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Curricular Integration of Education for Sustainable Development in Teacher Education: Insights from a Compulsory Introductory Module

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Abstract

Integrating Education for Sustainable Development (ESD) into teacher education raises a key curricular challenge: how can all student teachers be introduced to ESD while ensuring continuity beyond a single module? This study examines the first implementation of a compulsory, 1-ECTS introductory ESD module within a three-phase curricular integration strategy at a Swiss university of teacher education. An exploratory cross-sectional survey of 90 first-year primary student teachers (response rate: 94.7%) investigated their perceptions of the module's didactic design, learning opportunities, and sustainability-related transversal competencies. Students evaluated the module positively, particularly instructor engagement ($M = 3.33$, $SD = 0.61$). Among the competence domains, social competencies received the highest ratings ($M = 3.13$, $SD = 0.69$), whereas subject-specific and methodological competencies were rated less favourably ($M = 2.93$, $SD = 0.59$). Notably, motivation to engage with ESD in subsequent university modules was comparatively lower ($M = 2.79$, $SD = 0.91$), despite positive perceptions of the introductory learning experience. These findings reveal an important distinction between students' favourable evaluations of an introductory module and their motivation for continued engagement with ESD. Although based on self-reported perceptions rather than measured competence development, the study provides empirical insights into the implementation of compulsory ESD within teacher education. It highlights the need to connect introductory modules with progressively more complex, subject-specific, and practice-oriented learning opportunities across the curriculum.

Keywords: education for sustainable development; curriculum development; higher education didactics; transversal competencies

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1. Introduction

Global sustainability challenges such as climate change, biodiversity loss, and social inequality place increasing demands on educational systems. Within the framework of the Sustainable Development Goals (SDGs), Education for Sustainable Development (ESD) seeks to enable learners to engage critically and responsibly with complex sustainability-related questions [1]. Teacher education is particularly relevant in this context, as future teachers need to be prepared to address ecological, social, economic, and ethical dimensions of sustainable development in their professional practice [2].

Preparing future teachers for ESD involves more than acquiring subject-specific knowledge. It also requires opportunities to engage with transversal sustainability-related com-

petencies, including systems thinking, anticipatory thinking, critical reflection, collaboration, and participation [3]. Research therefore emphasises the importance of participatory and practice-oriented learning environments and of embedding ESD systematically within teacher education curricula rather than relying on isolated projects or optional initiatives [4,5].

At the institutional level, whole-institution approaches and sustainability governance frameworks highlight the need to connect teaching and curriculum development with broader organisational strategies [6,7]. For teacher education institutions, this raises the practical question of how ESD can be introduced to all students while creating meaningful connections to subsequent disciplinary, didactic, and practice-oriented learning opportunities. Compulsory introductory modules represent one possible curricular approach by providing a shared starting point for engagement with ESD.

Although research on ESD in teacher education has expanded, comparatively little attention has been devoted to the implementation and student reception of compulsory introductory ESD modules embedded within broader teacher education curricula [4]. Existing discussions frequently address institutional strategies, competence frameworks, or individual pedagogical approaches, while less attention has been devoted to students' perceptions of compulsory introductory formats embedded within a broader teacher education curriculum [2]. Examining such perceptions can provide insights into the reception of curricular implementation approaches and identify aspects that may require further development.

Against this background, the present study examines a compulsory introductory ESD module implemented during the first year of a bachelor's program in primary teacher education at a Swiss university of teacher education. Using an exploratory cross-sectional survey, it investigates students' perceptions of the module's didactic design, learning opportunities, and sustainability-related transversal competence domains. By documenting the implementation and student reception of this curricular format, the study seeks to inform the further integration of ESD within teacher education and contribute to discussions on coherent, institutionally embedded approaches.

2. ESD in Teacher Education

2.1. ESD as a Transformative Task for Teacher Education

ESD is increasingly understood as an educational approach that enables learners to engage critically with complex ecological, social, and economic challenges. Within the framework of the SDGs, ESD extends beyond the acquisition of sustainability-related knowledge to include reflection on values, consideration of different perspectives, and participation in shaping more sustainable futures [1]. This understanding places particular demands on teacher education, as future teachers are expected to address sustainability-related questions not only as curricular content but also as issues requiring pedagogical judgement and reflective professional practice [2].

Preparing student teachers for this responsibility involves engagement with transversal sustainability-related competencies, including systems thinking, anticipatory thinking, critical reflection, collaboration, participation, and ethical judgement [3,8]. These competencies are relevant to educational situations characterised by uncertainty, conflicting interests, and multiple perspectives. From this perspective, teacher education needs to provide opportunities for student teachers to examine their own assumptions and values, engage in dialogue, and consider how sustainability-related questions can be addressed in classroom contexts. Participatory and practice-oriented learning approaches are therefore particularly relevant to ESD-oriented professional preparation [9].

Despite the growing recognition of ESD in educational policy and research, its integration into teacher education remains challenging. Studies have identified tensions between sustainability-related educational expectations, established disciplinary structures, and the organisational conditions of teacher education programmes [4,5]. ESD-related learning opportunities may consequently remain fragmented or dependent on individual initiatives rather than being embedded coherently across the curriculum [2]. These challenges underline the importance of considering ESD as a shared responsibility within teacher education rather than as the concern of individual courses or lecturers alone.

In Switzerland, ESD is reflected in both the German-speaking Lehrplan 21 [10] and the French-speaking Plan d'études romand [11], providing a curricular basis for addressing sustainability-related questions in compulsory schooling. For teacher education institutions, these frameworks reinforce the relevance of preparing future teachers to work with interdisciplinary perspectives and societal challenges in their professional practice. The curricular integration of ESD in teacher education must therefore consider both the educational aims associated with sustainability and the professional requirements of teaching within these curricular contexts.

2.2. Curricular and Institutional Integration of ESD in Higher Education

The integration of Education for Sustainable Development (ESD) in higher education extends beyond the inclusion of sustainability-related content in individual courses. International frameworks emphasise the importance of embedding sustainability across institutional structures, curricula, and learning environments [1]. This perspective is reflected in the concept of a whole-institution approach, which considers sustainability a cross-cutting responsibility involving teaching, research, institutional governance, organisational practices, and external partnerships [7].

From an institutional perspective, integrating ESD requires coordination between strategic objectives and their implementation in educational programmes. Sustainability governance involves establishing structures and processes that support institutional commitment, participation, and collaboration across organisational units [6]. Research has identified leadership support, coherent institutional strategies, and interdisciplinary cooperation as relevant conditions for advancing sustainability within higher education institutions [12]. However, institutional commitments alone do not determine how students encounter ESD in their studies; these commitments also need to be translated into concrete curricular learning opportunities.

In teacher education, curricular integration is particularly important because sustainability-related perspectives need to be connected to the professional preparation of future teachers. Rather than treating ESD as an additional or optional topic, curriculum-wide approaches seek to establish connections between introductory learning experiences, subject-specific didactics, interdisciplinary activities, and school-based practice [2]. Such connections can provide opportunities for students to revisit sustainability-related questions in different educational contexts. Nevertheless, existing research points to challenges associated with fragmented curricula, limited institutional coordination, and the integration of ESD into established disciplinary structures [4,5].

Within this broader curricular perspective, compulsory introductory ESD modules represent one possible starting point. By reaching an entire student cohort, they can establish a shared basis for engaging with sustainability-related concepts, values, and professional responsibilities. Their curricular contribution, however, depends not only on the learning opportunities provided within the module itself but also on how these opportunities are connected to subsequent stages of teacher education. Introductory modules should therefore

be understood as potential components of a coherent curricular approach rather than as sufficient measures for integrating ESD across a programme.

Examining students' perceptions of such introductory formats can provide insights into how institutionally embedded ESD learning opportunities are received during the initial phase of teacher education. Although student evaluations cannot establish the effectiveness of a curriculum-wide integration strategy, they can inform the further development of introductory modules and their connections to subsequent learning opportunities.

2.3. Participatory and Competence-Oriented Learning Environments in ESD

A central characteristic of ESD is its emphasis on participatory, reflective, and competence-oriented learning processes. Rather than focusing exclusively on the transmission of factual knowledge, ESD aims to enable learners to engage critically with complex sustainability challenges, conflicting perspectives, and uncertain futures [1]. Consequently, the design of learning environments that encourage active participation, collaboration, reflection, and engagement with real-world sustainability issues is particularly relevant to ESD.

Within the international ESD discourse, sustainability-related competencies are commonly understood as transversal competencies that extend across disciplinary boundaries and encompass cognitive, social, ethical, and action-oriented dimensions of learning [3]. These include systems thinking, critical reflection, anticipatory thinking, collaboration, participation, and the ability to engage with complexity and ambiguity. As these competencies involve more than the acquisition of factual knowledge, their development calls for learning opportunities that extend beyond predominantly lecture-based teaching formats [8]. Recent research in sustainability education further highlights the importance of learning environments that combine sustainability-related content with active collaboration, critical reflection, participation, and engagement with real-world complexity [4,9].

Transformative learning provides a complementary theoretical perspective by emphasising the critical examination of existing assumptions, perspectives, and frames of reference [13]. Within ESD, reflective dialogue, encounters with different viewpoints, collaborative projects, and practice-oriented activities may create opportunities for such learning processes [9]. In teacher education, these approaches are particularly relevant because student teachers need to consider both their own orientations towards sustainability and the pedagogical implications of addressing sustainability-related questions in schools. However, participation in such activities does not, in itself, demonstrate that transformative learning or competence development has occurred.

Translating these educational aims into teaching practice requires coherence between intended learning outcomes, learning activities, and assessment. The concept of constructive alignment provides a useful didactic framework for considering these relationships [14,15]. In competence-oriented ESD, this means designing learning activities that correspond to the competencies being addressed [8]. For example, collaboration and perspective-taking can be addressed through group-based activities involving different viewpoints, whereas anticipatory thinking calls for opportunities to explore possible futures and consider their implications.

The implementation of participatory and competence-oriented learning environments nevertheless involves didactic challenges. Studies point to tensions between theoretical complexity, curricular constraints, assessment requirements, and students' expectations regarding structured knowledge acquisition [4]. Particularly in introductory ESD contexts, students may experience sustainability-related complexity, normative ambiguity, and interdisciplinary perspectives as both intellectually stimulating and demanding. The design of

introductory modules therefore requires a careful balance between conceptual input and opportunities for participation, reflection, and practical application.

Taken together, these perspectives provide a theoretical rationale for examining students' perceptions of participatory and competence-oriented learning opportunities within introductory ESD modules. Such perceptions can offer insights into how students experience the relationship between didactic design and sustainability-related competence domains. They do not, however, constitute direct evidence of competence acquisition or transformative learning.

3. Institutional Implementation of the Compulsory Introductory ESD Module

ESD is strategically embedded in the vision, institutional strategy, and quality assurance system of the University of Teacher Education Valais. In line with international recommendations advocating a whole-institution approach [1,7] and current developments in Swiss teacher education [2], the university aims to integrate sustainability not only as a thematic topic but as a cross-cutting educational principle throughout teacher education.

To support this institutional objective, a compulsory introductory ESD module was introduced in 2023 as the first element of a three-phase curricular framework designed to integrate ESD progressively throughout the Bachelor's program in Primary Teacher Education.

The framework consists of (1) an introductory module providing foundational orientations towards ESD, (2) the integration of sustainability-related perspectives across disciplinary and educational modules throughout the program, and (3) the transfer of ESD into professional practice during school placements and the final phase of teacher education. In parallel, professional development opportunities are offered to teacher educators to support coherent implementation across the curriculum.

The compulsory introductory ESD module provides first-year students with a common foundation regarding central concepts of sustainable development, SDGs, and the professional role of teachers in addressing sustainability-related challenges. Rather than focusing on the transmission of predefined solutions, the module encourages students to critically engage with complex sustainability issues, multiple perspectives, and context-dependent educational challenges.

The didactic design combines conceptual input, collaborative case-based learning, project-oriented group work, and reflective learning activities. Throughout the module, students analyze authentic sustainability challenges, develop educational project ideas for primary education, and discuss their approaches within collaborative learning settings. The learning environment follows competence-oriented principles by combining theoretical foundations with participatory, reflective, and practice-oriented learning opportunities.

The compulsory introductory ESD module is delivered over four thematically structured days and is jointly offered across the university's two campuses. Reflecting the bilingual profile of the institution, the module is conducted in both German and French and coordinated by a four-member bilingual teaching team. Students from both language regions participate together throughout the module and engage in collaborative learning activities in linguistically mixed groups. This learning arrangement is intended to foster exchange across linguistic and cultural contexts while encouraging students to engage with multiple perspectives on sustainability-related challenges. An overview of the thematic focus, learning objectives, and main learning activities of the four module days is provided in Table 1.

Table 1. Overview of the compulsory introductory ESD module.

Module Day	Thematic Focus	Learning Objectives	Main Learning Activities
Day 1	Foundations of sustainable development and ESD	Develop a foundational understanding of key concepts of sustainable development and ESD while reflecting on sustainability-related challenges and their implications for education.	Interactive lectures, exhibition visit, guided discussions, individual and group reflection
Day 2	Global supply chains: The example of jeans production	Analyse sustainability challenges from ecological, economic, and social perspectives and recognise interdependencies and trade-offs.	Collaborative analysis of a global supply chain, group work, plenary discussions
Day 3	ESD in primary education	Apply ESD principles by collaboratively designing an ESD learning project for primary education.	Collaborative project development, lesson planning, and peer exchange
Day 4	Presentation and reflection	Critically reflect on different didactic approaches to ESD through the presentation and discussion of project work.	Group presentations, peer feedback, plenary reflection and discussion

The compulsory introductory ESD module (1 ECTS) comprises four thematic learning days distributed across the first year of the Bachelor's program in Primary Teacher Education.

As a 1-ECTS introductory module, this learning experience constitutes only the first phase of the university's three-phase framework for integrating ESD throughout the teacher education curriculum. Its purpose is to establish a shared conceptual and pedagogical foundation rather than to provide comprehensive preparation for teaching ESD. The present study therefore examines students' perceptions of this initial curricular component, which is intended to be complemented by further ESD-related learning opportunities across disciplinary modules and professional practice.

4. Aim and Research Questions of the Study

Although research on ESD in teacher education has expanded [4], empirical evidence on how compulsory introductory ESD modules are perceived by students remains limited. In particular, little is known about students' perceptions of the learning opportunities and sustainability-related transversal competence dimensions addressed within such introductory curricular formats.

Against this background, the present study examines the compulsory introductory ESD module implemented at the University of Teacher Education Valais. The study seeks to generate empirically grounded insights into students' perceptions of the module's didactic design and competence-oriented learning opportunities. Rather than assessing causal effects, the study examines students' perceptions of the module and derives implications for the curricular integration of ESD in teacher education.

The study addresses the following research questions:

1. How do first-year teacher education students perceive the didactic design and learning opportunities of a compulsory introductory ESD module?
2. How do students assess their sustainability-related transversal competencies following the introductory ESD module, and what implications can be derived for competence-oriented learning opportunities?

Based on these findings, the discussion derives implications for the further curricular integration of ESD in teacher education programmes.

5. Methodology

5.1. Study Design and Sample

The present study adopts an exploratory cross-sectional survey design. Rather than testing predefined hypotheses or evaluating causal effects, the study aimed to provide descriptive and empirically grounded insights into student teachers' perceptions of the compulsory introductory ESD module, including its didactic design, learning opportunities, and sustainability-related transversal competencies.

Given the ongoing curricular integration of ESD at the institution, the study follows a practice-oriented evaluation approach that seeks to inform the further development of ESD within teacher education while simultaneously contributing to the broader international discussion on curricular ESD integration in higher education.

The study was conducted in May 2024 among first-year students enrolled in the Bachelor's program for primary teacher education at the University of Teacher Education Valais. All 95 students in the cohort had attended the compulsory introductory ESD module and were invited to complete the questionnaire at the end of the module. Participation was voluntary and anonymous. Students could discontinue the survey at any time and could refrain from answering non-mandatory questions. The eight items assessing sustainability-related transversal competencies were mandatory for survey completion.

The module instructors were not involved in administering the survey or collecting individual responses. This separation between module instruction and data collection was intended to minimise perceived pressure to participate and potential social desirability effects related to the teacher–student relationship. A total of 90 students participated in the survey, corresponding to a response rate of 94.7%. The reasons for the non-participation of five students are unknown. Because the survey was anonymous, individual-level comparisons between respondents and non-respondents were not possible.

Of the respondents, 47 students (52.2%) were enrolled in the Cycle 1 specialisation (training to teach at the kindergarten and early primary school levels) and 43 students (47.8%) in Cycle 2 (training to teach at the later primary school levels)—although both specialisations lead to a teaching diploma qualifying graduates to teach across all pre-primary and primary school levels. Most participants studied at the campus of St-Maurice (n = 71; 78.9%), while 19 students (21.1%) were enrolled at the campus of Brig. The sample comprised 68 female (75.6%) and 22 male (24.4%) students. These characteristics indicate that the survey captured the perspectives of almost the entire cohort of students participating in the first implementation of the compulsory introductory ESD module.

5.2. Data Collection and Instruments

Data was collected using a structured questionnaire assessing students' perception of the introductory ESD module, its learning environment, and the sustainability-related transversal competencies addressed during the module.

Students' perceptions of the module were assessed using 24 items adapted from the university's standard course evaluation instrument (EvaSys), which is based on established dimensions of higher education teaching quality [16]. The items addressed five areas: module structure and organisation, content delivery, didactic design, instructor engagement, and learning methods and materials. The underlying institutional evaluation instrument and the corresponding dimensions were used as a basis for adapting the questionnaire to the specific context of the ESD module. For example, structure and organization included the items "The learning objectives of the module are clearly communicated" and "The overall structure of the module is clearly recognisable across the four module days". Items addressing teaching and learning methods included, for example, "The exchange with other students during the four module days supports my learning" and "The (digitally supported) learning materials contribute to a deeper understanding of the content." Responses were recorded on a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree).

Students were also asked to identify which of the four module days they perceived as most and least beneficial and were given the opportunity to explain their choices in open-ended responses. These responses were used as illustrative material to contextualise the quantitative findings rather than as a separate qualitative dataset subjected to formal qualitative content analysis.

To examine students' self-assessments of sustainability-related transversal competencies, eight competence facets derived from the ESD competence framework developed by éducation21 [17] were included in the questionnaire. This framework overlaps with internationally discussed key ESD competencies, including systems thinking, anticipatory thinking, collaboration, and reflection on values [3]. The eight facets were grouped into three theoretically defined domains: (1) subject-specific and methodological competencies, comprising interdisciplinary and multi-perspective knowledge and interconnected/systemic thinking; anticipation (future-oriented thinking and action, including methodological-didactic tools); and creativity (critical and constructive thinking); (2) social competencies, comprising perspective-taking and cooperation and participation (collaboratively addressing sustainability-related issues and contributing to societal processes); and (3) personal competencies, comprising responsibility (recognising oneself as part of the world), values (reflecting on one's own and others' values), and action (taking responsibility and making use of opportunities to act). These descriptions reflect the competence facets addressed in the questionnaire. Responses were recorded on a four-point scale ranging from 1 (insufficient) to 4 (very good). The eight items captured students' self-assessed ESD-related competencies following the introductory module. These ratings were used as indirect indicators when discussing sustainability-related competence-oriented learning opportunities. As no pre-module assessment or objective competence measurement was conducted, they cannot be interpreted as evidence of actual competence development attributable to the module.

In addition, three questionnaire items assessed students' overall perceptions regarding (a) whether the four ESD module days enabled them to acquire fundamental knowledge of ESD, (b) their motivation to identify further ESD connections in subsequent modules, and (c) their motivation to implement ESD during future school placements.

The questionnaire was administered in German and French. The complete original bilingual questionnaire (German and French) is provided as Supplementary File S1, together with an English translation for international accessibility (Supplementary File S2). The English translation was not administered to participants or independently validated.

Prior to data collection, the questionnaire was reviewed by an interdisciplinary expert group comprising experts in higher education didactics and ESD didactics as well

as research staff from the same university of teacher education. The review focused on the comprehensibility and contextual appropriateness of the questionnaire items and their alignment with the module's learning objectives and the ESD competence framework. The questionnaire was subsequently pilot-tested with ten students. Based on their feedback, minor adjustments to the presentation of the questionnaire were made; no substantive changes to the items were required.

5.3. Data Analysis

Quantitative data were analysed using IBM SPSS Statistics (Version 27) [18]. Descriptive statistics, including means and standard deviations, were calculated for the questionnaire items and the theoretically defined multi-item scales. Scale scores were calculated as the arithmetic mean of the corresponding items for respondents with complete data on all items within the respective scale. In addition, 95% confidence intervals were calculated for the principal scale means to indicate the precision of the estimates. Comparisons between questionnaire items and theoretically defined competence domains were descriptive only. No inferential tests of differences between mean scores were conducted; consequently, observed differences are not interpreted as statistically significant.

Internal consistency of the theoretically defined multi-item scales was assessed using Cronbach's alpha. The coefficients ranged from $\alpha = 0.73$ to $\alpha = 0.93$, indicating acceptable to excellent internal consistency according to [19] (see Table 2). The scales were derived from the institutional course-evaluation framework and the ESD competence framework described in Section 5.2 and were used to provide a differentiated descriptive account of students' perceptions. The grouping of the eight competence facets into three domains was theory-driven and based on the competence framework developed by éducation21 [17]. No exploratory or confirmatory factor analysis was conducted to empirically validate this dimensional structure. Cronbach's alpha was used solely to assess internal consistency and should not be interpreted as evidence of construct validity or of the empirical distinctiveness of the three competence domains.

Table 2. Internal consistency of the theoretically defined questionnaire scales.

Scale	Number of Items	Cronbach's α
Module structure and organization	5	0.87
Content delivery	4	0.73
Didactic design of the module	6	0.80
Instructor engagement	4	0.86
Teaching and learning methods and learning materials	5	0.88
Sustainability-related (ESD) transversal competencies	8	0.93

Missing responses were examined at the item level. Across the closed-ended questionnaire items, the proportion of missing responses ranged from 0% to 8.89%. The highest proportion of missing responses occurred for the item assessing whether the learning arrangement enabled students to deepen the course content independently ($n = 82$ valid responses). As respondents were permitted to refrain from answering non-mandatory questions, the number of valid responses varied across items and scales (see Table 3). Importantly, the eight items assessing sustainability-related transversal competencies were configured as mandatory questions in the online questionnaire. Consequently, all 90 respondents who completed the survey provided valid responses to these items, resulting in a consistent sample size of $n = 90$ for the overall competence scale and all three theoretically defined competence domains. Missing responses occurred only in other, non-mandatory questionnaire items.

Table 3. Descriptive statistics of students' perceptions of the introductory ESD module.

Scale	N	M	SD	95% CI
Module structure and organization	90	3.13	0.68	[2.99, 3.27]
Content delivery	81	3.17	0.62	[3.03, 3.31]
Didactic design of the module	83	3.07	0.61	[2.94, 3.20]
Instructor engagement	85	3.33	0.61	[3.20, 3.46]
Teaching and learning methods and learning materials	81	3.15	0.66	[3.00, 3.30]

N = sample size, M = mean, SD = standard deviation, CI = confidence interval.

The open-ended responses were reviewed descriptively to provide additional context for the quantitative findings. No formal qualitative coding procedure or systematic qualitative content analysis was conducted. The illustrative quotations were selected based on their relevance to the reported quantitative findings, with the aim of reflecting both positive and critical student perspectives. They are not intended to represent the distribution of views across the sample.

6. Results

6.1. Students' Perceptions of the Introductory ESD Module

Table 3 presents the descriptive statistics for the five theoretically defined scales assessing students' perceptions of the introductory ESD module. Overall, students evaluated the module positively, with mean scores ranging from 3.07 to 3.33 on the four-point scale. The highest rating was obtained for instructor engagement ($M = 3.33$, $SD = 0.61$), followed by content delivery ($M = 3.17$, $SD = 0.62$), teaching and learning methods and learning materials ($M = 3.15$, $SD = 0.66$), module structure and organization ($M = 3.13$, $SD = 0.68$), and didactic design of the module ($M = 3.07$, $SD = 0.61$).

A closer examination of the individual questionnaire items provides a more differentiated picture. Within the scale of module structure and organization, students particularly positively evaluated the alignment between learning activities and assessment ($M = 3.21$, $SD = 0.80$). Within the scale of content delivery, the highest agreement was found for the statement that students were able to meet the module requirements, including preparation, follow-up work, and active participation ($M = 3.53$, $SD = 0.63$). Regarding the didactic design of the module, students positively evaluated opportunities for collaborative learning and interaction within the bilingual student cohort. Students were also asked to identify the module day they perceived as most and least beneficial in terms of its didactic design ($n = 83$). Day 4, which focused on developing and presenting ESD projects, received the highest number of positive selections ($n = 50$; 60.24%), followed by Day 3 ($n = 16$; 19.28%). Conversely, Day 1 was most frequently identified as the least beneficial ($n = 36$; 43.37%), followed by Day 2 ($n = 26$; 31.33%).

The open-ended comments provide illustrative context for these evaluations. Regarding Day 4, one student commented: "This allowed us to work in groups on a joint project related to sustainable development. It was also an opportunity to discover the projects of several groups and raise awareness of the topic" (Student comment 12; translated into English by the authors). In contrast, one student described the exhibition activity on Day 1 as follows: "The exhibition at the castle was interesting, but we spent too much time at the different information panels, which quickly became boring" (Student comment 3; translated into English by the authors). These comments illustrate students' appreciation of collaborative, practice-oriented activities and their more critical perceptions of less interactive learning arrangements.

6.2. Students' Perceptions of Sustainability-Related Transversal Competencies

Following the introductory ESD module, students rated their own competencies across eight sustainability-related transversal competence facets, which were grouped into three theoretically defined domains. Table 4 presents the descriptive statistics for the overall scale and the three domains. The overall mean score was 3.04 (SD = 0.58) on the four-point scale, indicating generally positive self-assessments of students' sustainability-related transversal competencies following the introductory module.

Table 4. Descriptive statistics of students' perceptions of sustainability-related transversal competencies.

Scale	N	M	SD	95% CI
Overall ESD transversal competencies	90	3.04	0.58	[2.92, 3.16]
Subject-specific and methodological competencies	90	2.93	0.59	[2.81, 3.05]
Social competencies	90	3.13	0.69	[2.99, 3.27]
Personal competencies	90	3.08	0.65	[2.94, 3.22]

N = sample size, M = mean, SD = standard deviation, CI = confidence interval.

Among the three domains, social competencies received the highest mean rating ($M = 3.13$, $SD = 0.69$), followed by personal competencies ($M = 3.08$, $SD = 0.65$). Subject-specific and methodological competencies received a comparatively lower mean rating ($M = 2.93$, $SD = 0.59$). Thus, students rated their social and personal competencies somewhat more positively than their subject-specific and methodological competencies. These differences are descriptive and reflect students' self-assessments following the introductory module.

At the item level, the highest mean ratings were observed for perspective-taking and cooperation and participation (both $M = 3.13$), followed by reflecting on values ($M = 3.12$, $SD = 0.72$). The lowest mean rating was observed for anticipation ($M = 2.81$, $SD = 0.62$). These findings provide a more differentiated picture of students' perceptions across individual competence facets, with comparatively positive ratings for social interaction and reflection and lower ratings for future-oriented thinking.

6.3. Overall Perceptions and Future Orientation

The three concluding questionnaire items provided additional insights into students' overall perceptions of the introductory ESD module and their future engagement with ESD. Students positively rated the module's contribution to their understanding of fundamental ESD concepts ($M = 3.15$, $SD = 0.82$) and expressed an intention to integrate ESD into their future teaching practice ($M = 3.06$, $SD = 0.78$). In comparison, motivation to engage further with ESD in subsequent modules of the teacher education program received a lower mean rating ($M = 2.79$, $SD = 0.91$).

The open-ended responses provided additional context for these findings. Some respondents suggested alternative formats for further engagement with ESD, including guest lectures and panel discussions involving experts from different professional backgrounds. As one student suggested: "Invite specialists to give lectures on different sustainable development topics [...] or organise a panel discussion with experts from various backgrounds [...]" (Student response 51; translated into English by the authors). Other comments expressed appreciation for the instructors' teaching and support throughout the module.

7. Discussion

7.1. The Role of Introductory ESD Modules in Teacher Education

The findings suggest that a compulsory introductory module can serve as a relevant curricular entry point for integrating ESD into teacher education. Students evaluated the

module positively and perceived it as contributing to their understanding of fundamental ESD concepts. These perceptions suggest that introductory learning opportunities may help establish a shared conceptual orientation towards sustainability-related issues and the role of ESD in future teaching practice.

This interpretation is consistent with previous research emphasising that the successful implementation of ESD requires more than isolated learning activities. Rather, ESD should be systematically embedded within teacher education through coherent curricular and institutional strategies [1,3,8]. Recent research also highlights the need to examine sustainability-related competence development across teacher education programmes through longitudinal and interdisciplinary perspectives [20].

At the same time, the findings reveal a noteworthy difference between students' positive evaluations of the introductory module and their comparatively lower motivation to engage with ESD in subsequent university modules. Although students perceived the module as contributing to their understanding of ESD and expressed an intention to integrate ESD into their future teaching practice, their motivation for further university-based engagement was less pronounced. One possible explanation is that students may not yet have had a clear understanding of how ESD would be addressed in subsequent modules or how these learning opportunities would contribute to their professional development. If the content, relevance, and practical benefits of future ESD-related learning experiences are not sufficiently apparent, students may find it difficult to recognise the value of continued engagement. However, the present study did not investigate the reasons underlying students' motivation, and this interpretation therefore remains tentative. Nevertheless, the findings highlight the importance of making curricular progression transparent and explicitly communicating how introductory ESD learning experiences connect to subsequent subject-specific and practice-oriented modules. This is consistent with [21], who emphasise the need for coherent, programme-wide curricular integration of ESD.

Taken together, these findings support viewing compulsory introductory ESD modules as one component of a longer-term curricular approach rather than as stand-alone educational interventions. Within such an approach, introductory modules can provide a common starting point, while subsequent learning opportunities enable students to revisit sustainability-related questions, engage with increasing complexity, and explore their application in professional practice [1,9].

7.2. Participatory Learning and Sustainability-Related Competence Development Opportunities

A second important finding concerns students' self-assessments of their sustainability-related transversal competencies following the introductory ESD module. Overall, students rated their competencies across all three theoretically defined domains—subject-specific and methodological, social, and personal competencies—positively, with the highest ratings observed for social competencies. At the level of individual competence facets, perspective-taking, cooperation and participation, and reflecting on values received particularly positive ratings. These patterns in students' self-assessments may provide a starting point for reflecting on the competence-oriented learning opportunities offered by the module.

These findings are consistent with current understandings of ESD, which emphasise participatory, collaborative, and reflective learning processes as important opportunities for engaging with sustainability-related competencies [1,3]. In particular, the prominence of social competencies in students' perceptions aligns with research highlighting dialogue, collaboration, and the consideration of multiple perspectives as central characteristics of ESD learning environments [4,9,22]. Recent reviews of teacher education for sustainable development similarly emphasise participatory pedagogies and critical reflection as important elements of competence-oriented learning environments [4].

This pattern can also be considered in relation to the didactic design of the module. Collaborative project work, discussions, reflective activities, and the presentation of group outcomes were central components of the learning environment. These activities provided opportunities for students to engage with different perspectives, cooperate on sustainability-related tasks, and reflect on their own values and assumptions. The comparatively positive ratings of social and personal competence facets are therefore consistent with the participatory and reflective orientation of the module. This interpretation corresponds with previous research highlighting authentic learning tasks, collaborative knowledge construction, and reflection as important features of competence-oriented ESD [8]. A systematic literature review by Imara and Altinay [23] likewise emphasises the importance of interactive and participatory pedagogical approaches when integrating ESD competencies into teacher education.

At the same time, subject-specific and methodological competencies received comparatively lower ratings, particularly the competence facet of anticipation. One possible interpretation is that future-oriented thinking requires learning opportunities that explicitly address alternative developments, uncertainty, and the long-term consequences of decisions. While the introductory module provided an initial engagement with sustainability-related challenges, its limited scope may have offered fewer opportunities for sustained work on these aspects. This finding therefore points to the potential value of revisiting anticipatory thinking through progressively more complex tasks in subsequent modules of the teacher education program [3].

7.3. Implications for the Curricular Integration of ESD in Teacher Education

The findings of this study highlight the potential of compulsory introductory ESD modules as part of a broader strategy for curricular integration in teacher education. By providing all first-year student teachers with a common introduction to sustainability-related concepts and educational approaches, such modules can establish a shared starting point for subsequent learning experiences. However, the positive student perceptions observed in this study should be considered in relation to the module's introductory function within the broader curriculum. Rather than representing a stand-alone learning experience, the module provides an initial foundation that is intended to be complemented by further opportunities to engage with ESD across subject-specific, interdisciplinary, and practice-oriented contexts throughout the teacher education programme [1,7].

At the module level, students' evaluations suggest that the introductory learning experience could be strengthened by incorporating collaborative and practice-oriented activities from the outset. In particular, the comparatively critical evaluations of Day 1 provide a basis for reviewing the balance between information-oriented and participatory learning arrangements.

An important implication concerns the relationship between the introductory module and subsequent learning opportunities. Students' comparatively lower motivation to engage with ESD in later university modules suggests that curricular continuity cannot be taken for granted. Teacher education institutions should therefore make the relevance of subsequent ESD learning experiences explicit, for example by linking sustainability-related questions to subject didactics, interdisciplinary teaching projects, and school placements. Such connections may help students recognise ESD not as an additional topic but as an integral part of their future professional responsibilities. This approach is consistent with research emphasising coherent curricular pathways and repeated opportunities for reflection and application [3,21].

The limited scope of the introductory module also has implications for curriculum design. With a workload of 1 ECTS credit, the module can provide an initial orientation and

opportunities for engagement with selected sustainability-related questions, but it cannot reasonably be expected to address the full complexity of ESD competencies. This reinforces the importance of distributing competence-oriented learning opportunities across different phases of teacher education. In particular, more demanding aspects such as anticipatory thinking could be revisited through extended case studies, scenario-based activities, and practice-oriented assignments in subsequent modules.

A further characteristic of the institutional implementation was the bilingual learning environment. Bringing together German- and French-speaking student teachers in collaborative activities created opportunities for exchange across linguistic and cultural perspectives. Although the present study did not specifically measure the effects of bilingual collaboration, this arrangement illustrates how institutional diversity can be incorporated into the didactic design of ESD. For teacher education institutions operating in multilingual contexts, such learning environments may offer opportunities to connect sustainability-related learning with dialogue, perspective-taking, and collaborative problem-solving [1].

Taken together, these implications suggest three considerations for curriculum designers: providing a common introductory foundation for all student teachers, establishing explicit connections between introductory and subsequent ESD learning opportunities, and ensuring that sustainability-related competencies are addressed through progressively more complex and practice-oriented activities. Rather than proposing a universally applicable model, the findings offer insights that may inform other teacher education institutions seeking to strengthen the curricular integration of ESD within their own institutional contexts.

7.4. Limitations and Future Research

The findings of this study should be interpreted considering several limitations. The study was based on an exploratory cross-sectional survey examining students' perceptions of a compulsory introductory ESD module at a single university of teacher education. Although the response rate was high (94.7%), the findings reflect self-reported perceptions rather than independently assessed learning outcomes or competence development. Consequently, the study does not allow conclusions about causal effects or changes in students' competencies over time. As the survey was conducted following the first implementation of the module, students' evaluations may also have been influenced by the novelty of the learning experience. Furthermore, although participation in the survey was voluntary and anonymous, the evaluation of a compulsory module within students' own institution may have encouraged socially desirable responses and potentially more favourable self-assessments.

The questionnaire scales were based on established course-evaluation and ESD competence frameworks and demonstrated satisfactory internal consistency. Nevertheless, their underlying dimensional structure requires further validation in larger and more diverse samples. In addition, the open-ended responses were used to provide descriptive context for the quantitative findings rather than being subjected to a systematic qualitative content analysis. Future studies could employ more extensive qualitative approaches to examine students' experiences and interpretations in greater depth.

A particular strength of the study lies in its coverage of almost the entire student cohort participating in the compulsory module and in the combination of structured questionnaire responses with students' written comments. This provides a detailed account of how the module's didactic design and competence-related learning opportunities were perceived during its initial implementation. However, the findings are specific to the institutional and curricular context examined and cannot be assumed to generalise directly to other teacher education settings.

Future research could build on these findings by examining how students' engagement with ESD evolves across successive phases of teacher education. Longitudinal studies combining self-reports with classroom observations, interviews, or performance-based assessments could provide a more comprehensive understanding of sustainability-related competence development and its application in teaching practice. Comparative research across institutions could further explore how different curricular structures, institutional conditions, and learning arrangements shape students' experiences of ESD.

7.5. Conclusions

This study examined students' perceptions of a compulsory introductory ESD module implemented as the first phase of a broader curricular integration strategy in primary teacher education. The findings concern the initial implementation and reception of this module and do not provide evidence of the effectiveness of the subsequent curricular phases or of the overall integration strategy.

The findings indicate that students evaluated the module positively, particularly its participatory and collaborative learning arrangements and the opportunities to engage with social and personal competence facets. At the same time, the comparatively lower ratings for anticipatory thinking and motivation to engage with ESD in subsequent university modules point to areas that warrant attention in the further development of the curriculum.

The study contributes to discussions on the curricular integration of ESD by illustrating how a compulsory introductory module can provide a shared starting point for student teachers within a broader institutional approach. Its contribution lies primarily in documenting the implementation and student reception of this curricular format rather than demonstrating measurable competence development or long-term educational effects. The findings therefore highlight the importance of considering introductory ESD learning experiences in relation to the wider teacher education curriculum.

For teacher education institutions, two practical implications emerge. First, introductory ESD modules should be explicitly connected to subsequent subject-specific, interdisciplinary, and school-based learning opportunities so that students can revisit and apply sustainability-related perspectives throughout their studies. Second, curriculum designers should provide repeated opportunities to engage with more demanding competence facets, particularly future-oriented and anticipatory thinking. In this way, compulsory introductory modules can form one component of a coherent, practice-oriented approach to embedding ESD in teacher education.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su182110775/s1. Supplementary File S1: Original bilingual questionnaire (German and French); Supplementary File S2: English translation of the questionnaire (provided for transparency and international accessibility; not administered to participants or independently validated).

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Abbreviations

The following abbreviations are used in this manuscript:

ESD	Education for Sustainable Development
SDGs	Sustainable Development Goals

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