

Article

Social Interaction: A Crucial Means to Promote Sustainability in Initial Teacher Training

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Abstract: This study aims to identify the set of elements in the educational process that affect the creation of a teaching profile consistent with the principles of sustainability. In this research, we focus on identifying those sustainability attributes related to understanding social interaction and its role in the learning process of logical-mathematical knowledge. Social interaction is an essential part of the principle of collaboration. The study participants were 133 future teachers, students of the degree in Early Childhood Education at the Universidad de Cádiz (Spain). Qualitative methods and techniques were used to collect data, and mixed methods and techniques were employed for their analysis. The data relating to the student's perception of the importance of social interaction in learning were gathered through the final reports produced by the students. The data were processed by classifying them into categories and subcategories. The meaning condensation method used enabled identifying 33 sustainability attributes linked to socio-cultural learning. Those attributes identify and describe the internal dynamics of cooperative learning and show the synergies and interrelationships between social interactions, socio-cognitive conflict and language. The results stress the importance of a meaningful understanding of the role of social interaction in learning in order to promote the principles of sustainability.

Keywords: initial teacher training; education for sustainability; socio-cultural learning; professional development; higher education; mathematics education



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1. Introduction

The 2030 agenda includes the 17 sustainable development goals (SDGs) that must be a priority for all governments and citizens in the coming years. These goals seek to promote sustainable development (SD) in an integrated manner and count on education as a key feature for their achievement [1]. Amongst them, we highlight SDG 4 (quality education), which contains a series of targets that focus on reorienting education and learning to acquire knowledge, skills and values that contribute to a sustainable future [2–5].

Sustainable development is about relationships between people and between people and their environment. It is therefore linked to the models of social and economic development, in which the human factor is essential. This research stresses the value of the social perspective since 10 of the 17 SDGs are related to the social pillar of sustainable development [6].

Society is a complex network of social interaction; that is, the people constituting it are mutually interdependent and are related to each other in various ways. If we regard social interaction as the process through which people learn, act and connect with everything that concerns their environment, it can be considered a key factor in the progress of sustainable development [7,8].

Universities play a vital role as agents of change and social transformation [9–11]. They occupy a privileged position when it comes to promoting education for sustainable development that guides the training of future professionals to respond to the global

challenges of today's society [12,13]. From this perspective, as teacher trainers, our responsibility is two-fold [14,15]. We are training the professionals who will train the future citizens of the 21st century [16].

From this perspective, it is important to analyse future teachers' concepts and principles of learning, given their influence on future practices. The studies that have examined the concepts of learning and educational practices used in education for sustainability show dependence between them [17]. Teachers must develop and implement processes that will enable their students to acquire sustainability skills [18]. This means teachers need learning principles that allow them to implement appropriate teaching abilities in their classrooms to develop sustainability competencies [19], creating learning environments in line with sustainability. It is, therefore, necessary for future teachers to make their ideas about both teaching and learning explicit and reflect on them, which is what our study is about.

The work presented is a research study that focuses on the role future teachers give to social interaction in the learning process; in our case, the learning process of mathematical knowledge. It also contemplates how teachers perceive that social interaction fosters the integration of sustainability in initial teacher training and early childhood education classrooms.

1.1. Integrating Sustainability in Teacher Training

This study is developed within the framework of initial teacher training for early childhood education teachers and from the perspective of their didactic-mathematical learning. Its purpose is to promote education for sustainability within this framework. Integrating sustainability into teacher training is not only about including competencies or environmental content in the curricula but also about providing a change of mentality in students. To do so, it is necessary to promote appropriate methodological strategies that imply a change in attitude, methodology and conception of teaching-learning processes that address the socio-environmental and socio-constructivist dimensions [20–22].

Integrating sustainability into initial teacher training has been approached from different perspectives that can be considered complementary [23,24]. The research studies that appear the most in scientific publications are those that focus on evaluating the presence of competencies, content and interesting proposals to promote implementing sustainability in the curriculum [25,26].

At the same time, another series of studies analyse aspects related to the teaching practice, teaching methodologies and assessment as essential aspects to integrate sustainability into the classroom [27]. However, they are less present in scientific publications. They pay attention to teaching practices that enable generating a learning environment compatible and consistent with the principles of sustainability they wish to promote in students. In other words, they advocate for the idea that the principles of sustainability should be present in the teaching activity itself through a methodology that allows students to experience sustainability criteria in an implicit manner, thus enabling those learners to master them in a meaningful way [28].

We focus our attention on this second perspective of inclusion of sustainability. We consider the university teacher as a dynamising agent whose practices and ideas have significantly transformative potential for students and institutions [29]. As teacher trainers, we face the professional challenge of defining training proposals that are consistent with the principles of sustainability we wish to promote in student teachers [30,31], as they will have to face that same challenge in their future teaching activity. Therefore, the purpose is to contribute to training professionals that engage in reflective thinking and are able to address the socio-environmental conflicts inherent in the practice of the teaching profession in an ethical and responsible manner [32].

Certain challenges must be addressed that bring teacher training closer to the all-around development of individuals. Teachers will hence have more tools to, themselves, be agents of change [33,34]. To this end, understanding and integrating the essential dimen-

sions of professional knowledge must be encouraged: mathematical knowledge, principles of learning, and principles of teaching performance. It must be a kind of learning that fosters the relationship between theory and practice, providing keys to analyse, understand and act in the classroom; in other words, it must strengthen professional knowledge from humanist principles [35].

As educators, we conceive the classroom as a scenario of collaborative events to promote exchanges, debate and dialogue, as well as the responsible action and participation of all the agents involved [36,37]. It must, therefore, encourage personal and group participation in the teaching-learning process of the values of sustainable development. These are fundamental strategies to develop teaching profiles consistent with these values.

Creating competent teacher profiles to manage a classroom in which sustainability values are fostered implies encouraging dialogue, debate and negotiation around problem-solving [38]. This, first of all, requires a meaningful understanding of the social nature of learning and the added value that social interactions provide to teaching and learning processes. This study, therefore, addresses social interaction and its role in learning processes, which are key for the socio-cultural consideration of learning and its impact on initial teacher training to promote professional learning for sustainability [39].

1.2. Social Interaction as a Learning Principle and Driver of Change

The different socio-cultural perspectives on human learning are based on the idea that human beings construct and understand knowledge in a social and cultural context through interactions that encourage dialogue, debate and negotiation [40–42]. Language is at the core of learning [43], considering that communication, thinking and learning are related processes modelled by culture [44] (p. 138).

As social beings, we need others to learn; thus, social interactions and communications of both teacher-student interactions (vertical interaction) and student-student interactions (horizontal interaction) are key. As pointed out by UNESCO [35] (p. 16), education and learning rest on human interactions, dialogue and exchange. This exchange shows cognitive conflict and fosters overcoming it, constituting it like another basic element of the learning process.

Implementing training for teaching methodologies that agree with the implications of socio-cultural theories and the professional competencies desired to be promoted in students helps teachers redefine the value, usefulness and meaning of social interaction in future teaching activities [45]. Quality, effectiveness and consistency in teaching practice are essential for social transformation to contribute to building a more sustainable, fairer and friendlier world [46].

There is no doubt that a profound understanding of social interaction and its impact on the training process is a priority from which teachers can act as agents of change. Teachers can facilitate the process of advancing towards a society based on cooperation, in which dialogue, debate and negotiation are promoted around significant problems based on free expression, respect and mutual trust.

Generating opportunities for future teachers to identify the importance of social interaction in learning and promoting a logical and rational understanding of fundamentals may lead to reflective practice [47]. The analysis of the implications that socio-cultural assumptions of learning have on the teaching role can build on professional solutions. They have an impact on the design, management and assessment of teaching-learning situations. Methodologies, strategies and cooperative work promote the values of sustainability, based on future teachers' experiences, should consistently be used in teaching-learning situations.

1.3. Training Context

This research study was conducted on the subject of the development of mathematical knowledge in early childhood education (DMKECE) in the first semester of the third year. The subject was taught by the same teacher to two groups of students, 3A and 3B, at the

Universidad de Cádiz (UCA) during the 2020–2021 academic year. It was taught online due to the COVID-19 pandemic.

The design, management and development of the subject seek to reflect the principles of education for sustainability [48]. This study is based on the four learning principles consistent with the competencies [31] we wish to promote in students:

- (a) Project-based learning and teaching (PBL) [49,50]. The importance of project-based work is stressed to learn logical-mathematical knowledge (LMK), oriented towards learning processes in initial teacher training and early childhood education classrooms.
- (b) Cooperative learning [51,52]. There is a firm commitment to the teamwork of university content and teaching strategies in early childhood education, which facilitates the development of the participants' previous ideas.
- (c) Analysis, reflection and criticism. A strategy of introspection, awareness of needs, access, selection and organisation of data [53].
- (d) Diversity of perspectives [54] facilitates contrasting ideas [55].

The subject (DMKECE), in which the research was developed, addresses three reflective moments that seek to encourage action strategies in future teachers, in accordance with the principles of sustainability:

- In the first reflective moment related to LMK, the students prepare a descriptive summary and a conceptual map of each area of curricular knowledge involved in groups of 4 or 5 members.
- During the second reflective moment, LMK learning is approached using two areas of attention, the cognitive characteristics of the students of the degree in ECE and the possible learning principles. The work of important authors in the field of learning, such as Piaget, Vygotsky, Ausubel and Perret-Clermont, was analysed in the subject of DMKECE in which the study took place.
- The third reflective moment focuses on teaching LMK and addresses the teacher's role [56], principles of performance, organisation of the classroom and activities organised in different spaces at different times (routines, corners and workshops), as well as the PBL methodology.

The initial explanation of ideas and their reconstruction in each formative moment are considered as a reference procedural tactic. Thus, from the beginning of the subject, a well-supported design of the intervention, framed within project-based learning (PBL), is requested. It will be rebuilt at the end of each of the methodological moments addressed.

The design of professional learning situations, guided by PBL, generates the need for student teachers to organise the different elements that make up a project in a logical and well-grounded manner. They will, therefore, have to analyse the logical-mathematical knowledge, principles of learning, characteristics of children and principles of teaching performance. This kind of activity represents a fruitful training context that contributes to developing and strengthening the teachers' professional identity. The aim is for cooperative groups of students to design an intervention proposal for a second cycle ECE classroom.

2. Materials and Methods

The study was carried out in the classroom, and one of the researchers was the teacher of the two groups of students. In agreement with the criteria established by [57], we understand that we are dealing with a descriptive-interpretive study [58] aimed at knowing the perceptions of a specific group of future ECE teachers. We opted for using mixed methods and techniques to analyse the data. Mixed methods combine the quantitative and qualitative perspectives in the same study. This allows for in-depth characterisation and interpretation of the data with complex research questions [59–63]. This enables us to characterise a singular reality by analysing the students' responses and their implications and obtain a more general image of the group of students because of the large number of participants. The students' perceptions were approached by analysing their reports. The

analysis was performed by both researchers; analyses were first conducted individually and later contrasted.

2.1. Research Question, Objectives and Participants

This paper focuses on understanding how the students perceive the social dimension of learning. By doing so, we elucidate the added value that socio-cultural perspectives of human learning have in creating teaching profiles consistent with the principles of sustainability [64].

The following research questions were posed: “What sustainability attributes do students of the degree of Early Childhood Education identify in their understanding of social interaction? Which is the role the students attribute to social interaction in the LMK learning process?”

Sustainability attributes are understood as the set of elements in the training process that allow students to shape a teaching profile consistent with the principles of sustainability [65], acquiring professional knowledge, assuming socio-environmental commitments inherent in teaching, projecting their actions from humanist values, and developing critical awareness that strengthens the ability to assess their own strategies in order to formulate new improvement actions.

The explicitness of their ideas about learning is the starting point to approach sustainability as a reference for their educational practice. This study aims to describe and analyse how students understand the role of social interaction in the learning process as a key element to approach teaching strategies consistent with education for sustainability. The link, described in previous sections, is established by the researchers a priori. The students establish it by means of the process itself [17–19].

The analysis of sustainability attributes may lead to a future reformulation of the training proposal. To approximate the answers to the research questions, the following objectives, which guide the study, were formulated:

- Identify whether or not the student teachers consider the value and usefulness of social interactions in learning;
- Identify, describe and understand how pre-service teachers describe and justify the importance of social interaction as a means to promote LMK learning.

Both sub-objectives will allow us to identify sustainability attributes linked to the meaningful understanding of social interaction.

A total of 133 third-year ECE students taught at UCA participated in the study. For the development of the training proposal, 32 groups of 4 to 5 students were organised into two groups, 3A and 3B. The students were told about the research that was going to be carried out and were informed that their personal data would not be used in the study.

2.2. Data Collection Procedure. Instruments

The data relating to the student’s perception of the importance of social interaction in learning LMK were collected through the final reports produced by the students. This report consisted of designing, developing and analysing a well-founded intervention proposal based on the development of a project for the second cycle of ECE. In their presentation, amongst other things, they had to clearly set out the learning principles supporting their intervention proposal and provide a logical and reasonable answer to how, when and why they learn.

The students’ reports were gathered in February 2021 online in the Moodle platform, where the subject was taught.

2.3. Data Processing and Analysis

The final written reports presented by the students correspond to the design, development and analysis of an intervention proposal for an early childhood education class based on the PBL methodology. They include the presentation of the project, its development, a didactic-mathematical analysis, instruments for its evaluation and conclusions. They also

had to include three annexes (logical-mathematical knowledge, learning and teaching), in which the students present the theoretical arguments that support the design of their intervention proposal. The information used to conduct this research is linked to the second annexe and corresponds to the second reflective moment of the course, in which the students explain their learning principles and rationale.

To process the data obtained from the students' final reports, a procedure of direct interaction with the data was used to properly select the meaningful information units.

The different reports presented by the students were read and analysed as a whole, mainly to give the proposal meaning. The relevant data for the purpose of our study were selected from the students' reports. The unit of information was the unit of significance to be coded and was highly variable in nature and size [63] (p. 79).

To perform the content analysis, we selected those units that concerned the learning principles related to social interaction elaborated by the participants. The data of each group were freely coded in accordance with how they identified, described and justified this learning principle. This enabled building emerging categories and arranging the students' reports into those categories following an iterative coding process. During this coding process, through grouping by units of meaning, different categories and indicators emerged that were refined during and after the subsequent analysis [66], following the meaning condensation method proposed by [67]. A total of five categories (C1–C5) were constituted. For each category, two dimensions related to identification and description were taken into account. A total of ten subcategories (C1-1, C5-2) (Table 1) and 33 indicators were obtained from the five categories.

Table 1. Emerging categories and subcategories related to the dimensions of identification and description.

Categories (C)	Subcategories
C1. Social dimension of learning	C1-1. Identification of social interaction as a learning principle
	C1-2. General description of social interaction as a learning principle
C2. The role of language in learning	C2-1. Identification of the role of language in learning
	C2-2. Description of the role of language in learning
C3. The role of socio-cognitive conflict in learning	C3-1. Identification of the role of socio-cognitive conflict in learning
	C3-2. Description of the role of socio-cognitive conflict in learning
C4. The role of horizontal interactions in learning	C4-1. Identification of the role of horizontal interaction in learning
	C4-2. Description of the role of horizontal interaction in learning
C5. The role of vertical interactions in learning	C5-1. Identification of the role of vertical interaction in learning
	C5-2. Description of the role of vertical interaction in learning

Within each subcategory, several kinds of information units were distinguished. This enabled formulating different indicators to group those units. The indicators reflect the different formulations included in the reports of the groups of students. They allowed us to classify the expressions the students used to identify, describe and justify social interaction as a basic principle of the learning process. Their explicitness enabled the students to understand the impact of those principles for sustainability during the learning process. The study detects and describes the presence of this principle in the students' reports by processing and analysing the data.

For each category, we first analysed whether or not the students identify social interactions in their reports. We then studied the ways of describing the formulated idea and classified them into two subcategories.

The rationale supporting their formulations, both in the identification and in the description, was considered a cross-curricular dimension. As shown in the presentation of results, it is reflected in the information units of both subcategories.

To characterise the subcategory related to the description and the justification dimensions, we used a rubric (Table 2). This enabled assessing the level of achievement obtained by each group both in the description and justification of their formulations. Levels 0 and 1 represent an unsatisfactory level of achievement, while levels 2 and 3 correspond to satisfactory levels of achievement.

Table 2. Rubric to assess the students' level of achievement with regard to the description and justification of the categories.

Category	Level 0	Level 1	Level 2	Level 3
Description	No description	Vague or superficial description	In-depth description that does not contemplate some of the expected elements	In-depth description that contemplates all the expected elements
Justification	No justification	Vague reference	In-depth reference (related to the work of the main authors used in the subject)	Excellent (in addition to the above, they are able to formulate constructive criticism)

3. Results

The results obtained for each of the five emerging categories are presented below. They are organised according to their frequency of mention (n_i) and distribution by groups (G_i). The aim is to detect if the pre-service teachers identify, describe and justify the role of social interaction as a means to promote learning, or to stress the importance of the principle of collaboration.

3.1. Social Dimension of Learning (C1)

The results reveal that 18.8% of the groups (6 out of 32) did not consider social interaction as a learning principle. The findings show that the ideas were put forward by 81.2% of the groups (26 out of 32). Those 26 groups considered social interaction as a significant learning principle in the all-around development of individuals and stressed the capacity of intervening in the environment and promoting its change.

Table 3 shows the indicators (SD_{I_i} and SD_{D_i}) related to the subcategories of identification (C1-1) and description (C1-2) of social interaction as a principle of learning. They correspond to how the different groups explained the meaning of social interaction and its representation in the educational process.

Table 3. Indicators related to subcategories C1-1 and C1-2.

C1. Social Dimension of Learning (SD)		
C1-1. Identification of social interaction as a learning principle (SD_I)	n_i	G_i
SD_{I1} . Learning is a social phenomenon	15	15
SD_{I2} . Social interaction encourages learning	9	9
SD_{I3} . Learning takes place in a social environment	1	1
SD_{I4} . Knowledge is a social construct	1	1
C1-2. General description of social interaction as a learning principle (SD_D)	n_i	G_i
SD_{D1} . Social dimension of human beings	4	3
SD_{D2} . The social and the cognitive are two dimensions of learning	19	10
SD_{D3} . Zone of potential development (ZPD)	10	7
SD_{D4} . Semiotic mediation (inter-psyhic and intra-psyhic processes)	18	9

Taking the 26 groups as a reference that identified social interaction as a principle of learning, the levels of achievement reached in the description and justification of said principles are shown below (Figure 1).

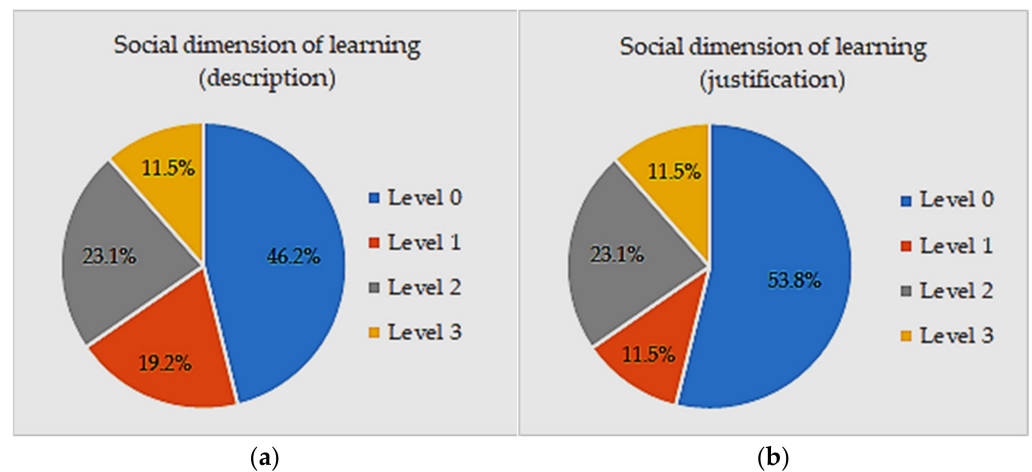


Figure 1. Level of achievement in the description (a) and justification (b) of category C1.

In Figure 1a, it is observed that 46.2% of the groups (12 out of 26) did not make a general description of the principle of social interaction in the groups identified. In their reports, they did not include any descriptive element regarding the general meaning of social interaction as a learning principle.

However, 53.8% of the groups (14 out of 26) did provide a general description of the idea of social interaction. Of this second group, 19.2% (5 out of 26) offered a vague and superficial description of it. The rest of the groups obtained a satisfactory level of achievement (levels 2 and 3), 23.1% (6 out of 26) made an in-depth description, although they did not contemplate any of the expected elements. Finally, 11.5% (3 out of 26) gave an in-depth description that included all the expected elements.

Regarding the theoretical justification (Figure 1b) on which these descriptions are based, it is seen that 53.8% of the groups (14 out of 26) did not present any evidence of justifying with respect to social interaction as a learning principle. Amongst the other groups, 11.5% (3 of 26) made a reference to some of the elements they had previously described in a vague and superficial way. A satisfactory level of achievement (levels 2 and 3) was obtained by 34.6% of the groups (9 out of 26). Of those 9 groups, 23.1% (6 out of 26) referred to them in-depth, relating the elements described to the work of the main authors used in the subject, while the justification of 11.5% (3 out of 26) was excellent. Those 3 groups were also capable of formulating constructive criticism. In Figure 1a, it is observed that 46.2% of the groups (12 out of 26) did not make a general description of the principle of social interaction the groups identified. In their reports, they did not include any descriptive elements with regard to the general sense of social interaction as a learning principle.

3.2. The Role of Language in Learning (C2)

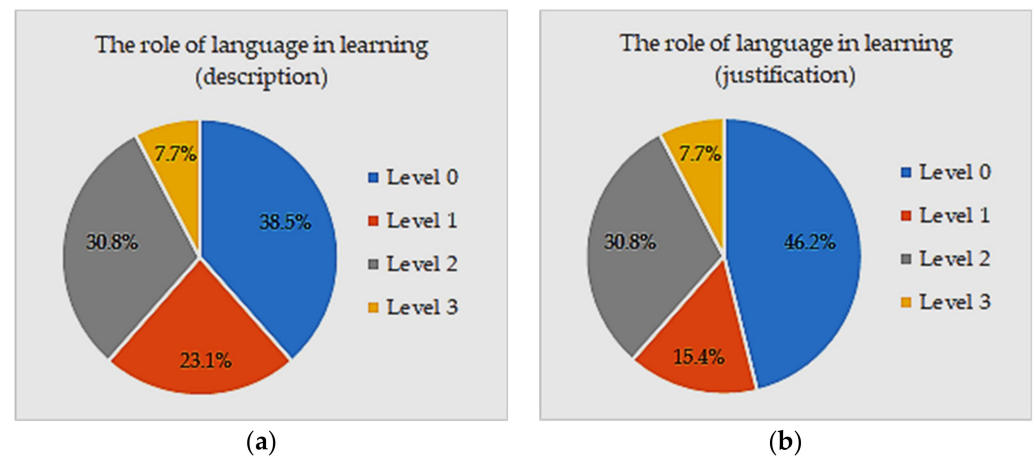
The results show that 50% of the groups (13 out of 26) did not identify the role of language in the process of social interaction, while the other 50% of the groups (13 out of 26) identified it as a crucial element in learning. The role of language is key for the development of communication and collaboration skills, considered to be basic principles in education for sustainability [1].

Taking as a reference the 13 groups that identified the role of language in learning, Table 4 shows the indicators (L_{ii} y L_{Di}) related to the subcategories of identification (C2-1) and description (C2-2) of the role of language in learning.

Table 4. Indicators related to subcategories C2-1 and C2-2.

C2. The Role of Language in Learning (L)		
C2-1. Identification of the role of language in learning (L_I)	n_i	G_i
L _{I1} . Language is the mediating mechanism of learning	3	2
L _{I2} . Language shapes thinking	3	2
L _{I3} . Communication plays a key role in learning	8	5
C2-2. Description of the role of language in learning (L_D)	n_i	G_i
L _{D1} . Pro-social adaptive answers are biological survival responses.	3	3
L _{D2} . Dialogue, debate and negotiation with others are necessary for learning, as they generate opportunities for restructuring thoughts.	20	9
L _{D3} . Dialogue, debate and negotiation with other environments around questions, content and problem-solving are situations of great value for learning.	3	2

The levels of achievement obtained both in the description and justification of the role of language in learning are shown below (Figure 2). The 13 groups that identified the role of language in learning were taken as a reference.

**Figure 2.** Level of achievement in the description (a) and justification (b) of category C2.

As far as the description of the role of language in learning (Figure 2a) is concerned, 61.6% of the groups (8 out of 13) did not obtain a satisfactory level of achievement (levels 0 and 1). Amongst them, 38.5% (5 out of 13) did not present any descriptive element of the value and usefulness of language in learning, while 23.1% (3 out of 13) made a vague and superficial description of it. A satisfactory level of achievement (levels 2 and 3) was obtained by 38.5% of the groups (5 out of 13). Of those groups, 30.8% (4 of 13) gave an in-depth description, although they did not contemplate any of the expected elements. An in-depth description including all the expected elements was made by 7.7% (1 out of 13).

Regarding the justification of the role of language in learning (Figure 2b), 61.6% of the groups (8 out of 13) did not obtain a satisfactory level of achievement (levels 0 and 1), and of those groups, 46.2% (6 out of 13) did not present any supporting evidence of the role of language in learning. 15.4% (2 out of 13) referred to some of the elements they had previously described in a vague and superficial way. A satisfactory level of achievement (levels 2 and 3) was obtained by 38.5% of the groups (5 out of 13). Of those, 30.8% (4 out of 13) referred to the elements in-depth and related the elements described to the work of the main authors used in the subject, while the justification of 7.7% (1 out of 13) was excellent and that group also managed to formulate constructive criticism.

3.3. The Role of Socio-Cognitive Conflict in Learning (C3)

The results show that 57.7% of the groups (15 out of 26) did not identify the role of socio-cognitive conflict in learning, while 42.3% of the groups (11 out of 26) identified it. When interacting with environment-related issues, the ability to overcome the conflict

it entails is often a significant aspect to be taken into account in order to address said problems [47,68,69].

Taking the 11 groups that identified the role of socio-cognitive conflict in learning as a reference, Table 5 shows the indicators (SC_{Ii} and SC_{Di}) related to the subcategories of identification (C3-1) and description (C3-2) of the role of socio-cognitive conflict in learning.

Table 5. Indicators related to subcategories C3-1 and C3-2.

C3. The Role of Socio-Cognitive Conflict in Learning (SC)		
C3-1. Identification of the role of socio-cognitive conflict in learning (SC_I)	n_i	G_i
SC_{I1} . Socio-cognitive conflicts are a source of learning.	10	9
SC_{I2} . Learning starts as a result of the contradictions that arise in social interactions.	6	4
SC_{I3} . Knowledge is built by overcoming obstacles, which manifest themselves through error, and originate in social interaction.	2	2
C3-2. Description of the role of socio-cognitive conflict in learning (SC_D)	n_i	G_i
SC_{D1} . Social expression encourages becoming aware of contradictions, allowing social regulations and consensus.	32	10
SC_{D2} . It starts through dialogue, debate and negotiation with others.	8	8
SC_{D3} . They start through dialogue, debate and negotiation with others about problems, questions and contents.	2	2

Taking the 11 groups that identified the role of socio-cognitive conflict in learning as a reference, the levels of achievement obtained both in the description and in the justification of said role are shown below (Figure 3).

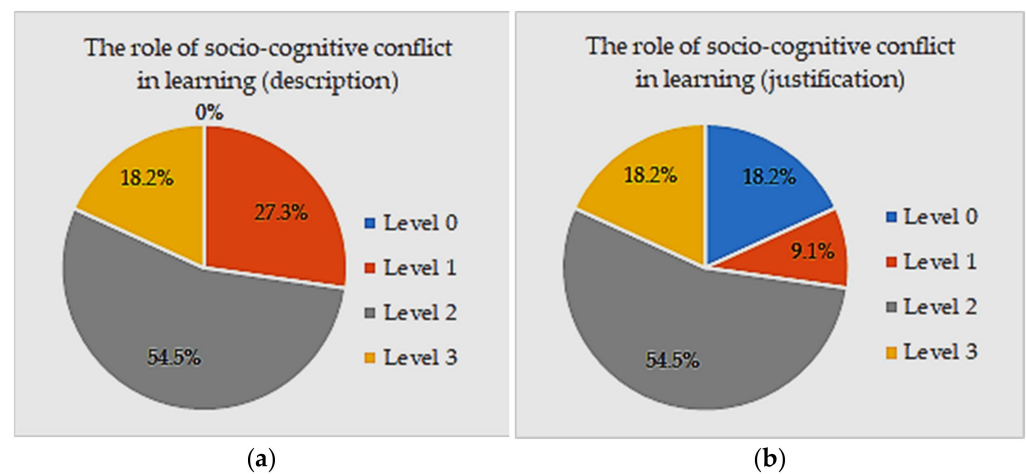


Figure 3. Level of achievement in the description (a) and justification (b) of category C3.

With respect to the description of the role of socio-cognitive conflict in learning (Figure 3a), 27.3% of the groups (3 out of 11) did not obtain a satisfactory level of achievement (levels 0 and 1). All of them made a vague and superficial description of the role and importance of creating conflict during the learning process. All the groups presented at least one descriptive element about how, when or why socio-cognitive conflict is important in learning. 72.7% of the groups (8 out of 11) obtained a satisfactory level of achievement (levels 2 and 3), and 54.5% of them (6 out of 11 groups) made an in-depth description. However, they did not consider any of the expected elements. An in-depth description that included all the expected elements was provided by 18.2% (2 out of 11).

As for the rationale that supports the role conflict plays in the processes of social interaction and learning (Figure 3b), it is observed that 27.3% of the groups (3 out of 11) did not obtain a satisfactory level of achievement (levels 0 and 1). Of those groups, 18.2% (2 out of 11) did not present any supporting evidence, while 9.1% (1 out of 11) made reference to some of the elements they had vaguely described previously. A satisfactory level of achievement (levels 2 and 3) was made by 72.7% of the groups (8 out of 11), 54.5% of which

(6 out of 11) referred to the elements described in-depth, relating them to the work of the main authors used in the subject. The justification of 18.2% (2 out of 11) was excellent, and those groups were capable of formulating constructive criticism.

3.4. The Role of Horizontal Interaction (Student-Student) in Learning (C4)

The results show that 26.9% of the groups (7 out of 26) did not identify the role of horizontal interaction (student-student) as a fundamental element of collaborative learning, whereas 73.1% of the groups (19 out of 26) did identify the role of said horizontal interaction.

Taking as a reference the 19 groups that identified the role of horizontal interactions in learning, Table 6 shows the indicators (H_{Ii} and H_{Di}) linked to the subcategories of identification (C4-1) and description (C4-2) of the role of horizontal interaction in learning.

Table 6. Indicators related to subcategories C4-1 and C4-2.

C4. The Role of Horizontal Interactions in Learning (H)		
C4-1. Identification of the role of horizontal interaction in learning (H_I)	n_i	G_i
H_{I1} . Horizontal interactions promote learning.	19	19
C4-2. Description of the role of horizontal interaction in learning (H_D)	n_i	G_i
H_{D1} . They enable the most skilled students to act as social mediators, encouraging their classmates to act beyond their zone of proximal development.	19	11
H_{D2} . Situations of dialogue, debate and negotiation among peers are a source of learning.	9	8
H_{D3} . They promote communication, collaboration, mutual help and establishing consensus, generating opportunities for the development of social skills and encouraging a sense of belonging to the group.	23	10
H_{D4} . They allow observing answers, proceedings, reasoning, and viewpoints that are different to one's own.	20	10
H_{D5} . Sharing, cooperating and putting one's own skills at the service of others enhances students' motivation and self-esteem.	5	5
H_{D6} . They promote the emergence of socio-cognitive conflicts that enable the construction of knowledge (assimilations and accommodations).	11	8
H_{D7} . Dialogue, debate and negotiation among peers about problem-solving being a privileged means for learning.	1	1

Taking as a reference the 19 groups that identified the role of horizontal interaction in learning, the achievement levels obtained in both the description and justification for the role of said interactions in learning are shown below (Figure 4).

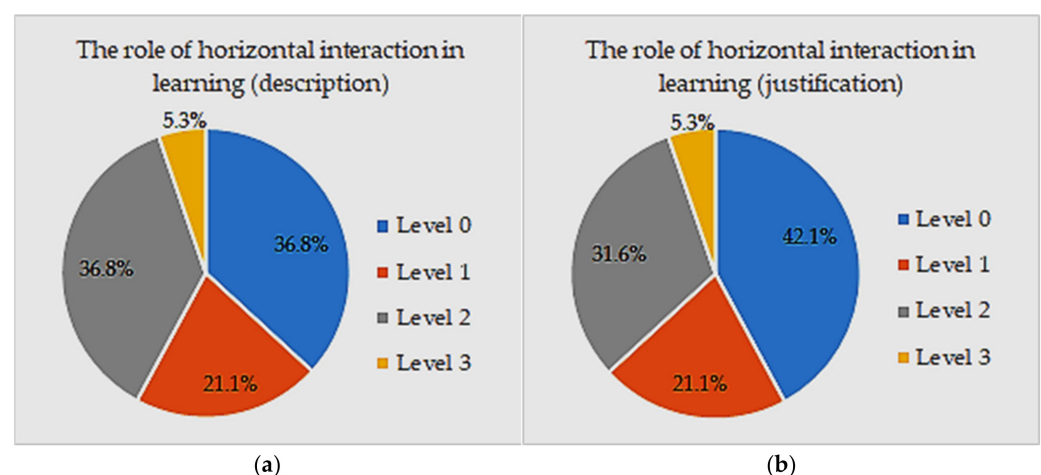


Figure 4. Level of achievement of the general description (a) and justification (b) of category C4.

Regarding the description (Figure 4a), 57.9% of the groups (11 out of 19) did not obtain a satisfactory level of achievement (levels 0 and 1), and 36.8% (7 out of 19) did not present any descriptive element related to the role and importance of horizontal interactions. A vague and superficial description was provided by 21.1% (4 out of 19), while 42.1% of the groups (8 out of 19) obtained a satisfactory level of achievement (levels 2 and 3), 36.8% (7 out of 19) of which made an in-depth description, although they did not contemplate any of the expected elements, and 5.3% (1 out of 19) made an in-depth description that included all the expected elements.

As for justifying the role of horizontal interaction in learning (Figure 4b), 63.2% of the groups (12 out of 19) did not obtain a satisfactory level of achievement (levels 0 and 1); 42.1% of the groups (8 out of 19) did not present any supporting evidence of the role of horizontal interaction in learning; 21.1% (4 out of 19) referred to some of the elements they had previously described in a vague manner; 36.9% of the groups (7 out of 19) obtained a satisfactory level of achievement (levels 2 and 3); 31.6% (6 out of 19) referred to the elements in-depth, relating the ones described to the work of the main authors used in the subject, while the rationale of 5.3% (1 out of 19) was excellent. This group was capable of formulating constructive criticism.

3.5. The Role of Vertical Interaction (Teacher-Student) in Learning (C5)

The results show that 34.6% of the groups (9 out of 26) did not identify the role of vertical interaction (teacher-student) in learning, while 65.4% of the groups (17 out of 26) did identify the role of said interaction in the learning process.

Taking as a reference the 17 groups that identified the role of vertical interaction in learning, Table 7 shows the indicators (V_{Ii} and V_{Di}) linked to the identification (C5-1) and description (C5-2) subcategories of the role of vertical interaction in learning.

Table 7. Indicators related to subcategories C5-1 and C5-2.

C5. The Role of Vertical Interactions in Learning (V)		
C5-1. Identification of the role of vertical interaction in learning (V_I)	n_i	G_i
V_{I1} . Teacher-student interactions are key for learning.	17	16
C5-2. Description of the role of vertical interaction in learning (V_D)	n_i	G_i
V_{D1} . The teacher acts as a social mediator in learning.	10	9
V_{D2} . The help and scaffolding the teacher provide facilitate student learning beyond their zone of proximal development.	19	12
V_{D3} . Situations of dialogue, debate and negotiation between the teacher and the students are a source of learning.	12	7
V_{D4} . Through student-teacher interactions, the learner internalises the teacher's behavioural structures and becomes aware of what has been learnt.	9	4

Taking as a reference the 17 groups that identified the role of vertical interaction in learning [68], the levels of achievement obtained both in the description and justification of the role of said interaction in learning are shown below (Figure 5).

With respect to its description (Figure 5a), 76.5% of the groups (13 out of 17) did not reach a satisfactory level of achievement (levels 0 and 1); 41.2% (7 out of 17) did not present any descriptive element concerning the role and importance of vertical interaction in learning, while 35.3% (6 of 17) made a vague and superficial description of it; 23.5% of the groups (4 out of 17) obtained a satisfactory level of achievement (levels 2 and 3). None of the groups made an in-depth description that included all the expected elements.

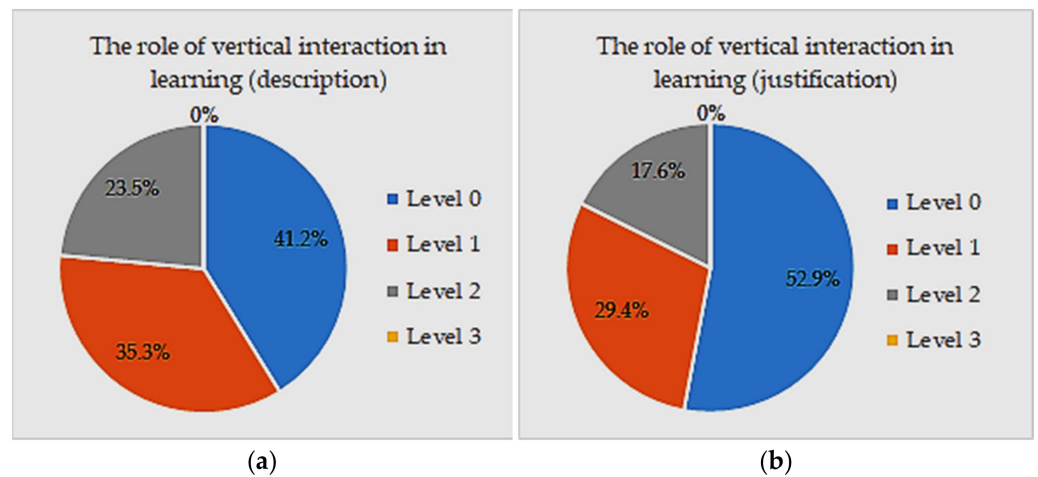


Figure 5. Level of achievement in the general description (a) and justification (b) of category C5.

Regarding the justification of the role of vertical interaction in learning (Figure 5b), 82.3% of the groups (14 out of 17) did not attain a satisfactory level of achievement (levels 0 and 1); 52.9% of the groups (9 out of 17) did not present any supporting evidence of the role of said interaction in learning and 29.4% (5 out of 17) made reference to some of the elements they had previously described in a vague and superficial way. Meanwhile, 17.6% of the groups (3 out of 17) obtained a satisfactory level of achievement (levels 2 and 3), and they all referred to the different elements in-depth relating those described to the work of the main authors used in the subject. None of the groups provided an excellent justification and they did not formulate any constructive criticism.

3.6. Global Presence of the Categories (C1–C5)

Finally, the general results regarding the frequency of mention of the categories (Figure 6), subcategories (Figure 7) and indicators (Figure 8) linked to social interaction as a learning principle are shown below.

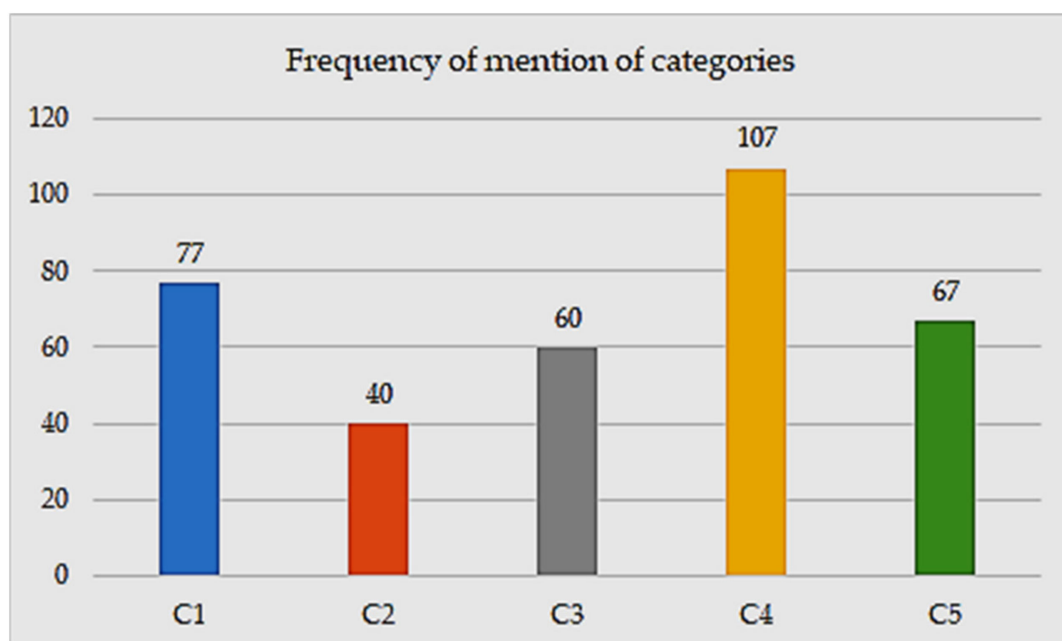


Figure 6. Frequency of mention of categories.

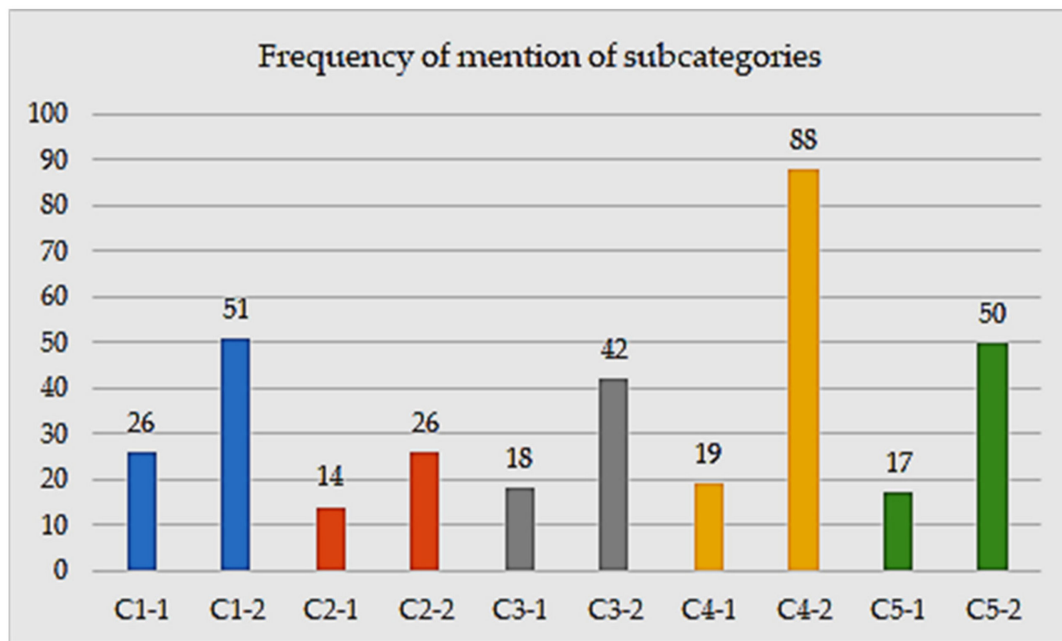


Figure 7. Frequency of mention of subcategories.

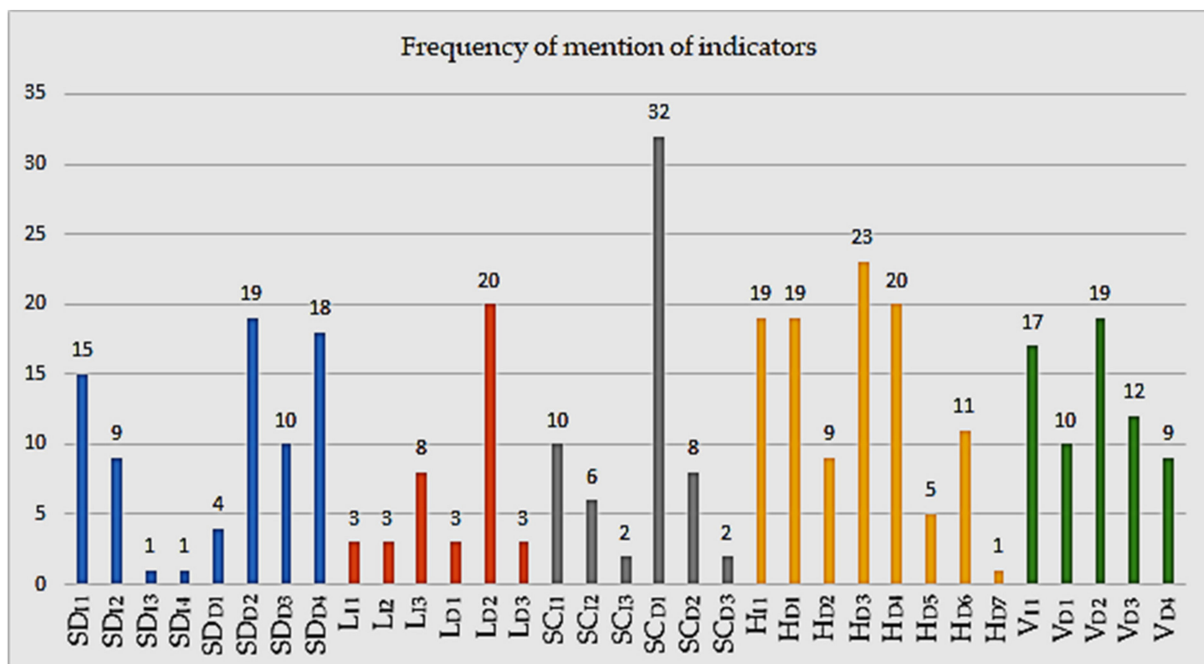


Figure 8. Frequency of mention of indicators.

The results (Figure 6) reveal that the most mentioned category is the role of horizontal interactions in learning (C4), which was mentioned 107 times. The results obtained in the categories of the social dimension of learning (C1), the role of cognitive conflict in learning (C3) and the role of vertical interactions in learning (C5) were similar (they were mentioned 77, 60 and 67 times respectively). Finally, the least mentioned category is the role of language in learning (C2), mentioned 40 times.

The results (Figure 7) show that the most mentioned subcategory is the description of the role of horizontal interactions in learning (C4-2), mentioned 88 times. The subcategories referring to the general description of the interaction (C1-2), the description of the role of cognitive conflict (C3-2) and the description of the role of vertical interactions in learning

(C5-2) obtained significantly high and similar results (they were mentioned 51, 42 and 50 times respectively). Finally, the rest of the categories obtained a considerably small number of mentions, and the category of identifying the role of language in learning (C2-1) stands out as the least mentioned category (14).

The results (Figure 8) reveal that the most mentioned indicator is SC_{D1} , which was mentioned 32 times. This shows the importance students give to social expression as a means to encourage the appearance of socio-cognitive conflicts. Amongst the seven most mentioned indicators, four were related to horizontal interaction (H_{D3} , H_{D4} , H_{I1} and H_{D1}). This again highlights the value the students give to social interaction among peers in learning processes; it is the aspect they valued the most in their considerations. Finally, the importance students give to language in learning through the processes of dialogue, debate and negotiation (L_{D2}) is worth noting. The sustainability attributes observed in the students' reports identify and describe a large part of the pedagogical foundations of socio-cultural learning, emphasising the influence social relationships (student-student and teacher-student) have on learning and pointing out the value of the role of social reinforcement. They also consider the central role of socio-cognitive conflict in learning, recognising that the importance of social interactions underlies, on the one hand, their ability to generate socio-cognitive conflicts and, on the other hand, their potential to provide social reinforcement that facilitates overcoming said conflict. Finally, they value the role of language and communication in learning, stressing the importance of verbal expression of socio-cognitive conflicts.

Table 8 shows how the frequency of mention is distributed among the groups, showing a heterogeneous and different level of achievement. Of the 26 groups, 13 (1A, 3A, 5A, 7A, 8A, 9A, 16A, 1b, 2B, 7B, 8B, 12B and 14B) included 88% of the indicators (309 out of 351). No significant difference was observed between the two groups, as 3A provided 53.3% of the indicators (187 out of 351), and 3B contributed with 46.7% of the indicators (164 out of 351).

Table 8. Distribution of categories and indicators by groups.

		Groups																									n _i	G _i	
		1A	2A	3A	4A	5A	6A	7A	8A	9A	10A	15A	16A	17A	1B	2B	3B	4B	6B	7B	8B	9B	10B	11B	12B	14B			15B
C1	SD _{I1}	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	15		
	SD _{I2}			1			1		1	1	1	1				1				1						1	9	9	
	SD _{I3}																						1				1	1	
	SD _{I4}		1																								1	1	
	SD _{D1}			1						1											2						4	3	
	SD _{D2}	4		1		1		3	1	2					1	2						2	2				19	10	
	SD _{D3}	2						2		1			1		1							2			1		10	7	
	SD _{D4}	3				2		3		2					2	1						1			2	2	18	9	
C2	L _{I1}				2										1												3	2	
	L _{I2}						2															1					3	2	
	L _{I3}	2			2									1							2				1		8	5	
	L _{D1}									1							1										3	3	
	L _{D2}	2		3				4		2					2	2					2		1			2	20	9	
	L _{D3}					1																2					3	2	
	SC _{I1}	1		1		2			1				1		1	1					1	1					10	9	
C3	SC _{I2}						2		1														2		1		6	4	
	SC _{I3}														1											1	2	2	
	SC _{D1}	4		2		3		5						4						2	4		1		4	3	32	10	
	SC _{D2}			1			1	1	1			1		1	1					1							8	8	
	SC _{D3}				1																1						2	2	
	H _{I1}	1		1		1	1	1	1		1	1	1	1	1	1	1			1	1	1		1	1	1	19	19	
C4	H _{D1}	2		2		2		1		2			1		2	1					3			1	2		19	11	
	H _{D2}	1				1		1					1		1						2				1		9	8	
	H _{D3}	4		2		3		3		2			1		3		1							3	1		23	10	
	H _{D4}			3		3		2			1			2			1						1	3		1	20	10	
	H _{D5}			1				1													1			1	1		5	5	
	H _{D6}	2								1			1			1					1	2			2	1	11	8	
	H _{D7}					1																					1	1	
C5	V _{I1}	1		1		1	1	1	2	1			1	1	1	1				1	1	1		1	1		17	16	
	V _{D1}	2				1	1	1	1	1				1										1			10	9	
	V _{D2}	2		1		2		2	3			1		2			1			1	1			2	1		19	12	
	V _{D3}	3				2		2				1		2			1								1		12	7	
	V _{D4}					2			3													1		3			9	4	
N° indicators		37	1	21	1	34	4	37	15	19	2	3	12	1	29	14	9	1	1	14	30	8	5	3	27	20	3	351	225

4. Discussion of Results

The results obtained from the analysis of the information units ($O_{i,j,k}$) collected in each category are discussed below. These information units were coded in such a manner that $O_{i,j,k}$ refers to the j -th information unit, of the i -th category ($i:1-5$), of the k -th group ($k:1A-17A$ or $1B-15B$).

In this second round of results, the answer to the initial problem is examined in more depth to elucidate which sustainability attributes related to the meaningful understanding of the social nature of learning to promote LMK appear in the students' reports.

4.1. Sustainability Attributes Related to the Identification and Understanding of Social Interaction as a Learning Principle (C1)

These sustainability attributes refer to the ability to identify the social nature of learning, as well as the general understanding of the importance and meaning of social interaction in learning. Returning to the initial ideas, to bring about an appropriate change in the attitude of future teachers, the role of cooperation as a fundamental principle of sustainability should be redefined. Its role in the processes of learning for sustainability is essential to change the educational model.

The future teachers identify the social nature of both the human being: "Man is a social being, he can only develop in a society and in close contact with others" ($O_{1,9,7B}$), and of learning: "Social interaction is essential for learning" ($O_{1,33,7A}$). In their proposals, they describe the added value of social interactions for learning and development: "Any higher function such as attention, memory or the formulation of concepts is first of all a social phenomenon (interpsychological process), which then progressively turns into a property of the individual (intrapyschological process)" ($O_{1,43,7A}$). The importance of social interaction in learning is considered to be closely related to its ability to promote action and the construction of knowledge: "Social interactions encourage action and promote the construction of knowledge" ($O_{1,38,7A}$). The teacher students' arguments are essentially based on the postulates of social learning and are supported by notions such as the zone of proximal development, the zone of potential development and semiotic mediation (inter-psychic and intra-psychic processes).

Awareness of the social dimension of learning and a meaningful understanding of it are essential elements for the construction of a teacher profile qualified to design, manage and assess teaching-learning situations that encourage cooperation. They are necessary aspects to promote group cohesion and the active participation of students in the construction of knowledge through the search for consensus through methodologies, strategies and cooperative work consistent with the values of sustainability [56].

4.2. Sustainability Attributes Related to the Identification and Understanding of the Role of Language in Learning (C2)

These sustainability attributes refer to the ability to identify the central role of language in learning, as well as its understanding of how, when and why language acts as a mediator in the construction of knowledge. Language offers people the ability to express their ideas, contrast them and establish relationships with their environment.

The future teachers identify the role of language in learning; "Language is the mediating mechanism of learning" ($O_{1,6,2B}$). They describe the added value of language in learning: "The contexts of dialogue, negotiation and debate, amongst other communicative contexts, encourage learning" ($O_{2,11,7B}$). They thus show how knowledge is formed through the use of language: "Socialisation around situations where communication and reflection are fostered allows, in the first place, the use of its previous schemes and, in the second place, facilitates their modification" ($O_{2,59,17A}$). Their arguments are essentially based on Ausubel's [70,71] theory of meaningful learning and Vygotsky's [72-74] theories of internalisation and semiotic mediation. From the first author, they allude to the crucial role language plays in conceptualisation, and from the second, the key role of language and words in semiotic mediation and, as a result, in the meaningful learning of content.

Being aware of the role of language in learning and communication is paramount to create a teaching profile akin to the values of sustainability [42].

It is important to recognise the impact that the expression of one's own thoughts and listening to other people's thoughts has on the construction of knowledge and on the development of individuals. It enables the teacher to give students an active role in the construction of knowledge in contexts that encourage dialogue, debate and negotiation around significant problems of the environment. More reflective and transformative principles of education for sustainability tend to stress the importance of developing skills and empower students to make their own decisions with regard to behaviour change [75].

4.3. Sustainability Attributes Related to the Identification and Understanding of the Role of Cognitive Conflict in Learning (C3)

These sustainability attributes are related to the ability to identify the vital role socio-cognitive conflicts play in learning processes, as well as the understanding of how, when and why socio-cognitive conflicts enable the meaningful construction of knowledge. The social expression of conflicts promotes awareness of contradictions, allows for social regulations to be implemented and consensus to be established with the aim of interpreting said contradictions and seeking a collective solution [76–78].

The future teachers identify the role of socio-cognitive conflicts in learning: "Cognitive conflicts between members of the same social group are a source of learning" (O_{3,3,2B}). They describe how social interaction in itself does not lead to learning, but through the appearance of socio-cognitive conflict: "Social interactions that provoke contradictions in the subject, revealing what is known as insufficient or ineffective or revealing aspects that are unknown, are the driver of learning" (O_{3,1,1B}). They also describe the internal dynamics that enable learning to occur: "New knowledge is formed from the person's own schemes, product of their reality and comparison with the patterns of the other individuals that surround the person" (O_{3,13,8A}). Their arguments are mainly based on Piaget's [79,80] equilibrium theory, using notions such as disequilibrium, schema, accommodation, assimilation and, on Vygotsky's [69–71] socio-cultural theory of learning.

Becoming aware of the role of socio-cognitive conflict in learning and the meaningful understanding of its consequences are again essential elements to build a teacher profile capable of managing situations of cooperative learning consistent with and related to the values of sustainability. Cooperative learning is one of the basic principles of sustainability [1].

Guiding the social regulations that are triggered with the appearance of socio-cognitive conflicts and encouraging the collective search for solutions helps the students adopt an active role in the construction of knowledge. It also fosters group cohesion.

4.4. Sustainability Attributes Related to the Identification and Understanding of the Role of Horizontal Interaction (Student-Student) in Learning (C4)

These sustainability attributes are about the ability to identify the role horizontal interactions play in learning processes, as well as the understanding of how, when and why horizontal interactions enable the construction of knowledge. They give a relevant role to the students, and from being mere spectators, they become active agents [81]. Horizontal interactions around problem-solving allow discovering other answers and ways of acting and thinking that differ from one's own that are fruitful for provoking socio-cognitive conflicts. The distress that occurs in horizontal interactions generates in the subject a need to coordinate different alternatives—their own and that of their classmates. This situation is potentially significant for learning and cognitive development [68]. Peer collaboration causes a cognitive activation that gives rise to a common benefit, enabling students to solve problems they might not have been able to solve individually.

The student teachers identify the role of horizontal relationships in learning: "Peer interactions are a very important factor for learning and progress" (O_{4,1,1B}). They describe how horizontal interactions encourage learning: "During peer interactions, opportunities arise in which children can observe the procedures followed by their peers, other reasoning

and points of view, which will contribute to their own learning" (O_{4,11,8B}). They describe how horizontal interactions facilitate intellectual progress through socio-cognitive conflict: "The socio-cognitive conflicts that occur in the interaction between students enable knowing other responses, implementing social regulations and establishing consensus with peers about a response" (O_{4,24,3A}). They also describe the role the most skilled students play in this process: "The most skilled or expert student builds a guide or scaffold that facilitates the inexperienced individual's learning, enabling their development towards higher levels" (O_{4,22,1A}). Their arguments are mostly based on Piaget's [79,80] equilibrium theory, using notions such as cognitive conflict, schema, accommodation and assimilation; as well as on Vygotsky's [72–74] socio-cultural theory of learning using notions such as scaffolding, socio-cognitive conflict, zone of proximal development and zone of potential development.

The awareness of the role of horizontal interactions in learning and the meaningful understanding of their pedagogical consequences is fundamental in learning processes. Understanding that human beings do not only learn by imitating a superior model is key to developing a teaching profile compatible with the principles of sustainability.

The meaningful understanding of the added value horizontal interactions represent for learning enables the teacher to act as a guide and mediator. It gives the teacher the opportunity to act in social regulations from a position of true confidence in the possibilities human beings have to thrive in collaborative contexts of equality.

4.5. Sustainability Attributes Related to the Identification and Understanding of the Role of Vertical Interactions (Teacher-Student) in Learning (C5)

These sustainability attributes are related to the ability to identify the role vertical interactions have in learning processes, as well as the understanding of how, when and why vertical interactions enable the construction of knowledge. The integration of sustainability configures this relationship as a process in which the teacher behaves as the mediator who brings learning tools into play [69]. Teacher-student interactions around the presentation of information, content discussion and problem-solving allow discovering other answers, other language and other ways of acting and thinking that are different from their own and those of their peers. They are, therefore, fruitful when provoking socio-cognitive conflicts [68]. The scaffolds the teacher puts in place through active listening, formulating appropriate questions and examples expand the learning possibilities of the students beyond their own autonomy and collaboration with their peers.

The future teachers identify the role of vertical interactions in learning: "The teacher's interaction with the student is a high value learning environment" (O_{5,16,5A}), and the role language plays in these interactions: "The teacher acts as a cultural mediator promoting communication and dialogue processes among and with students to promote learning" (O_{5,7,8B}). They describe the added value of the interaction for learning, in accordance with its potential capacity to provoke socio-cognitive conflicts: "Vertical interactions promote the appearance of cognitive conflicts that provoke the modification of previous ideas" (O_{4,30,16A}), and its potential capacity to contribute to its resolution: "The teacher, as an informed adult or expert, builds a guide or scaffold that facilitates the learning of inexperienced students, enabling their development in the zone of potential development" (O_{5,14,1A}). Their reasoning is based on the work of the same authors and notions as the ones discussed in the previous category related to horizontal interaction.

Being conscious of the role of vertical interactions in learning is significant for the teacher to abandon the transmissive teaching model and demonstrate the ability to transform classrooms into learning communities [48]. The meaningful understanding of the added value vertical interactions represented for learning enables the teacher to develop a critical and reflective attitude about when and how to intervene to encourage student learning and development without reducing the students' autonomy [81]. It is necessary to be aware of the fact that students do not only learn through their work but also from the mutual help students provide each other.

5. Conclusions

Contributing from initial teacher training to creating teaching profiles that promote the values of sustainability and humanist principles is an essential task [82]. Considering the teacher as an agent of change, we have chosen to promote the inclusion of sustainability in initial teacher training by setting the example [83]. A methodological proposal in line with the principles and values we wish to promote in students was implemented. We understand that the methodology used should simultaneously benefit professional and personal development [56]. The student must be guided towards the future as an educator and good citizen, and this guidance must be based on tolerance and a source of understanding in their interactions [84]. Likewise, ethics are taken into account. Teachers and students should have the ability to recognise themselves and others, their judgments and arguments, the results of analyses and should make appropriate use of this power [85].

The meaningful learning of didactic and disciplinary knowledge is undoubtedly one of the main axes from which to contribute to individual and social progress. This article stresses the importance of a meaningful understanding of the role of social interaction in learning to promote the principles of sustainability. Cooperative learning is undeniably a privileged means from which to promote the principles of sustainability. Knowing the basic elements of cooperative learning and how to apply them in the classroom is important but insufficient to encourage educational practices consistent with its pedagogical implications [86]. Designing, managing and assessing teaching-learning situations that promote the social construction of knowledge from dialogue, debate and negotiation require significant understanding of the internal dynamics of cooperative learning [87].

Our purpose was to identify, by means of a mixed methodology, the professional knowledge (sustainability attributes) that promotes and supports an educational practice based on cooperation. In accordance with these approaches, and going back to the research objectives, the results revealed that 81% of the students identified social interaction as a learning principle they identify with. In addition, they identified 54 sustainability attributes linked to socio-cultural learning. These attributes identify and describe the internal dynamics of cooperative learning, showing the synergies and interrelationships between social interactions, socio-cognitive conflict and language. Integrating these sustainability attributes into one's own profile contributes to the professional development of future teachers and facilitates advancing towards effective quality educational practices consistent with the principles of sustainability [88]. Fostering progress towards a society based on cooperation, in which dialogue, debate and negotiation around significant problems are encouraged, requires an understanding of the educational foundations of cooperative learning, leading by example and stimulating and participating in deliberative discussions in the classroom [89].

In agreement with the initial expectation that the analysis of sustainability attributes could give rise to a future reformulation of the training proposal [90], the results show that the non-identification of social interaction as a learning principle and the lack of awareness of its value and importance affects 19% of the students. This is a major obstacle for the construction of a teaching profile consistent with the principles of sustainability [91]. At a general level, the results also reveal an unsatisfactory level of achievement both in the description and in the justification of social interaction as a learning principle. We believe that, by introducing democratic practices in initial teacher training [92], explicitly addressing the sustainability attributes observed can help future teachers become aware of why, how and when social interactions are key for human learning.

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