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# How Do Prospective Teachers Address Pupils' Ideas during School Practices?

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**Abstract:** This paper assesses the coherence between the conceptions of prospective teachers about pupils' ideas and how these are used in their educational proposals for primary school classrooms. For this purpose, three dimensions were analysed: The nature, utilisation, and change of ideas. In addition, two instruments were used: A questionnaire, to find out what prospective teachers think about pupils' ideas, and the educational proposals they designed during their school practices. For the latter, qualitative content analysis was used to establish four levels according to the didactic approach on which they base the consideration of pupils' ideas: Transmissive or the construction of ideas. The results show that, in all three dimensions, the conception of pupils' ideas consistent with the construction of ideas orientation dominates. Nevertheless, their educational proposals do not show this orientation since the majority designed traditional educational proposals (Levels 1 and 2). Thus, there is no correlation between their conceptions about pupils' ideas and how these are considered in their proposals. Besides, this analysis shows that an inadequate interpretation of the nature of pupils' ideas could strongly condition how these ideas are considered in the teaching and learning process. The educational implications of these results in initial teacher training are discussed.

**Keywords:** initial teacher education; primary science teaching and learning; pupils' ideas



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## 1. Introduction

Initial teacher education programmes aim to contribute to the development of pedagogical content knowledge (PCK). This is a differentiating knowledge that teachers use when planning and teaching, which distinguishes them from other education professionals [1,2]. For science teachers, PCK includes knowledge of students' thinking about science, science curriculum, science-specific instructional strategies, assessment of students' science learning, and orientations to teaching science [3–5]. To develop knowledge of pupils thinking about science, an understanding of their initial science ideas and experiences (including misconceptions), the development of science ideas (including process and sequence), how pupils express science ideas (including demonstration of understanding, questions, responses), and the appropriate level of scientific understanding is necessary [6–9].

For science teaching, it is essential to recognise the didactic value of pupils' ideas [10,11], in order to establish teaching and learning (T/L) strategies that allow them to evolve [12–14]. Thus, it would be necessary to explore what prospective teachers learn about pupils' ideas and their utilisation during initial training. Some works indicate that prospective teachers fail to recognise the role of students' ideas in learning or do so slightly [15,16]. Then, it seems important to identify where the greatest difficulties lie when prospective teachers address pupils' ideas as an essential part of professional knowledge. It also allows one to describe the teacher's learning progression [17,18] that will impact their PCK [8,19].

Educational research has extensively addressed pupils' ideas about various scientific contents within the curriculum [20–22], as well as those of prospective and in-service teachers [23,24]. Nevertheless, fewer studies have investigated prospective teachers' conceptions of teaching and how these have been translated into school practices [25,26]. In fact, [27] (p. 28) concluded that "although attention to student thinking is essential to science teaching, researchers do not know enough about what teachers think this means in practice."

According to [12], a greater willingness to take pupils' ideas into account in didactic approaches seems to be related to a reduced tendency to follow transmissive or traditional teaching models. However, pupils-based teaching approaches, widely advocated in educational research, remain rare in classrooms [28,29]. In this sense, the Spanish Primary Education curriculum, which is immersed in educational reform in order to adapt to the challenges of the 21st century [30], advocates for student-centred, special, inquiry-based teaching in the area of natural, social, and cultural Knowledge. This requires the design and implementation of teaching proposals, which provide opportunities for pupils to connect their ideas with their learning and apply them in contexts close to their daily lives. For this purpose, teachers and prospective teachers play an essential role [9,31]. However, in general, prospective teachers' didactic approach is consistent with the ideological, epistemological, and didactic conceptions of the transmissive model of science teaching [32]. Consequently, in initial teacher education, it is not enough to understand the importance of starting from pupils' ideas in order to teach science, since this does not necessarily guarantee that prospective teachers will be able to translate this into a set of coherent educational action patterns in the classroom.

In fact, Ref. [8] found that it was very challenging for teachers to attend to, analyse, and respond to student ideas. According to [33], a high level of attention to pupils' ideas does not imply the use of them to analyse the T/L process or guide instructional responses. Analysis is the bridging skill between attending and responding since this analysis leads to effective reflection as a way to problematise science teaching.

The challenge facing prospective teachers is to acquire knowledge and skills during their initial training that will lead them to consider the nature, utilisation, and change of pupils' ideas in their didactic approaches [19]. Therefore, there is an important emerging need to recognise and favour teachers' knowledge of pupils' ideas with the aim of influencing their science-teaching practice [27].

Thus, in the context of prospective teachers' school practices, we set out to explore the connections between how prospective teachers understand and utilise their pupils' ideas in the educational setting.

## 2. Theoretical Framework

Among learning theories, in the field of the Didactics of Science, two didactic orientations are highlighted in this work. On the one hand, a constructivist orientation is assumed as a holistic and desirable vision for the teaching–learning process of science. Constructivism's assumptions about learning and the processes that support them (of construction–reconstruction of reality) differ from the traditional orientation, where the important thing is not to build knowledge, but to receive and reproduce information transmitted by the teacher [34,35].

We are aware that decisions about educational strategies are not limited to the dichotomy between transmission and constructivism. As indicated by [36] (p. 6), science teaching may require "interweaving in a dialectical and complex way, the teacher's moments of knowledge transmission with the student's inquiry moments". Being aware of this, in this work, we consider it desirable that prospective teachers approach constructivist orientations to teach science [3,27]. Understanding the epistemological particularity of students' ideas and the specificity of their didactics is an important tool for prospective teachers to progress in their PCK. In this way, a greater presence of more complex educational approaches to students' ideas in teaching practice is encouraged [16]. According to these authors, there are different dimensions of pupils' ideas that characterise these orientations. In this work, we focus on the nature and utilisation of pupils' ideas in science education, as well as on the change in pupils' ideas for learning science.

### *2.1. The Nature of Ideas in Science Education*

Pupils' ideas are considered spontaneous and personal constructs through which learners interpret the world around them [10,37]. Thus, ideas direct the processing and representation of information received from different sources, such as learners' perceptions, the cultural context, and their own teaching [38,39]. This is everyday knowledge based on reasoning strategies different from those underpinning school science knowledge. They are not ideas prior to scientific ones, but particular and differentiated knowledge, highly dependent on intuitive rules [11,40].

This view of pupils' ideas as alternative knowledge to scientific-scholastic knowledge is consistent with didactic constructivism [41]. According to [42], ideas have a number of features, such as stability and relative internal organisation, and they are highly functional insofar as they allow pupils to organise information and make predictions about what will happen in everyday contexts [43].

Nevertheless, in a traditional orientation to teaching, pupils' ideas have no epistemological value. The spontaneous ability to construct one's own ideas is not recognised but tends to be seen as the result of previous academic training [14,32]. If the ideas differ greatly from accepted scientific interpretations, they are not recognised as important, and then they are often ignored in educational planning [44]. As mentioned earlier, this traditional orientation is common among prospective teachers. Although they may make progress by recognising that the experiences and interests of pupils influence their ideas, they fail to identify the characteristics of the ideas themselves and how they condition the representations that pupils make [15,16].

### *2.2. The Utilisation of Ideas in the Teaching of Science*

In the T/L process, teaching situations must be generated in which pupils can become aware of their ideas, discuss them with each other, test their adequacy, and apply them in new scenarios [13,45]. However, the planning of teaching in accordance with this is not straightforward. It involves planning activities that support pupils' learning through the progression of their ideas [46].

This means promoting other ways of looking at the world, based on reasoning strategies specific to science [47]. Therefore, great flexibility must be incorporated into these approaches, as the complexity of constructing these new representations may lead to successive changes to the initial planning carried out by the teacher.

In the traditional view, learners' ideas are not utilised or are utilised in a restricted way, usually to establish their initial academic level [48]. This view is frequent among prospective teachers, who prioritise attention to academic prerequisites over ideas [49]. This is evidenced by the results of [50] where almost 90% of trainee teachers indicated the need to utilise what pupils remember about the content of previous years' studies as a starting point for their T/L process, without giving didactic utility to the ideas or recognising how they influence teaching methodology.

Other studies have shown that the didactic orientations of the transmission and construction of ideas tend to coexist in the conceptions of prospective teachers [51]. On the one hand, prospective teachers maintained that ideas are conceptual requirements that the teacher must consider in order to develop the subject. On the other hand, they consider it important for learners to be able to review their ideas throughout the educational process.

### *2.3. The Change of Pupils' Ideas for Learning Science*

The change in pupils' ideas is understood as a gradual process of enrichment and adjustment of existing ideas [44]. For this change to occur and for learning to take place, previous ideas must be related to the processing of new ones [28,52]. Nevertheless, we must assume that science teaching that is geared towards establishing the relationship between pupils' previous ideas and the new information does not guarantee that students' learning will be as intended [27,39]. This is largely because ideas are highly resistant to change, mainly due to their internal consistency and functionality [43]. Learners do not easily abandon their representations of everyday knowledge, but these often coexist with certain scientific ideas. Thus, learning goes beyond the mere replacement of prior ideas with scientifically more acceptable ones. It is a profound restructuring of pupils' conceptual structures [44].

In the traditional orientation to teaching, the change in ideas is seen as a replacement for ideas that are considered erroneous. Thus, learning consists of the appropriation of new information presented in the classroom, through a process of grasping, retaining, and fixing the content [53]. Several authors have pointed out that the majority of prospective teachers take this orientation, linking learning to rote retention [54,55]. However, other studies have also found a certain progression in prospective teachers' conceptions, when they recognise that pupils learn gradually through interaction with different sources of information [50,56,57]. This lack of consensus reflects the need to continue researching it.

### *2.4. Consideration of Pupils' Ideas in Teaching Practices*

School practices (SPs) constitute the first classroom experiences during initial teacher education. They represent a challenge for prospective teachers as they are confronted with real and concrete teaching situations, in which they must make their decisions and put them into practice [58–60].

Some authors consider SPs to represent a metacognitive process of reflection, which could favour the evolution of the PCK of prospective teachers [2,61,62]. Thus, within the organisational scheme of teaching knowledge, it identifies the teacher's personal PCK as the knowledge that is articulated and manifested only in the action of teaching [1]. It is strongly linked to and influenced by the beliefs the teacher has, their goals in teaching science, and students' results [3]. According to some authors, prospective teachers include their own considerations about pupils' initial ideas and experiences and the development of scientific ideas as part of their PCK [7,8,19].

Progressing as a prospective science teacher in the PCK involves reframing the role of pupils' ideas in T/L [18]. This refers to the consideration of pupils' ideas as personal constructs and alternatives to scientific knowledge, which change via reconstruction and are used throughout the T/L process through school research of relevant problems [16]. Therefore, from the initial training, it is necessary to assess how prospective teachers' actions are mediated by their conceptions of pupils' ideas of science teaching [19,63].

### *2.5. Aims of the Study*

In this paper, we tend to approach how prospective teachers address pupils' ideas in their school practices by setting the following questions:

- What conceptions of pupils' ideas do prospective teachers have?
- How do prospective teachers integrate pupils' ideas when they teach science?
- What coherence exists between both?

## 3. Methods

In this case study, a mixed-model design that includes qualitative and quantitative analysis was used, and it aimed to describe the relationship between prospective teachers' conceptions of pupils' ideas and how they address them in their educational proposals.

For this purpose, we differentiated between three key dimensions of pupils' ideas [16]:

- The nature of pupils' ideas, on which the prospective teachers' planning of the teaching of the scientific content is based.
- The utilisation of pupils' ideas, as proposed in the sequence of activities.
- The change in ideas, on which the assessment process of the prospective teachers during the T/L process is based.

### 3.1. Participants

Participants were 20 prospective teachers (PT), 14 women and 6 men, in their 3rd year of the Degree in Primary Education at the University of Murcia (Spain). They were performing their second 9-week SPs at different primary schools.

### 3.2. Data Collection

In this research, two instruments were used to collect information: (1) A questionnaire to determine what the prospective teachers thought about the ideas of pupils and (2) a report corresponding to the SPs to determine how they utilise pupils' ideas in their educational proposals.

#### 3.2.1. Questionnaire on Conceptions

This instrument was designed and validated by [42] in their extensive research on the conceptions of science teaching of prospective teachers, also used in recent works [3].

In it, the three key dimensions—the nature, utilisation, and change of pupils' ideas—were established as categories of analysis. Each was represented by four items: Two referring to the transmission of ideas orientation (T) and two referring to the construction of ideas orientation (C). Thus, the questionnaire comprised 12 items (Table 1), for which the prospective teachers expressed their degree of agreement, using a 6-point Likert scale (where higher values indicate positions closer to the didactic orientation represented by each item).

**Table 1.** Items included in the questionnaire, organised according to the dimensions and didactic orientation to which they belong.

| **DIMENSIONS** | **DIDACTIC ORIENTATION** | |
|---|---|---|
| | **Transmission of Ideas (T)**<br>**Teacher-Based Orientation** | **Construction of Ideas (C)**<br>**Pupils-Based Orientation** |
| Nature of Ideas (N) | NT1—Pupils, by themselves, do not have the capacity to spontaneously elaborate ideas about the natural and social world around them. | NC1—Pupils personally interpret the information they perceive from reality. |
| | NT2—Pupils' ideas about scientific concepts are often erroneous and, therefore, not useful for learning such concepts. | NC2—The ideas which pupils often utilise in their daily lives constitute an alternative to scientific knowledge. |
| Utilisation of Ideas (U) | UT1—Exploration of pupils' ideas should be done at the beginning of a topic to determine the starting level. | UC1—Discussion of pupils' ideas and interests throughout the teaching process is essential for learning science. |
| | UT2—The results of the initial exploration of pupils' ideas about a particular topic are of interest only to the teacher. | UC2—The manifestation of students' ideas and interests throughout the teaching of a topic can lead to changes in the teaching planning. |
| Change of Ideas (C) | CT1—Pupils learn when they mentally incorporate the scientific content taught; that is, when they are able to remember it. | CC1—Learning involves progressively reworking one's own ideas through interaction with different sources of information. |
| | CT2—Learning occurs when pupils' conceptual errors are replaced by correct scientific ideas. | CC2—Pupils' learning may be different from that intended by the teacher, even if the teaching is very well grounded. |

The questionnaire was completed at the beginning and end of the SP, as a pre-test and post-test. In a previous work [64], the comparison of the two datasets concluded that there were no significant differences in the didactic orientation held by these prospective teachers. Therefore, in this paper, we focus on the post-test data, which coincide with the collection of their school practices report.

#### 3.2.2. School Practices Report

This report is filled out by prospective teachers at the end of their school practices. It is organised into three blocks, which allowed the authors to describe how the PT consider the three categories of analysis:

1. Planning the educational proposal. In this block, prospective teachers were asked to carry out an analysis of the contents from a didactic point of view, in which the PT identified the most frequent pupils' ideas, their origin (social, analogical, etc.), and their role in the T/L process. It makes it possible to determine their conceptions of the nature of ideas.
2. Design of the sequence of activities and methodology. Here, prospective teachers were asked to specify, for each activity, (1) the teaching and learning objectives; (2) the teaching contents; (3) the material and management; and (4) the tasks of the pupils and the teachers' role. Thus, it allows us to establish how the ideas are utilised throughout the T/L process.
3. Evaluation. In this block, prospective teachers were asked to show the assessment instruments and their reflections on pupils' learning. It makes it possible to identify what considerations are made about the change in ideas.

### *3.3. Data Treatment*

Descriptive statistical analyses were applied to the questionnaire for each item and the didactic orientation it represented. To assess statistical differences between the items, the non-parametric Kruskal–Wallis test was applied and, if significance was detected, a post hoc analysis was carried out using the Mann–Whitney test. In order to give greater strength to the statistics, when making these comparisons, the mean achieved by each prospective teacher in each item was considered, with n = 80. This test was also applied to assess the differences between the two didactic orientations. The significance level was $p < 0.05$.

Regarding their educational proposals report, data analysis was performed within the methodological framework of qualitative content analysis [65]. This methodology is defined as "the process of categorizing qualitative textual data into clusters of similar entities, or conceptual categories, to identify consistent patterns and relationships between variables or themes" [66] (p. 120). In the first step, the significant units of information (SIU) in each participant's educational proposal were selected. These units were then examined and inductively coded using Atlas-ti 8. In the second step, the SIUs were grouped into levels according to the literature on the levels of complexity in utilising pupils' ideas for prospective teachers and the progression of learning in the components of PCK [3,16]. These levels were reformulated, or intermediate levels were defined to cater for the diversity of the data collected.

- To establish these levels as definitive, the units of information were reviewed and contrasted in several cycles of analysis, individually by two of the researchers involved, with 72% agreement. In order to resolve discrepancies, the three researchers contrasted them, obtaining 88% agreement in the coding, a value considered acceptable in the qualitative content analysis [66]. Thus, four definitive levels were established, and their frequencies were calculated. A higher level represents a PCK in which pupils' ideas are considered alternative constructs to scientific knowledge, which must be utilised throughout the T/L process to facilitate change by reconstruction [16,18]. These levels were as follows:
- Level 1 was assigned to the educational proposals with a clearly traditional orientation, which conformed to the transmissive items proposed in the questionnaire. Regarding the nature of the ideas, at this level, PT considered pupils' ideas as erroneous constructs, the result of bad learning, and not very useful for teaching. The ideas are used by the teacher to determine the initial level of knowledge. In terms of change, emphasis is placed on pupils remembering definitions and scientific terms.
- Level 2 was assigned to the educational proposals in which PT do not meet some of the transmission items, without fulfilling any of the items of the idea construction

orientations. Regarding the nature of the ideas, at this level, the ideas are limited to previous academic knowledge, and are recognised as relevant to the T/L process. In addition, the ideas are used at the beginning of the topic to identify the starting level of the students and their interest in the subject. The aim is to replace these ideas with scientifically correct knowledge, which can be applied in new situations.

- Level 3 was assigned to the educational proposals that do not meet some of the transmission items, but they do comply with some of the construction of ideas orientation. At this level, the spontaneous nature of pupils' ideas is recognised at this level. In relation to utilisation, ideas are used at different moments of intervention, especially at the beginning and end of the topic. Finally, the re-elaboration of ideas is facilitated, providing opportunities for pupils to assess the validity of their initial ideas.
- Level 4 was assigned to the educational proposals that expressly complied with the two items of the construction of ideas orientation in the questionnaire. In terms of nature, at this level, it is recognised that ideas constitute knowledge other than scientific knowledge, as a result of experiences, interests, and social interactions, from which students explain certain scientific phenomena. With regard to utilisation, the teacher pays attention to the use of ideas throughout the sequence, in order to facilitate their re-elaboration and also to detect the need for changes in the initial planning. Finally, the re-elaboration of ideas is encouraged, and the process of T/L is reviewed, assessing the reasons that may have led to learning that was different from what was planned.

Finally, correlations were determined between dimensions for (i) the conceptions of the prospective teachers about pupils' ideas; (ii) the levels achieved in their educational proposals; and (iii) between both (i) and (ii). For this purpose, Spearman's non-parametric correlation test was applied, establishing the significance level $p < 0.05$. Given the number of participants, the aim of this analysis is to provide indications of the relationship between the dimensions established. All statistical analyses were carried out using SPSS 24.0 software.

## 4. Results

### *4.1. Prospective Teachers and the Nature of Pupils' Ideas in Science Education*

In relation to what prospective teachers think about the nature of ideas, it was found to be closer to the idea construction orientation, with the mean of this orientation being significantly higher than the transmissive or traditional orientations (Table 2).

**Table 2.** Statistics of the conceptions regarding the nature of ideas dimension.

| Orientation | Item | Mean (SD) | Mean of the Orientation (SD) | Z (T-C) | *p* (T-C) |
|---|---|---|---|---|---|
| Transmission of Ideas (T) | NT1: No spontaneous ideas | 2.15 (1.18) | 2.32 (1.14) | −6.012 | $p < 0.001$ |
| | NT2: Wrong and unhelpful ideas | 2.50 (1.40) | | | |
| Construction of Ideas (C) | NC1: Ideas as personal interpretations | 5.30 (0.865) | 4.57 (0.69) | | |
| | NC2: Ideas as alternative knowledge | 3.85 (0.99) | | | |

When analysing each item individually, the prospective teachers mostly rejected both statements of the transmissive orientation. Although six students strongly or somewhat agreed that these ideas are not very useful in the teaching process (NT2), there were no significant differences between the items (Figure 1).

In relation to the items related to the construction of ideas orientation, there was a broad consensus that ideas are personal representations of the learners and a more intermediate position that ideas as knowledge are an alternative to scientific knowledge. Thus, differences existed between both construction items, and between them and traditional items.

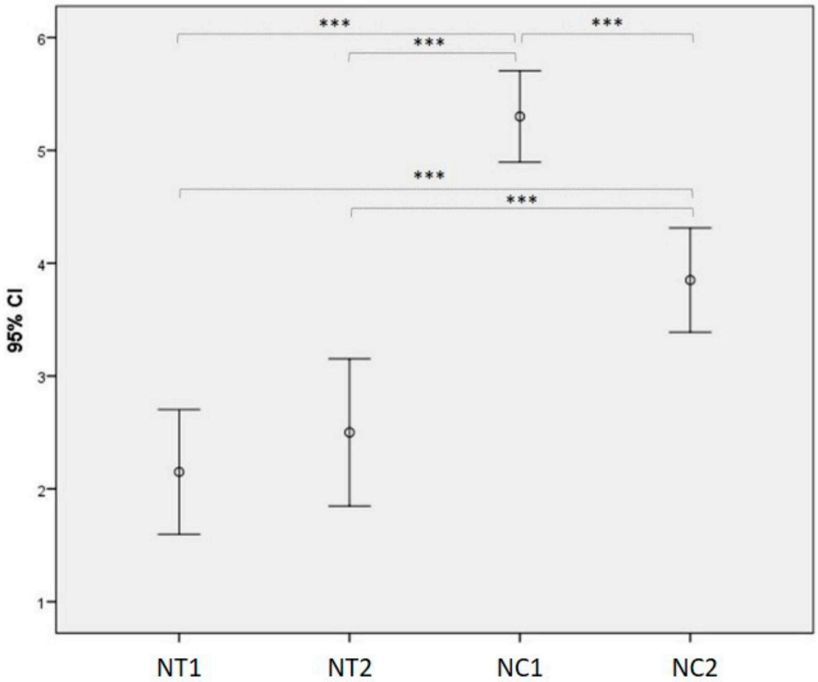


**Figure 1.** Error bars illustrating the distribution of items and the differences among them within the nature of ideas dimension, where *** represents $p < 0.005$.

With respect to their educational proposals (Figure 2), only three prospective teachers (PT 9, 13, and 15) interpreted pupils' ideas as erroneous as a result of inadequate learning and irrelevant to teaching (Level 1). In this sense, prospective teacher 9 (hereafter, PT 9) stated: *At the beginning I found that the pupils had forgotten what they worked on in other courses and they only remembered a few brushstrokes; so their ideas were not useful in this subject*.

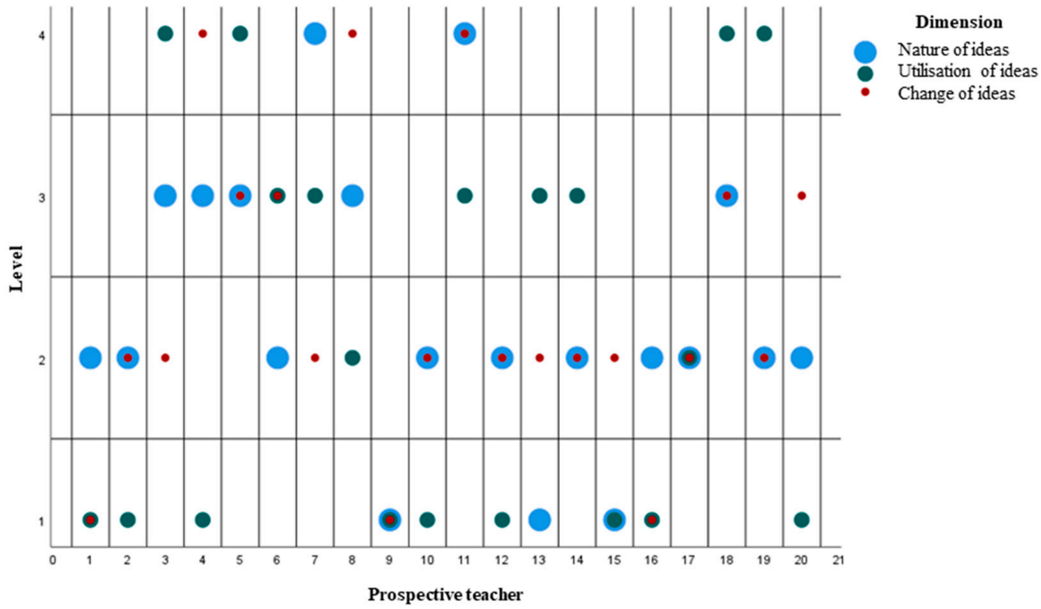


**Figure 2.** Level reached by each participant in each of the dimensions.

Half of the prospective teachers were in Level 2 (PT 1, 2, 6, 10, 12, 14, 16, 17, 19, and 20) because, although they acknowledged the importance of pupils' ideas in the T/L process, they limited this to the knowledge acquired by them in previous courses. Therefore, they did not consider them to be spontaneous, but the result of pupils' previous academic training. For example, PT 10 stated: *About the functioning of the circulatory system, the previous ideas of the pupils were very generic, and it was difficult for them to remember the parts of the heart and how blood circulates inside it, which they studied in the previous year*.

On the other hand, five prospective teachers (PT 3, 4, 5, 8, and 18) considered that pupils' ideas are spontaneous constructions resulting from their experiences (Level 3). For example, PT 3 pointed out that, concerning the reproductive system and sexuality, sixth-grade pupils: *have different ideas derived from their concerns and their conversations with each other*.

Level 4 comprised only two prospective teachers (PT 7 and 11), who acknowledged that pupils' ideas constitute knowledge—that is, not only scientific knowledge—which they use to explain phenomena in their environment. Specifically, they referred to the everyday knowledge used by pupils to explain how their body works and how plants grow, analysing the social origin of this knowledge.

### *4.2. Prospective Teachers and the Utilisation of Pupils' Ideas in Science Education*

With regard to what prospective teachers think about the utilisation of ideas, we observed a significantly lower degree of agreement with traditional items (Table 3).

**Table 3.** Statistics of the conceptions for the utilisation of ideas dimension.

| Orientation | Item | Mean (SD) | Mean of the Orientation (SD) | Z (T-C) | $p$ (T-C) |
|---|---|---|---|---|---|
| Transmission of Ideas (T) | UT1: To determine the starting level | 5.15 (0.933) | 3.80 (0.785) | −3.857 | $p < 0.001$ |
| | UT2: Only the teacher's interest is useful | 2.45 (1.468) | | | |
| Construction of Ideas (C) | UC1: To discuss them throughout the process | 5.40 (0.995) | 5.30 (0.657) | | |
| | UC2: To identify changes in planning throughout the process | 5.20 (0.768) | | | |

When looking at the items individually, there is a strong consensus regarding the idea that the exploration of ideas should be aimed at determining the starting level of the pupils (UT1). Nonetheless, they largely reject that it is useful only for teachers (UT2). Thus, there are significant differences between the two items (Figure 3).

The items of the construction orientation show a high degree of agreement. Prospective teachers consider the importance of discussing ideas throughout the teaching sequence (UC1), which may imply changes in the teaching sequence (UC2), with no significant differences between these items. There are also no differences between them and UT1, but there are differences with respect to UT2.

When analysing their educational proposals (Figure 2), we found that eight of the prospective teachers (PT 1, 2, 4, 9, 10, 12, 15, and 16) utilised pupils' ideas only at the beginning of the topic, with the sole purpose of enabling the teacher to establish their initial level of knowledge (Level 1). For example, PT 1 stated: *At the beginning I was interested to see what ideas they had, so that I could start from that knowledge*.

On the other hand, four prospective teachers (PT 8, 13, 14, and 17) were at Level 2. They proposed situations in which the pupils share their ideas at the beginning of their educational intervention, so that both the pupils and the teacher may recognise gaps in their initial knowledge and interests with regard to the subject. To this end, they mainly proposed initial brainstorming. In this sense, PT 8 indicated: *On the blackboard, two columns were drew: what the students already knew about this topic and what they wanted to learn*.

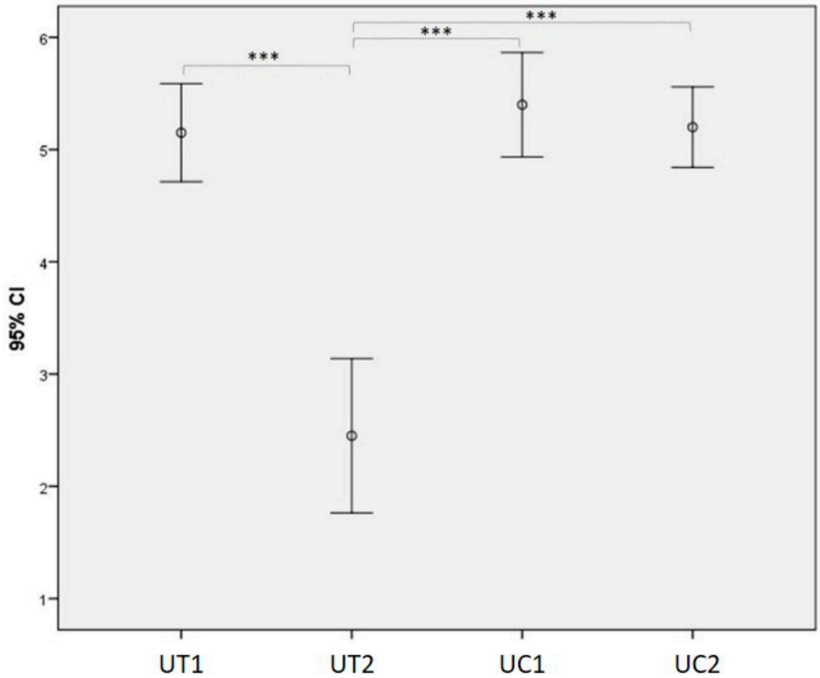


**Figure 3.** Error bars illustrating the distribution of the items and the differences among them within the utilisation of ideas dimension, where *** represents $p < 0.005$.

Another four prospective teachers (PT 6, 7, 11, and 20) encouraged pupils to verbalise their ideas at the beginning and end of the sequence so that they recognised their learning (Level 3). In this respect, PT 7 indicated *At the end, my students valued the differences between what they thought at the beginning and what they had learned*.

Finally, four prospective teachers (PT 3, 5, 18, and 19) offered opportunities to review ideas at different points in the T/L process, leading them to propose some modifications to their initial educational planning. For example, PT 5, who deals with the locomotor system in 6$^{th}$ grade, at the end of all his activities, returned to some of the questions initially raised, so that the pupils could review them. Thus, with one detecting difficulties among them in the understanding of the characteristics of bones, he included an additional activity on this subject.

### *4.3. Prospective Teachers and the Change of Pupils' Ideas in Science Education*

The prospective teachers did not show a definite position in relation to the change in ideas (Table 4). The degree of agreement was highest for the items of the construction of ideas orientation (CC1 and CC2), although the prospective teachers did not show a clear rejection of the items of the transmissive orientation ($\overline{x} > 4$). Despite this, significant differences existed between the two didactic orientations.

When the individual items were analysed, intermediate positions dominated for CT1, so it seems that they attached some importance to the memorisation of content. There was more agreement that the change in ideas happens through their substitution with scientifically correct ones (CT2). Thus, there were significant differences between the two items (Figure 4).

Among the items included in the construction orientation, the agreement was slightly higher for CC2 (learning can be different from that intended) than for CC1 (it takes place by reworking ideas). No significant differences were found between the two items.

**Table 4.** Statistics of the conceptions for the change of ideas dimension.

| Orientation | Item | Mean (SD) | Mean of the Orientation (SD) | Z (T-C) | *p* (T-C) |
|---|---|---|---|---|---|
| Transmission of Ideas (T) | CT1: Mental incorporation | 3.90 (1.252) | 4.3 (0.923) | −3.997 | $p < 0.001$ |
| | CT2: Substitution | 4.70 (1.174) | | | |
| Construction of Ideas (C) | CC1: Reworking | 5.25 (0.639) | 5.35 (0.360) | | |
| | CC2: Learning other than intended | 5.45 (0.826) | | | |

Significant differences were found between respondents' scores on the transmissive and constructivist items in all pairings, except between CT2 and CC1, despite the fact that they represent opposing views of learning: Substitution and reworking, respectively (Figure 3).

With regard to their educational proposals (Figure 2), three of the prospective teachers (PT 1, 9, and 16) considered that the change in pupils' ideas occurs when they are able to reproduce the theoretical contents (Level 1). All three designed assessment instruments in the form of a final theory test, aimed solely at getting students to remember and describe terms and definitions.

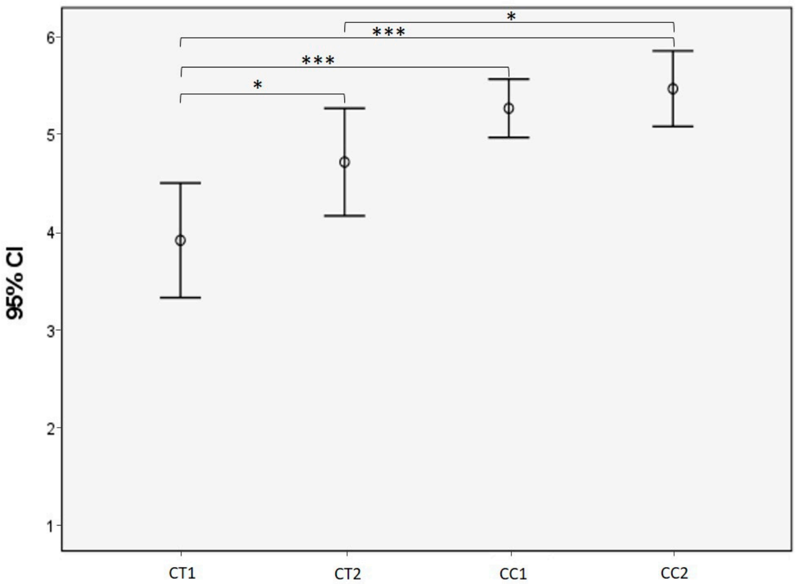


**Figure 4.** Error bars illustrating the distribution of items and the differences among them within the change of ideas dimension, where * represents $p < 0.05$ and *** represents $p < 0.005$.

Half of the prospective teachers (PT 2, 3, 7, 10, 12, 13, 14, 15, 17, and 19) saw change as the replacement of pupils' ideas with scientifically correct ones (Level 2). They evaluated pupils' explanations at the end of the process, using application activities for which they proposed learning indicators such as: *in their explanations, the pupils used the concepts of reproduction correctly* (PT 3) or *the pupils knew how animals are really classified* (PT 12).

Four prospective teachers (PT 5, 6, 18, and 20) were grouped in Level 3. They considered that change occurs when pupils structure their ideas, which favours their reworking. Their evaluations involved the use of instruments in which the students reflect on the validity of their initial ideas. For example, PT 20 set up several practical tasks related to the characteristics of the matter and used the final report produced by the pupils to evaluate them, including having them revise and examine their own ideas.

Only three prospective teachers (PT 4, 8, and 11) proposed an evaluation that involved the pupils in the reworking of their ideas throughout the process, going so far as to discuss that pupils' learning may be different from that intended by the teacher. One participant (PT 11) proposed different tasks on the subject of plant nutrition, where she evaluated pupils' learning with indicators related to the interpretation of data and the drawing of conclusions. Moreover, for some tasks, she proposed a co-evaluation of the communication of results. In addition, she used a teacher's diary to evaluate the teaching process, by reflecting on the learning achieved by the pupils in each task.

### *4.4. Correlations Statistics*

#### 4.4.1. Correlations within Prospective Teachers' Conceptions

The analysis reveals moderate positive correlations between the nature of ideas and the other two dimensions (N-U = 0.545; $p < 0.001$; N-C = 0.480, $p < 0.001$). Thus, the degree of agreement on the nature of ideas items is related to the agreement on the items on utilisation and change.

#### 4.4.2. Correlations When Prospective Teachers Integrate Pupils' Ideas in Educational Proposals

The analysis of the correlations based on the educational proposals showed how the levels achieved in the three dimensions were related. Positive correlations were found again between the nature of ideas and the other two dimensions (N-U = 0.456, $p < 0.001$; N-C = 0.595, $p < 0.001$).

This suggests that limiting pupils' ideas to academic knowledge would lead prospective teachers to be more interested in knowing the level of this knowledge at the beginning of each subject and to consider achieving learning by substituting such knowledge with scientifically accepted knowledge. Thus, an inadequate interpretation of the nature of learners' ideas could strongly condition how they are considered in the T/L process in science.

#### 4.4.3. Correlations between Conceptions and Integration of Students' Ideas

Finally, when analysing the correlation between the aforementioned aspects, no significance was detected in any of the dimensions (Table 5). Therefore, there seems to be no coherence between them. The data suggest that, although these prospective teachers had conceptions closer to the construction of ideas orientation, they maintained transmissive orientations in their educational proposals.

**Table 5.** Correlation statistics between prospective teachers' conceptions about pupils' ideas and level of integration in educational proposals.

| DIMENSION | TOTAL | Transmission of Ideas | Construction of Ideas |
|---|---|---|---|
| Nature of Ideas | $r_s = 0.105$; $p = 0.354$ | $r_s = 0.245$; $p = 0.127$ | $r_s = 0.094$; $p = 0.565$ |
| Utilisation of Ideas | $r_s = -0.064$; $p = 0.572$ | $r_s = -0.168$; $p = 0.299$ | $r_s = 0.032$; $p = 0.846$ |
| Change of Ideas | $r_s = -0.070$; $p = 0.537$ | $r_s = -0.156$; $p = 0.338$ | $r_s = -0.017$; $p = 0.915$ |

## 5. Discussion

This paper analyses the coherence between the conceptions of teaching that prospective teachers hold in relation to pupils' ideas and how they integrate them into their educational proposals. This analysis may be useful for identifying possible difficulties in this respect and, in this way, guiding their initial training [67].

### 5.1. Prospective Teachers' Conceptions about the Nature, Utilisation, and Change of Pupils' Ideas in Science Education

Among the participants, a vision of teaching closer to the construction of ideas orientation dominated, with varying results depending on the dimension analysed. With regard to the nature of ideas, we found a greater rejection of the transmissive orientation, but without a firm position on the construction of ideas. The participants clearly accepted that pupils make spontaneous and personal representations of scientific phenomena, but they had difficulty recognising that these representations make up everyday knowledge [11,68]. This could make it difficult for prospective teachers to contemplate that learning science requires the promotion of specific logic and reasoning and selecting appropriate strategies for their development [69,70].

Regarding the utilisation of ideas in the T/L process, a clear tendency for the two educational orientations to coexist can be seen, in line with other studies [50,51]. On the one hand, the prospective teachers openly rejected the orientation that ideas are only interesting for the teacher and attached importance to schoolchildren discussing their ideas throughout the T/L process, assuming that this can lead to changes in teacher planning. On the other hand, they were found to pay equal attention to determining the starting level of the pupils at the beginning of this process. This conception seems to have been deeply rooted among the prospective teachers, reflecting possible difficulties in recognising the value of ideas for educational planning [54]. If they are not identified until the beginning of the proposal, they will hardly be considered in the selection of strategies or appropriate educational contexts to test their validity [16].

In relation to the change in pupils' ideas, it seems that they do not take a clear position on either of the two orientations, rather they seemed to unify them. That is, they seem to interpret the restructuring of ideas as a substitution of ideas with scientifically appropriate ones [71,72], reducing the construction of meanings to a simple reflection of the content presented in the classroom [53]. Hence, even when certain progression in the prospective teachers' conceptions is detected (for example, that children rework their ideas through different sources of information [50,56,57]), it would be interesting to investigate whether or not they are understanding this reworking as a substitution. This is an oversimplified view of how ideas condition the learning process. It fails to recognise that each pupil constructs his or her own understanding, where there is usually strong resistance to abandoning everyday knowledge and to this coexisting with certain scientific ideas [43,68].

### 5.2. Prospective Teachers' Orientation When Addressing Pupils' Ideas during School Practices

Prospective teachers' conceptions about pupils' ideas were not necessarily reflected in the educational proposals designed. For none of the three dimensions was there any correlation between the vision of the prospective teachers and their educational activities.

This lack of coherence has even been recognised by practising teachers, who acknowledged the existence of a gap between what they value as important and what they actually propose in their classrooms [19,73,74]. Specifically, the educational proposals analysed in this study made the difficulties of overcoming the transmissive orientation even more evident. Although the prospective teachers stated that pupils' ideas had a spontaneous character, in their proposals, they detracted from their epistemological value by reducing them to content that pupils would have learned in previous years [16].

It seems that the initial teacher training plan, which emphasises the consideration of learners' ideas, had an impact on their conceptions, but not so explicitly on their proposals. Most of these prospective teachers utilised ideas only at the beginning, to establish the starting level of the pupils. Moreover, in very few cases, they proposed modifications to the initial teacher planning. Thus, it seems that the proposed activities are poorly adjusted to the concrete reality of the classroom, in relation to the ideas and interests of the learners [17,51,75].

Furthermore, it seems that the didactic orientations that prospective teachers proposed were not intended to generate changes in the knowledge structures of the pupils [39,44].

Despite the general agreement that learning may be different from what is intended by the teacher, very few prospective teachers reflected on this in their school practices reports. Moreover, in most of the proposals analysed, the change in ideas was evaluated only at the end of the process. Thus, a view of scientific knowledge as a product, rather than as a process of restructuring everyday knowledge and regulating the process of T/L, seemed to predominate [44,76].

Finally, in relation to the correspondence between the levels achieved in the three dimensions of the proposals put forward, the nature of the ideas turned out to be key. This dimension had a positive correlation with the other two (utilisation and change). Thus, reducing the ideas to academic knowledge, detracting from their epistemological value, would strongly hinder the ability of the teacher to offer opportunities for pupils to recognise, confront, and reinterpret their ideas in light of more complex forms of knowledge. Thus, these prospective teachers did not really succeed in their development of didactic orientations aimed at fostering progression in pupils' ideas, which is a prerequisite for learning science [14,76].

Therefore, these proposals reflected scarce pedagogical content knowledge about the understanding of pupils' ideas. Although they considered the spontaneous character of these ideas, prospective teachers detracted from their epistemological value in their proposals. In addition, prospective teachers tend to utilise these ideas only at the beginning, and seldom do they propose modifications in their initial planning. Likewise, for the majority of these prospective teachers, learning occurs when pupils' ideas are replaced by correct scientific ones, instead of the progressive construction of meanings by the pupils.

We are aware of the limitations of the study in relation to the number of participants, which limits the relevance of statistical inferences and the generalisation of these conclusions. Nonetheless, we must highlight the fact that these results were obtained in a real classroom context, where prospective teachers worked in a professional practice context. In any case, it can be considered an approximation to reality in initial teacher training.

We believe that, in teacher education, special emphasis should be placed on the nature of ideas. However, discussions in this respect are very demanding, not least because they may involve a high level of theorisation and abstraction about PCK [19]. This can make it difficult for prospective teachers to engage in these discussions, limiting their recognition of how the characteristics of didactic orientations condition learning. Moreover, we should adopt progressive orientations, as we should not expect prospective teachers to replace their conceptions of teaching with the approaches proposed by didactics [16]. In fact, our study shows how the two visions of teaching coexist among prospective teachers.

Given that these conceptions of teaching do not seem to significantly mediate the prospective teachers' educational practices, it will be interesting to investigate what other elements are involved in their decision-making in teaching, such as the dynamics in the classrooms where the school practices were carried out [77]. This is key to anticipating the difficulties encountered and ensuring that the orientations in their training process are more efficient in order to contribute to the progression of the PCK of prospective teachers.

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