorporates reciprocity through Figure 3. By considering the number of exemplars and clear instances of reciprocity, as well as the number of exploitative examples, we observe a shift toward positive and more reciprocal outcomes for the *approach* and *student impacts* elements. SLCE efforts benefit university students who participate, and, aspirationally, in the approaches taken and the goal of doing “good” in the community, the *approaches* articulated are typically ones that espouse reciprocity.

6.1.2 | Limited or exploitative engagement with SLCE reciprocity

Additionally, a significant number of papers show potential harm, where community partnerships are leveraged for the university's benefit (solely and/or at the expense of community involvement and benefit). In contrast to positive engagement, the lowest levels of reciprocity or the absence of reciprocity were indicated by deficit language, unstructured approaches, downplaying community outcomes, and positioning the community solely as receiver rather than a co-producer of knowledge.

Exploitative and minimally reciprocal partnerships can stem from a failure to conceptualize and mitigate the potential harmful influences within context, knowledge structures, and power, privilege, and oppression. With respect to context, emphasis on the university, students, and framing the SLCE efforts as “service” or tightly around the idea of exchange, in particular as providing a technical solution to the community, is reflective of positioning, describing, and reporting in ways lacking reciprocity. Similarly, emphasis on process and product knowledge, or course content and design, in the ideation phases of projects leaves the consideration of reciprocal ways of knowing at the periphery, while overemphasizing student gains. Finally, neglecting to address power dynamics and skewing the distribution of power toward the university and/or students minimize reciprocity. At worst, these power imbalances enable community exploitation. In practice, disregard for reciprocity in the conceptualization phases results in approaches that are negligibly reciprocal in terms of stakeholder relationships. When students have little meaningful engagement with community stakeholders, it can lead to limited potential for high reciprocity. These interactions could then be characterized by misunderstandings or community disengagement and may harm the community. Additionally, problems may be identified unilaterally by the institution without the input of the community.

More specifically, through engaging with Figures 2 and 3, the areas in which engineering is struggling with reciprocity become evident. This is apparent from fewer number of exemplars, contrasted with the number of explicitly exploitative practices, particularly in the elements of power, privilege, and oppression, knowledge, and relationship. Implicit beliefs held by engineers about community knowledge can manifest in very non-reciprocal engagements (Delaine et al., 2021), and this value is reflected in our review. The relationship between the university and community actors emerges from one of unequal power. Unless intentionally subverted, this dynamic seems to persist, even along the valence of the more powerful actor “serving” the community. The *community impacts* element falls in the middle, with some reciprocal and some exploitative examples, which may best illustrate Dostilio's “exchange” relationship. The communities do glean some benefit from programs, but the cost may be in one of long-term sustainability, local markets, or tradeoffs of power in relationships. The *community context* further illustrates this as a more exploitative and therefore less reciprocal element.

6.1.3 | Undisclosed or under-articulated engagement with SLCE reciprocity

Ultimately, a lack of explicit articulation of engagement with reciprocity in SLCE is perhaps the most common form of representation within engineering, as illustrated in Figure 3. While some of the reviewed papers demonstrate reciprocity in diverse contexts, details on research practices are lacking. Many of the papers lack sufficient information on SLCE procedures and outcomes. Not only was no evidence provided, but our analysis team was not able to glean any implicit data; this, to us, indicates a need for a research-based process by which SLCE implementers and researchers could structure the language and intervention when designing, implementing, and reporting SLCE research projects. By creating this heat map of frequencies from each analytic element per article, we can visualize reciprocity as widely present to some extent, but that it is often surface level, indicating a need to develop a standardized language that

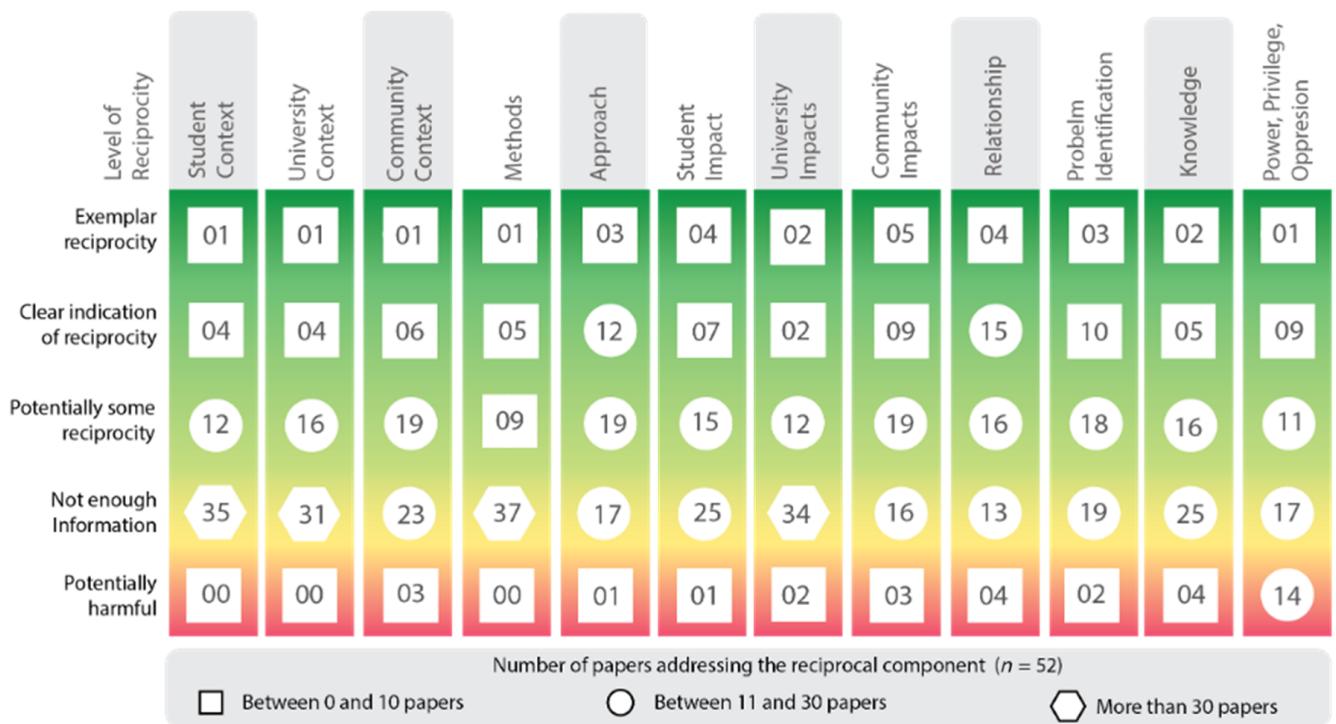


FIGURE 3 Levels to which each framework element is articulated across the reviewed engineering SLCE literature.

clearly demonstrates the extent reciprocity is developed in SLCE research projects, and how communities benefit from these projects. This connects directly with how to further the acknowledgment of, and engagement with, reciprocity in engineering SLCE efforts.

More specifically, Figure 3 highlights how limited articulation extends both across framework elements and individual papers. While there are papers that are exemplary across multiple elements, only 1 paper across the 52 articulated engagement across all eight elements. Further, one of the most undefined elements is *methods*. Many of the papers that provided rich details on approach and program design had very little in terms of the research methods. This represents a major gap in the perception of SLCE as an area for engineering scholarship as well as an opportunity for the development of future work. To a lesser extent, this was true of student context and university impacts, other areas for future potential exploration.

Ultimately, this lack of articulation presents various opportunities upon which engineering SLCE scholars and practitioners can strengthen engagement with reciprocity in their efforts, highlighted in the next section.

7 | IMPLICATIONS

We articulate four concrete implications of our investigation for SLCE researchers and practitioners: (i) we recommend intentional pursuit of reciprocity in the conceptualization and practice of SLCE programming and initiatives; (ii) we support and contribute to developing and incorporating consistent language of reciprocity in future work; (iii) we argue for broadening the scope of SLCE research; and (iv) we suggest the field move toward including reciprocity statements. Ultimately, these implications point to using the emergent framework, which we discuss in the final section.

7.1 | Intentional pursuit of reciprocity

In the literature we reviewed, conceptual understanding and explicit acknowledgement of reciprocity as a construct and a goal for engineering SLCE was largely assumed, implicit, or missing. Scholars and practitioners must be aware of the various forms of reciprocity to meaningfully pursue reciprocal relationships. The wide breadth of engagement with

reciprocity presented in this work enables reciprocity to be envisioned and reflected upon to advance in SLCE efforts. For example, narrow conceptualizations and enactments of reciprocity can indicate an imbalance of power and pose the need for a critical reevaluation of the goals and structure of an SLCE effort. Our framework can serve as a checklist along a multidimensional spectrum of reciprocity, for thoroughly evaluating SLCE efforts. Further, this research provides indicators that stakeholders can use to gauge their progression toward more reciprocal partnerships. Integrating and assessing reciprocity across the elements can enhance the design, implementation, and evaluation of SLCE efforts.

Reciprocity must be explicitly acknowledged and pursued in SLCE efforts. In the SLCE conceptualization phase, centering contexts, knowledge structures, as well as issues of power, privilege, and oppression are critical in aspiring toward advanced forms of reciprocity (Claussen et al., 2019; Delaine et al., 2023; Leydens & Lucena, 2017). For example, partnerships that value community knowledge pursue high-level geographic and demographic information about the community and also deliberately seek to understand the context from the community stakeholder perspective and culture. Additionally, when power dynamics are acknowledged, partnerships can be pursued as collaborative, power-sharing relationships in which reciprocity is a cornerstone (Dostilio et al., 2012). When SLCE is enacted in such a relational approach, it enables moving beyond the exchange of benefits and supports stakeholder transformation.

7.2 | Language of reciprocity

Our analysis revealed an imbalance in articulation of reciprocity that is skewed toward a university- and student-centric perspective, positioning the university as the central stakeholder. In our review, language connected all elements of the analytical framework. Language choices reveal implicit beliefs about power, privilege, and oppression. Reynolds (2014) notes that deficit language can reveal whose knowledge and contributions to a partnership are most valued. Certain words can marginalize the community or its members, while indicating how members from the university view themselves from a position of authority. For example, referring to a community as “needy,” “disadvantaged,” or “underprivileged” reflects an “implicit disacknowledgement of the knowledge in the community” (Reynolds, 2014, p. 81). As such, language that “others” the community partner might indicate a view of reciprocity that is transactional or minimally reciprocal. It is important, therefore, for authors to consider the language used in dissemination as well as in practice, as it could highlight the extent and orientation of reciprocity achieved.

7.3 | Broadening the scope of engineering SLCE research

Our findings indicate that most articles report SLCE efforts from the university perspective. Emphasis on framework elements such as student and university context, impact on students' learning, university and faculty approaches to designing and facilitating SLCE courses, and challenges encountered by faculty to initiate SLCE courses highlight this focus. This approach is perhaps promoted by the scope of engineering education journals being maintained or perceived to be linked to the professionalization of engineers. Therefore, orientation toward university stakeholders is expected. Yet, as SLCE is explicitly oriented toward community partnership, the scope of research conducted by engineering educators should be expanded to include outcomes, impacts on, and benefits for external stakeholders (in this case community partners). To support higher levels of reciprocity, we recommend that journal editors request, and researchers provide, more detail about the community: their involvement, their contributions during the various stages of the partnership, the impact of SLCE efforts on the community, and any change or transformation of the stakeholders. We also encourage journal editors to enhance the scope and mission of their journals, incorporating requirements for acknowledging stakeholders in partnerships. Lastly, reciprocity can be further supported by integrating theoretical perspectives in SLCE research and practice. Leveraging existing theoretical and conceptual frameworks can provide evidence-based insights into the various stages and forms of engagement in SLCE efforts (Clayton et al., 2010; Delaine, 2021; Delaine et al., 2019). Prior literature reviews in similar domains have also concluded that using theory in SLCE settings can support the efficacy of intended partnership outcomes (Holsapple, 2012) and suggest that drawing on other fields can inspire SLCE research and practice directions specific to engineering (Shermadou & Delaine, 2022). By making a conscious effort to center and report on community perspectives and experiences, as well as intentionally integrating theoretical perspectives in SLCE, highly reciprocal partnerships can be more readily pursued.

7.4 | Reciprocity statements

A limitation emerging from our review is the often vague or unclear articulation of reciprocity, despite its centrality to SLCE. SLCE efforts could benefit from authors explicitly articulating the presence and form of reciprocity, fostering a broader and deeper understanding of its achievement in engineering SLCE. Therefore, the final implication of this study is the recommendation for authors to include statements of reciprocity in their articles, similar to the positionality statements included in qualitative research (Martin et al., 2022). The elements in our analytic framework can provide a meaningful starting point for such statements. The reciprocity section could elaborate on the approach taken by the university to initiate, build, and sustain reciprocal partnerships with the community. Authors should detail their intended and actual impact, and provide direct evidence of efforts toward reciprocal SLCE. Leverage existing frameworks and orientations from reciprocity scholarship can support articulating its elements in engineering SLCE efforts (e.g., Dostilio et al., 2012; Thompson & Jesiek, 2017). Existing scholarship can be particularly useful for practitioners and researchers seeking a nuanced understanding of the dynamics of meaningful versus limited relationships among stakeholders. An explicit reciprocity statement can support clear intentions to engage in SLCE in more reciprocal ways.

8 | CONCLUSION

Only through centering reciprocity can engineering SLCE embody the potential to promote student learning while positively impacting partner communities. Without reciprocity, this pedagogy can harm and further marginalize partner communities while developing engineers who struggle to connect with their clientele, involve stakeholders, and broader societal needs. Engineering educators must understand the historical and evolving state of reciprocity in SLCE to advance within evidence-based best practice in which reciprocity is intentionally considered and pursued.

Therefore, we performed a systematic literature review to explore the extent and forms of reciprocity present in the engineering SLCE literature. We produced an eight-element multidimensional framework informed by prior articulations of reciprocity. It was shown that while engineering practices SLCE within a broad distribution of reciprocity from minimal to mutual engagement, the literature predominantly focuses on the student- and university-centric content. Publications articulating exemplary approaches to reciprocity highlight the potential for engineering SLCE to embrace it in all phases of development, enactment, and reporting. The explicit inclusion of “reciprocity statements” or articulation of reciprocity across a manuscript can further highlight how reciprocity is practiced within engineering. Using prior scholarship on reciprocity and the framework emerging from this research, engineering educators must consider their efforts with respect to reciprocity to promote more equitable practice and more meaningful partnerships that embody local/societal impact. SLCE is only one form of pedagogy and community-engaged/based practice used by engineering and other disciplines. Reciprocity must be central to all multi-stakeholder and community-based pedagogies, highlighting the potential for further examination of additional pedagogies and engineering contexts. Although this work sought to understand how the engineering literature is positioned with respect to reciprocity, individual efforts can be analyzed on a more nuanced basis than this systematic review could support. Individual reviews of SLCE efforts can lead to the emergence of additional framework elements that provide insight into how reciprocity is being manifested in engineering.

ORCID

David A. Delaine  <https://orcid.org/0000-0003-2851-5842>

Sarah Redick  <https://orcid.org/0000-0003-3440-5439>

Dhinesh Radhakrishnan  <https://orcid.org/0000-0001-6959-196X>

Amena Shermadou  <https://orcid.org/0000-0002-6328-3779>

Mandy McCormick Smith  <https://orcid.org/0000-0002-8367-7791>

Rohit Kandakatla  <https://orcid.org/0000-0003-0137-2589>

Linjue Wang  <https://orcid.org/0000-0003-3095-6719>

Claudio Freitas  <https://orcid.org/0000-0003-2841-8751>

Casey L. Dalton  <https://orcid.org/0000-0002-5391-6157>

Jennifer DeBoer  <https://orcid.org/0000-0003-0877-6244>

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* = journal article included within systematic review

** = conference proceeding/article included within systematic review

AUTHOR BIOGRAPHIES

David A. Delaine is an Associate Professor in the Department of Engineering Education at the Ohio State University.

Sarah Redick is a STEM Education Program Specialist at the Ohio Department of Education.

Dhinesh Radhakrishnan is a Research Scientist at DeBoer Lab in the School of Engineering Education at Purdue University, West Lafayette, Indiana, USA.

Amena Shermadou is a Visiting Assistant Professor in the School of Engineering Education at Purdue University.

Mandy McCormick Smith is an evaluation specialist at Guardians of Honor, LLC for the NASA Office of STEM Engagement. 1990 K St. NW Suite 650 Washington, D.C. 20006.

Rohit Kandakatla is the Director of KG Reddy College of Engineering and Technology and Adjunct Faculty in the Center for Engineering Education Research at KLE Technological University.

Linjue Wang is an Instructional Consultant at the Center for Research on Learning and Teaching in Engineering at the University of Michigan, Gorguze Family Laboratory, Room 216, 2609 Draper Dr, Ann Arbor, MI 48109, USA.

Claudio Freitas is an Assistant Professor in the Department of Electrical Engineering at Purdue University Fort Wayne, ETCS Building, 2101 E Coliseum Blvd, Fort Wayne, IN 46805, USA.

Casey L. Dalton is a graduate student in the School of Engineering Education at Purdue University, West Lafayette, IN, 47907.

Lina D. Dostilio is the Vice Chancellor for Engagement and Community Affairs and Associate Professor of Practice in the School of Education at the University of Pittsburgh, 710 Alumni Hall, 4227 Fifth Avenue, Pittsburgh PA 15260, USA.

Jennifer DeBoer is Director of Practice for Education and Youth at Purdue Applied Research Institute - Global Development and Innovation and Associate Professor of Engineering Education and Mechanical Engineering (courtesy) at Purdue University, 701 W Stadium Ave., West Lafayette, IN 47907.

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APPENDIX

DESCRIPTION OF DOSTILIO ET AL.'S (2012) THREE ORIENTATIONS OF RECIPROCITY

TABLE A1 Descriptions and vignettes of the three orientations to reciprocity.

Exchange description	Influence description	Generative description
In exchange-oriented reciprocity, the focus is on the interchange of benefits during service-learning between the stakeholders. Specifically, participants “give and receive something that they would not otherwise have ... reciprocity is the interchange of benefits, resources, or actions” (Dostilio et al., 2012, p. 19).	Influence-oriented reciprocity emphasizes that processes and outcomes are changed “as a result of being influenced by the participants and their contributed ways of knowing and doing” (Dostilio et al., 2012, p. 19). Influence-oriented reciprocity depends on relational connections that are “informed by personal, social, and environmental contexts” (pp. 19–20). Unlike exchange-based orientations, influence-oriented reciprocity is more dependent on the multidirectional flow of knowledge and an active consideration of the role of contexts.	In generativity-oriented reciprocity, the participants and relationships are transformed as a consequence of the partnership. Participants are co-creators of knowledge who “produce something new together that would not otherwise exist” (Dostilio et al., 2012, p. 20). Additionally, generativity-oriented partnerships may lay the foundation for sustaining collaboration between the university and community as “ways of knowing, and as systems of belonging evolve” (p. 20).
Context		
A humanitarian engineering course, that is formally labeled as a “service-learning” course, involves a partnership with a non-profit organization in South America that specializes in supporting families struggling with the challenges of poverty in a small town. The service-learning effort that emerges around the course is manifested differently from within each of the orientations.		
Exchange vignette	Influence vignette	Generative vignette
The semester is built around the design and installation of a rainwater retention system to be installed at hospital in the local community. The students interact with the local NGO in a virtual meeting at the start of the semester to provide context to the work. After working on the project independently, the students travel on-site to South America for a week to deliver the engineering solution. The students benefit from the hands-on experience of designing and installing the engineering solution as well as the brief immersion in the cultural context. The community benefits from the delivery of the engineering solution which was requested by the community and was conceptualized and developed by the students.	The course is centered around the relationship between the course instructor and the non-profit organization. The process of collaboratively developing and installing the rainwater retention system is facilitated through continued virtual meetings and communications among the multiple stakeholders involved. The week-long on-site visit by the engineering students centers the relationships and opportunities for cultural exchange among the stakeholders. The installation is performed collaboratively, with the engineering students making contributions, but the work is primarily performed by a local contractor from within the community.	The multi-year partnership between the non-profit and the course instructor has evolved over time expanding beyond the initial intended scope. The relationship which initially centered water retention and security has evolved to now include efforts within STEM education, health and wellness, as well as an international trip of the South American students to the institution which offers the service-learning course. The South American school is able to more effectively teach a larger number of students, the local contractors have seen increased work at the school, the local non-profit has transformed the way it seeks to impact the community, and the engineering students have begun to visit the community regularly in their own time. All partners agree the partnership has taken on a life of its own and are committed to supporting continued involvement of all stakeholders.

Note: As demonstrated in these example vignettes, the three orientations suggest opportunities for deeper understanding of reciprocity in engineering SLCE. However, a significant barrier exists: these orientations are rich with detailed description, rendering them unwieldy and challenging for evaluating reciprocity systematically.