Examining Pre-service Teachers' Critical Thinking Competences within the Framework of Education for Sustainable Development: A Qualitative Analysis

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Article

Examining Pre-Service Teachers' Critical Thinking Competences within the Framework of Education for Sustainable Development: A Qualitative Analysis

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Abstract: Empowering teachers with Critical Thinking and understanding of sustainability is vital for guiding students' informed decisions and actions in today's world. Higher education needs innovative, student-centered methods like case-based teaching in order to promote Critical Thinking and the principles of Education for Sustainable Development. The aim of the study was to explore and evaluate pre-service teachers' Critical Thinking when engaged with case studies in a practicum preparation course centered on Education for Sustainable Development. Nine undergraduate students in Teacher Education participated in the study and answered four case studies. The case studies' responses were analyzed through a bottom-up content analysis revealing eight higher-order categories. While approaching the case studies, student-teachers followed thinking processes similar to the processes proposed by the iterative models of Critical Thinking as perceived by Garrison (1991) and/or Brookfield (1987). Nevertheless, in some cases, pre-service teachers' disengagement was evident. The rubric assessment highlighted that the responses fell under three profiles, namely the "Deficient Critical Thinker", the "Emerging Critical Thinker" and the "Competent Critical Thinker". The findings emphasize the need for targeted and individualized teaching interventions in teacher higher education programs aiming at Education for Sustainable Development complying with the learning needs of student-teachers' Critical Thinking profiles.

Keywords: Critical Thinking; Pre-service Teachers; Education for Sustainable Development; Case-based Teaching; Rubric; Content Analysis

1. Introduction

In the rapidly evolving world as shaped by the recent pandemic, the rise of generative AI, and the convergence of various environmental crises, empowering prospective teachers to instill Critical Thinking (CT) and promote an understanding of complex sustainability issues has become of paramount importance. This empowerment will equip pre-service teachers to effectively guide students towards informed and responsible decision-making and acting to help promote global environmental and social well-being. At an applied level, meeting this demand requires Higher Education Instructors to transform their teaching by employing student-centered instructional approaches fostering active learning and decision-making, such as problem-based and case-based teaching [1]. Case-based teaching has been effectively associated with Education for Sustainable Development (ESD) [2,3] and CT [4,5]. Still, this task, namely transforming Higher Education instruction for ESD and CT, has proven challenging and only limited empirical findings can be identified in the literature e.g., [6]. Hence, this study aims to investigate pre-service teachers' CT in case-based teaching centered on a practicum preparation course in the context of the ESD and to assess the quality of their CT responses within this context.

Education for Sustainable Development and "Environmental Study"

ESD in Higher Education has long been an established field as its role was recognized relatively early [7,8], and its expansion was propelled by the efforts of many initiatives and programs,

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particularly by the United Nations [9,10]. ESD in Higher Education aligns with the current UNESCO's ESD for 2030 education program [11] and particularly in teacher education, focuses on fostering knowledge and competencies that are essential for restructuring educational processes and educational institutions towards sustainability [12] (p.51). Teachers, as key facilitators of learning, are critical for providing good quality education [10] and are powerful change agents who can deliver the educational response needed to achieve the Sustainable Development Goals [12] (p.51). Hence, globally, actions are implemented to embed ESD in teacher education [13].

In K-12 education, ESD is not a subject on its own, and it is promoted interdisciplinary [14]. In Greek primary education, there is a compulsory subject, "Environmental Study" (in Greek, Μελέτη Περιβάλλοντος), which shares many common aspects with ESD, such as aims, characteristics, and thematic areas. According to the current Interdisciplinary Unified Curriculum Framework of the Greek School System [15] the overarching aim of the subject "Environmental Study" is the construction of knowledge and the development of skills, values and attitudes that allow students to observe, describe, interpret, and predict the functions, relations, and interactions of the natural and human-made environment in which human activity develops. Ultimately, the subject renders students aware of the advantages and the imperative for sustainable development. The subject is offered in the first four grades of primary education. The main characteristics of the subject are interdisciplinarity and emphasis on CT, and it focuses thematically on the *how* and *why* environment in which students' live. Thus, "Environmental Study" is within the context of ESD.

Teacher training programs in Greek Higher Education not only provide courses on ESD, but also provide courses focusing on the instruction approaches suitable to meet the overarching aim of the Greek Primary School Curriculum. The aim of such a course, named "Teaching approaches of the Environmental Study" in Primary School is to familiarize student-teachers with the conceptual and methodological framework of the subject and to enable them to acquire conceptual and procedural knowledge, as well as the skills necessary for the design, implementation and evaluation of lesson plans based on the relevant curriculum.

Conceptualization of Critical Thinking

The concept of CT, a multifaceted cognitive process essential for informed decision-making, stands as a subject of perplexity even among the scientific community. The multidimensional aspects of CT encompass analytical skills, logical reasoning, evidence evaluation, and the ability to synthesize information from diverse sources, making it a challenging task to encapsulate within a singular definition. There is a strand of scientists highlighting that CT is a two-dimensional construct composed of skills, namely cognitive abilities or competences and dispositions, which refer to attitudes and intellectual traits e.g., [16–18]. According to [17], CT skills include interpretation, analysis, evaluation, inference, explanation and self-regulation, while CT dispositions encompass truth-seeking, open-mindedness, analyticity, systematicity, self-confidence, inquisitiveness and cognitive maturity.

However, there is another strand of scientists encompassing CT as an iterative process or cycle rather than a static skill engaging thinkers in ongoing thinking with specific steps [19–21]. In particular, the renowned philosopher John Dewey conceptualized CT as closely related to reflective thinking underlining the importance of five stages where this type of thinking is triggered while the learner is engaged in solving a problem. Firstly, the learner is engaged in making suggestions wherein the mind proposes possible solutions (suggestion). Then, the learner identifies and clarifies the ideas into a solvable problem (problem definition). At the same time, the learner uses one suggestion after another as a leading idea or hypothesis guiding observations and other operations while collecting factual material (hypothesis generation). Moreover, the learner mentally elaborates on the idea or supposition (reasoning). Finally, the learner engages in hypothesis testing (hypothesis testing).

[20] envisioned CT in a similar way, where the learner is engaged through five thinking phases starting with the triggering event, then the appraisal of the situation, the exploratory phase to explain anomalies or variances, the development of alternative perspectives and finally the integration of alternatives into ways of thinking or acting. According to [21] CT is a complete cycle of thinking

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activities including both problem-solving and creative thinking. Akin to Dewey or Brookfield the thinking cycle of Garrison includes problem identification, problem definition, exploration, applicability, and integration. Although CT is a cyclical process for Garrison, he underlines that according to the context and the nature of the problem, the phases of CT could overlap.

Education for Sustainable Development and Critical Thinking

CT is considered one of the key competencies of achieving sustainability [22] because it enables students to understand the state of the environment [23], analyze and solve environmental problems [24], and understand how new political, social and economic structures and processes can lead us to sustainability [25]. More importantly, CT can empower students to question norms, practices and opinions, reflecting on their values, perceptions and actions as well as taking a position in the sustainability discourse [12], which will eventually allow them to participate in a democratic society [26]. CT is the quintessence of ESD, by definition and mission [12] as it teaches students "how to think" and not "what to think" [27] (p.5). Studies that explore the connection between ESD and CT development in Higher Education are mounting although they also point to the need for further research and practice [e.g., 28–31]. Although CT is considered as a key competence for educators promoting Sustainable Development goals [32], very little relevant research has been conducted on mapping the primary education teachers' skills for the topic [26].

For Higher Education Instructors to promote CT and the principles of Sustainable Development in learning and instruction, they need to transform their teaching. ESD pedagogies enable educators to shift from teacher-centered to student-centered instruction [33]. This shift helps in steering away from traditional instruction and embracing problem/case-based methodologies that foster CT and social analysis [1]. Besides, ESD pedagogies and instruction for CT are interconnected in many ways. First, to promote ESD effectively, it is necessary to support students' construction of content knowledge [1]. Content knowledge is also essential for students to be able to exercise CT [34]. Second, ESD calls for students not only to think but also to act to promote sustainability by promoting an action-oriented learning approach [35]. This concept is in line with the concept of criticality introduced by [36] and further developed by [37], which expresses the need for students not only to argue, judge or reflect critically but also to act critically and be critical thinkers. Finally, [1] suggest that ESD requires emotional learning for values and ethics to be activated, which in return could lead to a sustainable way of acting and being. [38] argued that moral reasoning and citizenship are intertwined with CT. Moral reasoning involves understanding and empathizing with diverse perspectives and values. CT aids in developing this empathy by encouraging individuals to explore and analyze different viewpoints. In that way, individuals can move from egocentric to more global perspectives and make decisions or take actions defending the public good.

Case-based teaching

Various terms have been used in relevance to case-based teaching, which has been widely recommended as an appropriate approach for teacher training and teacher professional development [e.g., 39–42]. Cases are considered realistic class or school narratives essential for teacher training as they can exercise students' professional judgement. Case-based teaching can vary in implementation. For instance, [39] suggest that the case, namely the scenario, is introduced, and students building on their previous knowledge, generate hypotheses, which they can verify upon enquiry. This action leads them to a conclusion or a decision. Empirical research has concluded that teacher education should be case-based for various reasons [43,44]. First, case-based teaching facilitates students' understanding that every situation in practice is unique and complex. Second, case-based teaching links theory and practice, as it can enhance students' understanding of educational theories and principles and offer real-life settings for their application. Third, a case study allows for various acting approaches according to the diagnosis made by the teacher. Further, case-based teaching can provide student-teachers with insights on their preconceptions of teaching.

Case-based teaching is deemed an appropriate method for promoting the principles of ESD in Higher Education. In particular, ESD calls for instructional approaches that facilitate active learning

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and promote responsibility and accountability while amplifying the ability to understand the interconnectedness of knowledge with real-life situations along with recognizing the potential consequences of one's actions in the future [45]. Empirical studies highlight that case-based teaching can promote not only knowledge about sustainability concepts [3] but can also change students' perceptions towards more sustainable decision-making [46].

Besides ESD, case-based teaching has been indicated as an effective approach to promoting CT. A line of the literature articulates the relationship between CT and the learning processes involved in teaching approaches including case-based teaching. At the same time, stresses the effectiveness of case-based teaching for CT through empirical studies, reviews, and meta-analyses. To illustrate, [47] suggests that case-based teaching is appropriate for promoting CT as students engage in processes like analysis of the case, perspective-taking, evaluation of the sources of information, identification of alternatives, and assessment of the consequences of decisions or actions. Additionally, [48] (p.8) in her definition of CT, mentioned explicitly that CT is the type of "thinking involved when solving problems, formulating inferences, calculating likelihoods, and making decisions", processes engaged in case-based teaching as well. Further, [40] indicated that student teachers may learn to identify a problem and become aware of different perspectives through case-based teaching crucial for their CT. A meta-analysis conducted by [4] indicated that exposure of students to "authentic or situated problems" and examples can positively affect CT. Authors perceived "authentic or situated problems" as including instructional approaches like applied problem-solving, case studies, simulations, playing games and role-playing. Similar were the results obtained by [5]. In their systematic review [5] and meta-analysis they conceptualized problem-based learning similar to [4], including teaching strategies such as real cases/problems, (Socratic) class discussions/debate, inquiry-oriented experiments, problem-solving, problem finding, brainstorming, decision making, and analysis. Their findings indicated that, when compared to the control groups, participants' scores of CT were improved in the experimental groups.

Assessing Critical Thinking

Conceptual and procedural aspects promoted during learning and instruction are essential to be assessed. Still, assessing CT can be challenging for instructors. One reason is that CT has multiple definitions, resulting in a lack of agreement about one instrument that successfully measures CT. There are various standardized CT tests, such as the Cornell Critical Thinking Test, the California Critical Thinking Dispositions Inventory, the Ennis-Weir Critical Thinking Essay Test, and the Halpern Critical Thinking Assessment test, among others [49]. Since each of the above tests is grounded on a particular definition of CT, one can argue that they differ in the aspects of CT they measure, namely different skills or dispositions [50]. Moreover, they have been criticized for failing to take into account fundamental issues regarding the nature of CT (e.g., domain specificity and transferability) [49]. Further, the CT standardized tests have been considered having significant weaknesses in terms of validity and reliability [49,51]. Additionally, the standardized CT tests rely primarily on multiple-choice questions rather than on open-ended performance assessments. Therefore, it has been argued that such assessments are not authentic to the CT process triggered in real-life contexts or present unfamiliar situations to students [49,50]. Although one can find additional drawbacks in the literature with respect to the use of CT standardized tests, we conclude by highlighting that such tests are not easily accessible and are costly for mainstream use.

Recently, the use of assessment rubrics [52] has been highlighted as an appropriate assessment method for concepts such as CT. Assessment with rubrics falls under performance assessment [53], which reflects students abilities to solve real-world problems, analyze, synthesize information, and apply their knowledge and skills, while their performance is assessed against a set of well-defined criteria [54]. Rubrics are perceived as a criterion-referenced assessment, namely an evaluation method where students' performance is measured against a set of predefined criteria or standards [55]. Rubrics can be categorized either as holistic, namely providing a single score based on an overall impression of a student's performance on a task, or as analytic, to wit, providing specific feedback on several dimensions and levels [56,57].

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Among the benefits reported in the literature regarding the effectiveness of rubrics are the increased consistency of judgement in evaluating performance and authentic tasks, the consistency in scoring across different students, assignments as well as among multiple raters [56]. Moreover, rubrics enable valid assessment of complex competencies accurately while providing a balance between validity and reliability of measurements [56]. Further, they are perceived as quick and easy to use, providing feedback to both students and instructors, as well as assessing individual aspects of a skill providing more detailed feedback [58]. Additionally, rubrics can be tailored to measure students' performance either on specific content or specific skills, such as CT skills [e.g., 59]. Still, there are CT rubrics which attempt to assess performance on both content and skills [52,60]. Acknowledging the importance of rubrics in CT assessment, various scholars have employed this approach when assessing students' CT performance [52,55,58,61,62].

The current study

In light of the evolving educational landscape, it is an imperative need for prospective teachers to be capacitated both in CT and in instruction for sustainability. Our previous literature review revealed some gaps and limitations, which the current study aims to address. First, the transformation of Teacher Education to integrate ESD and CT remains a challenging task, with only scarce empirical evidence in the existing body of research [6]. Second, although CT is recognized as a pivotal competency for educators supporting Sustainable Development Goals [32], there is a lack of research examining primary education teachers' CT, particularly in the context of ESD [26]. Moreover, the assessment of CT with standardized tests presents various limitations [49–51]. Consequently, the exploration of alternative assessment methods, such as rubrics, becomes increasingly pertinent. Therefore, the primary aim of the study is to investigate and evaluate pre-service teachers' CT when engaged with case studies in a practicum preparation course centered on Education for Sustainable Development. The research question of the current study was:

How do student-teachers approach case studies on 'Teaching approaches of the Environmental Study' and what is the quality of their responses regarding CT?

2. Materials and Methods

In order to meet the objectives of the study, a cross-sectional research design was followed. Cross-sectional research design was deemed appropriate as we gathered data from a sample of individuals at a specific time. In addition, such research designs are useful for exploring relationships or associations between variables [63].

Sampling method and Participants

A purposive sampling strategy, one of the non-probability sampling methods often adopted in qualitative studies [64], was employed, and students enrolled in the course "Teaching approaches of the Environmental Study" were considered as participants of the current study. In particular, participants were nine (seven women) third and fourth-year bachelor students in a Teacher Education program.

The course "Teaching approaches of the Environmental Study"

The course "Teaching approaches of the Environmental Study" is a compulsory course offered to students enrolled in a bachelor program on Teacher Education at a Greek University. The course focuses on teaching methodology and content knowledge of the specific subject matter "Teaching approaches of the Environmental Study", which is taught in primary education. The academic course had a total duration of thirteen three-hour sessions per semester. Five sessions of the course focused on theoretical aspects of how to design a lesson plan as well as which teaching approaches and strategies are appropriate for the subject matter of the "Study of the Environment". The rest of the sessions were more practical as they had an integrated apprenticeship format. Students were designing their lesson plans, which then they implemented at primary education schools

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collaborating with the University. After the implementation of students' lesson plans reflective sessions were taking place at the University. The instructor of the course employed student-centered teaching approaches, such as problem-based learning and case studies.

Moreover, the course integrated aspects of CT with the infusion approach. According to [65], infusion refers to the explicit instruction of CT aspects during the instruction of a specific subject matter. Thus, the instructor of the course, who was trained in CT [see 66 for more details on the training], during the first session of the "Teaching approaches of the Environmental Study" explicitly taught students about the nature of CT particularly referring to CT skills and dispositions. After explicit instruction of CT, students were engaged in case-based teaching through structured activities that would foster the application of CT knowledge. In the end, students reflected on the CT skills and dispositions activated during case-based teaching. These activities allowed students familiarization with case-based teaching.

Procedure and data collection instruments

The study received ethical approval from the Research Ethics Committee of the University of Western Macedonia (Reg. No.: 230-2023/26-05-2023). In order to meet the study's objectives three data collection measures were used, namely (i) four case studies and (ii) the Critical Thinking quality of Response Rubric.

The case studies

After the explicit instruction of CT and familiarization with case-based teaching during the first session of the course, the instructor provided four examples throughout the semester to students and four case studies in order to further train students' lesson planning skills as well as their CT skills. The case studies were real ill-structured lesson plans that could be applied in the school setting. The aim was for students to identify the inconsistencies in the case studies and suggest how they could be addressed. The case studies varied in complexity, from simple to complex. One indicative case study of medium complexity provided to the students was the following:

A student of the Department of Primary Education has designed his lesson on "Air pollution". His teaching will take place in the context of practical training in the 4th Grade of Primary School at the 5th Primary School of Florina. The 4th grade class consists of 10 boys and 10 girls. The student in his lesson plan set a cognitive learning objective: "To make students aware of human activities that cause air pollution".

In the lesson plan he states that as a related activity to this objective within the lesson, he will share with all students' information he found in a 2012 publication from a personal blog. This information states that "the area of Ptolemaida-Kozani has high air pollution values due to the coal power plants and calm weather, that the area around the coal power plant in the area of Megalopolis in the prefecture of Arcadia has a significant problem, and then lists several areas in Greece that have air pollution problems due to industrial plants (e.g. Lesbos: lime kilns and seed oil extraction plants at the entrance to the town, Syros and Neorio (Cyclades): PPC station, etc.)". The student intends to read and discuss the information on this page in class. The instructor encourages the student to reconsider the quality of his proposed activity before implementing it in the classroom. He also points out that the information in the personal blog he found does not help achieve the objective he set for his lesson. The student is not sure that he should take the instructor's suggestion into account, as he believes that the information on the personal blog does mention human activities that cause air pollution.

What should the student do?

Students were engaged with the case studies individually. The activity was initiated during the face-to-face sessions at the University but was completed by students as homework assignments. Therefore, students had an interval of a week to finalize each case study and submit it to the instructor via Moodle. There was no word limit while answering the case studies. No extra credits or tokens were provided to students for completing the cases. The case studies were among the activities that students had to complete in order to be awarded a mark at the end of the semester after engaging in

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the course's final exams. Each case study was accompanied by seven questions that further guided students in engaging with the case study and aimed at triggering their CT skills. Table 1 presents the questions of each case study.

Table 1. The questions included at each case study.

No	Case study questions
1	Read and comprehend the problem. Then, draw a table that organizes the information provided by the case you have read. Identify which of the information presented in the scenario is not relevant or does not affect the problem.
2	What is my opinion about the problem?
3	How do I justify this opinion?
4	Write down your intuitive proposed position on the problem question and explain your choice.
5	Search and find the information you need to solve the problem.
6	Formulate your proposed solution to the problem and explain your answer.
7	Did I change my way of thinking about the problem?

The Critical Thinking Quality of Response Rubric

The Critical Thinking Quality of Response Rubric (CTQRR) employed in the study assessed the quality of students' responses across case-based teaching. The rubric was inspired by the common rubric proposed by [61]. While there is large body of literature discussing critical thinking in higher education, there is a less substantial body of scholarship exploring methods for teaching it. There are several tests being used nationally to assess critical thinking. Rather than just assessing critical thinking, we explored the use of performance tasks with a common rubric as a way of raising student and instructor awareness of the tools and practices involved in critical thinking. In this exploratory study, faculty in three different fields, Teacher Education, Social Sciences, and Life Sciences, designed performance tasks in a problem-based learning environment that were appropriate to their disciplines and aligned to the skills of critical thinking. Although the tasks differed for each cohort, they were structured similarly and explicitly taught using a common rubric with corrective feedback, aiding both the development and assessment of critical thinking. Students completed a pre-post assessment on a critical thinking assessment test. Some cohorts evidenced measurable improvements in critical thinking skills with less discernable improvement among other cohorts. Qualitative results tended to confirm the value of student participation in rigorous and challenging performance tasks. We conclude that using performance tasks with corrective feedback on a common rubric may be useful in many fields. We further suggest that regular use of performance tasks in a problem-based learning environment can contribute to the transferability of critical thinking skills and dispositions. Our rubric provided explicit criteria for seven CT skills, namely inference, interpretation, explanation, evaluation, analysis, self-regulation and reflection (see Appendix A). We developed unweighted additive criteria, which we assumed to be equally relevant for CT. We chose these skills for three reasons. First, they were explicitly taught to students during the course of "Teaching approaches of the Environmental Study". Second, these skills are often included in the definitions of CT [17,48] and recognized as relevant to problem-solving and case-based teaching [67]. We also included reflection as an essential element of CT [19,68]. Third, these skills are essential for the teaching profession [69]. Moreover, depending on the quality of the responses, students were categorized in one out of the three levels of the rubric, namely "below or merely meet expectations-level 1", "meets expectation-level 2", and "exceeds expectation-level 3". For each level, the criteria were 18. At the first level, each criterion could be scored with one point, with two points for the second level and with three points for the third level. Thus, the highest score for the first level was 18 points, for the second level was 36 points and for the third level was 54. If a criterion was not applicable, it was scored with no points. To ensure that the rubric accurately measured the intended CT skills, two experts in the field of CT reviewed the content validity of the rubric. The rubric was considered as valid by the experts, who completed an evaluation sheet and marked the validity for

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each criterion as high (five points scale: 1=low validity, 5=high validity). Some minor suggestions for improvement concerned the wording of some criteria and the CTQRR was refined before implementation. Further, the inter-rater reliability was calculated to assess the consistency of ratings between two raters. One rater was an expert in CT and the other at the "Teaching approaches of the Environmental Study". Both raters assessed students' responses to the four case studies assigning a level of quality to the responses. Cohen's kappa coefficient was high between the two raters (.86), who reached entire agreement after discussion.

Data analysis

In order to answer the research question of the study, we employed a qualitative content analysis, which is an appropriate method for analyzing written, verbal, or visual communication [63]. The qualitative analysis aims at classifying large amounts of text into several categories, which share similar meanings and interpret a broad context [70]. The data were analyzed employing the inductive approach, but theoretical evidence was considered for naming the categories and subcategories that emerged from the analysis. The unit of analysis was the entire answer that students wrote for each case study question (see Table 1). Two experienced raters in social sciences coded the data and the interrater agreement was high (k = .85). Any differences between the two raters were alleviated after discussion.

3. Results

How do student-teachers approach case studies on 'Teaching approaches of the Environmental Study'?

In total, 263 units of analysis were identified across the four case studies for all students engaged in the study. These units of analysis were classified into 25 codes, which in turn were grouped in 19 subcategories that resulted in eight higher-order categories (see Annex B for more information and examples).

From the total 252 units of analysis identified, almost one-third (n=78) revealed a lack of students' answers and their disengagement with the questions of the case studies. We perceived this finding as rather interesting and decided to code these units of analysis in one subcategory, which resulted in one higher-order category. The category was named "Disengagement from the case study".

The next most frequently coded (n=39) category was named "Clarifying concepts and ideas". In this category, we grouped units of analysis revealing that students either tried to understand and clarify the concepts and ideas depicted in the case study. Two subcategories were grouped under this higher-order category and are presented in frequency order. In the first subcategory students clarified concepts and ideas drawing information from the case study or their previous knowledge. Thus, we named this subcategory "Clarifying concepts and ideas drawing from the case study or previous knowledge". The second subcategory included statements revealing that students did not clarify any concepts or ideas from the case study and either focused on suggesting solutions to the case studies or highlighted the importance of engaging with such case studies for better teacher training. Therefore, we named the subcategory "Avoiding clarifying concepts and ideas".

Another frequently coded category (n=34) referred to students' reflection while engaging with the case studies and was named accordingly "Reflection". Reflection was linked with students' monitoring of their thinking process and the changes students made in their way of thinking. Therefore, two subcategories were grouped under this category. The first one was more frequently coded and included students' statements revealing that they engaged in monitoring their thinking and was named "Monitoring thinking". The second subcategory was less frequent and statements depicting that students not only monitored their thinking but also changed their thinking were included. Thus, the subcategory was named "Monitoring and changing thinking".

The fourth category, which was quite often coded (n=31), revealed that students engaged in the process of justifying their ideas. Therefore, we named this category as "Justification of ideas". Three

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subcategories with different frequencies among the data were merged under this higher-order category revealing that students justified their ideas on external sources (e.g., their instructor), on the scenario of the case studies per se, and their intuitions or beliefs. To depict these differences, we named the subcategories as "Justification of ideas on external sources", "Justification of ideas on the scenario," and "Justification of ideas on intuitions and beliefs" accordingly.

The fifth category identified in the data (n=24) included students' statements highlighting that they could or could not categorize the information provided in the case study. In the case that students categorized information it was evident that they often completed the categorization inadequately. This category was named "Categorizing information" and included three subcategories. The most frequently coded subcategory revealed that students categorized the case study information insufficiently. Thus, we named it "Inadequate categorization of information". The following two subcategories were not so often identified among the data. They depicted that students either categorized sufficiently the information of the case studies or avoided conducting any categorization of information. Therefore, we named them "Adequate categorization of information" and "Lack of categorization of information", respectively.

The sixth and seventh categories had the same frequency among the data (n=22). The sixth category included students' statements highlighting that they approached the case study by suggesting solutions for the case study or by repeating information from the case study. However, these ideas were unclarified or initial ideas that would require further elaboration to be considered solutions for the case studies. The category was named "Initial approach to the case study" and included two subcategories. The majority of statements were included in the first subcategory and denoted that students directly suggested an unjustified solution to the case study. Hence, we named the subcategory as "Suggesting a solution for the case study". In addition, we identified a few statements highlighting that students' ideas for solving the case study were in fact, a repetition of ideas presented in the case study. Thus, we named this subcategory "Repeating case studies' information".

In the seventh category, we included statements showing that students suggested solutions to the case studies, and we named this category "Suggesting solutions for the case study". In this specific category, we included three subcategories, which will be presented in frequency order. Specifically, the first one included students' statements suggesting one or multiple solutions for the case studies. In some cases, the solutions were justified and in some other cases, they were unjustified. Therefore, this subcategory was named "Suggesting one or multiple solutions for the case studies". In the second subcategory, statements depicting that students suggested their initial ideas as solutions to the case studies were included. The ideas that have been suggested as final solutions were in some cases provided with explanations. This subcategory was named "Accepting initial ideas as final solutions to the case study". Finally, there was one statement identified where no solution was provided, instead the student suggested a general opinion on how problems related to lesson planning should be solved. This subcategory was named "Lack of suggesting a solution".

Finally, the last category identified in the data was the least frequently coded (n=13) and referred to the inquiry that students were, in some cases, engaged to gather the information that would foster the suggestion of a solution to the problem. We named the category "Inquiry of information". This category included three subcategories. The first one included statements revealing that students identified gaps and recognized the information they needed, but they engaged with no inquiry. Thus, we named this category as "Identifying gaps but avoiding inquiry". The second subcategory denoted that students realized there was no need for searching for information. In addition, students' statements included in this subcategory repeated information from the case studies. Hence, we named this subcategory "Lack of inquisitiveness". The last subcategory included only two statements from students who searched for further information and provided examples of the information they enquired about. Therefore, the subcategory was named "Engaging in inquiry of information".

What is the CT quality of student-teachers' responses when approaching case studies on 'Teaching approaches of the Environmental Study'?

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A rubric-based assessment was followed to answer the second part of the research question. Students' responses were classified into three levels indicating different quality of students' CT responses. According to the level of students' classification, a profile was sketched. In Table 2, we present the results of students' CT quality responses to the four case studies. Overall, the quality of the students' responses revealed that the students were primarily categorized in Level 1 of the rubric. Still, some scarce Level 2 classifications were evident.

In the first level, were classified responses below or merely meeting the expectations. In particular, students' Level 1 responses reflected students' inability to categorize information effectively, misinterpreting problem details, and weak analysis of arguments with the exploitation of limited or no evidence. Moreover, the responses demonstrated students' inability to identify gaps and deficiencies in logical reasoning. They lacked self-awareness, exhibited bias, and failed to correct errors or reflect on their thinking process. The majority of students fell under this category and students displaying the qualities mentioned above were perceived as "Deficient Critical Thinkers" (see Table 2).

Table 2. The answers provided per question in the fourth case study by Student 4, who was assessed as a Deficient Critical Thinker.

Case study questions	Answers to the case study questions
Read and comprehend the problem. Then, draw a table that organizes the information provided by the case you have read. Identify which of the information presented in the scenario is not relevant or does not affect the problem.	Relevant information: teaching "air pollution", 4th grade, cognitive objective: "to make students aware of human activities that cause air pollution.", she will share relevant information she found in a 2012 publication from a personal blog (plus all the information she mentions below). Irrelevant information: number of boys and girls in class, 5th primary school of Florina.
What is my opinion about the problem?	I believe that the problem posed by the professor is logical and correct.
How do I justify this opinion?	The activity chosen by the student, although it partly serves the goal he has set, is not entirely suitable for children in 4th grade.
Write down your intuitive proposed position on the problem question and explain your choice.	My intuitive suggested position on the question is what I stated above, namely that the problem posed by the teacher is reasonable and correct because the activity chosen by the student, while partially serving the goal the student has set, is not entirely appropriate for 4th graders.
Search and find the information you need to solve the problem.	No response.
Formulate your proposed solution to the problem and explain your answer.	I would create and present to the students a simple, understandable and enjoyable video, enriched with images, containing a variety of sources of air pollution (e.g. transport, households, industries -fossil fuel combustion & waste management-). I would then divide

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	them into 3 groups, and each group would be responsible for presenting one of the sources of air pollution they observed in the video and propose a solution.
Did I change my way of thinking about the problem?	No I didn't.

Responses that met the expectations were classified in the second level of the rubric. Such responses were evidenced by students' ability to categorize information accurately, decode problem data effectively, and offer reasonable interpretations. Further, they demonstrated adequate analysis of ideas and arguments, which were supported by sufficient evidence and well-structured reasoning. Additionally, they displayed an ability to identify gaps, generate plausible alternatives, draw logical conclusions, and present well-justified procedures. Their assessments considered credibility as a valuable criterion. Although they avoided biases, they reflected occasionally, leading to sporadic self-correction and infrequent reflection on outcomes. Only a few students were classified in Level 2 and they were characterized as "Competent Critical Thinkers" (see Table 3).

Table 3. The answers provided per question in the fourth case study by Student 7, who was assessed as a Competent Critical Thinker.

Case study questions	Answers to the case study questions
Read and comprehend the problem. Then draw a table that organizes the information provided by the case you have read. Identify which of the information presented in the scenario is not relevant or does not affect the problem.	No response.
What is my opinion about the problem?	I believe that the student should follow the professor's suggestion, because on the one hand he has more experience than him and on the other hand I also believe that the cognitive objective he has set will not be achieved with this activity because the existence of factories is not the only cause of air pollution but there are other factors that pollute the atmosphere such as means of transport, chimneys of fireplaces etc.
How do I justify this opinion?	I support my opinion on my beliefs, my personal experiences and my previous knowledge.
Write down your intuitive proposed position on the problem question and explain your choice.	The problem is challenging to solve. The student needs to be convinced with an appropriate argumentation that in order to have a better result in his teaching, he should modify the activity he has thought of and obey the professor's suggestion as he has more experience than the student and on the other hand I also think that the cognitive objective he has set is not going to be achieved with this activity because the existence of factories is not the only

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	cause of air pollution but other factors pollute the atmosphere such as the increasing amount of pollution in the atmosphere. Therefore, if he continues to support his viewpoint categorically, unfortunately, his teaching will not provide students with a comprehensive presentation of the subject of 'air pollution' but only a part of it. Personally, I believe that the student will consider both views equally and will come to the decision that is more correct for him, which is to change the activity.
Search and find the information you need to solve the problem.	I would search for information to answer the following questions: Are only the specific areas of Greece (Ptolemaida - Kozani, Megalopolis, Lesvos) with high levels of air pollution? Is air pollution caused solely by industries/factories? Or are there other contributing causes?.
Formulate your proposed solution to the problem and explain your answer.	This blog in fact, should not be the student's only source for his/her teaching topic, because it is not an authoritative source to obtain information on his/her topic. Well, in order to express a more in-depth opinion, it would be advisable for him to read some books, articles, journals, encyclopedias, etc. related to his topic of "Atmospheric Pollution" and then try to reformulate his activity. Having a very good knowledge of the subject, the student will feel confident and able to modify his activity to achieve his cognitive objective and also be ready to answer and support any argument against the students' questions.
Did I change my way of thinking about the problem?	Yes, I changed my way of thinking about the problem.

Responses categorized in the third level were perceived as exceeding expectations. Still, no response was classified at this level. Students' responses that could have been categorized at this level would be expected to exhibit thorough categorization of information, insightful decoding of problem data, and comprehensive interpretation of information. Moreover, the responses would reflect rigorous examination of ideas, articulation, and analysis of arguments with compelling evidence, consistent gap identification, and suggestions of meaningful alternatives. Further, students in Level 3 would be able to consistently make well-founded conclusions and present persuasive, structured arguments with nuanced logical reasoning. Students would consistently assess credibility, avoid biases, and provide insightful evaluations with cogent reasoning. Finally, students would be expected to engage in systematic self-correction, unbiased thinking, and thoughtful reflection. Thus, they could be characterized as "Proficient Critical Thinkers".

Taking into account the complexity of the case studies, it was evident that four out of the nine students managed to display an improvement in their CT skills when answering the third case study. Nevertheless, only "student 6" managed to retain this improvement and transfer the way of thinking to the fourth case study, which was the most complicated. No other pattern was identified in the data regarding the effect of the case studies' complexity on students' quality of CT responses.

We then further examined students' responses, which were classified at the second Level of the CTQRR, to identify any marginal classification. For that reason, the scores assigned by the raters for

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each student and each scenario were considered. The analysis revealed that for Students N6 and N7 a clearer score that fell under level 2 of the CTQRR was assigned. However, Students 1, 2, and 3 (see Table 4), were marginally classified as Level 2. It was evident that the raters had scored students' answers with a mixed approach, namely most of the indicators were assigned one point (Level 1), while some were assigned two points (Level 2). This finding reveals that some students had a profile indicating their CT skills development. Although their CT skills were closer to Level 1, some (e.g., analysis, evaluation) were classified as Level 2. Accordingly, we decided to sketch another profile between the "Deficient Critical Thinker" and the "Competent Critical Thinker". This profile was named the "Emerging Critical Thinker". Students in this profile show some promising growth in CT. Still, they demonstrate an inability to categorize information effectively or interpret problem data. Notably, their ability to evaluate and analyze arguments has improved, supported by the utilization of evidence. Nevertheless, gaps in comprehension arise, as well as an inability to address biases and demonstrate efforts in reflective practices (see Table 5).

Table 4. The quality of students' responses regarding CT across the four case studies.

Students	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Student 1	Level 1	Level 1	Level 1	Level 2*
Student 2	Level 1	Level 1	Level 2*	Level 1
Student 3	Level 2*	Level 1	Level 2*	Level 1
Student 4	Level 1	Level 1	Level 1	Level 1
Student 5	Level 1	Level 1	Level 1	Level 1
Student 6	Level 1	Level 1	Level 2	Level 2
Student 7	Level 1	Level 1	Level 2	Level 1
Student 8	Level 1	Level 1	Level 1	Level 1
Student 9	Level 1	Level 1	Level 1	-
*Marginal classification in Level 2 with a total score between 19 and 22.				

Table 5. The answers provided per question in the fourth case study by Student 3, who was assessed as an Emerging Critical Thinker.

Case study questions	Answers to the case study questions
Read and comprehend the problem. Then draw a table that organizes the information provided by the case you have read. Identify which of the information presented in the scenario is not relevant or does not affect the problem.	Relevant information: The instruction topic "Air pollution", 4th grade in a Primary School in Florina, the cognitive objective set: "To make students aware of human activities that cause air pollution", The activity that relates to this objective is the student-teacher to share with all students' information found in a 2012 publication from a personal blog. This information states that "the area of Ptolemaida-Kozani has high air pollution values due to the power plants and high apnea, that the area around the power plant in the area of Megalopolis in the prefecture of Arcadia also has a significant problem, and then lists several areas in Greece that have air pollution problems due to industrial plants (e.g. Lesvos: lime kilns and kernel oil mills at the entrance to the city, Syros and Neoreio (Cyclades): a power station, etc.). Irrelevant information: the instruction will take place in the context of practicum, 5th Primary School, 10 boys and 10 girls.

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What is my opinion about the problem?	It is an issue that may arise during lesson planning. I believe that reflection and, more generally, the observations of the teacher are parameters that must be taken into account in order to implement a "good" instruction.
How do I justify this opinion?	I support my opinion on my personal experience in designing lesson plans.
Write down your intuitive proposed position on the problem question and explain your choice.	The student should accept the teacher's suggestions, as the material is not reliable, the proposed activities do not achieve the objective set and, in general, I do not believe that the student will have the learning outcomes aiming for.
Search and find the information you need to solve the problem.	I would need the lesson plan of the student to be able to comprehend the information provided by the instructor fully.
Formulate your proposed solution to the problem and explain your answer.	My solution to the problem is for the student to accept the professor's proposed changes.
Did I change my way of thinking about the problem?	No, I didn't change my way of thinking about the problem.

4. Discussion

How do student-teachers approach case studies on 'Teaching approaches of the Environmental Study'?

A content analysis was carried out to answer the first research question of the current study. The macroscopic content analysis, namely the higher-order categories that emerged contributes to our understanding of how student-teachers approach case studies. Particularly, they revealed that pre-service teachers' approach to the case studies aligned with the conceptualization of CT according to scholars like Dewey, Brookfield and Garrison. According to [20] and [21], CT is an ongoing thinking process with specific steps, including the triggering event or problem identification, the appraisal of the situation or problem definition, the exploratory phase, the development of alternatives or applicability and the integration of alternatives into ways of thinking or acting. In our study, similar steps of the thinking process were revealed. For instance, pre-service teachers engaged in organizing information on the problem, which can be realized as the problem identification phase according to Garrison. Then, they clarified and justified concepts and ideas, which we can argue are in line with the problem definition phase. Then, an exploratory phase followed where students participated in the information inquiry. Further, student-teachers suggested initial ideas for solving the case study, which can be perceived as the phase of developing alternatives. Moreover, the integration of alternatives into ways of thinking or acting in our case was realized through the suggestion of final solutions for the case study. Prior studies have provided similar results. For instance, [71] employing among others, Garrison's framework of five stages of CT, offered a set of indicators for measuring CT in face-to-face learning and computer conference seminars. Additionally, [72] indicated that medical students' answers in a problem-based learning discourse could be coded following the CT framework of Garrison.

Another line of relevance of the current findings lies in the fact that the microscopic content analysis, namely the emerged subcategories, revealed that some students did not engage effectively in the phases of the CT cycle, as suggested by Garrison or Brookfield. To illustrate, subcategories such

as *"Avoiding clarifying concepts and ideas"*, *"Lack of categorization of information"*, *"Inadequate categorization of information"*, *"Unjustified solution for the case study"*, *"Solution repeating case studies' ideas"* indicate that some students were deficient or emerging critical thinkers. In his study [71] indicated that some students did not engage in CT. Those students were perceived as "uncritical thinkers". Similarly, [73] argued in their literature review that not all students may be good at CT suggesting eight learner types who present deficits in CT; (1) those acting without thinking (impulsive thinking), (2) need help at each step (overdependent); (3) use goal-incompatible strategies (do not perceive cause–effect relationships); (4) have difficulty with comprehension (miss meaning); (5) are convinced of the 'rightness' of their beliefs (dogmatism); (6) operate within narrow rule sets (rigidity/inflexibility); (7) are fearful (not confident); and (8) condemn good thinking as a waste of time (anti-intellectual). The previous research could support our findings suggesting that not all student-teachers engaged in the cyclical model of CT when approaching case studies.

In the previous conceptualizations of CT, there is no explicit reference to reflection as a step in the thinking cycle, nonetheless, our analysis revealed one respective category. Still, student-teachers' answers categorized under this category indicated that they only monitored and failed to examine their thinking process resulting in a change in their conceptual perspectives. There were only a few cases where students monitored their thinking and changed their perspectives, providing examples to justify this change. Hence, we cannot argue with confidence that the students engaged in reflection as well as that in our study reflection was an additional and explicit phase of the iterative thinking cycle of CT. Nevertheless, monitoring and changing conceptual perspectives or beliefs could impact prospective teachers' problem-solving skills. Still, teaching for (critical) reflection would require the exploitation of explicit strategies that support reflection and render student-teachers aware and conscious of their thinking processes, perspectives or beliefs [74].

So far, we provided insights into how student-teachers approach case studies and engage in CT. Later, we will attempt to present a deeper interpretation of the content analysis results by highlighting potential challenges that hindered student-teacher CT while approaching case studies. Moreover, the practical implications of these findings on teaching practices or curriculum development will be discussed.

One unexpected finding of the content analysis was that almost one-third of the responses revealed a lack of students' engagement with the case studies' questions. This finding could be attributed to multiple factors. First, the case studies or the concept of CT, *per se*, were perceived by the pre-service teachers as more complex than expected, which could lead to students' disengagement with the task. According to [75], if students experience too much or persistent confusion when engaging with learning tasks or concepts, they are more likely to feel frustration, hopelessness, and boredom and give up the task. Second, there is a likelihood that if the material provided to the students was perceived as challenging and time-consuming, then it might also be perceived as less appealing [76]. Third, there is a possibility that pre-service students considered the case studies or the content as over- or under-challenging and lacked perceived value of the tasks and content for their professional development, experiencing as a result, academic boredom [77]. Finally, there is a chance that students experience intellectual laziness, namely a tendency to give up quickly when faced with an intellectually challenging task [78]. Learners experiencing intellectual laziness can be reluctant to put in any effort, refrain from challenging tasks, and prefer easy or passive activities. Thus, constant disengagement from academic tasks could hinder student-teachers intellectual growth and CT. Nonetheless, further research would be required to examine the real reasons behind prospective teachers' disengagement in the current study.

Our results revealed a challenge that most likely inhibited student-teachers CT, namely the latter's naive epistemological beliefs. From the subcategories that emerged under the category "Justification of ideas", it was evident that student-teachers justified their ideas on external sources/authorities (e.g., the instructor), on the case study, *per se*, as well as on their beliefs or intuitions. Relying on external sources/authorities, beliefs or intuitions for validation of ideas implies that learners perceive knowledge as certain and invariable [79], usually act as passive learners and are unable to assume that knowledge comes from empirical evidence and reasoning [80]. Moreover,

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previous empirical findings have indicated that students' naive epistemological beliefs predicted poorer performance on everyday evaluative thinking, closed-mindedness and poorer cognitive ability, hampering good CT performances [81]. Further, the content analysis indicated that prospective teachers were most likely discouraged from seeking information and disinclined to explore alternative viewpoints or evidence to support their ideas. We argue that this result might be interpreted by student-teachers perception of information and knowledge as absolute and unalterable, which aligns with naive epistemological beliefs. This claim can be supported by previous research findings outlining that students engaging with problem-solving through a superficial process, namely without engaging in analysis, interpretation or evaluation, hold epistemological beliefs, characterised by an uncritical acceptance of authoritative sources and a lack of evaluation, which can be considered naïve [82]. Addressing student-teachers' naive epistemological beliefs should be a priority in teacher education. Higher Education Instructors can integrate activities that encourage students to question the sources of knowledge, test, reflect and reconceptualize their beliefs in real-life situations, engage student-teachers in peer discussions, and exploit augmented activation and refutational texts in learning and instruction [83,84].

An additional challenge that we identified in the results concern sub-skills related to student-teachers' comprehension, such as clarification of concepts and ideas and categorization of information. The results indicated that on the one hand, some students clarified concepts and ideas drawing from the case study or their previous knowledge. Clarification often involves breaking down complex concepts into more straightforward, more understandable parts. At the same time, clarification requires the learner to build their mental representation of a concept and identify potential relationships of the concept with pre-existing knowledge. This process might allow learners to deepen their own understanding of a concept. Hence, the fact that student-teachers drew on the case-study or their previous knowledge to clarify the meaning of the case studies' concepts was perceived as the first step towards clarification. Nevertheless, it revealed their lack of knowledge of strategies that could foster clarification and therefore comprehension, such as re-representation, questioning and explaining, concept maps, and spatial representation of thought [48]. On the other hand, some student-teachers avoided clarification by focusing directly on suggesting a solution to the case-study or highlighting the importance of the case-study for their professional development. This finding could indicate that when learners are not aware of the importance of engaging in clarification or lacking respective strategies, they can be disoriented from the aim of the task or engage in a superficial thinking process. Teacher Education programs could benefit by providing direct instruction on the anatomy of an argument and clear guidance on justifying ideas and solutions to help students improve their argumentation skills.

Further, our results revealed that the majority of student-teachers partially or to no extent engaged in the categorization of information. The inadequate categorization can hinder student-teachers ability to identify the core components and nature of a problem, leading them to misdiagnosis or overlooking critical aspects of the issue impeding adequate comprehension. Moreover, research in cognitive psychology suggests that when individuals are confronted with unorganized information, it can lead to increased cognitive load, making it harder to process and understand a problem [85]. This cognitive load can impede effective problem comprehension. Hence, it seems crucial to support student-teachers while working on complex learning tasks (i.e., problem-solving). This support may involve coaching through the provision of hints, prompts, and feedback; modelling the utilization of cognitive strategies by thinking aloud; offering cue cards, checklists, and process worksheets; posing guiding questions; and providing partial solutions [86].

Finally, another finding that stands out from the current results revealed that most prospective teachers encounter challenges in providing justified ideas or solutions for the case studies. This finding outlines a gap in the argumentation skills of student-teachers. Future teachers express an opinion, belief, or claim but do not recognize the importance of providing additional evidence to support them. Previous research has identified learners' difficulty distinguishing between their beliefs and evidence [87]. Justification refers to providing reasons, evidence, or support for a conclusion or hypothesis. Justification is necessary because CT often deals with complex or ill-defined

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problems where conclusions cannot be easily tested, so it is essential to demonstrate the plausibility of one's position through well-reasoned arguments and supporting evidence [88]. Still, student-teachers inability to offer justified ideas or solutions indicates that they require additional support and instruction in developing their justification skills [89].

What is the CT quality of student-teachers' responses when approaching case studies on 'Teaching approaches of the Environmental Study'?

In order to answer the second research question of the current study, we engaged in a rubric assessment of student-teacher quality of CT responses. From the assessment, three profiles emerged: the "Deficient Critical Thinkers", the "Emerging Critical Thinkers," and the "Competent Critical Thinkers". Our assessment revealed that "Deficient Critical Thinkers" lack or display limited ability to categorize information, clarify problem information, analyze argumentation, justify ideas or solutions, identify gaps or deficiencies in reasoning, exhibit self-awareness or reflect on their thinking process. "Emerging Critical Thinkers" was deficient in some CT skills, such as categorization and interpretation of information as well as reflection, but displayed some competency in other CT skills, including argument analysis, evidence-based justification and evaluation, and justification. Only a few "Competent Critical Thinkers" were identified among the study-participants, whose profile indicated that they categorized information accurately, decoded problem data effectively, offered reasonable interpretations, demonstrated adequate analysis of ideas or arguments, and employed evidence-based and well-structured reasoning. Moreover, those student-teachers characterized as "Competent Critical Thinkers" occasionally examined and exploited the thinking processes resulting in a conceptual perspective change.

Initially, we had expected another profile to emerge, namely the "Proficient Critical Thinkers". Still, this expectation was not met. Nevertheless, this finding is not surprising. Taking into account the results from the first research question indicating that student-teachers experienced many challenges as far as the CT processes activated during case-based teaching are concerned, the predominance of the "Deficient Critical Thinkers" profile and the absence of the "Proficient Critical Thinkers" profile is justified. Although previous studies have indicated that explicit instruction of CT [90–92] and case-based teaching can prove beneficial for CT [67,93], more guided and structured activities could have been required to scaffold participants towards achieving a better quality of CT. Moreover, the results from previous metanalysis indicate that CT can be achieved with a medium or more extended length intervention, implying that a more targeted holistic educational approach could be required [94]. Finally, the complexity of the case studies could have been an inhibiting factor for transferring the acquired CT from one case study to the next.

Further, the three profiles identified in the current study indicate that learners can improve their CT. This finding is in line with the proposed stage theory of CT by [95] suggesting that passage from one stage to the next is dependent upon the necessary commitment and conscious effort of an individual to develop as a critical thinker (Stage 1=The Unreflective Thinker, 6=The Master Thinker). We argue that apart from learners' commitment and conscious effort, carefully designed and well-articulated interventions should be implemented to meet the learning needs of each CT profile.

Limitations and Future Research

This study involved a small sample of students in one discipline only. Future studies should examine how a larger number of participants across various disciplines approach case studies and how their CT quality is affected. In addition, in the current study, CT dispositions were not considered. Our current results regarding student-teachers disengagement during case-based teaching might indicate that disengagement is a dispositional affecting their CT. In addition, previous studies have indicated that CT dispositions mediate students' problem-solving skills [96]. Therefore, we argue that future research should consider student-teachers CT dispositions and their role in approaching case studies. Moreover, a longitudinal study, extending in a longer period than an academic semester, could better allow us to track the development of CT skills. In some cases, a timeline of up to one or more than one academic semester is proven efficient for CT skills development [94]. Further, studies could examine the impact of more structured teaching

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interventions on student-teachers CT. Finally, in future studies, the discipline content could also be assessed through the use of rubrics in order to examine whether it mediates the development of CT.

5. Conclusions

The current study explored how prospective teachers approach case studies focused on the "Teaching approaches of the Environmental Study" and the quality of their CT responses through a rubric-based assessment. The content analysis revealed that student-teachers' approached the case studies aligning their thinking with the cyclical model of CT proposed by scholars like Garrison and Brookfield. However, some student-teachers encountered challenges, which most likely hindered their CT, including task disengagement, naive epistemological beliefs, lack of sub-skills related to comprehension (i.e., clarification and categorization), and difficulty in providing justified ideas and solutions. These findings emphasize the importance of addressing epistemological beliefs and supporting comprehension and argumentation skills in teacher education programs. The rubric assessment underscored the need for more structured CT interventions and suggested that CT development requires ongoing efforts and commitment not only on behalf of the learners but also of the instructors.

The findings from this study made several contributions to the current literature. First, our research offers valuable insights into the CT process of student-teachers, providing a detailed understanding of the phases they navigate when approaching complex case studies. This contributes to the literature by enhancing our comprehension of how pre-service teachers engage with multifaceted teaching scenarios.

Secondly, identifying deficiencies in CT among student-teachers underscores the need for targeted interventions in teacher education programs. This finding emphasizes that not all pre-service teachers effectively employ the cyclical model of CT, thereby advancing our understanding of CT development in this population.

Thirdly, our exploration of the impact of naive epistemological beliefs on CT processes adds a novel dimension to the literature, highlighting the necessity of challenging such beliefs to foster more effective CT among student-teachers.

Fourthly, the study underscores the importance of comprehension sub-skills, like clarification and categorization, in the CT process, emphasizing the requirement for explicit instruction to enhance problem-solving and argumentation abilities.

Next, the study highlights that there is a need to recognize potential factors impeding pre-service teachers' active engagement with case studies. Educators could address and mitigate the specific challenges, ultimately enhancing the effectiveness of teacher preparation programs.

Lastly, the categorization of student-teachers into distinct CT profiles offers a view of CT development and underlines the importance of tailored educational interventions to address the specific needs of each profile. These contributions collectively advance our knowledge of CT in the context of teacher education and offer valuable guidance for future pedagogical practices and curriculum development.

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Appendix A

Skill	Below or Merely Meets Expectation	Meets Expectation	Exceeds Expectation
Interpretation	Fails to categorize information or categorizes some concepts at the problem.	Adequately categorizes information or concepts of the problem.	Thoroughly categorizes information or concepts of the problem.
	Struggles to clarify meaning or decode the significance of data included in the problem.	Adequately clarifies meaning and decodes the significance of data included in the problem.	Thoroughly clarifies meaning and decodes the significance of data included in the problem.
	Misinterprets or misunderstands problem information.	Demonstrates adequate interpretation of problem information.	Thoroughly interprets the information of a problem.
Analysis	Fails to examine ideas thoroughly or in a systematic manner.	Adequately analyses ideas with some depth and structure.	Thoroughly examines ideas in a systematic and rigorous manner.
	Struggles to identify arguments within a given context. Or doesn't identify at all.	Adequately identifies arguments with reasonable accuracy.	Recognizes and articulates arguments thoroughly.
	Weakly/never analyses arguments, providing limited or no supporting evidence.	Adequately analyses arguments with sufficient supporting evidence.	Critically analyses arguments with compelling evidence.
Inference	Rarely/Never queries evidence or lacks the ability to identify gaps.	Adequately queries evidence and identifies some gaps.	Consistently queries evidence and identifies significant gaps.
	Offers few (or none) or irrelevant conjectures about possible alternatives.	Adequately generates reasonable conjectures about alternatives.	Consistently formulates insightful conjectures about meaningful alternatives.
	Draws unsubstantiated or weak conclusions. Or	Adequately draws logical and well-supported conclusions.	Consistently draws sound and compelling conclusions.

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	draws no conclusions at all.		
Explanation	Struggles to state results or justify procedures coherently.	Adequately states results and justifies procedures with some clarity.	Consistently states results and justifies procedures effectively.
	Presents weak or incomplete arguments to support claims. Or presents no arguments at all.	Presents arguments that support claims adequately.	Consistently presents well-structured and persuasive arguments to support claims.
	Lacks consistency in presenting logical reasoning.	Adequately presents logical reasoning consistently and coherently.	Consistently presents compelling and nuanced logical reasoning.
Evaluation	Rarely/Never assesses the credibility or validity of claims.	Adequately assesses claims for credibility and validity to some extent.	Assesses claims for credibility and validity all the time in a consistent way.
	Assesses arguments in a biased manner (influenced by beliefs, etc). Or doesn't assess at all.	Adequately assesses arguments avoiding personal biases.	Consistently assesses arguments avoiding personal biases.
	Provides limited or shallow reasoning in evaluations. Or presents no reasoning at all. Uses intuition.	Offers adequately well-reasoned evaluations with some depth.	Consistently provides insightful and nuanced evaluations with cogent reasoning.
Self-regulation	Shows little or no self-examination or awareness of biases.	Demonstrates some self-examination and awareness of biases.	Exhibits consistent self-examination and unbiased thinking.
	Rarely/Never corrects errors or modifies thinking when needed.	Occasional self-correction and modification of thinking.	Systematically engages in self-correction and adapts thinking effectively.
Reflection	Fails to internally examine and explore the thinking process and result in a change in conceptual perspective.	Occasionally examines internally and explores the thinking process resulting in a change in conceptual perspective.	Engages systematically in deeper reflection over a thinking process resulting in beliefs transformation.

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Appendix B

Category	Subcategory	Code	Indicative Unit of Analysis
Disengagement from the case study	Disengagement from the case study	Disengagement from the case study	No response was provided to the case studies question(s).
Clarifying concepts and ideas	Clarifying concepts and ideas drawing from the case study or previous knowledge	Clarifying concepts and ideas drawing from the case study	The student is not relying on a credible source and no reference is made to human activities.
		Clarifying concepts and ideas drawing from previous knowledge	Also, if the information the student has gathered does not meet the learning objective set, the student must either modify the objective or gather additional information.
	Avoiding clarifying concepts and ideas	Focusing on the solution of the problem	My opinion about the student's problem is that the student should listen to the professor's opinion and suggestion.
		Focusing on the importance of the case study for the teaching profession	It's something that can happen in my professional life, and I have to take action.
Reflection	Monitoring of the thinking process	No change in the thinking process	I didn't change my thinking process
	Monitoring and changing their thinking process	Change in the thinking process	I extensively changed the way I think during problem solving.
Justifications of ideas	Justification of ideas on external sources	Justification of ideas on an external source (e.g., instructor, previous knowledge, previous experience)	I justify my opinion on the knowledge I have acquired while attending the course "Teaching approaches of the Environmental Study".
	Justification of ideas on the scenario	Justification of ideas on the scenario	I justify my ideas on the information of the case study.
	Justification of ideas on intuitions and beliefs	Justification of ideas on intuitions and/or beliefs	I justify my ideas on my belief that misconceptions should not be perpetuated.
Categorizing information	Inadequate categorization of information	Incomplete organization of information and difficulty in detecting and categorizing information	Relevant information: Getting to know the animals, 10 boys and 10 girls, cognitive and emotional objective, the zoo, the song, the working groups, the worksheets, the products, home (of the animals) Irrelevant information: the name of the school, "He will have asked … the animals", camera.

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		Organization of relevant and non-relevant information but with no explicit reference to the information, per se	Irrelevant information: that the teaching will take place in the context of an internship the name of the school the 4th grade class consists of 10 boys and 10 girls. Relevant information: All others not mentioned above.
	Adequate categorization of information	Complete organization of the problem information	Relevant information: The cognitive objective of the student The (teaching) method chosen. The activity of the discussion The instructor's suggestions The student's reluctance to accept the instructor's suggestions. Irrelevant information: The teaching is part of a practical exercise. The school in which it will take place. The number of pupils in the classroom The details of what is 'student-centered teaching'
	Lack of categorization of information	No categorization of information but a personal view of the problem and of a solution	The problem as presented here is that the guide, in answering the student, reproduced a well-known misconception associated with the Theory of Evolution. He did not phrase the answer correctly. As a professional guide he should have known the (appropriate) answer for a 4th grade elementary school student. I believe all the information given is relevant to the problem.
Initial approach of the case study	Suggesting a solution for the case study	Suggesting a solution for the case study	The student should accept the professor's suggestion because firstly, the professor pointed it out to him and he must have a point. Secondly, as we understand from reading the text, his lesson plan is incomplete.
	Repeating information from the case study	Repeating information from the case study without adding new ideas	In my opinion, the professor is partially right and partially wrong at the same time. The professor suggests that the student reconsider the choice of the activities included in the lesson plan as the information included in the worksheet will not help the pupils achieve the cognitive learning objective stated in the plan.
Suggesting solutions for the case study	Suggesting one or multiple solutions for the case study	Proposing an unjustified solution	The proposed solution is to revise the lesson plan, because this will meet the criteria of effective teaching of this course.
		Proposing multiple solutions without indicating the most appropriate one	The student should think again about the validity of information provided in the study he found. It would be better to organize his lesson plan based on valid information.
	Accepting initial ideas as	Accepting the first proposed idea as a	A suggested solution is that upon class return the teacher could encourage a class discussion

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	final solutions to the case study	solution to the problem without any justification	about the students' tour impressions. The teacher should then inform the students that a mistaken statement about the weasel was proposed by the tour guide. In that way we stimulate the students' interest to undertake a project, which will eventually solve the question of the evolution of the weasel and its characteristics. At the end of the process and presentation of the results, the students themselves will correct the tour guide's misconception regarding the weasel.
		Acceptance of the first proposed idea as a solution to the problem along with a justification	I would advise the student to review the terms of the learning objective, the method and the proposed activity. This is because only saying that a student-centered approach will be used in instruction, does not imply that active action and free expression of the students will be ensured. Also, I do not think that socratic dialogue could be used feasibly for third grade students, as it is more advanced than their developmental level.
	Lack of a suggested solution	No solution was suggested	The combination of respect, attention and tolerance against the words and opinions of the professor, the arguments that support his ideas, and the flexibility of the student-teacher are important elements in order to reach a solution to the problem.
Inquiry of information	Identifying gaps but avoiding inquiry	Identifying knowledge gaps without searching for information	I will look for information on teaching strategies used in the "Environmental Study". I will seek information about the purpose and objective of the particular content and the verbs that can be used (in the formulation of the objectives).
	Lack of inquisitiveness	Repeating information of the problem	All the necessary information for solving the problem is given in the text.
	Engaging in inquiry of information	Conducting inquiry by providing the information	Here is some necessary information that I need: https://www.tanea.gr/2008/04/25/greece/toksiko-aera-anapneoyn-6-ellinikes-poleis/ Manolis Voutirakis (Environmentalist): "The impact of pollution on human health" at www.ecocrete.gr

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