Pre-service teachers' conceptions about the quality of explanations for the science classroom in the context of peer assessment

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This study explored student-teacher conceptions of explanations for the science classroom during teacher education programs through peer-assessments of 20 pre-service teachers from three universities. The peer-assessments were reciprocal and focused on the explanation of scientific concepts during microteaching episodes. Student-teacher conceptions about the quality of scientific explanations were obtained by analysing their assessment-feedback comments to peers and by focus groups. The results showed that student-teacher conceptions about the quality of explanations for the science classroom were related to constructivist theory applied to science teaching, for instance, the participants noticed that better explanations were those that connected the concepts with the students' ideas and experiences. A follow-up with a sub-sample of six participants during a practicum in schools explored through interviews the perceived enablers and obstacles that affected their explanation construction in real settings leading to reframing their conceptions. This study revealed that peer assessment and feedback could play a significant role in teacher education by eliciting student-teacher conceptions about essential teaching practices and the challenges of explaining in real teaching, which might enhance and empower their skill development. We discuss implications for research and practice, with emphasis on peer assessment as a tool for internalising assessment criteria for fruitful science teaching.

Keywords: pre-service teachers, scientific explanation, peer assessment, learning

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1 Introduction

There is an international discussion about the capacity of teacher education programs in the development of student-teacher skills and knowledge for implementing teaching strategies (e.g., Lawson, Askell-Williams, & Murray-Harvey, 2009). There is also a call for sustainable assessment practices in teacher education programs, aimed at encouraging pre-service teachers to reflect on their practices and improve their teaching strategies by autonomously seeking professional development opportunities (e.g., Borman, Mueninghoff, Cotner, & Frederick, 2009).

Additionally, it is recognised that for pre-service teachers, changing roles from student to teacher is a complex process (Fernandez, 2010; Jian, Odell, & Schwille, 2008) that might be facilitated by early teaching experiences in real contexts or simulated ones, through microteaching, co-teaching or peer coaching of critical teaching practices (Hume, 2012; Inoue, 2009; Lu, 2010; Ostrosky, Mouzourou, Danner, & Zaghlawan, 2013). On these role-change processes, eliciting pre-service teachers' ideas of teaching through reflection is crucial for detecting change (Benedict-Chambers & Aram, 2017).

Some of the essential teaching practices are based on a type of knowledge that is unique to pedagogy, called Pedagogical Content Knowledge (PCK). Shulman proposed the idea of PCK and stated it included "the most useful forms of representation of ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations—in a word, the ways of representing and formulating the subject that make it comprehensible to others" (Shulman, 1986, p.9). More specifically in science education, PCK has been described as teacher knowledge at the interface between knowledge and practice (Rollnick & Mavhunga, 2015), combining knowledge of the subject matter, knowledge of students, general pedagogical knowledge and knowledge of context that affects certain teaching practices; representations, curricular saliency, and topic-specific strategies such as explanations (Davidowitz & Rollnick, 2011).

In our study, we focus on this last point; teacher explanation, because it is a common concern in the field and, more importantly, explaining has been proven to be one of the central practices highly conducive to student learning (Windschilt, Thompson, & Braaten, 2018; Windschitl, Thompson, Braaten, & Stroupe, 2012). Additionally, teacher explanations might expand or limit student-teacher knowledge about the nature of science and their understanding of how scientific knowledge is constructed in classrooms (Leinhardt, 2001).

The explanations that teachers construct during the lessons are manifestations of teachers' PCK (Davidowitz & Rollnick, 2011). The model actualised by Rollnick & Mavhunga (2015) recognises the importance of teachers' beliefs and conceptions about PCK as mediators of the enactments in practice. Indeed, not only knowledge, but also teachers' beliefs are likely to determine the teaching quality of explanations (Kulgemeyer & Riese, 2018). Recently, the connections between pre-service teachers' explanations and PCK have been empirically supported. We know now that science pre-service teachers' PCK is a mediator of their explaining performance; then, PCK affects their enacted knowledge to explain (Kulgemeyer & Riese, 2018; Kulgemeyer et al., 2020).

Teacher explanations have been generally defined as communicative actions used to connect some part of the subject matter knowledge to the learners and support their understanding (Leinhardt, 2001), a necessary form of discourse in classroom teaching (Wittwer & Renkl, 2008). In science education student understanding through explanations is promoted by models, analogies, metaphors, representations, making the nature of science explicit, linking the contents with the history of science, and the students' intuitive ideas (Duit & Treagust, 2003; Lehrer & Schauble, 2010; Thagard, 1992; Treagust & Harrison, 2003). The construct of such an explanatory framework enriched the idea of explanation as an answer to a why-question, highlighting how teachers use analogy, metaphor, examples, axioms and concepts, linking them together into a coherent whole for the classroom (Geelan, 2003). However, constructing explanations is a complicated process, and many teachers struggle to transform academic knowledge into explanations for the school (Cabello, Real, & Impedovo, 2019; Charalambous, Hill, & Ball, 2011; Gobierno de Chile, 2013; Hadzidaki, 2008; Kulgemeyer, et al., 2020; Inoue, 2009; Wittwer & Renkl, 2008). Indeed, this is even more critical for beginner teachers (Leinhardt, 2001; Ospina-Quintero & Bonan, 2011; Marzabal et al., 2019), and practical experience without reflection is unlikely to automatically lead to better results in explaining. Practical experience of working as a science teacher helps pre-service teachers to become aware of how difficult it is to be a good explainer (Kulgemeyer & Riese, 2018).

Those difficulties might be due to the lack of opportunities for practising and reflecting on explanations during initial teacher education (Charalambous et al., 2011; Inoue, 2009; Marzabal et al., 2019). Moreover, the research regarding student-teacher explanations is still not as developed as the studies focused on student explanations (e.g., Besson, 2010; Herman et al., 2019; Kampourakis & Zogza, 2008). Hence, the intersection of explanation construction and the factors affecting its development in teacher education is still an under-researched field of inquiry (Charalambous et al., 2011; Geelan, 2012; Kulgemeyer & Riese, 2018; Kulgemeyer et al., 2020; Marzabal et al., 2019). Therefore, there is little knowledge about the development of pre-service explanations and relevance for future classroom practice.

In connection to this, some have argued that peer assessment (PA) is an effective strategy to enhance general teaching performance (Andreu et al., 2006; Sluijsmans & Prins, 2006), which also promotes reflection and self-reflection about practice (Nilsson, 2013). PA is a process that allows learners to consider and specify the level, value, or quality of a product or performance of other equal-status learners (Topping, 2010), in this case, between pre-service teachers. Indeed, PA is a form of collaborative learning between peers (Kollar & Fisher, 2010). Specifically, PA of performance aims to help learners make judgments about structured tasks and provide their impressions of peer performances, the quality of those actions and their suitability for a purpose (Norcini, 2003). Peer feedback seems to be an essential element of PA (Liu & Carless, 2006). However, useful peer feedback depends on the assessor's skills in giving feedback on a particular task (Van der Pol, Van den Berg, Admiraal, & Simons, 2008). Microteaching is a context for applying PA - a short episode of simulated teaching to their peers, usually in reciprocal turns (Mohan, 2007). This teaching rehearsal strategy might help pre-service teachers become reflective practitioners by discussing their performance with peers (l'Anson, Rodrigues, & Wilson, 2003).

Previous research about PA has shown its applicability at different stages of teacher preparation, in initial (undergraduate) education, as well as in professional development programs (in-service training) (Kilic & Cakan, 2007; Tsai, Lin, & Yuan, 2002; Wen & Tsai, 2008). Important aspects of PA are the definition of assessment criteria and roles (Kim, 2009; Sluijsmans, Brand-Gruwel, & van Merriënboer, 2002), self-reflection and critical analysis of peers and their practice (Harford & MacRuairc, 2008; Kim, 2009; Sluijsmans, Brand-Gruwel, van Merriënboer, & Martens, 2004) and the enhancement of attitudes towards assessment (Kim, 2009). Nonetheless, studies that follow-up with the pre-service teachers when they are actually in service are required for understanding what occurs in real teaching contexts after being part of PA (Sluijsmans, Brand-Gruwel, van Merriënboer, & Bastiaens, 2002).

PA as a social process involves negotiation and inter-subjective construction of meaning (Moje, Collazo, Carrillo, & Marx, 2001), which in this case was developed among students of a similar level of teaching experience and knowledge (as per Nicol & Boyle, 2003). Stiggins (1991) asserted that internalisation of assessment criteria during PA is crucial to promoting understanding and high-quality performance. PA allows self-regulation of learning which is, according to Vermunt and Endedijk (2011), necessary but not sufficient to develop pre-service teachers' skills to teach in real settings.

Regarding the teachers' practices and the factors that might affect them, the role of teachers' thinking - theories, beliefs and conceptions - has been identified as crucial (Isikoglu, Basturk, & Karaca, 2009). The terms "belief" and "conception" have had different definitions in educational research (Pajares, 1992), and some shared usages, making the boundaries between the concepts somewhat arbitrary. Moreover, there are some common aspects between beliefs and conceptions: they are part of personal practical knowledge for teaching (Crawford & Capps, 2018), they are deeply rooted in personal histories about the nature of knowledge, and they are usually acquired through the student-teacher's own learning experiences - as tacit knowledge (Da-Silva et al., 2006). Expressing tacit knowledge verbally is typically challenging; it results mainly from experience (Grangeat & Kapelari, 2015). It is likely to guide the teacher's actions and situational responses despite him or her being unaware of the principles that govern the thinking behind those actions (Kahneman, 2011).

To differentiate these concepts, in this study, we take educational belief as a general set of representations about teaching, linked to students' learning. At the same time, conceptions are representations or ideas focused on specific teaching topics or strategies used for certain purposes (Hermans, van Braak, & Van Keer, 2008). Conceptions of teaching are instructional ideas about the nature of the content to be taught, about how to teach the content to students and about how students learn the content (Da-Silva et al., 2006). We use these notions due to their potential influence on teaching and the chances of capturing them through collective reflection, knowing that conceptions of teaching are usually accessed as complex sets of propositions classified in dimensions (Chan & Elliott, 2004; Koballa et al., 2005).

Some studies on teacher conceptions have found a correlation between teacher actions and their thinking, while others saw only a partial relationship or no link (Alt, 2018; Mellado, 1998). Zhang and Liu (2013) found that teachers who held constructivist conceptions of learning favoured student participation and interaction, while teachers with traditional conceptions placed more importance on students' memorisation processes and teachers' authority in the classroom. Although there is no agreement on the extent to which teachers thinking predicts teaching practices, it is clear that changes in the quality of teaching are unlikely to happen without changes in teacher conceptions of what high-quality teaching means (Kember & Kwan, 2000).

The current study explored the extent to which PA prompted more developed student-teacher conceptions regarding the quality of explanations for the science classroom, and the reframing of the conceptions in this context. The two research questions we posed were: RQ1. What are the conceptions of pre-service teachers about the quality of explanations for the science classroom, and how are these developed by peer assessment? RQ2. What factors affect pre-service teachers possible reframing of their conceptions about the quality of explanations for the classroom when in a real teaching context?

2 Methods

This study was action research, which not only seeks to investigate a phenomenon but to transform practitioners' actions (Goodnough, 2010). The study was embedded in a ten-session workshop based on PA and intended to analyse student-teacher skills in microteaching. The workshop was conducted in three Chilean universities in undergraduate teacher education, in each case with a cohort who were about to finish the program. After six months, a case study followed a sub-sample of the participants, who were involved in a practicum at schools as beginner teachers.

2.1 Participants

The sampling sought information-rich cases for in-depth study (Patton, 2001). The initial participants were 60 pre-service teachers from three universities who voluntarily enrolled in the workshop. However, just 20 of them completed six of the ten sessions (this was a time of considerable student unrest in this country), which represented the minimum number of sessions required for inclusion in this study. The final group had similar teaching experience of around three weeks, mostly in observation of practice but not teaching implementation. They were 25 years old on average (SD=1.7) and came from an urban zone with low-middle socioeconomic status. For the follow-up study, six of these participants were selected because they were in practicum teaching in real settings. The follow-up participants represented each of the three universities. The schools hosting the practicum were located in urban zones near the universities and were from different socioeconomic groups.

2.2 Procedure

The PA workshop had a simple design. First, the methodology and ethical issues were described, and if the pre-service teachers decided to participate, they signed the consent form. Then, the researchers showed a video of an explanation and modelled the assessment. It was a ten-minute video in which a young teacher explained the concept of matter. The video was used to avoid possible anxiety in participants regarding PA and to rehearse the practice of evaluating an explanation performed by a student-teacher. This element was necessary because it familiarised the participants with the process of noticing aspects of teaching performance and learning to take useful notes for the next assessment.

Second, the pre-service teachers prepared a microteaching lesson with an explanation of a concept they chose, with the requirement that it should be part of the national curriculum and the first time the students would study it. The participants simulated the explanation to a small group of peers (between two and five) and mutually assessed their explanations, giving feedback and changing roles. After the experience, throughout several discussions based on their conceptions -not on theoretical inputs - they designed and refined the assessment criteria for the next round of peer assessments, using these criteria to improve their explanation about the same concept for the second round. Third, they simulated the second round of microteaching episodes. Finally, a focus group was conducted with each group to reflect on the experience.

The follow-up study consisted of observing each student-teacher of the sub-sample during one or two science lessons, in which they constructed an explanation in front of real students. We interviewed them after the class to explore what they thought about the quality of the scientific explanation delivered. We also inquired about the factors that they consider might have affected the quality of their explanations in a real teaching context compared to the simulated context in the university, and the elements affecting the way they currently evaluated their explanations.

The ethics committee of the university leading the study approved the complete procedure.

2.3 Data gathering

Student-teacher conceptions about the quality of explanations were obtained through questions oriented to collective reflection in the context of PA and reflection on practice in real classrooms. An expert panel viewed and revised a preliminary version of the items. Then, a pilot study used the questions focused on the conceptions of pre-service teachers of a different cohort, using video analysis instead of PA.

The participants' conceptions were first gathered for 14 sessions of reciprocal PA in a simulated context, in which they progressively constructed criteria for mutually assessing the quality of the explanations by their peers. During these sessions, open-ended questions were posed to gather pre-service teachers' conceptions and facilitate group reflection. The questions were: How would you assess the quality of the scientific explanation your peer constructed for the classroom? Why? Why do you think he/she took these pedagogical decisions? What would you do in the same situation? Why? The questions were repeated during the peer assessment, and the participants constructed assessment criteria based on the group emergent ideas.

Additionally, three focus groups were conducted at the end of the workshop with the aim of exploring to what extent the pre-service teachers considered the seminar was a valuable learning experience. The main focus group questions were: Do you think it was useful doing the microteaching and receiving feedback from a peer? Why? /Why not? (If they say yes) In what aspects was it worthwhile? Why? Do you believe this method of teaching should be used with other students? Why? What were the most important things that you learned in these sessions? Do you think what you learned will be sustained over time? Why?

In the follow-up study, six semi-structured interviews were conducted at the participants' schools after observing their lessons, and asked: How would you assess the quality of the scientific explanation you constructed? Why? What factors affect the quality of your explanations in a simulated and real teaching context? What elements affect the way you evaluate your explanations? Do these elements affect the way you think about the quality of explanations for teaching?

In these three instances of gathering information, student-teacher answers were transcribed, and their conceptions were interpreted following a systematic coding process according to the nature and extension of the data. The coding categories were organised in vignettes, and two independent researchers conducted inter-rater reliability on the interpretations.

2.4 Data analysis

Student-teacher answers during assessment sessions and the assessment criteria design were examined through thematic analysis to understand their underlying conceptions. NVivo software was used to organise the transcripts and code the assessment sessions (QSR, 2011), and methods triangulation was utilised to work towards reliability (Patton, 2001). Thematic analysis is a method for identifying and reporting patterns or themes within data, through the organisation and description of the data set in detail (Braun & Clarke, 2006). The assessment sessions, the focus groups and interviews were transcribed verbatim and coded following Grounded Theory types of coding: open and axial using comparisons until saturation (Glaser, 2004). The interviews in the follow-up study were coded using the constant comparative method of analysis adapted to teacher narratives, recommended by Valanides (2010).

3 Results

The following section summarises the results obtained, pursuant to the research questions. First, the results of the exploration of pre-service teachers' conceptions about the quality of explanations are organised from most to least frequent, according to data gathered through the PA sessions and focus groups (RQ1). Details about the participants' actual explanation quality can be found in prior work (Cabello & Topping, 2018). Second, the crucial factors that promoted a reframing of conceptions about the quality of explanations for the classroom once real teaching instances are faced are presented and organised as perceived enablers and obstacles.

3.1 RQ1. What are the conceptions of pre-service teachers about the quality of explanations for the science classroom and how are these developed by peer assessment?

Most of the pre-service teachers' conceptions about the quality of the explanations for the science classroom in the context of PA were related to constructivist theory. Contextualisation of the content appeared as a fundamental idea that they recognised as helping to increase students' understanding of the concepts. A useful context involved the participants in structuring the scientific explanation in more concrete terms while using simpler or broader elements to connect students' ideas with the concept, theory or phenomena taught. The participants conceived good explanations for the science classroom if they were linked with students' prior knowledge, and the teacher explicitly used this prior knowledge in the explanation. The explanation would be then be constructed with students by integrating their questions, intuitive ideas, experiences, etc.

The participants highlighted the importance of constructing scientifically clear explanations. Clarity was achieved, for instance, when the scientific terms used in an explanation were agreed between teacher and students, or communicated in a simple language, with evident connections between the concepts and students' ideas, or making explicit the similarities and differences of conceptual meaning when used in daily life versus in a scientific context. The participants saw posing questions to deepen and verify student understanding of the concepts as a form of checking the clarity of the explanations. Finally, the use of examples in the explanation emerged as relevant - all of the pre-service teachers considered examples as a crucial part of generating scientific explanations for the classroom. In their view, examples were useful if they were as concrete as possible to illustrate the content, if they were related and pertinent to the scientific concept being explained and familiar or closer to learners' experiences.

As attributes of the explaining action in the classroom, the pre-service teachers valued the explicit inclusion of a diversity approach in the selection of examples, for instance, including gender, cultural differences, ethnical inter or intraindividual differences in the selection of learning resources and images to support the explanation construction.

3.2 RQ2. What factors affect pre-service teachers possible reframing of their conceptions about the quality of explanations for the classroom when in a real teaching context?

The factors that influenced participant conceptions during their first teaching experience were organised into enablers and obstacles. In order to illustrate the interpretations of participants' ideas, excerpts are presented as quotations, on which "I" indicates the number of the interviewee, followed by the paragraph number of the interview transcription.

1. Perceived enablers

The participants indicated that they felt confident explaining scientific concepts in the classroom if they were able to transfer what they had learnt at university. However, this did not necessarily mean that their explanations would be good quality; thus the role of a tutor or guide teacher was fundamental to reframe their conceptions and practice. The tutor was seen as the primary support in the participants' daily work, helping to make decisions and preparing lesson plans. Thus, this figure was mentioned by four of six beginning teachers as a facilitator of transference of a successful explaining performance when he or she was perceived as a good teacher, with high levels of content knowledge and available for being a role model.

> “Once a week, I sit with the coordinator to discuss lesson plans for half an hour… Before, I thought that a good quality explanation was, for example, when you know everything by memory, you can stand up in front of the class, and recall the topic transmitting it. But I never thought about emphasising the use of examples, the correct use of the concepts and prioritising them well ... to make them easier to understand and to be more consistent about that, because the examples must be consistent with the concept, about what you are teaching. Then you are creating the model.” (I5:19)

> “My guide teacher motivates me; I think she is one of the only good teachers in this school because the others do not have a good academic level, she is one of the few that does ... She is an outstanding teacher because knows how to teach, and she handles the content well.” (I2:32)

> “The teacher, for example, my teacher is for me a guide and a strong pillar.” (I4:14)

The second issue mentioned by three of the six participants was the school support or flexibility. It included support for beginning teachers' lessons and flexibility to incorporate their ideas, styles and interests in their way of teaching through explanations. This idea is shown, for instance, in these quotes:

> “And the other is also the access I have to the laboratory, the facilities the laboratory has in structure and implements... Or just if you want to do something different, you have it; in a different environment, here you have the water and everything you want to work differently. Then the laboratory is an enabler, a good facilitator.” (I4:14)

> “There is a lot of flexibility in this school to do the type of lesson I want.” (I5:13)

Finally, an element that facilitated teachers' reframing of conceptions about good explanations for the classroom was the process of criteria construction as a tool for their current practice and the critique they received in PA intervention, and as a way of learning which might be internalised as self-critique.

> “I think the creation of criteria was fundamental. Because now I check it in my mind, and I am going to the criterion I formulated. Because the things we saw in the university - after we do not remember it, but when you create criteria, it is different, because you think 'let's see how I did the lesson.” (I1:11)

> “I think our ability to create an instrument was essential because it helps us to improve our practices. Then, from what we have created, we correct ourselves now.” (I5:3)

> “...and because several times in the placement places they go once a day or twice, but doing the explanation within the [PA] seminar context, and then another explanation in the practice place would allow us to evaluate and compare reality with what we can do during the peer assessment seminar.” (I4:21)

> “I agree on the fact that now we are more concise and precise in what we are assessing, we are not focused only in macro aspects, but we are more focused now in the connecting ties of the lesson, or things that we were not focused on before. Now we can attack direct points, not general.” (I3:16)

2. Perceived obstacles

The participants identified four main impediments. The first two were associated with the students: their lack of scientific knowledge and participation or interest during the lessons. Some participants described this low interest as an obstacle to getting students motivated to learn science, to pay attention or think about alternative explanations. These were mentioned by four of the six teachers.

> "Well, in this case, I could easily explain and explain generating a monologue. But when you ask questions to the students, and you make students participate, you notice here students do not participate when I ask them." (I1, 29)

> "The pupils have the concepts in a still very basic way… I have to start levelling out to be able to teach." (I3, 14)

> "The pupils had problems with previous teachers, and then they have some content deficiencies." (I5, 7)

> "When you try to focus them [students] and get them interested in learning what you are showing… There are only 5 or 6 students who are interested in learning science because others are more interested in learning music or other things. They are also important areas to teach but getting them motivated to study science is difficult. This allowed me to think 'but if I had been explaining it, how I would do it? How would I take it?" (I4, 8)

Another obstacle was the limited time they had to plan the lessons, prepare the materials for the explanations and reflect on their explaining performance. This was a persistent factor mentioned, nine times by two of the teachers:

> "I would like to have more time to prepare lessons because time is a crucial determining factor. I dedicate the weekend to do it, in between that I have to have time for family life, and now, for example, I am taking paperwork to be done while I teach the other lesson." (I3, 16)

> "As I have little time for preparing the lessons, I would like to distribute less time to it and being able to apply what I already have structured only. I would like to do that." (I3, 20)

> "I would consider that here [in real classrooms], the teacher reflection process is much more valuable than how the lesson was made." (I3:39)

> "Each of us says we follow constructivism but in practice, but when you stand in front of the class it is different." (I1:30)

> "I believe that more than the lack of time for planning, the problem is the time for teaching reflection. When I am supposed to do my teaching reflection? On my pillow?" (I1, 57)

Additionally, some participants mentioned that trying to deal with low school resources hindered explanations for the classroom.

> “Here there is very little material to create worksheets, all that is printing I need to do it; and I pay for it. So, in that sense I would like to have more support, in order to do more exercise sheets, more explanatory sheets, having that resource ... I just want them to print it and distribute it to my two grades, fourth and fifth grade... that would facilitate my work a lot.” (I3, 22)

Furthermore, some participants were critical about the initial teacher education they received, considering it disconnected from real teaching contexts. This might make them feel less confident at the moment of explaining to real students.

> “But I think that lessons we received in the university were planned considering that we will have an ideal class, where students' skills are high, where the classroom climate is good, where we are not considering the problems that students are exposed to.” (I5, 11)

> “Regarding the explanations, they are always more related with the students' knowledge they already have, than with what I want to teach them.” (I1, 27)

Finally, there was an element perceived with a potential role of enablers or obstacles, which reframed conceptions towards the relevance of classroom climate for constructing explanations. Five beginning teachers identified it as a potent mediator that could facilitate or hinder explaining in the way they wanted.

> “But only when I generate this good classroom climate, I can explain, and I am achieving a real lesson.” (I1, 13)

> “I believe that children sometimes... they are not staying quiet, and then they do not listen. So, if they do not listen, you lose the connective thread of the explanation, because there are people making noise, disturbing, and there are other pupils concentrating. You think, 'Why are they not listening to me, maybe they do not care'... and I think that makes teaching more difficult sometimes.” (I2, 26)

4 Discussion

From the participants' perspective, they gained awareness about their conceptions about explaining for the classroom after PA. They mentioned that most of their conceptions were related to the constructivist theory of learning. After comparing the ideas they had about teaching with their actual practice during the PA experience and reflecting on it, their elicited conceptions about explanations for the classroom were that scientific explanations that are fruitful for the classroom are contextualised. This means that the contents are not isolated but presented through concrete terms, using simpler or broader elements to connect students' ideas with the concept, theory or phenomena taught, and linked with students' prior knowledge. From this view, explanations should be constructed *with* students by integrating their questions, ideas, experiences, etc.; not delivered from teachers' knowledge only. Furthermore, scientifically clear explanations made explicit the similarities and differences of the concept meaning when used in daily life versus in a scientific context, including illustrative or worked examples. Some of these elements have also been proposed as a framework for explaining in the classroom (Kulgemeyer and Riese, 2018), such as explaining concepts in everyday language. Our participants pointed out crucial elements for dialogical explanations; considering the students' ideas and questions, and contextualising the explanation in broader terms. Those elements help shift the notion of explanation as a transmissive dispositive of knowledge towards a more horizontal view of knowledge creation opportunity.

After six months of the PA experience, the former attributes of the explaining action in the classroom were triggered by constructing the assessment criteria collectively. Participants mentioned that being systematically assessed and receiving constructive feedback was a key factor for noticing their conceptions and reframing their focus of analysis. This might contribute to having more tools for self-regulating their practices of constructing explanations (Nilsson, 2013). Changing the focus of analysis is crucial for participants' attention and observation for teaching, which has three main components; (a) identifying what is essential in teaching and learning interactions, (b) using principles of teaching and learning to reason about what one sees, and (c) making choices about how to respond on the basis of an analysis of the observations (Benedict-Chambers & Aram, 2017). In our study, the pre-service teachers identified what was fundamental for interaction through explanations, linked these ideas with theories of teaching and learning and used these ideas to reflect on their application and decision-making process in real teaching contexts.

The participants worked together to develop the criteria to assess their peers' explanations, which were, moreover, a form of negotiation of meaning about quality teaching through explanations. This might imply that PA works by increasing the critical capacity of pre-service teachers before they start teaching in real contexts. This necessary capacity for developing an analytical view of the explanations for science education might challenge pre-service teachers' tacit knowledge about teaching through explanations. Considering that explanations are manifestations of teachers'

PCK (Davidowitz & Rollnick, 2011; Rollnick & Mavhunga, 2015), the conceptions of explanations by the participants, as dually constructed from fragments of students' ideas and teachers' knowledge, opens new lenses for the notion of explaining. Some of the participants' considered the questions as part of the explanation, not only as a method for checking their understanding. Thus, explanations can be understood as a complex process that implies the use of representations of knowledge in construction, instead of teaching artefacts as final points of finished knowledge. Consequently, the notion of an explanatory framework as the way in which teachers use an analogy, metaphor, examples, axioms and concepts, linking them together into a coherent whole for the classroom (Geelan, 2003), would be enriched from the perspective of the participants in this study, resonating with the notion of explanations as communicative actions used to connect some part of the subject matter knowledge to the learners (Leinhardt, 2001), *with* the learners.

The development of pre-service teachers' professional knowledge comprises not only declarative knowledge but also procedural knowledge (Kulgemeyer & Riese, 2018). In our study, tacit knowledge about teaching through explanations was elicited and then confronted with real teaching challenges, perhaps helping pre-service teachers to arrive at a more realistic view of the processes of teaching, contributing to the awareness of how difficult it is to be a good explainer in the science classroom (Kulgemeyer & Riese, 2018). Moreover, the follow-up showed that the participants confronted the conceptions they elicited through PA during their real experience, while many of their ideas about high-quality explanations were constrained by the challenges of actual teaching. The beginner teachers seemed to self-evaluate their explanations focused more on the classroom environment they created and less on their explanation construction process. This perhaps brings into question the induction mechanisms of schools, in light of the fact that accompanying beginner teachers in their reflection on practice can be beneficial and that role models and mentors were mentioned as relevant for pre-service teachers. The participants showed concern about the quality of their explanations when they were observed in schools, due to the high level of noise in their classrooms and various students not concentrating on the lesson. This relates to Treagust and Harrison's (2003) ideas:

> "Teachers who are conscious of the constraining influence of the science content, the educational context, the students and their teaching and content knowledge limitations are more likely to recognise the challenge posed by classroom explanations. Indeed, teachers who purposefully reframe some of their explanations in light of these factors will likely enhance the quality of their classroom interactions." (pp. 40-41).

The present research showed that from the pre-service teachers' perspective, the design of assessment criteria and their application was the crucial element in further internalisation of criteria about constructing explanations and generalisation of these strategies into the teaching context, more so than receiving feedback on their other activities. Given that teachers in classrooms usually work alone, the internalisation of PA criteria seems a crucial element for promoting autonomous improvement in real teaching contexts. Furthermore, previous works in initial teacher education using PA were able to demonstrate that PA can help pre-service teachers' self-reflection and critical analysis of their peers' and their own practices (Harford & MacRuairc, 2008; Kim, 2009; Sluijsmans et al., 2004). Our study adds the relevance of the social construction of student-teacher conceptions, supporting Stiggins' (1991) idea of internalising quality criteria through PA with a perspective coming from the practitioners, not only from researchers. So, pre-service teachers could have a personal repositioning through discussing their performance in microteaching episodes with tutors and peers (l'Anson, et al., 2003).

Finally, an important point pertains to peer feedback and assessment. Van der Pol, Van den Berg, Admiraal, and Simons (2008) argued that useful peer feedback depends mainly on the assessor's skills in giving feedback. However, in our study, the peer assessors did not have prior training in delivering or receiving feedback. The present research resonates with the relevance of feedback but further extends the argument. Significant learning in teacher education is not only achieved as a consequence of the assessor's ability to give feedback, but in the internalisation and enactment of assessment criteria by the assesses. Perhaps the pre-service experience of constructing assessment criteria together and reciprocally peer evaluating their explanations contributed to facilitating observation of relevance for teaching. Moreover, the use of shared criteria for good quality explanations in the context of PA might have prompted participants' tacit knowledge into a more explicit - and modifiable - form of knowledge, crucial for self-regulated learning and teaching science in daily life (Nilsson, 2013). In other words, the design of assessment criteria in teacher education for PA and feedback could contribute to teachers developing an internalised self-assessment tool, useful for making autonomous decisions for their practice or future performance evaluation.

Teaching science through explanations is still an area in which much research remains to be done (Kulgemeyer & Riese, 2018), especially from the practitioners' perspective. We have identified student-teacher conceptions aided by peer assessment as a novel contribution. However, critically analysing the methodology of the present research, a consequence of implementing action research based on an elective workshop was the reduced number of participants and the progressive modification of participants' ideas, with no possibility to establish an initial and final state on those. We did however combine multiple sources of data regarding the participants' conceptions. Thus, the results of this research might be considered useful for other teacher education programs, although with careful contextual interpretation.

5 Conclusion

Student-teacher conceptions about the quality of scientific explanations were elicited in this study by analysing their assessment-feedback comments to peers, focus groups and interviews. The results showed that student-teacher conceptions about the quality of explanations for the science classroom were declared in connection with constructivist theory applied to science teaching, for instance, noticing that better explanations were those which connected the concepts with the students' ideas. The follow-up study showed the perceived enablers and obstacles about explaining in the classroom, reframing the participants' conceptions in the light on the constraints of real science instruction. This study revealed that peer assessment and feedback could play a significant role in teacher education by eliciting student-teacher conceptions about essential teaching practices, which might enhance end empower their skill development. Constructing explanations is a comprehensive strategy in teaching, but the opportunities for reflecting on it by pre-service teachers are still insufficient in teacher preparation programs. The few studies that reported using PA in science teacher education positioned it as a new research area. These studies were not focused on understanding the formative power of PA, as in the present research, which increases the range of available research in the usage of PA and highlights the significant role that PA can play in teacher education.

Moreover, the reframing of teacher conceptions in simulated and real teaching contexts as presented in this study is perhaps an input to sustainable project assessment. This point is made under the assumption that maintaining good practice is problematic if it is not underpinned by inward dispositions. The results obtained here revealed student-teacher conceptions about the quality of a common practice for teaching and the different focus between simulated and real contexts. We recommend to other programs that intend to modify specific student-teacher strategies, patterns or routines, that starting first by deconstructing the ideas that support practice in order to reconstruct them is a good idea. The participants in this study appreciated this method as a source of sustainable professional learning, embedded in free workshops. This can help both pre-service teachers and in-service teachers to assume a more professional role and give them a sense of ownership of their learning. For instance, constructing criteria to assess their work among peers within the schools could mean depending less on external examiners to define the quality of their practices - and more on local communities of learning.

Finally, this study opens new research questions about the role of peer assessment in teacher education. Is it possible to design opportunities for enhancing practices that rely upon student-teacher judgements? Is the incorporation of PA at the early stages of teacher education worthwhile for promoting autonomy and self-regulation of teaching practices? These and other questions are for further study.

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