

Article

Professional Identity and Education for Sustainability: Exploring Perceived Change Following Service-Learning in Pre-Service Primary Teacher Education

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Abstract

Training educators to integrate sustainability into their practice is crucial for the 2030 Agenda. This article presents a mixed-method design to explore perceived changes in sustainability-oriented professional identity among pre-service primary teachers following a Service-Learning intervention. The design combines an instrumental case study with convergent mixed methods and a qualitative emphasis. Core instruments include reflective diaries structured around Kolb's experiential learning cycle and a 10-item questionnaire on perceived competence development. Participants were 37 pre-service primary teachers in their fourth year of study. Inductive thematic analysis of the diaries revealed a shift from a teacher identity centred on content transmission towards one focused on facilitating experiential learning and acting as a community agent. Descriptive analysis showed mean scores between 3.59 and 4.51, with significant differences from the scale's neutral point ($p < 0.001$). Methodological triangulation evidenced a gap between high endorsement of the community role ($M = 4.30$) and lower self-efficacy in collaboration strategies ($M = 3.62$) and in addressing complexity ($M = 3.59$). The article suggests that this design offers a promising framework that may be transferable to similar teacher education contexts, potentially providing a useful tool for operationalising Sustainable Development Goal 4.7 assessment in higher education. Its strengths, limitations, and transferability potential are discussed.

Keywords: Service-Learning; Education for Sustainable Development; teacher professional identity; pre-service teacher education; experiential learning; competency-based assessment



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1. Introduction

Higher education faces the need to train professionals who are competent in their disciplines but also committed to the major social and environmental challenges of our time [1]. In the field of initial teacher education, this challenge translates into the need to develop educators who integrate Education for Sustainable Development (ESD) into the core of their identity and professional practice [2]. In this regard, merely acquiring knowledge about sustainability is insufficient; a process of identity reconstruction is required, through which future teachers come to perceive themselves as agents of socio-ecological change [3]. Furthermore, pre-service teachers have limited knowledge of the Sustainable Development Goals (SDGs), which underscores the need for more experiential and committed training

interventions [4]. Hence, assessing whether future teachers develop a professional identity aligned with SDG 4.7, which calls for ensuring ESD, becomes a research priority [1]. Therefore, identifying best practices in educational research that may contribute to the SDGs is essential. This study responds to that need by offering a mixed-methods design to explore perceived changes in teacher professional identity for sustainability, a key lever for SDG 4.7. Given the exploratory nature of the study, the findings are interpreted as evidence of perceived transformation rather than as causal demonstration.

In this context, high-impact pedagogical methodologies such as Service-Learning (SL) have shown their potential to facilitate such transformation by linking academic learning with community action in response to real needs [5]. Moreover, SL contributes to the development of sustainability competences in initial teacher education [6,7] and supports the construction of a professional identity more deeply committed to the community [8,9]. However, examining the effects of these interventions on complex and subjective dimensions such as professional identity poses a significant methodological challenge [10], since purely quantitative approaches often tend to be reductionist; whereas, exclusively qualitative studies may have limitations regarding generalisation and systematisation.

This article addresses this gap by presenting and discussing a mixed-methods research design specifically developed to comprehensively explore participants' perceived changes in sustainability-oriented teacher professional identity associated with the SL experience. The design is characterised by being theoretically grounded in established frameworks (such as experiential learning, narrative professional identity, and ESD competences); being methodologically hybrid, combining the interpretative depth of qualitative methods with the systematisation of quantitative ones; being operationally viable, as it can be integrated into the regular dynamics of a university course; and incorporating triangulation procedures that enhance analytical credibility. The main objective is to provide researchers and teacher educators with a methodologically explored and potentially transferable proposal for studying identity-change processes associated experiential pedagogies.

Furthermore, although previous studies have analysed the effects of SL on initial teacher education and the development of competences for sustainability [6], there remains a limited understanding of how this type of experience specifically contributes to shaping a sustainability-oriented teacher professional identity [8]. Likewise, studies that combine quantitative evidence with longitudinal reflective processes to understand the mechanisms through which these experiences transform pre-service teachers' professional conceptions are still scarce [11,12]. In this regard, the present study aims to help fill this gap. Unlike previous studies focused on attitudes or competence outcomes [7], the present study investigates the reconfiguration of professional identity, a more fundamental dimension of teacher development, and introduces a mixed-methods device that integrates narrative, reflective, and self-efficacy dimensions through triangulation.

In light of the above, the following research questions arise:

- (1) What perceived changes in the teaching role towards sustainability are reported by pre-service primary teachers following a SL intervention?
- (2) Is there a perceived gap between the acceptance of the role of change agent and self-efficacy in practical skills such as community collaboration or addressing complexity?
- (3) What internal consistency and utility does a mixed-methods device (reflective diaries structured around Kolb's cycle and a competence perception questionnaire) present for exploring the perceived changes in teacher professional identity following the SL experience?

2. Theoretical Framework

The proposed design is based on the intersection of three fundamental theoretical frameworks (Figure 1): the conceptualisation of teacher professional identity as a narrative process, Kolb's theory of experiential learning, and the key competences for ESD. These aspects are developed below.

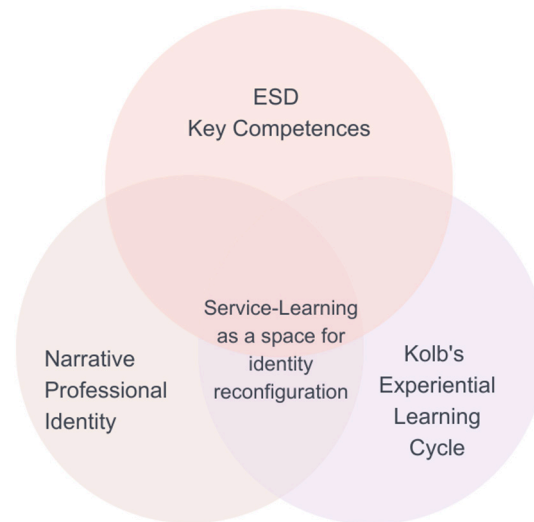


Figure 1. Triple Venn diagram showing the conceptual intersection of narrative professional identity, Kolb's experiential learning, and ESD competences. The central overlap highlights SL as a context for fostering sustainability-oriented teacher identity change. This conceptual intersection directly informed the research design: the diary structure was grounded in Kolb's cycle, the questionnaire items were based on ESD competences, and the triangulation approach was designed to capture the narrative dimension of identity development.

2.1. Teacher Professional Identity

From a sociocultural perspective, teacher professional identity is conceptualised as a dynamic and situated narrative process [13]. Thus, pre-service teachers continuously construct and reconstruct their professional self-concept through stories that give meaning to their training and practical experiences [14]. This process of “becoming” a teacher involves negotiating meanings between the personal self, the expected professional role, and experiences in real contexts [15], so that experiences that challenge prior conceptions are particularly powerful in fostering significant identity changes [16]. In this sense, SL, by placing students in authentic and often unfamiliar contexts, has the potential to generate precisely this type of liminal experience [17], considering the complexity of this process and the need for methodological approaches that capture its dynamic nature [18,19]. This understanding of identity as a narrative process places reflection on experience in a central position, which leads us to the second framework: experiential learning.

2.2. Kolb's Experiential Learning

Kolb's Experiential Learning Theory [20] provides the central pedagogical framework for the intervention and data collection. Kolb posits that optimal learning occurs through an iterative four-phase cycle: concrete experience, reflective observation, abstract conceptualisation, and active experimentation. This cycle is especially relevant for identity development, since critical reflection on experience allows individuals to examine and potentially reconfigure their frames of reference and self-perceptions [21]. In the context of SL, structured reflection on the service experience helps pre-service teachers connect theory with practice and reinterpret their professional role in light of new understand-

ings [22]. Kolb's cycle provides the mechanism for change, but it requires specific content: sustainability. That is the third framework.

2.3. Education for Sustainable Development as an Action Framework

ESD, as defined by UNESCO [23], seeks to empower learners to make informed decisions and take responsible actions that lead to a viable future. It goes beyond mere environmental education by integrating the social, economic and environmental dimensions of sustainability, and by fostering competences such as systemic thinking, anticipation and collaboration [24]. For pre-service teachers, internalising ESD implies developing a specific self-efficacy, namely the belief in their ability to design and implement educational activities that promote sustainability [25]. This self-efficacy is a crucial component of their emerging professional identity. In this regard, there are validated scales to measure this self-efficacy in pre-service teachers and studies showing that SL programmes significantly improve attitudes towards sustainable development [7,26]. These competences for sustainability do not develop in a vacuum; they require a pedagogical context that makes them operational. SL provides precisely that context.

2.4. Service-Learning as a Context for Identity Change

The integration of these three frameworks, the conceptualisation of teacher professional identity as a narrative process, Kolb's theory of experiential learning, and the key competences for ESD, suggests that SL, when intentionally designed, can create a privileged pedagogical space for the reconfiguration of teacher professional identity towards sustainability, where community service provides the concrete and authentic experience. Guided reflection, based on Kolb's cycle, facilitates reflective observation and the conceptualisation of that experience in terms of teaching role and responsibility. Finally, the design of educational proposals for the community represents the active experimentation of a new professional role. The evaluation of this complex process therefore requires a methodology that explores retrospective narratives of transformation, such as perceptions of self-efficacy and commitment. In this sense, it can be noted that SL in higher education effectively contributes to sustainability training, although the need for more studies with rigorous mixed designs is also indicated [11,12].

From an experiential perspective, SL can be understood as a particularly promising mechanism for fostering processes of teacher professional identity transformation, as it places students in authentic situations that require reflection, decision-making, and ethical positioning [20–22]. Following the experiential learning cycle already described, lived experiences, accompanied by systematic reflective processes, can facilitate a progressive redefinition of the professional teaching role and the responsibilities associated with education for sustainability [13–16,21,22].

The three theoretical perspectives were selected because they complement each other in explaining the process of identity development in the context of SL. Narrative identity theory was chosen because it captures the subjective, processual, and socially situated nature of professional identity construction, which is essential for understanding how pre-service teachers make sense of their experiences. Kolb's Experiential Learning Theory was selected because it provides a concrete mechanism for identity change through structured reflection on authentic experiences, which aligns with the pedagogical core of SL. Finally, ESD competences were included because they define the substantive content and learning outcomes that the intervention aims to foster, ensuring that the study is grounded in the specific goals of sustainability education. Alternative frameworks, such as social cognitive theory [25], were considered but not adopted because they focus more on individual motivation or behavioural regulation rather than on the narrative and experiential dimensions

of identity reconfiguration, which are central to our research questions. This combination of perspectives is widely used in teacher education research and provides a coherent and comprehensive lens for investigating the complex process of identity change.

3. Research Objectives

This study pursues three specific objectives:

1. To explore the changes in the teaching role towards sustainability among pre-service primary teachers following a SL intervention as perceived by the participants.
2. To explore possible gaps between the attitude of being a change agent and self-efficacy in practical skills such as community collaboration or addressing complexity.
3. To design and apply a mixed-methods device (reflective diaries structured around Kolb's cycle and a competence perception questionnaire) to explore participants' perceived changes in sustainability-oriented professional identity following the SL experience analysing its internal consistency.

4. Methodological Design

4.1. Research Approach

In this research, an instrumental case study design [27] was adopted with convergent mixed methods and a qualitative emphasis [28]. The case was the implementation of a SL project integrated into a teacher education course. This approach allows an in-depth, contextualised exploration of the phenomenon (identity development), prioritising the richness of qualitative data while using quantitative data to complement and triangulate findings [29]. Qualitative and quantitative data collection occurred in parallel, and their integration was carried out during the analysis and interpretation phase.

4.2. Context and Participants

The study was carried out in the Environmental Education course of the Primary Education Degree at the University of Burgos (Spain), with the participation of 37 fourth-year students (28 women, 9 men), aged between 21 and 24 years ($M = 22.3$, $SD = 0.9$). All were taking the course for the first time. Although the sample size is moderate ($N = 37$), this is consistent with the contextualised nature of the educational intervention and the approach applied to a natural group of initial teacher education [27]. Furthermore, the high participation of enrolled students favours an adequate representation of the analysed educational context.

4.3. Description of the Intervention

The intervention consisted of an eight-week SL project integrated into the course. The project was developed in five phases. In the first phase (week 1), students received a face-to-face training session on the fundamentals of SL and ESD, and were introduced to the reflective diary (entry 1). In the second phase (weeks 2–3), the work groups (4–5 people) contacted primary education schools or community associations in the area to identify real needs related to sustainability. In the third phase (weeks 4–5), each group designed an educational activity to address the identified need, receiving weekly support from the teaching staff. During this phase they completed diary entry 2. In the fourth phase (weeks 6–7), the students implemented the activity at the school or association, and after implementation they completed entry 3. Finally, in the fifth phase (week 8), each group presented their project and a final reflection, completing diary entry 4 and the questionnaire. Throughout the process, the teaching staff offered weekly follow-up tutorials, both face-to-face and online.

The SL project involved 7 primary schools and 3 community associations (two neighbourhood associations and one civic centre). The sustainability needs identified by the groups included: school waste management, lack of green spaces in playgrounds, energy consumption awareness, and recycling habits. The activities designed by the students included waste audits, creative recycling workshops, school garden designs, water consumption awareness campaigns, and cooperative games on sustainability. Each group completed between 10 and 12 service hours (distributed in 2–3 h sessions). Groups were formed randomly at the beginning of the course, with 4–5 students each. Community partners provided feedback through a short questionnaire at the end of the project and participated in a closing meeting with the students. The SL project accounted for 25% of the course grade, based on a rubric assessing: (a) quality of the activity design, (b) implementation and community engagement, and (c) final reflection (diary and presentation).

4.4. Instruments and Data Collection Procedure

The first instrument was a structured reflective diary, informed by and adapted from Kolb's experiential learning cycle [20]. The diary consisted of four guided entries, each aligned with a phase of the cycle and a specific moment of the SL project. Table 1 shows the structure of the entries. The diary was administered in face-to-face sessions for entry 1 and asynchronously online for entries 2 to 4, within the course schedule. The estimated time per entry was 20 to 30 min. The diaries were anonymised by assigning a code (P01 to P37), and in the presentation of results the notation PXX_EY is used to refer to participant XX, entry Y.

Table 1. Structure of the reflective diary entries according to Kolb's cycle.

Entry	Phase (Adapted from Kolb's Cycle)	Application Moment	Main Guiding Question
1	Initial conceptions (pre-experience)	Week 1 (pre-intervention)	What role should a primary teacher play in promoting sustainability?
2	Reflective observation	Weeks 4–5 (mid-project)	Describe a situation that has made you reflect on your role as a future teacher.
3	Abstract conceptualisation	Weeks 7–8 (after implementation)	How would you now define the concept of “teacher for sustainability”?
4	Projected application (planned experimentation)	Week 8 (post-intervention)	Compare your initial vision with your current vision. How will you apply what you have learned?

The diary prompts were designed to be informed by Kolb's experiential learning cycle, while also adapting the cycle to the specific context of the study. Entry 1 captured participants' initial conceptions of the teaching role and sustainability before the SL experience, which corresponds to a pre-experience baseline rather than a concrete experience of the intervention itself. Entry 2 prompted reflective observation by asking participants to describe a meaningful situation and its implications for their role. Entry 3 invited abstract conceptualisation by connecting experience with ESD theory. Entry 4 asked participants to project their learning into future practice, representing planned or anticipated active experimentation rather than observed experimentation. This adaptation allowed the diary to capture the full trajectory of perceived change, from initial conceptions to projected future application, while remaining grounded in the key principles of Kolb's cycle.

The second instrument was an ad hoc questionnaire of our own design, based on the key competences for ESD [24] and on the construct of teacher self-efficacy [25], as well as on previously validated scales [26]. The questionnaire consisted of 10 items on a 5-point Likert

scale (1 = Strongly disagree; 5 = Strongly agree). It was administered once, retrospectively, at the end of the project, asking participants to compare their current perception with the one they had at the beginning. Reliability was calculated using Cronbach's alpha coefficient for the sample ($N = 37$), obtaining a value of 0.88, which provides preliminary evidence of internal consistency for the questionnaire in this sample [30]. The questionnaire was administered online via Google Forms, anonymously, with an estimated time of 10 min. The questionnaire also included two open-ended questions: one about the aspect that had the greatest impact on the conception of the teaching role, and another about the obstacles encountered during the project. The questionnaire was conceived as a retrospective self-perception instrument, asking students to compare their perception at the end of the experience with respect to how they considered their initial situation. Consequently, the results obtained should be interpreted as retrospective perceptions of change rather than as conventional pre-test–post-test measurements (Appendix A).

4.5. Data Analysis

For the qualitative analysis, the inductive thematic analysis method of Braun and Clarke [31] was followed, which consists of six phases. In the first phase, familiarisation with the data, the principal investigator carried out an exhaustive reading of the 148 entries (37 participants $\times$ 4 entries) and took notes on recurring ideas. In the second phase, generation of initial codes, NVivo 12 software was used for open, inductive coding, obtaining 78 initial codes (examples: *ROLE_TRANSMITTER*, *INITIAL_CONFUSION*, *MEANINGFUL_EXPERIENCE*, *COMMUNITY_LINK*, *ETHICAL_RESPONSIBILITY*). The coding unit was a complete meaning unit (sentence or paragraph). To ensure trustworthiness, the first researcher (the principal investigator) coded the complete dataset of 148 diary entries (37 participants $\times$ 4 entries). A random sample of 20% of the diaries (30 entries) was selected using a random number generator and was independently coded by a second researcher. The inter-coder agreement index was calculated as simple percent agreement on this subsample, yielding an initial agreement of 78%. Discrepancies were discussed and resolved through consensus, which also served to refine the definition of codes and themes. This consensus process was not used as a reliability coefficient, but as a means to enhance the consistency and credibility of the analysis. The 78 initial codes were merged into three central themes through an iterative process of abstraction and grouping, involving: (i) grouping codes with similar content; (ii) identifying broader patterns; (iii) refining groupings by consensus; and (iv) naming themes to capture their core meaning. Each theme was operationally defined through a consensus process, using grouped codes and verbatim quotes as anchors. Data saturation was assessed by reviewing the final diary entries (entries 3 and 4); no new codes or themes emerged, indicating adequate depth of analysis. In the third phase, searching for themes, the codes were grouped into potential themes using concept maps. In the fifth phase, three central themes were operationally defined. Finally, in the sixth phase, the analytical narrative was written, intertwining verbatim quotes and the researchers' interpretation.

For the quantitative analysis, questionnaire data were exported to IBM SPSS Statistics v.25. Frequencies, percentages, means (M) and standard deviations (SD) were calculated. In addition, 95% confidence intervals were calculated for each mean, and one-sample t -tests were performed to compare each mean with the neutral point of the scale (3.0). Reliability was estimated using Cronbach's alpha. For the integration of qualitative and quantitative data, a convergence matrix was constructed in which the main qualitative themes were crossed with the most relevant quantitative items, jointly discussing the degree of corroboration, complementarity or divergence between the two sources. The judgments of convergence, complementarity or divergence were established through analytical inter-

pretation of the degree of alignment between quantitative trends and qualitative evidence, following the logic of mixed methods integration [28,29]. In operational terms, convergence was considered when both sources pointed in the same interpretive direction (for example, high quantitative scores accompanied by consistent narrative evidence), complementarity when one source expanded or nuanced the findings of the other, and divergence when interpretive discrepancies emerged between quantitative trends and qualitative discourses. The classification was carried out by consensus among the researchers during the results integration process. An illustrative example of the convergence matrix used is shown in Appendix B.

For the purposes of language revision and textual clarity, the authors used DeepSeek (DeepSeek AI) during the manuscript preparation process. The tool assisted in refining the wording and generating an initial draft of the English translation, which was subsequently reviewed, edited, and validated by the authors.

5. Results

In relation to the first objective, to explore the perceived changes in the teaching role towards sustainability after the SL intervention, both qualitative and quantitative results were obtained that converge in the same direction.

On the one hand, the thematic analysis of the reflective diaries made it possible to identify three central themes that describe the evolution of the participants' professional identity. Table 2 summarises the prevalence of each theme in the sample (N = 37). A theme was considered clearly present in a participant's narrative when at least two coded segments from different diary entries (e.g., entries 2 and 4) were identified and confirmed by consensus between the two researchers. This criterion ensured that the theme was not based on a single isolated comment but reflected a consistent pattern across the participant's reflective journey.

Table 2. Prevalence of the themes identified in the qualitative analysis (N = 37).

Theme	Brief Description	Number of Participants Whose Narrative Clearly Showed the Theme	% of the Sample
1. Re-conceptualisation of the role: from expert to facilitator	Transition from a vision of the teacher as a source of authorised knowledge towards one as a guide for inquiry processes.	31	83.8
2. Internalisation of socio-ecological responsibility	Awareness and assumption of the teacher's ethical responsibility as a promoter of justice and sustainability.	29	78.4
3. The school as a node of community connection	Reconceptualisation of the school as an open space interconnected with its social and environmental surroundings.	27	73.0

A detailed description of the themes, supported by textual evidence, is presented below.

Theme 1: Re-conceptualisation of the teaching role: from expert to facilitator. The conceptual core of this theme is the change in self-perception of authority and teaching function, moving from a model based on unidirectional transmission to one centred on facilitating autonomous and meaningful learning. The textual evidence clearly shows this evolution. In the initial narrative (pre-SL state), one participant wrote: *"I have always thought that the teacher has to know a lot and explain it very well so that children learn. My main concern was how I was going to organise all that information for them"* (P12_E1). In a transitional narrative, another excerpt indicates: *"Today, instead of giving a talk about recycling, we went*

out to analyse the waste in the neighbourhood. The children asked questions that I had not thought of. I had to listen more and guide their observation rather than explain" (P12_E2). Finally, in the final narrative (post-SL state), the same participant reflects: "Now I see that my value is not so much in what I know, but in knowing how to create the conditions for them to explore, ask questions and build their own knowledge. My role is more about asking good questions and creating situations where they themselves investigate" (P12_E4).

Theme 2: Internalisation of socio-ecological responsibility. This theme refers to the integration of an ethical and civic commitment dimension into professional identity, linking teaching practice to the resolution of socio-environmental problems. One participant expressed: "At first, sustainability was just another 'topic' in the curriculum, like verbs or mammals. But seeing the children's enthusiasm when proposing solutions to reduce plastic in their school canteen, and their anger when they learned that the problem reaches the sea. . . it clicked for me. This is not a topic, it is a responsibility. Educating for sustainability is a responsibility towards their future" (P23_E3).

Theme 3: The school as a node of community connection. The core of this theme is the expansion of the mental boundaries of the educational space, understanding the school as a permeable institution in constant dialogue with the territory and its actors. One participant wrote: "We worked with a neighbourhood association. The children presented their proposals to real people, not just to the teacher. The project opened my eyes. The school has to go out and the community has to come in. We are part of the same social ecosystem, not a bubble" (P05_E4).

On the other hand, the quantitative data from the questionnaire complement these findings. Table 3 presents the descriptive statistics for the 10 items, including means, standard deviations, 95% confidence intervals and the results of one-sample *t*-tests. The overall Cronbach's alpha was 0.88, providing preliminary evidence of internal consistency for the questionnaire in this sample. The means are clearly above the theoretical midpoint (3.0) for all items, and the *t*-tests confirm that these differences are statistically significant ($p < 0.001$ for all cases). The items with the highest means ($M > 4.4$) and lowest dispersion are those related to the appreciation of experiential learning (item 9, $M = 4.49$), the reconceptualisation of education as a transformative tool (item 5, $M = 4.51$), and the centrality of sustainability in teacher identity (item 4, $M = 4.46$). These results corroborate the trend observed in the qualitative analysis: a clear evolution towards a teaching identity more committed to sustainability and the facilitator role. The effect sizes (Cohen's *d*) for the one-sample *t*-tests ranged from 0.69 to 2.70, indicating moderate to very large effects. However, these values should be interpreted with caution, as they reflect the magnitude of perceived agreement with retrospective statements rather than actual change from a true baseline. Notably, the largest effect sizes were observed for items related to the reconceptualisation of the teaching role (item 5, $d = 2.70$), the appreciation of experiential learning (item 9, $d = 2.66$), and the centrality of sustainability in teacher identity (item 4, $d = 2.42$). In contrast, the smallest effect sizes were found for items measuring self-efficacy in practical skills: collaboration with the community (item 8, $d = 0.82$) and addressing complexity (item 10, $d = 0.69$). This pattern reinforces the qualitative finding of a gap between strong identity endorsement and lower perceived competence in specific skills.

Table 3. Descriptive statistics and *t*-tests for the questionnaire items (N = 37).

Item	<i>M</i>	<i>SD</i>	95% CI Lower	95% CI Upper	<i>t</i> (df = 36)	<i>d</i>	<i>p</i> -Value	% Agreement (4–5)
1. Facilitator vs. transmitter	4.35	0.67	4.13	4.57	12.27	2.02	<0.001	89.2
2. Teacher as change agent	4.30	0.66	4.08	4.52	11.98	1.97	<0.001	89.2

Table 3. Cont.

Item	<i>M</i>	<i>SD</i>	95% CI Lower	95% CI Upper	<i>t</i> (df = 36)	<i>d</i>	<i>p</i> -Value	% Agreement (4–5)
3. Ability to integrate sustainability	4.32	0.63	4.11	4.53	12.81	2.11	<0.001	89.2
4. Sustainability in teacher identity	4.46	0.60	4.26	4.66	14.73	2.42	<0.001	94.6
5. Education as a transformative tool	4.51	0.56	4.33	4.70	16.43	2.70	<0.001	97.3
6. Designing activities with real problems	4.27	0.65	4.05	4.49	11.85	1.95	<0.001	86.5
7. Awareness of ethical responsibility	4.38	0.68	4.15	4.61	12.27	2.02	<0.001	89.2
8. Strategies for collaborating with community	3.62	0.76	3.37	3.87	4.96	0.82	<0.001	59.5
9. Appreciation of experiential learning	4.49	0.56	4.30	4.67	16.16	2.66	<0.001	97.3
10. Preparedness to address complexity	3.59	0.86	3.31	3.88	4.18	0.69	<0.001	59.5

Note: *M* = mean; *SD* = standard deviation; CI = confidence interval; df = degrees of freedom. The scale ranged from 1 (strongly disagree) to 5 (strongly agree). The % agreement shows the proportion of participants who answered 4 or 5.

Given the retrospective nature of the questionnaire, the percentage of agreement (responses 4 or 5) is considered a more meaningful indicator than the *p*-values, as it reflects the proportion of participants who perceived positive change, while the *p*-values only indicate that the mean differs from the neutral point.

Overall, the scores obtained show high values for most items, together with moderate dispersion, which suggests a relatively consistent perception among participants regarding the formative contributions of the experience. This pattern seems to indicate a shared positive evaluation, although a generalised ceiling effect was not observed. Figure 2 visually shows this pattern of means and confidence intervals.

The responses to the open-ended questions reinforce this interpretation. When asked about the aspect that had the greatest impact on their conception of the teaching role, 14 participants mentioned the connection between theory and practice or working with real problems; 11 pointed to reflection on social commitment and ethical responsibility; and 8 highlighted collaborative work.

To address the second objective, *to detect possible perceived gaps between the attitude of being a change agent and self-efficacy in practical skills*, the triangulation of qualitative and quantitative data is presented in Table 4. The items linked to attitude and vision (for example, item 2: “Teacher as change agent”, *M* = 4.30, 89.2% agreement) show very high values, while the items measuring self-efficacy in specific skills show noticeably lower means: strategies for collaborating with the community (item 8, *M* = 3.62, only 59.5% agreement) and preparedness to address complexity (item 10, *M* = 3.59, 59.5% agreement). Regarding the obstacles or difficulties encountered, 12 participants cited coordination of schedules and group dynamics; 10 mentioned lack of time or high workload; and six indicated an initially unclear understanding of the task. Nine participants responded that they had not encountered any notable difficulties. Table 4 synthesises the integration of both types of data.

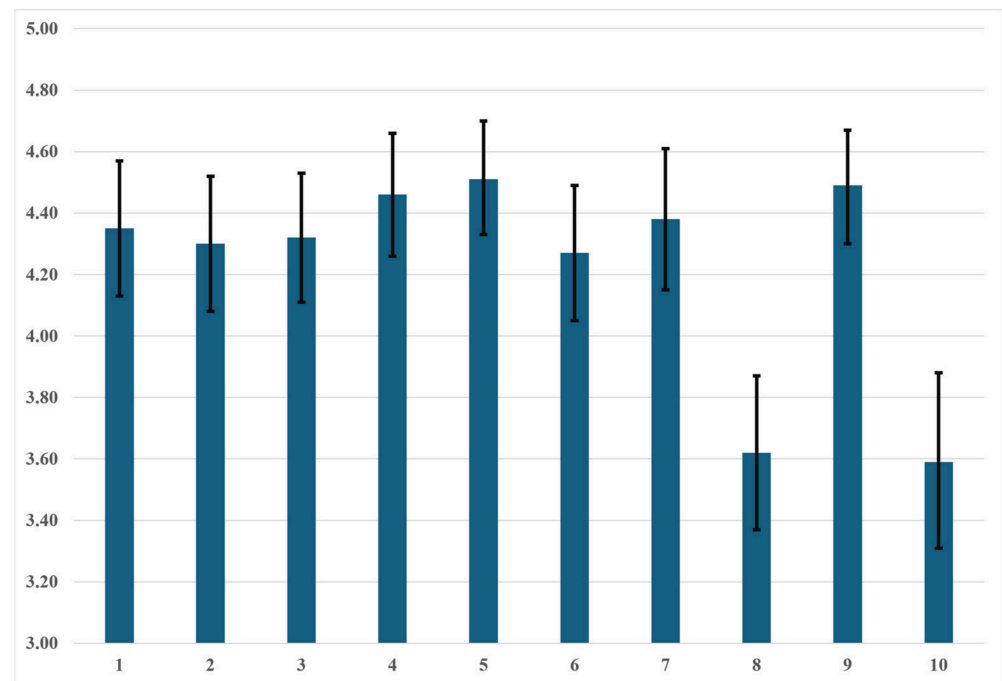


Figure 2. Means and 95% confidence intervals for the 10 items of the competence perception questionnaire (N = 37). Items 8 and 10 show significantly lower means and greater dispersion. Item numbers correspond to: 1. Facilitator vs. transmitter; 2. Teacher as change agent; 3. Ability to integrate sustainability; 4. Sustainability in teacher identity; 5. Education as a transformative tool; 6. Designing activities with real problems; 7. Awareness of ethical responsibility; 8. Strategies for collaborating with community; 9. Appreciation of experiential learning; 10. Preparedness to address complexity.

Table 4. Triangulation matrix of findings.

Central Qualitative Theme	Relevant Quantitative Item(s) and Result	Triangulation Judgement	Integrated Interpretation
T1: From expert to facilitator (quote P12_E4)	Item 1 (M = 4.35, 95% CI [4.13, 4.57], 89.2% agreement) and item 9 (M = 4.49, 97.3% agreement)	High convergence	The SL experience appears to be associated with a widespread reconceptualisation of the teaching role, from a transmission paradigm towards a facilitator one, with a very high appreciation of experiential learning.
T2: Socio-ecological responsibility (quote P23_E3)	Item 2 (M = 4.30, 89.2% agreement), item 5 (M = 4.51, 97.3% agreement) and item 7 (M = 4.38, 89.2% agreement)	High convergence	SL seems to facilitate a process of internalisation of professional-civic responsibility. It is not merely cognitive learning, but an ethical identity position-taking, reflected both in the narratives and in the quantitative self-perceptions.
T3: School-community (quote P05_E4)	Item 2 (M = 4.30, 89.2% agreement: role as change agent) and item 8 (M = 3.62, 59.5% agreement: strategies for collaborating)	Complementarity (gap)	The narrative reveals a new relational conception (vision). The quantitative self-perception shows widespread acceptance of this role (attitude), but moderate confidence in the skills to execute it (competence). This gap is supported by the very different agreement percentages (89.2% vs. 59.5%) and by the open responses pointing to group coordination and time management as the main difficulties.

Finally, regarding the third objective, *to design and apply the mixed-methods device and analyse its internal consistency*, the results show that the ad hoc questionnaire achieved acceptable reliability ($\alpha = 0.88$) and the confidence intervals of the means were sufficiently precise (see the 95% CIs in Table 3). The reflective diaries structured around Kolb's cycle allowed us to capture in-depth narrative perceptions of change, as shown in the verbatim quotes. Both instruments proved to be complementary and feasible to integrate into the course dynamics, fulfilling the purpose of exploring the perceived changes in teacher professional identity associated with the SL experience.

The longitudinal analysis of the reflective entries made it possible to identify a progressive evolution in the students' conceptions, observing a transition from initially more descriptive approaches towards increasingly critical, complex and professionally situated interpretations. This evolution was particularly evident in the understanding of the teaching role and of educational sustainability.

6. Discussion

The results obtained allow us to answer the research questions and are consistent with the three stated objectives. However, given the study design, the findings should be interpreted as evidence of perceived transformation rather than as causal demonstration of intervention effectiveness.

In relation to the first objective, *to explore perceived changes in the teaching role towards sustainability*, the qualitative results showed a clear evolution from an identity of "content transmitter" towards "facilitator and community agent". The quantitative data corroborated this trend, with very high means for items such as reconceptualisation of the role ($M = 4.35$), appreciation of experiential learning ($M = 4.49$) and education as a transformative tool ($M = 4.51$). The convergence between both sources is high, as reflected in the first two blocks of Table 4. These findings coincide with previous studies showing that SL favours transitions towards more constructivist and committed conceptions [8,9,32].

Regarding the second objective, *detection of perceived gaps between attitudes and practical self-efficacy*, the results revealed a critical nuance: there is high acceptance of the role of change agent (item 2, $M = 4.30$, 89.2% agreement), but moderate self-efficacy in specific skills such as collaboration with the community (item 8, $M = 3.62$, only 59.5% agreement) or addressing complexity (item 10, $M = 3.59$, 59.5% agreement). This gap, identified thanks to mixed integration, has immediate practical implications for teacher education. It suggests that after a SL experience, it may be necessary to incorporate a specific module that reinforces the competences of linking and managing projects with external agents, as well as strategies for managing uncertainty and controversy in the classroom. The open-ended responses reinforce this interpretation: the most frequently cited difficulties were group coordination (12 participants) and time management (10 participants), pointing to needs for scaffolding in organisational and collaborative skills. To further examine the statistical significance of this gap, we conducted paired comparisons between item 2 (role as change agent) and item 8 (collaboration strategies), and between item 2 and item 10 (addressing complexity). Both comparisons were statistically significant (item 2 vs. item 8: $t(36) = 7.82$, $p < 0.001$, $d = 1.26$; item 2 vs. item 10: $t(36) = 6.95$, $p < 0.001$, $d = 1.12$), suggesting a substantial descriptive difference in our sample and reinforcing the qualitative findings.

This finding is particularly relevant, as it suggests that the development of teacher professional identity might precede the full consolidation of teacher self-efficacy, revealing a possible temporal asynchrony between identity commitment and perceived competence [13,19,25,33]. It should be noted that some studies have found limited effects of SL on professional identity, and the absence of a control group and pre-test means that

changes could be influenced by social desirability, maturation, or course expectations. These alternative explanations should be considered when interpreting the results.

Regarding the third objective, *design and application of the mixed-methods device, for which good internal consistency was observed*, the questionnaire showed a Cronbach's alpha of 0.88 and the confidence intervals of the means were sufficiently precise. The diaries, for their part, made it possible to capture in-depth narrative perceptions of change. Both instruments proved to be complementary and feasible to integrate into the course dynamics. The systematic triangulation (Table 4) demonstrated the usefulness of the convergence matrix for integrating both sources.

Thus, the findings are consistent with the idea that structured reflection based on Kolb's cycle [20] may help to make perceived identity reconfiguration explicit [21,22]. However, the identification of the competence gap contributes a relevant novelty: it is not enough for pre-service teachers to "want" to be agents of change; they need to develop the confidence and concrete skills to collaborate with the community and manage the complexity of socio-environmental problems. This result aligns with the warnings in the literature on teacher self-efficacy [25] and with research indicating that sustainability training must attend to both attitudes and specific competences [26,34].

Beyond the agreement with previous research, the findings suggest that the potential of SL to foster perceived transformation could be explained by the combination of authentic experience and structured reflection, elements widely noted in the literature on experiential learning and teacher professional development [20–22]. In this study, the interaction with real problems linked to sustainability, together with the systematic reflection processes promoted through the diaries, seems to have favoured processes of professional redefinition and progressive integration of values associated with sustainability into the emerging teacher identity [13–16,33,35].

The design offers methodological transparency and credibility, as it is grounded in solid theoretical frameworks, uses triangulation, and provides thick description of the context and procedures [36]. This allows readers to assess the transferability of the design to their own settings [37]. The internal consistency of the questionnaire should be considered preliminary, as it is based on a single sample ($N = 37$) and has not been confirmed through factor analysis (recommended minimum 5–10 cases per item). Future studies with larger samples should undertake psychometric validation of the questionnaire.

The use of diaries structured around the phases of Kolb's cycle appears to be a valuable qualitative tool. By anchoring reflection in the experiential cycle, mere anecdotal description was overcome and participants were guided towards critical and projective reflection, which is where identity negotiation occurs [33]. The ad hoc questionnaire, although limited in general psychometric validity, proved very useful as a complementary tool for identifying group trends and quantifying key aspects of self-perception that emerged from the narratives. The reliability obtained ($\alpha = 0.88$) and the confidence intervals provide robustness to these estimates.

Limitations of the Design and Ethical Considerations

Several limitations must be acknowledged. First, generalisation: as a case study, the findings are deeply contextualised. Transferability [37] is achieved through thick description, allowing others to judge its applicability. Second, the quantitative instrument is ad hoc and, although it shows preliminary internal consistency in this sample, it has not been validated through factor analysis. Its use should be understood as complementary and contextual. Third, the retrospective design (without a real pre-intervention measurement) may introduce memory bias. This has been partially mitigated by asking participants to explicitly compare their current state with their prior one, but it is a limitation that must be

taken into account. Fourth, social desirability bias is possible, especially in an evaluated context. To reduce it, anonymity was guaranteed in the questionnaire and the diary instructions emphasised the value of authenticity over “correctness”. Fifth, the study was embedded in a course where the researchers were also instructors. To minimise potential bias, consent was obtained at the beginning of the course, diaries were not graded, data collection occurred after grades were submitted, and non-participation had no academic consequences. Anonymity was protected by using codes and aggregating data. Sixth, the findings are context-specific to one Spanish university and one course, and may not be transferable to other settings without careful adaptation. Seventh, the study did not include independent measures of competence development, observational data, or assessment of children’s or community partners’ perspectives. Finally, rigorous qualitative analysis (double coding, consensus) is time-intensive and requires trained researchers. Therefore, the results should be interpreted from a logic of contextual transferability rather than statistical generalisation [37], although they offer relevant clues for the design of similar educational experiences in initial teacher education. Likewise, the absence of a real pre-intervention measurement prevents strict causality from being attributed to the observed changes, so the results should be interpreted as evidence consistent with a perceived transformation process rather than as causal demonstrations.

In addition, ethical approval for the entire project, including the involvement of children, schools, and community partners, was obtained from the Bioethics Commission of the University of Burgos (reference IO 8/2024). Informed consent was obtained from the directors of the participating schools and from the community associations. Written parental consent was obtained for all children involved in the SL activities. Data from minors were not collected; the study focused exclusively on pre-service teachers’ perceptions and reflections. Community partners were informed of the research purpose and provided consent for their participation in the project. All procedures involving children were carried out in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments.

7. Conclusions and Future Directions

This article has presented and explored a comprehensive mixed methodological design to explore perceived changes in the construction of professional identity for sustainability in pre-service primary teachers. Its main contribution is to provide a methodologically explored and potentially transferable proposal that combines the narrative depth of reflective diaries with the systematic nature of a competence perception questionnaire.

Unlike previous studies focused predominantly on competence outcomes or attitudes towards sustainability, this proposal simultaneously integrates identity, reflective and self-efficacy dimensions through a convergent mixed design, providing a methodological approach still little explored in initial teacher education [6–9,11,12].

The key strengths of the design are fourfold. First, a coherent theoretical-methodological integration, connecting identity, experiential learning and ESD frameworks with specific instruments and analyses. Second, analytical rigour that includes detailed protocols for qualitative analysis (multiple coding, thematic analysis) and its systematic triangulation with quantitative data, including descriptive statistics and confidence intervals to complement the qualitative interpretation. Third, practical feasibility, since the instruments are integrated into the teaching dynamics, facilitating data collection and increasing ecological validity. Fourth, a diagnostic capacity that captures both narratives and trends, identifying not only changes but also areas of gap, such as the difference between acceptance of the community role and self-efficacy to collaborate effectively, which directly informs future pedagogical design. This finding is particularly relevant, as it suggests that professional

identity construction may precede the full development of teacher self-efficacy, revealing a possible asynchrony between identity commitment and perceived competence [13,19,25,33].

As a future direction, this design is a starting point. Its application in diverse educational contexts and levels is recommended to further test its robustness. Likewise, the development and full psychometric validation of an improved version of the questionnaire would be advisable, which could become a brief standardised tool to assess key components of teacher identity for sustainability. Finally, longitudinal analyses are suggested that, using this design as a basis, follow the identity trajectory of participants during their first years of professional practice, assessing the persistence and evolution of the change initiated in initial training. Future research with controlled designs and larger samples would be needed to confirm the causal nature of the observed patterns and to undertake psychometric validation of the questionnaire. This methodological design illustrates a promising approach in educational research oriented towards the SDGs, as it offers a mixed procedure to explore perceived changes in teacher professional identity towards sustainability, a key component of SDG 4.7 [1]. However, given the exploratory nature of the study, these findings should be interpreted with caution and as evidence of perceived transformation rather than as causal demonstration.

Consistently with the study's exploratory nature, the results suggest that SL experiences oriented towards sustainability can constitute particularly relevant spaces for favouring not only competence learning, but also early processes of teacher professional identity construction [6–9,38]. In this regard, the systematic incorporation of authentic, reflective and socially contextualised experiences may play a strategic role in the initial training of teachers committed to the challenges of sustainability [1,2,23,24,39].

At a time when teacher education must respond to the urgent demands of sustainability, having robust, sensitive and practical evaluation methodologies is essential. This design aims to be a contribution in that direction, facilitating the generation of evidence on how to train not only teachers who know about sustainability, but who are, at the core of their professional identity, educators for sustainability.

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Informed Consent Statement: Informed consent was obtained from the teachers and students. All of them aged 18 and above, who took part in the study granted explicit consent for the statistical analysis of their data.

Data Availability Statement: Data supporting the results of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Abbreviations

The following abbreviations are used in this manuscript:

ESD Education for Sustainable Development
SDG Sustainable Development Goal
SL Service-Learning

Appendix A

Questionnaire on Perceived Competence Development

Instructions: Below you will find a series of statements. For each one, indicate your level of agreement or disagreement using the following scale:

1 = Strongly disagree; 2 = Disagree; 3 = Neither agree nor disagree; 4 = Agree; 5 = Strongly agree

(Reflect on each statement by comparing your perception AT THE END of the project with how you were/perceived things AT THE BEGINNING)

No.	Statement	1	2	3	4	5
1	After the project, I perceive myself more as a facilitator of experiential learning than as a mere transmitter of content.					
2	I now consider that my role as a teacher necessarily includes being an agent of change in my educational community.					
3	I feel more capable of integrating sustainability transversally into my future teaching practice.					
4	Sustainability has become a more central aspect of my identity as a future teacher.					
5	I now see education as a more powerful tool for social transformation towards sustainability.					
6	I feel more competent to design activities that connect the curriculum with real socio-environmental problems.					
7	I have developed greater awareness of my ethical and social responsibility as an educator.					
8	I have clearer strategies for collaborating with external agents (associations, community) in educational projects.					
9	I value more highly learning based on authentic experiences and in real contexts.					
10	I feel more prepared to address the complexity and controversies of socio-environmental issues in the classroom.					

Open-ended complementary questions

11. Of the project carried out, which aspect or experience has had the greatest impact on your conception of the teaching role? (Short answer, 2–3 lines).

12. What obstacles or difficulties did you encounter in integrating sustainability into your educational practice during the project? (Short answer, 2–3 lines).

Appendix B

Convergence matrix: cross-tabulation of qualitative themes and quantitative items

Qualitative Theme (Diaries)	Quantitative Item	Judgement	Brief Justification
Reconceptualisation of the teaching role as a transformative agent	Item 2 (role as change agent, $M = 4.30$)	Convergence	The high scores coincide with narratives of redefinition of the teaching role towards transformative functions and community commitment.
Appreciation of experiential learning	Item 9 (experiential learning, $M = 4.49$)	Convergence	The diaries show recognition of the value of learning from real experiences.
Difficulties in collaboration with external agents	Item 8 (working with the community, $M = 3.62$)	Complementarity	The questionnaire shows moderate self-efficacy and the diaries explain the practical difficulties (coordination, uncertainty, time).
Complexity of socio-environmental problems	Item 10 (addressing complexity, $M = 3.59$)	Complementarity	The moderate score is nuanced by narratives that express insecurity when faced with complex contexts.
Education as a transformative tool	Item 5 (transformative education, $M = 4.51$)	Convergence	The narratives reinforce the idea of teacher responsibility in the face of sustainability problems.

Note: Convergence judgements were established when the quantitative trend (item mean) and the qualitative pattern (diary narratives) pointed in the same direction. Complementarity was applied when both sources addressed different but related dimensions of the same phenomenon: the quantitative source provided information on magnitude or frequency, while the qualitative source explained processes, meanings or practical difficulties. No divergences were identified in the crosses presented. M = mean on a 1–5 Likert scale.

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