Effects of an inquiry-based science education training program on pre-service teachers. A mixed-methods case study

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Abstract

The purpose of this research is to evaluate the impact of a one-semester training program on the teaching profile of five pre-service secondary science teachers, following a case study that allows us to focus closely on their perceptions related to inquiry-based science education (IBSE). Through a mixed-methods analysis of a variety of qualitative and quantitative research instruments, we aim to identify the changes in the pre-service teachers' IBSE educational achievements in terms of their capability to effectively design inquiry activities, as well as in the perceptions affecting their teaching practice concerning emotions and self-efficacy. After a general overview of the results, we provide a specific vision for each participant, and present the conclusions regarding the acceptable level developed in both inquiry learning and teaching. Finally, we analyze the possible links between all the factors considered (perceptions, emotions, and design performance) and put forward several suggestions for professional development programs.

Keywords: inquiry-based science education, pre-service teacher training, case study research

INTRODUCTION

In recent years, inquiry-based science education (IBSE) has grown in importance since it began to form part of the majority of international policies and initiatives on science education as a way to promote scientific literacy (Sjøberg, 2019). The advantages associated with IBSE (Durando et al., 2019), in line with the principles of constructivism, envision, among other aspects, improving motivation and interest in learning (Marshall & Alston, 2014), decreasing the gender gap (Sjøberg, 2019), enhancing scientific vocations (Minner et al., 2010) and creating a lasting effect on attitudes towards science (Chen et al., 2014). Students participating in inquiry-based science learning (IBSL) are exposed to a series of student-centered methodologies that engage them in activities and processes comparable to those employed by research scientists, usually resolving real and contextualized problems (Heindl, 2018).

Successful inquiry-based education places far greater demands on the instructor than typical teacher-led and textbook-based curriculum coverage. One of the key aspects of high-quality inquiry is the teacher's engagement and guidance throughout the process. Implementing inquiry-based science teaching (IBST) in the classroom remains difficult since it necessitates a conceptual change in teaching, a shift towards more open positions, to the role of researcher, mentor, motivator, or, in short, a guide for the students (Crawford, 2014). This slow process imposes a series of constraints on the inquiry practice (real or perceived) and that, even in the pre-service teaching programs, influence the pedagogical decisions and strategies of future teachers (Binns & Popp, 2013), limiting their success. The different starting points of pre-service teachers should be considered in professional development programs (Tiberghien et al., 2018), and the support they are given should be adapted so that teachers acquire the confidence, knowledge, and teaching skills necessary to approach inquiry processes with the students.

In teachers' collective imagery, the inquiry process has been carried out in a recipe-like approach, with teachers providing precise, structured instructions to their students to follow the protocol, thus avoiding the formulation of questions, the planning of an experimental design or a discussion of the results, key aspects in scientific practices (Pérez & Furman, 2016).

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Contribution to the literature

- This study contributes to the existing literature about pre-service science teachers' (PSSTs) perceptions when approaching IBSE, combining, in an unprecedented way, the analysis of their cognitive and emotional profiles developed from the student and teacher roles.
- The uniqueness of the study relies on a mixed-methods approach using a variety of research instruments, offering an in-deep analysis of each of the PSSTs, regarding the initial and final perception of IBSE, as well as their emotions and the quality of the inquiry activities designed.
- Results show an increase in positive emotions during the inquiry-based science learning (student role), which vary from positive to negative during the IBST (teacher role), together with an acceptable development of the PSSTs in terms of IBSE skills, based on the quality of the inquiry activities designed.

This misconception highlights the need for efficient IBSE professional development programs that help teachers to transition to a group-based pedagogy or increase their engagement with science by developing critical thinking skills, gathering evidence, and promoting metacognition knowledge on how to self-regulate their learning processes. Given that most PSSTs have had a traditional, teacher-directed education, it is essential to identify the type of teaching and learning experiences that might effectively build inquiry-oriented instructors (Syer et al., 2013).

Efficiency in IBSE Professional Development Programs

During recent decades, a wide range of publications has focused on the impact of specific training programs (TPs) aimed at developing pre-service teachers' perceptions and practice of IBSE. A general review of the expressed PSST perceptions on IBSE and the impact of some demographic variables has recently been described by García-Ruiz et al. (2021). Regarding the TPs, for instance, Lotter et al. (2009) discussed the importance of incorporating multiple low-stakes practicum experiences, resulting in positive changes in PSST perceptions and practice of inquiry. Several authors orientated their teacher training proposals towards the better understanding of the inquiry processes and the phases included, such as the works by Herranen et al. (2019) and Rodríguez-Arteche and Martínez-Aznar (2016), who emphasized the difficulties PSSTs encounter when designing resolution strategies.

Interestingly, Suters et al. (2002) also explored the lasting effectiveness of an inquiry-based research course through a three-year longitudinal study, accentuating the importance of reflection to modulate the PSST practice towards inquiry-friendly methodologies.

However, although there are diverse educational strategies to support teachers in the better implementation of IBSE activities, our knowledge about teachers' experiences during their learning is still limited, and the identities they develop through this process are mainly unknown (Gormally, 2016). The whole grouping of difficulties identified by the PSSTs about IBSE regarding personal understandings and perceptions (Akuma & Callaghan, 2019) shows the need for specific IBSE development programs for PSSTs to guarantee its success through the enhancement of their inquiry teaching competence (Nicol, 2021). However, although numerous studies have already addressed specific professional development programs, most of them obviated the PSSTs' beliefs and emotions, and their real needs when practicing it (Tseng et al., 2013) despite the fact that challenges such as curriculum management, class size and tensions over the teacher's role during the inquiry process are widely described in the literature (Anderson, 2002).

Moreover, PSSTs training methods usually focus on direct instruction on pedagogical information or abilities, causing issues comparable to those seen with scientific content knowledge, such as impersonality, low motivation, and a mismatch between theory and practice. Also, some authors point out that teachers' views on what is appropriate or not are more effective in guiding teacher practice than educational theories, showing the inefficiency of direct instruction in transferring pedagogical knowledge unless PSSTs accept the knowledge intrinsically (Wang & Buck, 2016).

To become an efficient inquiry teacher, we should also consider the backgrounds of individual PSSTs. For instance, PSSTs with significant professional research experience tend to have a more open and guided inquiry practice (Windschitl, 2003). Hence, the success of inquiry teaching requires teachers to understand the nature of the process itself, integrating scientific inquiry and how students incorporate these processes (Lotter et al., 2006).

All these factors, together with the long time needed to convince PSSTs to adopt an inquiry approach and gain both the competencies and favorable attitudes towards it, makes the process of teacher preparation a real challenge for PSSTs educators (Sizer et al., 2021).

Consequently, to achieve success in the iterative process of teacher education, one central strategy is to involve PSSTs in inquiry activities with meaningful questions generated from their own experiences to develop a whole and grounded understanding of how scientists study the natural world and the ideas they form in the process (Constantinou et al., 2018). To do so, different authors recommend engaging PSSTs in the use

Figure 1. Structure & goals of TP (Constantinou et al., 2018).

of questioning strategies, the planning of the degree of scaffolding, the guiding of appropriate discussions or the designing of formative assessment methods, among others (Barrow, 2006).

Significance of the Study

Following this framework, the purpose of this research is to examine the influence of a medium-term IBSE TP outlined for pre-service secondary science teachers (PSSTs), from both their emotional and cognitive profiles.

Considering how previous research on the development of IBSE TPs mainly focus on the promotion of inquiry through an enactment of the nature of the science, but completely ignores the emotional profile of PSSTs regarding their learning, our goals focus on the analysis of the perceptions of the PSSTs before and after the TP, describing the relationship between those perceptions and the emotions associated with the inquiry processes, and analyzing the capability of designing inquiry teaching proposals. In accordance with the stated objectives, we pose the following research questions:

1. How do the perceptions of the PSSTs regarding IBSE change before and after the TP?
2. What emotions are expressed by the PSSTs when performing IBSE in the role of student or teacher during the TP?
3. How does the IBSE TP reflect on the development of the PSSTs' inquiry designed proposals?
4. What is the relationship (if any) between the perceptions, emotions and the level of the inquiry teaching proposals elaborated by the PSSTs?

STUDY CONTEXT AND DESIGN

Setting of the Study: The Inquiry-Based Training Program

As part of this research project, we designed a TP to promote PSSTs' understanding and implementation of inquiry-based teaching practices, integrate instruction in pedagogical content knowledge about IBSE, support the design and implementation of IBSE activities and encourage their transfer into practice. A pilot study was carried out during the 2018-2019 academic year. Based on an analysis and evaluation of the pilot study, we improved the TP for the 2019-2020 academic year. A total of six stages of 90 minutes each took place.

Figure 1 reflects those teaching skills, which are essential in order to organize and facilitate inquiry-oriented learning processes, and their relationship with the different stages of the proposal. The design and contents included in the TP and some aspects of their contribution to professional development are described in more depth in García-Ruiz et al. (2020a).

The definition and interpretation of what is considered inquiry in science is critical (Mesci et al., 2020) not only for the development of the TP but also to satisfy the fundamental principles of the design of teaching activities and approach how scientists investigate the natural world and the ideas developed during the process. Hence, the first stage addressed this question primarily, although it continues to be approached throughout the TP.

Other teaching capacities relate to the difficulties associated with both the students' learning and the preparation of an ingenious and planned scaffolding. In this regard, it is essential to involve PSSTs in exemplifications that facilitate understanding both the role of the students and the role of the teachers in the inquiry process.

Consequently, stages 2 and 4 highlight the differences between carrying out a structured inquiry (in which the teacher poses the research question and the procedure), a guided inquiry (in which the teacher proposes the research question, and the students carry out the procedure, providing a final response or explanation) and an open inquiry (in which students are responsible for all the inquiry phases).

The third stage focuses on curricular skills and teaching practice, while stage five focuses on the design and evaluation of inquiry activities and provides a variety of tools and examples to undertake this. Finally, stage six centers on teacher self-efficacy which often refers to both the use of educational strategies and classroom management and the motivation or enthusiasm for teaching (Constantinou et al., 2018).

Table 1. Participants' profile

PSST	Gender	Age	Degree	Prior research	Prior teaching
1	Female	25-30	Physics	PhD*	Private tutoring
2	Male	>30	Environmental science	None	None
3	Male	>30	Industrial engineering	None	Higher education**
4	Male	<25	Environmental science	None	None
5	Female	>30	Chemical engineering	None	Private tutoring

Note. *PSST1 was the only participant holding a PhD in Physics, obtained just before enrolling in the MEd & **PSST3 had teaching experience in higher education, specifically in the teaching of industrial & mechanical engineering degree courses

Methodology

We conducted a case study based on quantitative and qualitative analyses (mixed-methods) that provide us with a better understanding of the focus of this study and allow us to triangulate data effectively (Creswell & Plano Clark, 2017). The exploratory research we present, consisting of five cases, aims to offer an enriched exploration of their inquiry-based teaching perceptions and future implementation.

Participants and researchers

Five PSSTs participated in this study at the University of Málaga. All were enrolled during the 2019-2020 academic year in the master's degree in secondary education (MEd), in the specialty of physics and chemistry, a prerequisite for teaching in secondary schools in Spain. The five participants constitute a selected sample of the nineteen PSSTs enrolled in the MEd and were chosen based on the diversity of their previous teaching and research background, as well as their gender and age. Given that this is essentially a convenience sample, we recognize that it is not representative of all PSSTs, a factor which limits our study.

Each of the participants held a bachelor's or a master's degree in either science or engineering. Although they had different levels of teaching and research experience, none of them had professionally taught in secondary education when the results were collected. It should be noted that none of the PSSTs had previous experience with the IBSE before the training. More detailed information regarding their characterization is provided in **Table 1**.

The main researcher, who also acted as science education teacher and conductor of the TP, had a PhD in Chemistry, with ten years of professional science research experience and was doing a second PhD in Science Education. This present study was part of this researcher's dissertation project. The researcher worked collaboratively with the other two science education teachers, co-authors of this article, who have a dilated experience in the field and who contributed to creating the IBSE TP and analyzing the results.

Research instruments and data collection

We initially applied a variety of instruments to collect relevant data. Thus, to analyze the perceptions and emotional profile of the PSSTs and their evolution through the TP, we applied two types of questionnaires. Firstly, we applied a four-point Likert-type questionnaire (1: totally disagree; 2: disagree; 3: agree, and 4: totally agree) about pre-service science teachers' perceptions on IBSE (pre- and post-tests), adapted from the validated PRIMAS project (Engeln et al., 2013) by reformulating the questions for PSSTs, adapting the verb tenses to reflect the intention concerning their future teaching practice (**Appendix A**).

The questionnaire consisted of 28 items, written in a combined positive and negative way and structured in three main dimensions: the teaching-learning process of inquiry (I1-I8) (which considered aspects such as interaction in the classroom, experimental activities or the importance of inquiry), the inquiry approach (I9-I16) (which included questions related to the connections between IBST and student motivation, the dependence on the student's initial knowledge or the contribution to scientific competencies development), and the difficulties associated with its implementation (I17-I28) (such as resources, classroom management and educational system restrictions) (García-Ruiz et al., 2021). Since this adapted and translated version of the questionnaire has not been validated yet, we performed the analysis item by item, grouping them into categories according to the original PRIMAS questionnaire (Engeln et al., 2013).

Secondly, the emotions questionnaires were designed *ad hoc* to assess the emotions experienced by the PSSTs during the TP (García-Ruiz et al., 2020b). While emotions questionnaire 1 referred to the emotions associated with the stages of the inquiry process (A-H), as described in the work of Jiménez-Liso et al. (2019) (**Figure 2**), the second emotions questionnaire (**Figure 3**), adapted from Ferrés-Gurt et al. (2015), referred to the emotions associated with the stages of the design of the inquiry activities (I-P). Both of them included achievement (confidence, satisfaction, shame, and dissatisfaction) and epistemic emotions (interest, concentration, boredom, rejection, and insecurity), and PSSTs could choose more than one emotion per stage.
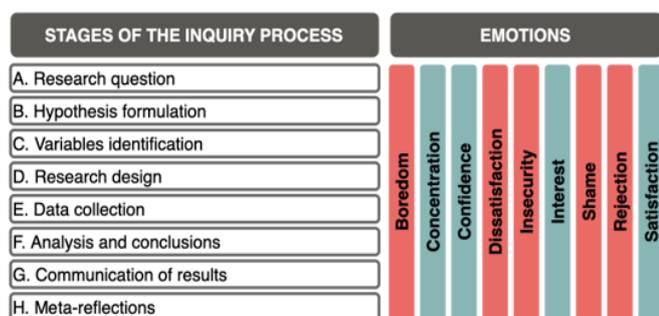
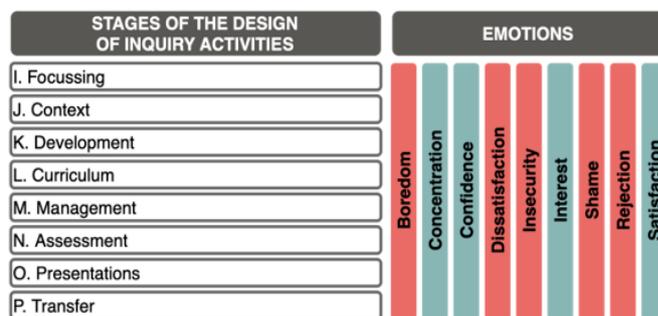**Figure 2.** Emotions questionnaire 1 (Source: Self-designed using www.draw.io)

Figure 3. Emotions questionnaire 2 (Source: Self-designed using www.draw.io)
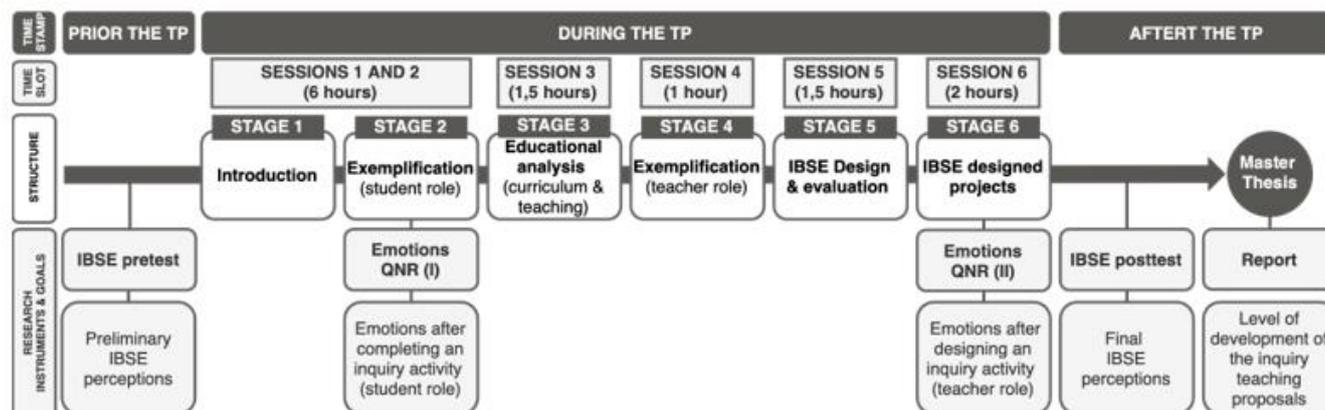

Figure 4. Timeline of the TP and the research instruments involved (Source: Self-designed using www.draw.io)

Finally, we decided to analyze the quality of the PSSTs' inquiry designed proposals, contained in their master's thesis (MT) reports. These reports summarize the training acquired during the MEd and reflect the application and development of the associated knowledge and skills. As such, they describe what PSSTs have learned and applied during their teaching practices in educational centers. They are considered works which contain a reflection, an evaluation, and suggestions for improvement of the teaching practice carried out, and which include the following aspects:

1. a contextualizing framework of the teaching profession,
2. the design and foundation of a project or work plan that reflects the competencies of the teaching specialty studied, and
3. a critical reflection on the implementation in practice of the designed project and personal conclusions.

Nevertheless, due to the COVID-19 situation during the spring of 2020, these PSSTs could not apply their original teaching proposals (not even in a virtual scenario). Hence, in the qualitative analysis of the MT reports, we will refer to the original proposal and the adaptation to a virtual scenario, but with no data on the result of the implementation. Although these reports do not necessarily focus on the IBSE, students who implemented it during their teaching practices usually include their approach to the IBSE in all aspects of the reports.

To gain insight into the research context, **Figure 4** depicts the chronological sequence of the TP (12 hours through six sessions) in conjunction with the research instruments employed during the study.

We conducted the study during the second semester of the MEd in the 2019-2020 academic year. To better understand and monitor the impact of the TP on the five PSSTs, data were collected at different moments, selected according to the IBSE learning moment they were enrolled in (prior to the TP, to identify what they initially perceived as IBSE; during the TP, to reflect about the emotions experienced; and after the TP, to analyze any changes in their initial perceptions, and to determine the level of development of the designed teaching proposals).

Data analysis

According to the research questions and the TP developed, three dimensions of analysis emerged: perceptions about IBSE, emotions expressed when performing IBSE from the student and teacher roles, and the level of development of the inquiry designed proposals elaborated by the PSSTs in their MT. Therefore, we performed the corresponding quantitative and qualitative analysis for each category according to the data type.

The use of multiple data sources and researchers ensured rigor in the analysis, enhancing the validity of our research through the triangulation process (Creswell & Plano Clark, 2017).

To ensure the reliability of the study and minimize any possible errors and biases in the study, we followed the recommendation by Yin (2003), making as many steps as operational as possible. Thus, throughout our research, we revised all data analyses and met periodically to discuss emerging themes and interpretations.

We performed our quantitative descriptive study using RStudio software (version 1.3.1093). For the IBSE pre/post comparison, we proceeded item by item, since the adapted version to PSSTs from the original PRIMAS questionnaire (Engeln et al., 2013) has not yet been validated. We considered each item's positive and negative sense, estimating the difference between the post-score and the pre-score to gain insight into the evolution of PSSTs regarding their perception of IBSE.

For the emotions questionnaires analysis (both in the role of student and teacher), we collected the frequencies of emotions and their percentage representation, and provided the emotions gain regarding the positive and negative balance, per participant and step.

In order to investigate the designed IBSE proposal for secondary education classrooms, we performed a qualitative analysis of the MT reports. These reports should reflect the actual implementation accomplished during the participants' period of teaching practice. However, due to the COVID-19 situation, the PSSTs did not apply their original teaching proposals. Consequently, we have analyzed the level of development of the original proposals and the possible adaptation to the virtual scenario dually.

First, we analyzed the number of mentions of the word "inquiry" and those closely related to it (for instance, group words like scientific research, investigation, indignation, scientific work or experimental practice and their possible variations were considered) within the main structure the PSSTs should follow when writing their reports (Cebrián-Robles et al., 2018). This well-stablished structure includes title, abstract, theoretical background, design, critical reflection, and literature references.

Having gained an insight into the weight of the inquiry in their designs, we then looked for the distribution of those mentions in terms of the training received during the TP, which included aspects related to the introduction, curriculum, methods, and assessment of IBSE. We considered that the inclusion of these IBSE features acquired during the TP would be an indicator, together to the number of mentions, of the level of development of the teaching proposals designed by the PSSTs in their MT.

Consequently, we assigned different levels of development, considering both analysis: level 1, for those PSSTs who infrequently included IBSE in their design and their theoretical background; level 2, for those PSSTs who frequently mentioned IBSE in their design, but not in the rationale, and level 3, for those PSSTs who frequently mentioned IBSE in their design and provided a proper rationale in the theoretical background.

All the data were previously selected, coded into coding units and then grouped into broader categories (Saldaña, 2009). Researchers negotiated the coding consensus, completing the content analysis in three phases using ATLAS.ti software (version 8.4.4) and organizing the reflections according to the dimensions and codes specified in each corresponding table of results.

RESULTS

To structure the results of this study, we will follow the previous categorization explained in the data analysis (IBSE perceptions, emotions, and level of development of the inquiry teaching proposals designed), presenting a general overview of the group of five teachers and reviewing the possible similarities or differences among cases. Finally, we will develop an in-depth individual analysis of all the categories for each particular PSST, providing a broad understanding of the effects of the TP.

General Results on the Perceptions About IBSE

We looked at some aspects related to the teaching-learning process of inquiry (items I1-I8), the inquiry approach (items I9-I16) or the difficulties associated with its implementation (items I17-I28).

Figure 5 shows the difference stated for each participant in terms of total gain per item (in green, positive evolution; in red, negative evolution) as well as the whole pretest and posttest profiles in terms of the score given to each item (dotted and black lines, respectively).

Although all the participants exhibited a very similar profile, PSST1 and PSST4 scored higher in the pretest, meaning they started the TP with a very favorable view. However, they also experienced a lower gain after completing the TP, this being particularly obvious with PSST4 who negatively changed the perception of the difficulties when implementing IBSE. On the contrary, although PSST2, PSST3, and PSST5 depicted a lower pretest profile, they also experienced a significant total gain in their IBSE perceptions throughout the three main categories (teaching-learning process, inquiry approach and difficulties), with PSST2 being the one who most evolved after completing the TP.
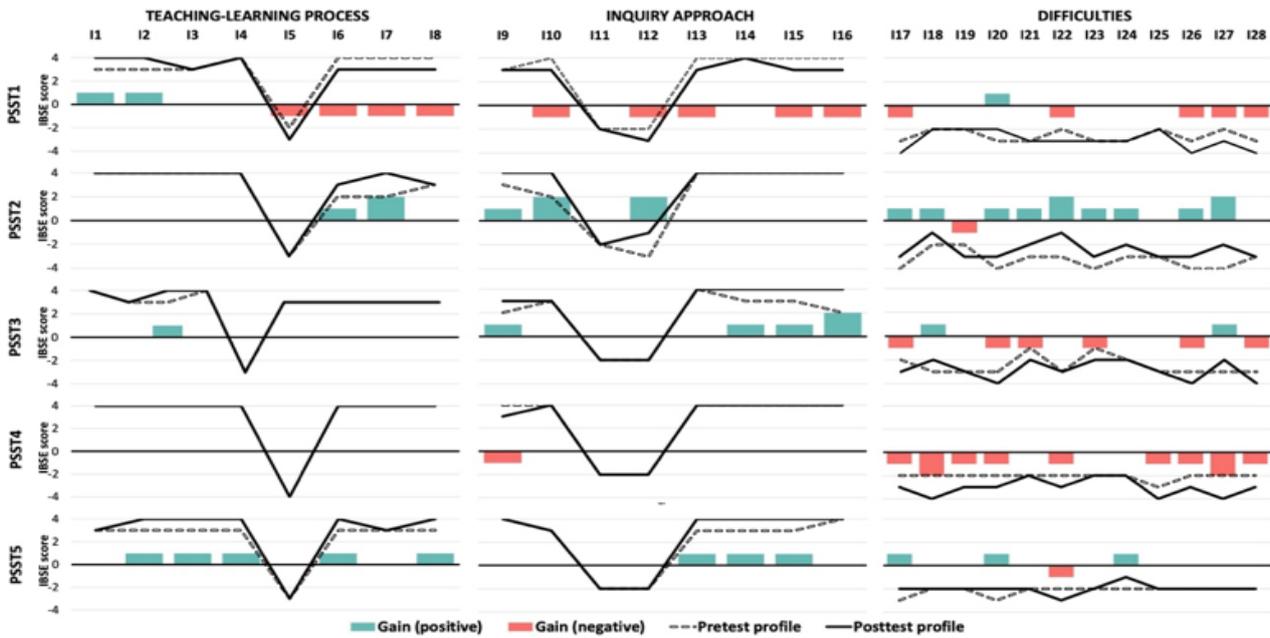
Figure 5. Comparison of the pre/post IBSE profile and total gain (positive/negative) (Source: Self-designed using www.draw.io)
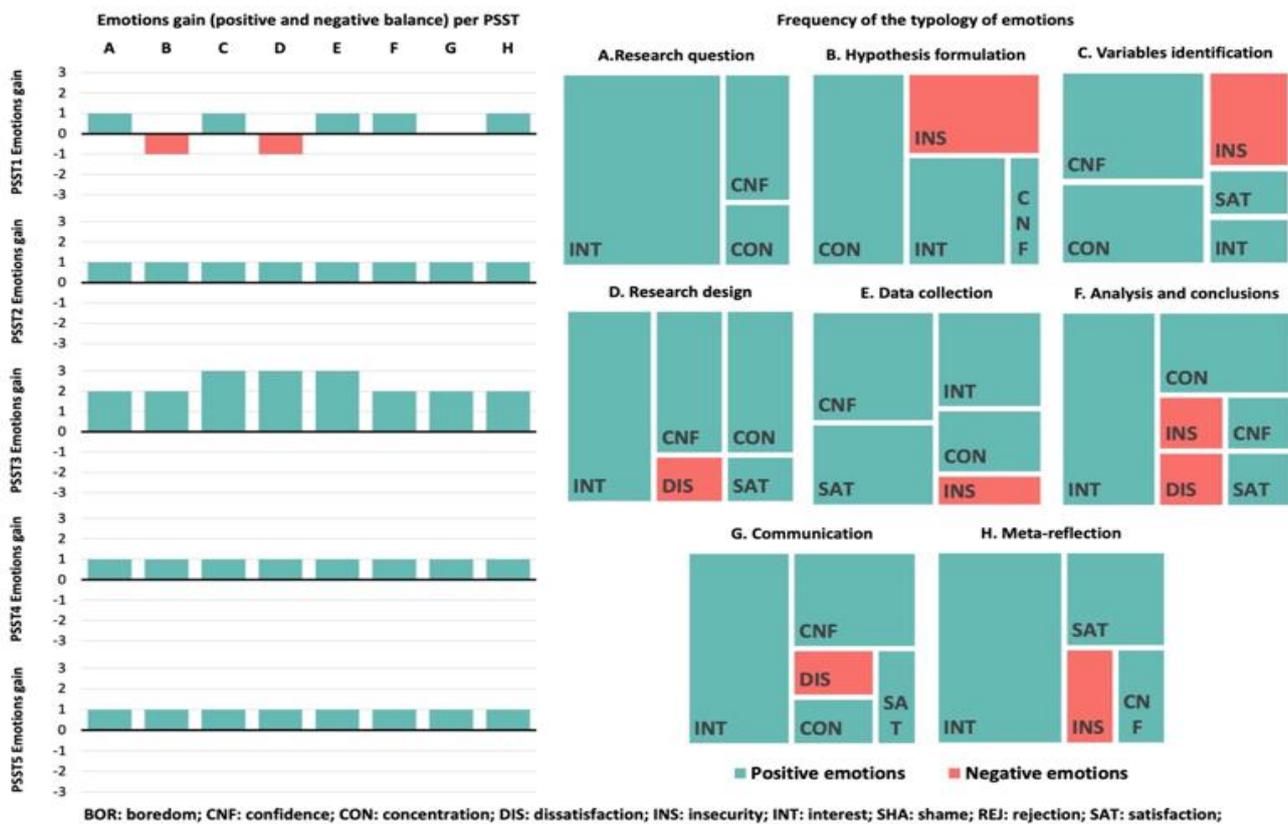

Figure 6. Emotions profile in the student role (Source: Self-designed using www.draw.io)

General Results Regarding the Emotions Expressed by the PSSTs During the TP

With reference to the emotional profile when performing the student role, **Figure 6** shows the emotions gain regarding positive and negative balance, per participant and step. Except in the case of PSST1, who experienced a negative gain in steps related to the hypothesis formulation and the research design, the balance for the rest of the PSSTs was positive. When considering the frequency of the typology of emotions per step, most of them are positive, with *insecurity* being the most repeated negative emotion, showing a percentage of less than 25% in steps B, C, E, F, and H.
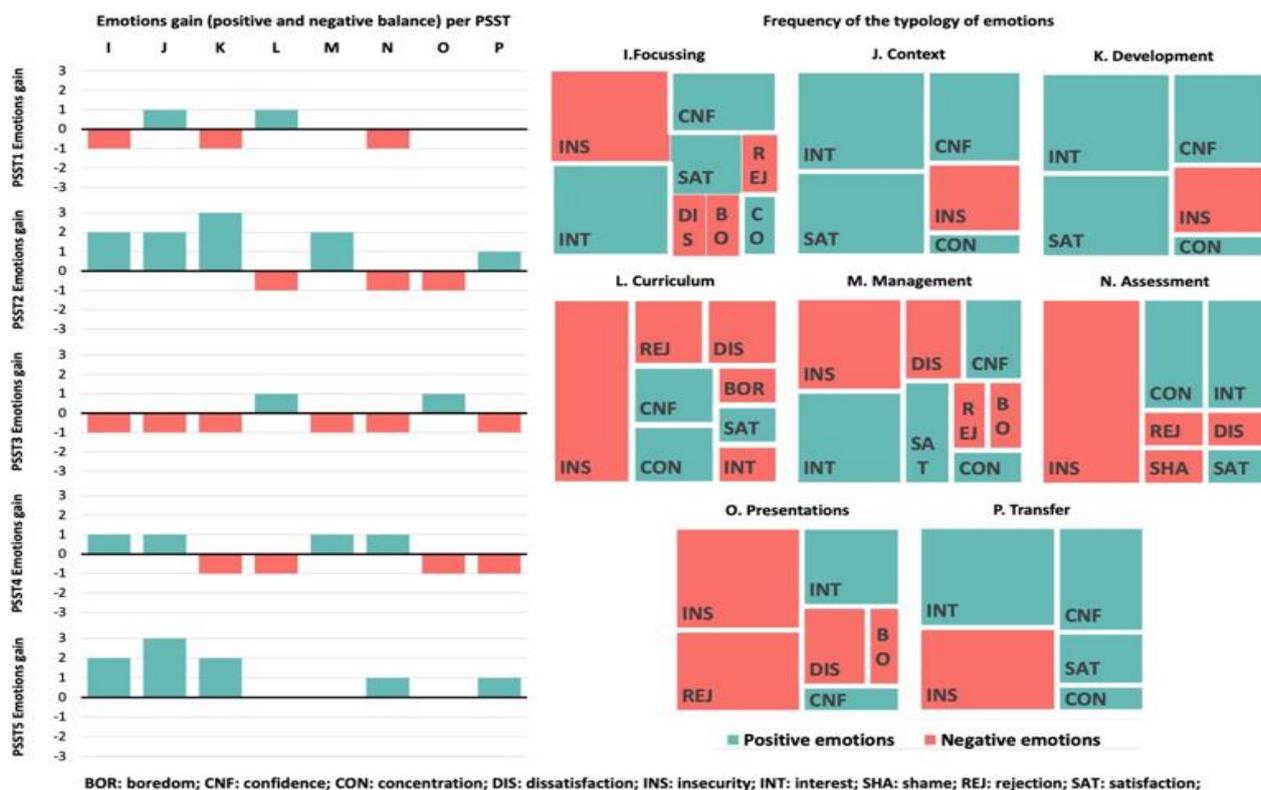
Figure 7. Emotions profile in the teacher role (Source: Self-designed using www.draw.io)

Table 2. Frequency of mentions of "inquiry" per PSSTs according to the MT structure

MT structure codes	PSST					Total per category
	1	2	3	4	5	
Title	1	1	0	0	0	2
Abstract	1	1	1	0	1	4
Theoretical background	5	10	1	0	5	21
Design						
Original project (face-to-face scenario)	13	18	20	11	5	67
Development and evaluation	16	2	25	8	13	64
New proposal (virtual scenario)	8	30	8	1	4	51
Critical reflection	2	1	0	0	0	3
Literature references about IBSE	5	3	2	0	0	10
Total per PSST	52	67	58	21	29	227

On performing the teacher role, **Figure 7** shows the emotions gain regarding positive and negative balance, per participant and step. The whole picture is quite different from the inquiry process, with a significant influence of negative emotions in all the steps considered. Once again, *insecurity* is the most selected negative emotion with a frequency of between 45% and 25%. PSST5 was the only participant with a positive global balance.

General Results Regarding the Level of Development of the Inquiry Designed Teaching Proposals

According to the data analysis explained, **Table 2** shows the frequency of mentions of the word "inquiry" and those closely related to it by structure feature and participant.

In total, participants included up to 227 mentions in their MT reports, mainly concerning the original project (67), development and evaluation (64) and the new proposal (51), which was included because of the adaptation to the virtual scenario due to the COVID-19 situation.

On the one hand, PSST1, PSST2, and PSST3 included the greatest number of mentions (over 50). On the other hand, PSST4 and PSST5 inserted less than 30 mentions.

Regarding the inclusion of the IBSE features acquired during the TP in the MT, **Table 3** shows the frequency for each feature and participant.

Once again, as expected, we observe the same participant distribution as stated before (PSST1, PSST2, and PSST3 vs PSST4 and PSST5). However, there is a marked difference between PSST4, who included 20 features, and PSST5, who included just nine.

Table 3. Frequency of codes analyzed according to the IBSE training received

Features of IBSE codes		PSST					Total per category
		1	2	3	4	5	
INTRODUCTION	Definition of IBSE	1	1	1	0	0	3
	Relevance						
	Benefits	5	4	1	2	1	13
	Difficulties	0	1	0	0	0	1
	Forms and dimensions						
	Phases	1	1	0	0	0	2
	Cyclic character	1	0	0	0	0	1
	Scaffolding level	1	1	1	1	0	4
CURR.	Goals and competencies						
	Teaching objectives	2	1	1	0	0	4
	Competencies development						
	Key competencies	2	4	5	4	0	15
	PISA dimensions	3	2	3	3	0	11
METHODS	Design principles						
	Constructivism	0	1	1	0	0	2
	Context-based learning	1	1	1	1	0	4
	Cooperative learning	1	1	1	1	1	5
	Implementation						
	Research problem intro	1	1	1	1	1	5
	Research question	1	1	0	0	1	3
	Hypothesis	0	1	1	0	1	3
	Variables	1	1	1	1	0	4
	Research planning	1	1	1	1	1	5
	Data collection	1	1	1	1	1	5
	Data analysis	1	1	1	1	0	4
	Conclusions	1	1	1	1	1	5
	Communication	1	1	0	0	0	2
	Meta-reflection	0	1	1	0	0	2
ASSMT.	Assessment processes	1	0	0	1	0	2
	Assessment criteria	1	1	1	1	1	5
	Instruments	2	2	2	2	1	9
	Total per PSST	30	31	26	22	10	119

In the introduction features, it is notable that PSST1 and PSST2 were the only ones who considered the phases of inquiry, and only PSST1 referred to its cyclic character. These two participants also covered the greatest number of benefits, with PSST2 being the only participant mentioning associated difficulties. Four of the PSSTs also described the scaffolding level of their designs, selecting a guided inquiry.

The curriculum features were more equally distributed, except for PSST5 who did not include any mention of the teaching objective or contribution to competency development. In methods, we first look at some of the principles of IBSE, with all PSSTs establishing cooperative learning, four also considering context-based learning, and just two (PSST2 and PSST3) talking about constructivism. We then focus on implementation, analyzing whether the design included all of the inquiry steps. In this part, we found some difficulties when posing the research questions or the hypothesis, with only three participants mentioning it. Also, just two out of five PSSTs explained how to approach the communication and meta-reflection steps.

Finally, only PSST1 and PSST4 described general consideration when discussing IBSE assessment, referring specifically to the processes (self-evaluation, co-evaluation, and hetero-evaluation). The remaining participants just explained the criteria and instruments they would use. In all the cases, PSSTs referred to a summative assessment since they just mentioned the students' results rather than emphasizing the teaching-learning process.

Looking closely at the number of mentions and the number of features included by each participant, we could see a clear differentiation, which might provide evidence of the importance given to IBSE for its future implementation in secondary education classrooms. For instance, in level 1, we placed those PSSTs who infrequently included IBSE in their design and their theoretical background (PSST4 and PSST5), followed by PSST3, who frequently mentioned IBSE in his design, but not in the rationale (level 2). Finally, in level 3, we included those PSSTs who frequently mentioned IBSE in their design and provided a proper rationale in the theoretical background (PSST1 and PSST2).

Figure 8. Summary of results for PSST1 (Source: Self-designed using www.draw.io)

Figure 9. Summary of results for PSST2 (Source: Self-designed using www.draw.io)

Analysis Per Participant

PSST1

PSST1 was one of the two youngest participants (under 30 years old). She was also the only one with research experience, holding a PhD in physics, and had previous non-professional teaching experience as a private tutor.

This participant, who selected the sports context in her MT report, scored highest in the IBSE pretest, meaning she had a very favorable perception towards the inquiry, which might be in accordance with her previous research background. However, after completing the TP, she experienced some concerns, especially related to students' autonomy and the scaffolding level during the inquiry (I5-I8) or the contribution of IBSE to promote scientific competencies (I15-I16) (**Figure 5**). She also expressed some difficulties related to classroom management and the lack of time (I26-I28).

With regards her emotional profile in the student role (**Figure 6**), she experienced some negative emotions (insecurity) related to the hypothesis formulation. In fact, despite her MT being the most complete of all the five participants, she omitted this step in her proposal. She also experienced some insecurity during the teaching role, when focusing, developing the design, and approaching the assessment of her proposal (**Figure 7**).

In her MT, PSST1 recognized the greatest number of benefits (five) when doing IBSE (**Table 3**), such as the promotion of argumentation and skills, critical thinking, and the motivation towards science.

A summary of her results is depicted in **Figure 8**. Although she ended with a lower IBSE perception, on balance she achieved a high inquiry development (level 3) in the design of the IBSE proposal.

PSST2

This participant was a male over 30 years old, holding a degree in environmental science and with no previous research or teaching experience. His IBSE initial profile was very similar to PSST1. He also expressed a clear preference for the use of real-life contexts, which he demonstrated in his choice of products of daily use (such as the making of soap) in his inquiry proposal. His IBSE

pretest profile was also quite favorable (**Figure 5**). Moreover, he ended the TP with a significant positive change towards it which was particularly notable in the aspects related to the contribution of IBSE to students' motivation or learning problems (I9-I10). Also, after the TP, he expressed more confidence in the contribution of IBSE to the acquisition of scientific attitudes and values towards science (I12). However, maybe the most relevant change involved the difficulties (I17-I28), where there is a positive global balance for each item, except for the time required item (I19).

His first emotional profile exhibited a total positive balance for all the inquiry steps. In fact, he was the only participant who included all of them in his design proposal (**Figure 6**). Nevertheless, the second emotional profile (**Figure 7**), although exhibiting quite a positive balance, showed some concerns in the different steps compared to PSST1. For instance, PSST2 expressed some insecurity when adapting his design to the curriculum or considering the assessment of his proposal. Also, he experienced rejection when presenting his keynote in the teacher role.

PSST2 included the greatest number of references (67) in his MT (**Table 2**), considering almost all the features in his report. Satisfyingly, after the TP, in his MT he also agreed that IBSE contributes to content knowledge, the development of critical thinking and the acquisition of inquiry skills.

To sum up, in addition to a higher IBSE perception after the TP, on balance we found a high development profile (level 3) in the design of the proposal (**Figure 9**).

PSST3

This participant was the only one with professional teaching experience, although in higher education. Although the evolution of his IBSE perceptions during the TP was rather statical, at the end of the TP it showed a very poor balance in the part related to difficulties (I17-I28) (**Figure 5**).

With respect to emotion questionnaire 1 (**Figure 6**), he experienced a highly positive balance for each step, in contrast to the second questionnaire (**Figure 7**), in which insecurity determined almost every phase (except for the curriculum and the presentation).

In accordance with the number of mentions of inquiry in his MT (58) and the features included (**Table**

IBSE perception*	Emotions		Inquiry teaching proposals (Level of development)	
	IBSL	IBST	Structure	Features
+2	+19	-4	58	26
Moderate	Positive	Negative	Level 2	

*Total gain in the pre/post comparison

Figure 10. Summary of results for PSST3 (Source: Self-designed using www.draw.io)

IBSE perception*	Emotions		Inquiry teaching proposals (Level of development	
	IBSL	IBST	Structure	Features
-12	+8	0	21	22
Lower	Positive	Neutral	Level 1	

*Total gain in the pre/post comparison

Figure 11. Summary of results for PSST4 (Source: Self-designed using www.draw.io)

2 and **Table 3**), PSST3 developed quite an acceptable level in his inquiry teaching proposal. For instance, he considered just one significant benefit in his proposal (contribution to content knowledge) and omitted some fundamental steps when implementing IBSE, such as posing the research question or communicating the results.

Thus, in conclusion, PSST3 exhibited a moderate IBSE perception after the TP and a general moderate inquiry development (level 2) in the design of IBSE activities (**Figure 10**).

PSST4

PSST4 was the youngest participant (less than 25 years old) and shared common aspects with PSST2, such as having a degree in environmental science and a lack of research or teaching experience. His results resemble PSST3, and like him, his IBSE perception evolution was entirely statical (**Figure 5**), except for the difficulties, which were much worse after the TP, especially concerning student's attitudes and the time required factor. Again, this participant experienced only positive emotions when tackling the inquiry steps (**Figure 6**), but insecurity when going through the development and transfer of his proposal, the application of the curriculum or the presentation (**Figure 7**).

PSST4 included a considerably lower number of mentions of inquiry in his report (21) (**Table 2**). Thus, he forgot some key features, such as the definition of IBSE, phases, or relation with the didactic objectives. Also, his design did not include any mention of the posing of the research question, the formulation of the hypothesis, communication, or meta-reflection. Consequently, he was classified into level 1. In short, PSST4 shared with PSST1 his lower final perception of IBSE, also exhibiting a poor inquiry level in the design of IBSE activities (**Figure 11**).

IBSE perception*	Emotions		Inquiry teaching proposals (Level of development	
	IBSL	IBST	Structure	Features
+10	+8	+9	29	10
Higher	Positive	Positive	Level 1	

*Total gain in the pre/post comparison

Figure 12. Summary of results for PSST5 (Source: Self-designed using www.draw.io)

PSST5

PSST5 was the second engineering graduate of the group, as was PSST3. This woman over 30 years old had no prior research experience but some teaching practice as a private tutor. Her IBSE profile changed moderately after the TP in all the categories (**Figure 5**), particularly in some aspects regarding the dynamic of the teaching-learning process (I2-I3, I6, and I8), the contribution to autonomy or scientific attitudes (I14-I16). Her only negative balance in the difficulties categories was related to the belief that IBSE is not included in textbooks (I22).

Her emotional profile was positive in both questionnaires (**Figure 6** and **Figure 7**), meaning she did not experience great concern when applying inquiry or designing her proposal. She identified just one benefit in her design proposal and her lack of knowledge about IBSE is also reflected in the number of mentions in her MT report (29), especially the key features included, with just nine of them, which corresponded to level 1 in this category (**Table 2** and **Table 3**). Lastly, as depicted in **Figure 12**, PSST5 showed a higher IBSE perception after the TP but exhibited a poor level in the design of IBSE activities.

DISCUSSION

In this study, we have shown how PSSTs changed their perception and emotions about IBSE after completing a TP, also exploring the level of development of the inquiry teaching proposals designed and included in their MT reports. Unfortunately, although the COVID-19 situation did not allow us to explore the transfer of these designs into practice, we decided to analyze the degree of achievement in incorporating all the key features of IBSE approached during the TP. Since PSSTs require several opportunities to practice a method of instruction and immersion in a society that values the practical aspects (Cian et al., 2017), our discussion will use our findings to provide an opportunity to progress in the practical aspects.

Research Question 1. How Do the Perceptions of the PSSTs Regarding IBSE Change Before and After the TP?

Related to the perception of IBSE, despite the previous level being quite acceptable in all the

Figure 13. Summary of results (Source: Self-designed using www.draw.io)

categories, the TP had a negative influence in PSST1 and PSST4, positive in PSST2 and PSST5 and moderate in PSST3. Although we cannot see any particular pattern, we do observe that, for all the participants, the perception of the difficulties of the IBSE implementation after the TP was less favorable. This might mean that although they have indeed understood the essence of inquiry, they are more concerned about their lack of experience (Tseng et al., 2013).

Research Question 2. What Emotions are Expressed by the PSSTs When Performing IBSE in the Role of Student or Teacher During the TP?

On the other hand, when considering the emotional profile, we differentiate two separate tendencies. Thus, we find the emotions experienced in task 1 favorable, when PSSTs took on the role of students (IBSL) and which correlated with an increase in positive emotions towards learning. Nevertheless, the emotions related to task 2, where PSSTs were in the role of teachers (IBST), and which vary from positive to negative, were not predictable and had no relationship to the degree of development and the levels of quality observed. This result might also be described by Smit et al. (2021), who observed how PSSTs emotions became more negative over time within an instructional course. More specifically, the emotional profile exhibited during the TP, although with some insecurity in complex design steps (such as the curriculum application, management, or assessment), was quite positive, and it might have contributed to the final inclusion of inquiry teaching in the secondary education classroom.

Research Question 3. How Does the IBSE TP Reflect on the Development of the PSSTs' Inquiry Designed Proposals?

Again, we found a somewhat acceptable development of the PSSTs during the TP. All the participants included an inquiry activity into their MT, and three of them designed it appropriately, including key features in their proposal.

Research Question 4. What is the Relationship Between the Perceptions, Emotions, and the Level of the Inquiry Teaching Proposals Elaborated by the PSSTs?

As a way of summarizing all the results and analyzing possible relationships, **Figure 13** represents the performance of each PSSTs for all the data sources considered.

When considering the change in IBSE perception, we do not find any relationship. On the contrary, for instance, PSST5, who developed a poor IBSE design, exhibited a more remarkable IBSE perception change and was highly favorable towards this approach. However, PSST1, whose perception ended up in a lower level, presented a proper level of development in her inquiry teaching proposal. These results must be taken with caution since the literature widely describes the influence of previous perceptions in the final IBSE teaching performance (Akuma & Callaghan, 2019).

This tendency towards a lack of relationship also manifests itself when considering emotions. The positive emotions experienced either in their roles as students or as teachers do not necessarily imply a more favorable IBSE perception or better inquiry teaching designs. Taken together, these results may highlight the necessity for more extended learning and practice time to incorporate the educational change in teaching required when practicing IBSE, although, in general, the performance was highly satisfactory for at least three of the four participants.

CONCLUSIONS AND IMPLICATION

The findings of this study lead us to make the following conclusions which should be considered with caution due to the reduced number of participants in this case study, and which should not be extrapolated to other contexts. Concerning this, we have considered validating the results in the near future since the TP has repeatedly been implemented in the last few years. In general, the IBSE TP applied contributed considerably to developing the IBSE skills of the PSSTs, a conclusion supported by the emotional profiles exhibited during these processes, with a positive balance in the learning process, a variable profile in the teaching process and an acceptable performance in IBSE activities designed leading us to consider the short-term training successful.

However, as shown throughout the study, and despite the fact that PSSTs enacted inquiry during the TP, the small differences in pre-and posttest results when measuring the IBSE perceptions made us reconsider how complex it is for the pre-service teacher to undertake this conceptual change. To face this challenge and considering the very unusual scenario these participants encountered due to the COVID-19 situation which ruled out any possibility of real high-school teaching practice, we consider several

improvements. On the one hand, we found it necessary to delve deeper into the inquiry teaching strategies, review the design and implementation processes, and ensure that the IBSE activities reflect all the concepts the PSSTs have already incorporated. On the other hand, the support provided by experienced inquiry teachers might prove a useful contribution, in which they could act as mentors achieving real experiences and enhancing the self-efficacy that the PSSTs demand for inquiry teaching.

REFERENCES

Akuma, F. V., & Callaghan, R. (2019). A systematic review characterizing and clarifying intrinsic teaching challenges linked to inquiry-based practical work. *Journal of Research in Science Teaching, 56*, 619-648. https://doi.org/10.1002/tea.21516

Anderson, R. D. (2002). Reforming science teaching: what research says about inquiry. *Journal of Science Teacher Education, 13*, 1-12. https://doi.org/10.1023/A:1015171124982

Barrow, L. H. (2006). A brief history of inquiry: from Dewey to standards. *Journal of Science Teacher Education, 17*(3), 265-278. https://doi.org/10.1007/s10972-006-9008-5

Binns, I. C., & Popp, S. (2013). Learning to teach science through inquiry: Experiences of pre-service teachers. *Electronic Journal of Science Education, 17*(1), 1-24.

Cebrián-Robles, D., Franco-Mariscal, A. J., & Blanco-López, Á. (2018). Preservice elementary science teachers' argumentation competence: impact of a training programme. *Instructional Science, 46*, 789-817. https://doi.org/10.1007/s11251-018-9446-4

Chen, H. T., Wang, H. H., Lin, H. S., Lawrenz, F. P., & Hong, Z. R. (2014). Longitudinal study of an after-school, inquiry-based science intervention on low-achieving children's affective perceptions of learning science. *International Journal of Science Education, 36*, 2133-2156. https://doi.org/10.1080/09500693.2014.910630

Cian, H., Dsouza, N., Lyons, R., & Cook, M. (2017). Influences on the development of inquiry-based practices among pre-service teachers. *Journal of Science Teacher Education, 28*(2), 186-204. https://doi.org/10.1080/1046560X.2016.1277832

Constantinou, C. P., Tsivitanidou, O. E., & Rybska, E. (2018). What is inquiry-based science teaching and learning? In O. E. Tsivitanidou, P. Gray, E. Rybska, L. Louca, & C. P. Constantinou (Eds.), *Professional development for inquiry-based science teaching and learning* (pp. 1-26). Springer. https://doi.org/10.1007/978-3-319-91406-0_1

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. In N. G. Lederman, & S. K. Abell (Eds.), *Handbook of research on science education*. Routledge. https://doi.org/10.4324/9780203097267

Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research*. SAGE.

Durando, M., Sjøberg, S., Gras-Velázquez, A., Leontarai, I., Martín-Santolaya, E., & Tasiopoulou, E. (2019). *Teacher training and IBSE practice in Europe–A European Schoolnet overview*. European Schoolnet EUN Partnership AISBL. https://doi.org/10.5565/rev/educar.434

Engeln, K., Euler, M., & Maass, K. (2013). Inquiry-based learning in mathematics and science: A comparative baseline study of teachers' beliefs and practices across 12 European countries. *ZDM-International Journal on Mathematics Education, 45*(6), 823-836. https://doi.org/10.1007/s11858-013-0507-5

Ferrés-Gurt, C., Marbà-Tallada, A., & Sanmartí-Puig, N. (2015). Trabajos de indagación de los alumnos: Instrumentos de evaluación e identificación de dificultades [Students' inquiry works: Assessment tools and identification of difficulties]. *Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias* [*Eureka Magazine on Teaching and Dissemination of Sciences*], *12*(1), 22-37. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2015.v12.i1.03

García-Ruiz, C., Lupión-Cobos, T., & Blanco-López, Á. (2020a). Propuesta formativa sobre indagación para profesorado de Física y Química en formación inicial [Training proposal on inquiry for Physics and Chemistry teachers in initial training]. In D. Cebrián Robles, A. J. Franco-Mariscal, T. Lupión-Cobos, M. C. Acebal Expósito, & A. Blanco-López (Eds.), *Enseñanza de las ciencias y problemas relevantes*

de la ciudadanía. Transferencia al aula [Teaching science and relevant problems of citizenship. Transfer to classroom]. Graó.

García-Ruiz, C., Lupión-Cobos, T., & Blanco-López, Á. (2020b). Emociones y percepciones sobre indagación de profesorado en formación inicial [Pre-service teachers' emotions and perceptions about inquiry]. *Investigación en la Escuela, 102*, 54-70. http://doi.org/10.12795/IE.2020.i102.04

García-Ruiz, C., Lupión-Cobos, T., & Blanco-López, Á. (2021). Perceptions of pre-service secondary science teachers on inquiry-based science education: An analysis of the demographic variables. *European Journal of Science and Mathematics Education, 9*(4), 168-182. https://doi.org/10.30935/SCIMATH/11205

Gormally, C. (2016). Developing a teacher identity: TAs' perspectives about learning to teach inquiry-based biology labs. *International Journal of Teaching and Learning in Higher Education, 28*(2), 176-192.

Heindl, M. (2018). Inquiry-based learning and its possibilities for primary schools with fewer digital resources–A qualitative study. *Pedagogical Research, 3*(3), 1-8. https://doi.org/10.20897/pr/3932

Herranen, J., Kousa, P., Fooladi, E., & Aksela, M. (2019). Inquiry as a context-based practice – A case study of pre-service teachers' beliefs and implementation of inquiry in context-based science teaching. *International Journal of Science Education, 41*(14), 1977-1998. https://doi.org/10.1080/09500693.2019.1655679

Jiménez-Liso, M. R., Martinez-Chico, M., Avraamidou, L., & López-Gay, R. (2019). Scientific practices in teacher education: The interplay of sense, sensors, and emotions. *Research in Science and Technological Education, 39*(1), 44-67. https://doi.org/10.1080/02635143.2019.1647158

Lotter, C., Harwood, W. S., & Bonner, J. J. (2006). Overcoming a learning bottleneck: Inquiry professional development for secondary science teachers. *Journal of Science Teacher Education, 17*, 185-216. https://doi.org/10.1007/s10972-005-9002-3

Lotter, C., Singer, J., & Godley, J. (2009). The influence of repeated teaching and reflection on preservice teachers' views of inquiry and nature of science. *Journal of Science Teacher Education, 20*(6), 553-582. https://doi.org/10.1007/s10972-009-9144-9

Marshall, J. C., & Alston, D. M. (2014). Effective, sustained inquiry-based instruction promotes higher science proficiency among all groups: A 5-year analysis. *Journal of Science Teacher Education, 25*, 807-821. https://doi.org/10.1007/s10972-014-9401-4

Mesci, G., Schwartz, R. S., & Pleasants, B. A. S. (2020). Enabling factors of pre-service science teachers'

pedagogical content knowledge for nature of science and nature of scientific inquiry. *Science and Education, 29*, 263-297. https://doi.org/10.1007/s11191-019-00090-w

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction–what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching, 47*(4), 474-496. https://doi.org/10.1002/tea.20347

Nicol, C. B. (2021). An overview of inquiry-based science instruction amid challenges. *EURASIA Journal of Mathematics, Science and Technology Education, 12*(12), em2042. https://doi.org/10.29333/ejmste/11350

Pérez, M. C. B., & Furman, M. (2016). What is a scientific experiment? The impact of a professional development course on teachers' ability to design an inquiry-based science curriculum. *International Journal of Environmental and Science Education, 11*(6), 1387-1401. https://doi.org/10.12973/ijese.2016.353a

Rodríguez-Arteche, I., & Martínez-Aznar, M. M. (2016). Introducing inquiry-based methodologies during initial secondary education teacher training using an open-ended problem about chemical change. *Journal of Chemical Education, 93*(9), 1528-1535. https://doi.org/10.1021/acs.jchemed.5b01037

Saldaña, J. (2009). *The coding manual for qualitative researchers*. SAGE.

Sizer, A., Tharp, H., Wrigley, J., Al-Bataineh, A., & Park, D.-Y. (2021). The impact of pre-service teachers' orientation on the implementation of inquiry-based science instruction. *EURASIA Journal of Mathematics, Science and Technology Education, 17*(11), em2028. https://doi.org/10.29333/ejmste/11247

Sjøberg, S. (2019). Critical perspectives on inquiry-based science education in Europe. *EUN Partnership, European Schoolnet*. https://www.researchgate.net/publication/331529566_Critical_Perspectives_on_Inquiry-Based_Science_Education_IBSE_in_Europe

Smit, R., Robin, N., & Rietz, F. (2021). Emotional experiences of secondary pre-service teachers conducting practical work in a science lab course: Individual differences and prediction of teacher efficacy. *Disciplinary and Interdisciplinary Science Education Research, 3*(5), 1-17. https://doi.org/10.1186/s43031-021-00034-x

Suters, L., Melear, C. T., & Hickok, L. G. (2002). Views of science teachers one-three years after a pre-service inquiry-based research course. In *Proceedings of the Annual International Conference of the Association for the Education of Teachers in Science* (pp. 1-9).

Syer, C. A., Chichekian, T., Shore, B. M., & Aulls, M. W. (2013). Learning "to do" and learning "about" inquiry at the same time: Different outcomes in valuing the importance of various intellectual tasks in planning, enacting, and evaluating an inquiry curriculum. *Instructional Science, 41*(3), 521-537. https://doi.org/10.1007/s11251-012-9242-5

Tiberghien, A., Badreddine, Z., & Cross, D. (2018). Designing teacher education and professional development activities for science learning. In O. E. Tsivitanidou, P. Gray, E. Rybska, L. Louca, & C. P. Constantinou (Eds.), *Professional development for inquiry-based science teaching and learning* (pp. 245-259). Springer. https://doi.org/10.1007/978-3-319-91406-0_13

Tseng, C. H., Tuan, H. L., & Chin, C. C. (2013). How to help teachers develop inquiry teaching: Perspectives from experienced science teachers. *Research in Science Education, 43*(2), 809-825. https://doi.org/10.1007/s11165-012-9292-3

Wang, J., & Buck, G. A. (2016). Understanding a high school physics teacher's pedagogical content knowledge of argumentation. *Journal of Science Teacher Education, 27*(5), 577-604. https://doi.org/10.1007/s10972-016-9476-1

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87*(1), 112-143. https://doi.org/10.1002/sce.10044

Yin, R. K. (2003). *Case study research: Design and methods.* SAGE.

APPENDIX A

Table A1. IBSE pre- and post-test (adapted from Engeln et al., 2013)

IDENTIFICATION
a What is your age range? • **< 25** • 25-30 • > 30
b Please, indicate your gender.
c Please, indicate your MEd specialty.
d From what degree did you access to the MEd?
e Have you had any previous teaching experience? Could you describe it?
f Have you had any previous research experience? Could you describe it?

TEACHING-LEARNING PROCESS				
To what extent do you agree with the following statements?	**TD**	**D**	**A**	**TA**
I1 It is important to provide opportunities for students to express and explain their own ideas.	•	•	•	•
I2 I consider it necessary for students to have discussions/debates on topic we are working on.	•	•	•	•
I3 It is important that students participate in the debate and discussions that take place in class.	•	•	•	•
I4 It is important to carry out practical activities.	•	•	•	•
I5 It is essential that students perform experiments/simulations/modeling following instructions.	•	•	•	•
I6 It is essential that students draw conclusions from experiments/simulations/models they did.	•	•	•	•
I7 It is essential that students design their own experiments/investigations.	•	•	•	•
I8 Students should conduct investigations/experiments to test their own ideas.	•	•	•	•

YOUR VISION AS A FUTURE TEACHER				
I think that IBST …	**TD**	**D**	**A**	**TA**
I9 is well suited to overcome problems with students' motivation.	•	•	•	•
I10 is well suited to overcome students' learning problems.	•	•	•	•
I11 requires students to have extensive initial knowledge to be successful.	•	•	•	•
I12 is not effective in underperforming students	•	•	•	•
I13 develops critical thinking in students.	•	•	•	•
I14 favors the acquisition of scientific attitudes and values towards science.	•	•	•	•
I15 promotes the development of students' autonomy and personal initiative.	•	•	•	•
I16 helps to make the role of science visible in society.	•	•	•	•
4 I would have difficulties in implementing IBST, because …	**TD**	**D**	**A**	**TA**
I17 I would have a lack of adequate teaching materials.	•	•	•	•
I18 IBST is not included in textbooks.	•	•	•	•
I19 I would need access to any adequate training program involving IBST.	•	•	•	•
I20 I would not have sufficient resources such as computers, laboratory, etc.	•	•	•	•
I21 I would worry about students' discipline being more difficult in IBST lessons.	•	•	•	•
I22 I would not feel confidents with IBST.	•	•	•	•
I23 I would worry about my students getting lost and frustrated in their learning.	•	•	•	•
I24 Group work is difficult to manage.	•	•	•	•
I25 The curriculum does not encourage IBST.	•	•	•	•
I26 There is not enough time in the curriculum.	•	•	•	•
I27 My students have to take assessments that do not reward IBST	•	•	•	•
I28 The number of students per class is usually too high for IBST practice to be effective.	•	•	•	•

Note. **TD:** Totally disagree; **D:** Disagree; **A:** Agree; & **TA:** Totally agree

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