

Learning How to Make Scientific Concepts Explicit in Teacher Education: A Study of Student Teachers' Explanations, Their Modifiability and Transference

Aprender a explicar conceptos científicos en la formación inicial docente: un estudio de las explicaciones conceptuales de profesores en formación, su modificabilidad y su transferencia

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Abstract

This study explored student teachers' explanations of scientific concepts during their last year of preparation in three teacher education programs in Chile. An intervention based on formative peer assessment was conducted to analyze the modifiability of the participants' explanations, and a follow-up study determined that it was transferred into science classrooms where they were beginner teachers. The results showed that participants' explanations of scientific concepts improved significantly after the intervention. Moreover, they sustained the improvement into real classroom teaching and demonstrated high performance in explaining scientific concepts to pupils in most of the elements assessed. This study demonstrated that this crucial practice can be learned in teacher education through peer collaboration and that this type of improvement is strong enough to be sustained in the medium term. Implications for initial teacher education practice and policy are discussed.

Keywords: science teacher education, explanations, scientific concepts, peers, practice

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Resumen

Este estudio exploró las explicaciones de conceptos científicos de profesores en formación de último año en tres programas universitarios de formación inicial docente en Chile. Se condujo una intervención basada en evaluación formativa entre pares con el fin de analizar la modificabilidad de las explicaciones de los futuros profesores. A través de un seguimiento de casos, este estudio determinó, además, la transferencia del aprendizaje para desarrollar explicaciones conceptuales a la sala de clases como profesores noveles. Los resultados mostraron que las características y elementos con los que ellos explicitaban conceptos científicos a través de explicaciones mejoraron significativamente luego de la intervención. Además, los participantes mantuvieron la mejora al ejercer en la sala de clases y mostraron un alto nivel de desempeño al construir explicaciones científicas con sus estudiantes en la mayoría de los elementos. Este estudio demostró que es posible aprender esta crucial práctica de enseñanza durante la formación inicial de profesores mediante la colaboración entre pares y que este tipo de mejora es suficientemente potente como para sostenerse a mediano plazo. Se discuten las implicancias para la formación inicial docente tanto en términos prácticos como políticos.

Palabras clave: formación inicial, explicaciones, conceptos científicos, pares, práctica

Science education standards and curricula (National Research Council, 2000), as well as the definition of scientific literacy (OCDE, 2009), all treat the explanation of scientific concepts or big ideas of science as an essential component, a central skill for teachers and a fundamental part of scientific inquiry (Ruiz-Primo, Li, Tsai, & Schneider, 2010).

In the last decade, the topic of explanation has captured the attentions of researchers, philosophers and scientists (Braaten & Windschitl, 2011; Edgington, 1997; Geelan, 2003; Glynn, Taasoobshirazi, & Fowler, 2007; Welsh, 2002). Explanations have been understood as systematic demonstrations, usually employing cause-and-effect relations, of how and why a phenomenon occurs (Treagust & Harrison, 1999). In its guidelines for primary school science education, Unesco states that one of the main goals for students is to explain the natural world, its mechanisms and processes through their own scientific reasoning, applying scientific concepts to understand the world and, consequently, behaving responsibly toward it (Leymonié-Sáenz, 2009).

However, students do not develop their explanations in a vacuum, but rather they are deeply influenced by the explanations presented to them, generally by teachers (Ruiz-Primo et al., 2010; Zangori & Forbes, 2013), textbooks (Ryoo & Linn, 2014) and teaching activities (Camacho, 2012). As a result, the characteristics and/or elements of teachers' explanations and how they learn to communicate scientific concepts to non-expert audiences are relevant topics in the context of initial teacher training, in order to ensure that they acquire this knowledge during their preparation and apply it into their future classes.

Teacher explanations of scientific concepts in the classroom

Explanations lie at the heart of teaching (Geelan, 2012). Likewise, explaining a discipline's concepts is viewed as one of the practices that, when employed competently, will likely improve students' learning, and it is seen as one of the central skills to develop during initial teacher training (Ball, Sleep, Boerst, & Bass, 2009). In fact, among Chilean science teachers, explaining is one of the most commonly used strategies to illustrate concepts (Preiss, Alegría, Espinoza, Núñez, & Ponce, 2012). In addition, according to Alvarado (2012), students think that knowing how to explain is the most important characteristic of (in their view) a good teacher. However, the Chilean Education Ministry has identified teachers' major weakness in this area, which systematically produces one of the lowest teacher performance indicators (Gobierno de Chile, 2013).

In this study, classroom explanations are understood as a coherent unit by which the teacher connects analogies, metaphors, examples and axioms with concepts to facilitate student comprehension (Geelan, 2003). Here, this encompasses not just verbal aspects, but also non-verbal, representational and

experimental elements, as well as the connections between the students' and the teacher's ideas while an explanation is developed. In this sense, teacher explanations do not necessarily contradict the inquiry views of learning and teaching or other forms of constructivist comprehension and, therefore, explanations are not limited to expository teaching (Geelan, 2012).

The current studies on teacher explanations are not sufficient to articulate a complete framework for science education (Dagher & Cossman, 1992; Geelan, 2012), since a majority of research on this topic has been centered on the explanations that students construct to demonstrate their knowledge (Camacho, 2012; Ruiz-Primo et al., 2010; Sandoval & Reiser, 2004). In fact, a recent meta-analysis by Geelan (2012) found that a search of the Education Resources Information Center (ERIC) database for the terms *science teach* explain** resulted in 1,362 hits; of these, however, fewer than 35 articles focused on some aspect of teacher explanations. Thus, the research potential in this area is very clear and even, according to some authors, remains overlooked (Edgington, 1997; Geelan, 2012). Of the limited research on teacher explanations, the studies describing the elements of an effective explanation focus primarily on communicational aspects, such as audience adaptation and clarity of language used (Faye, 2011; Leite, Mendoza, & Borsese, 2007; Treagust & Harrison, 1999; Wragg & Brown, 2001), and there was only one study found that made reference to science student teachers learning how to convey concepts by explanation during their professional education (Mohan, 2007).

As a result, there is a very limited understanding of how to develop this skill during initial teacher education, something which, in words of Koziol, Minnick and Sherman (1996), implies the need of a profound examination of how teaching skills are acquired during teacher education.

Developing practical teaching skills: The role of peers

Peer collaboration has been explored as a method of developing practical skills during initial teacher education, for example, through peer assessment (Cabello, 2014; Lu, 2010). Peer assessment is a procedure by which students evaluate and state the level, value or quality of the work or performance of other students of equal status, usually incorporating feedback (Topping, 2010). In fact, it has been noted that peer assessment foments more participatory culture (Kollar & Fisher, 2010) and it can also serve to identify good practices in teacher education (Sonmez & Can, 2010). For some authors, feedback is the component of peer assessment that contributes most to the learning experience (Gielen & De Wever, 2012; Liu & Carless, 2006; Thurlings, Vermeulen, Bastiaens, & Stijnen, 2013). However, this idea is still under debate, since empirical studies of this method are scarce, and they have mostly compared peer assessments with instructor evaluations (Strijbos & Sluijsmans, 2010).

Likewise, the available studies of peer assessment during initial teacher training have not carried out follow-up work on the results in real classrooms (Sluijsmans, Brand-Gruwel, van Merriënboer, & Bastiaens, 2002). Therefore, the evidence is inconclusive as to whether peer assessment is an effective tool for improving practical teaching methods, such as, for example, the ability to explain, and whether it facilitates their transferability. Given the above, this study aims to answer the following questions: (a) What elements do student teachers use to explain scientific concepts?; (b) Are all of these elements equally modifiable through formative peer assessment?; and (c) Can changes in student teacher explanations be transferred into a real classroom and maintained over the medium term?

Methods

This study followed a quasi-experimental design with repeated measurements (pretest, post-test and follow-up). It sought to explore the extent to which formative peer assessment affects student teacher explanation and its transferability to the classroom.

Sample

The sample was intended to examine cases that were rich in information and, at the same time, typical or representative (Patton, 2001), in this case, of Chilean training programs for science teachers for

primary education. Three universities were selected, two of which offered a degree in primary education with a specialization in science and the third offered pedagogy of biology degree with a specialization in primary education. The three institutions received students from similar academic and socioeconomic backgrounds. The selection was stratified based on a maximum variation criterion for the variable *knowledge of science*, measured through the mandatory science-related courses taken by the student teachers: high in University 1 (U1), with 14 courses; intermediate in University 2 (U2), with nine courses; and low in University 3 (U3), with four courses.

The participants were 20 student teachers in their final year of university who agreed to take part of the study and attended at least 80% of the intervention sessions focused on peer assessment. As shown in Table 1, 40% of the participants were male and 60% were female, with an average age of 25 (SD=1.7). The participants were from an urban area of lower-middle socioeconomic status and had similar previous educational backgrounds, as the majority have had a few weeks of internship experience. For the follow-up study, six participants were selected according to the maximum variation criterion for their progress during the intervention —high, medium and no progress— using subjects from the three universities who were working in a classroom six months after the intervention concluded. The schools were urban and of low, middle and upper-middle socioeconomic status. From this group, 67% were male and 33% were female, indicating a favorable trend for the males.

Table 1
Sample characteristics

Study	Number of Participants	Females (%)	Males (%)	Age (average)	Age (SD)	Age (min.)	Age (max.)
Pre-/post-test	20	60	40	24.9	1.7	23	28
Follow-up	6	33.3	66.6	24.8	1.83	23	28

Instruments

The participants' explanations were measured at the beginning and at the end of the intervention through microteaching episodes recorded on video. The follow-up study recorded the explanations during one or two full in-class sessions.

To measure the variables present in the explanations, a rubric designed for this purpose was used (Cabello, 2013), with three levels of achievement and a final score between 0 and 20 points. A score between 0 and 6 was interpreted as a low performance; between 7 and 13 as an intermediate performance; and between 14 and 20 as a high performance. The criteria for the rubric were based on a review of the literature on science education and general guidelines for good teaching. The criteria evaluated were: clarity of explanation; coherence and consistency; organization; conceptual precision; completeness; connection with students' prior ideas or experiences; use of analogies, metaphors, simulations, experiments or models; use of examples, images or graphs; use of non-verbal language; and treatment of students' mistakes as a learning opportunity. Table 2 lists and describes, in general terms, each of these criteria.

Expert science teachers validated the rubric's content, after which a pilot study confirmed its high internal consistency ($\alpha = 0.77$, $n = 10$). Almost half of the correlations were statistically significant ($p < 0.05$), and all criteria were highly associated with the total score.

Table 2
Components of evaluation rubric for conceptual explanations by science student teachers

Component	Description
1. Clarity	Proper use of explanatory language
2. Coherence and consistency	Connection between different parts that configures the explanation as a coherent unit
3. Organization	Structural progression of explanation
4. Conceptual precision	Adherence to scientific models and theories
5. Completeness	Explanation's sufficiency in terms of teaching objectives
6. Connection with students' ideas	Link between explanation and students' prior ideas or experiences
7. Use of analogies, metaphors, simulations, experiments or models	Proper application of tools to help students deconstruct the concept
8. Use of examples, images or graphics	Proper application of tools to help students interpret the concept
9. Use of non-verbal language	Gestures to represent concept, intonation or inflections in voice
10. Treatment of student errors as learning opportunities	Usage of errors in understanding of concept as source of inquiry, opportunity for learning and/or evaluation

Procedure

The formative peer assessment intervention took the form of a workshop for classroom explanations. All student teachers in the last year of the university programs selected for the study were invited to participate in the workshop, and the terms of participation were provided in both written and verbal form. Approximately half of the student teachers who attended the initial meeting voluntarily agreed to take part in the study and signed an informed consent form.

The intervention had the following format: two sessions that introduced the background rules so that the formative peer assessments would be carried out properly (respect, constructive criticism, etc.) and the requirements for participating in the study. Further, a session was dedicated to analyzing a class video to replicate a peer performance evaluation, simulating the feedback that a young teacher would receive. Subsequently, the initial peer assessment was conducted in two sessions, where the student teachers developed microteaching episodes of a scientific concept of their choice and provided feedback one to another. Some of the concepts chosen were: the structure of the Earth, evolution, electric charge, and the transformation of matter.

Then, two sessions were held in which the participants discussed about their practice models and which ones could be improved. This discussion covered some guidelines from the cognitive model for science teaching (Jorba & Sanmartí, 1996), such as the incorporation of students' alternative conceptions when introducing new points of view, inquiry and application. Following this, two sessions were dedicated to the final peer assessments. For these assessments, the concepts that the participants chose to develop their explanations included: the Earth's movements, hormonal cycles, electrical current flow in a circuit, and the atomic structure, among others. In the final session, the participants' opinions on the methodology were solicited. It should be noted that the participants did not have access to the rubric used to measure their explanations.

To carry out the in-class follow-up study, all participants were contacted six months later to determine whether they could continue the study. Of these, only ten were teaching at that moment, and eight of them showed interest in being visited at their schools. The researchers contacted the administrators of these schools to request permission to record the teachers giving science lessons and, in six cases, authorization was granted. From these, five cases were possible to be recorded. Table 3 indicates the grade levels included in the follow-up study, as well as the scientific concepts explained.

Table 3
Characteristics of courses and scientific concepts in follow-up study

Participant	Grade	Students	SES	Concept Explained
1	8th	40	Lower	Evolution
1	6th	45	Lower	Electric circuits
2	4th	45	Lower	Life cycles
3	4th	35	Lower	Classification of living things
4	8th	40	Middle	Natural selection
4	8th	40	Middle	Heredity and environment
5	7th	30	Upper-middle	Heat and temperature

Data analysis

Quantitative analytical techniques, via categorical observation, were used to evaluate the conceptual explanations with the rubric. Internal consistency was evaluated using Cronbach's alpha, while Pearson correlations were also calculated. Following this, the Levene test for similarity of variance was calculated in order to conduct statistical analyses: the Student's T-test and analysis of variance (ANOVA) and explore possible changes using the program SPSS (IBM Corp., 2010). The data was triangulated by researcher (Patton, 2001) to reinforce the analysis' reliability, as all the videos were rated by two researchers in a blinded manner. Interjudge agreement was 80%, which is considered a high measurement (Jindal-Snape & Topping, 2010). A consensus was reached for the cases with discrepancies, and the final scores of these were used for the analyses and results report.

Results

During the initial microteaching episodes, the performance results for the student teachers' conceptual explanations varied, but the general pattern leaned toward intermediate on the rubric's scale (min. 5, max. 17, SD 3.386). The three groups were quite heterogeneous internally, but similar when compared with one another. Since the universities were categorized into three maximum variation criterion-based groups for knowledge of science, it was expected that U1 would perform better than U2 and U3 because its participants had a stronger conceptual background. Nonetheless, the differences among the groups were not statistically significant ($df = 19$, $F = 0.764$, $p = 0.384$). This result suggests that during the final years of initial teacher training, the ability to communicate scientific concepts through explanations is not directly associated with the number of science courses taken in previous years. Based on the initial measurement, the highest scoring criteria on rubric were the organization of the explanations and the use of examples, graphics and images. The weakest points were the use of metaphors, analogies, simulations, experiments or models, along with the treatment of student misunderstandings as learning opportunities. For the other rubric criteria, scores were intermediate.

In the microteaching episodes after peer assessments, the performance results for the participants' explanations were equally wide ranging (min. 6, max. 19, SD 3.379). When comparing the pretest and post-test results, as shown in Table 4, the student teachers performed better in the second test compared to their initial scores (pretest average = 10.1; post-test average = 14.65). This difference was statistically significant ($F = 16.540$, $df = 39$, $p < 0.001$), and the effect size of the improvement was high ($d = 1.4$).

Table 4
Summary of pre-/post-test results

Measurement	Average	N	SD	Minimum	Maximum
Pretest	10.10	20	3.38	5	17
Post-test	14.65	20	3.38	6	19

The above confirms that there was progress in the characteristics and elements used by the student teachers to communicate scientific concepts through explanations. The explanations were improved and richer, both in their variety and the support elements used. In general, the student teachers who started at a lower level experienced a more marked improvement during the intervention. This could mean that peer assessment was particularly useful for the participants who initially faced difficulties. Participants in all three groups showed wide improvements, which implies that the intervention worked independently of the participants' prior science knowledge.

Comparing patterns in the initial and final results, one can observe that the two criteria that presented the lowest initial scores remained the two least developed elements after the intervention. The pretest results showed that the student teachers made practically no use of metaphors, analogies, experiments or models, nor did they treat students' mistakes as learning opportunities. In the post-test, although some participants used more resources or elements related to these criteria, their usage did not reach a high level as determined by the rubric. This implies that these elements were not only the participants' weakest points, but also the most difficult to improve through peer assessment. It is likely that improving both of these elements requires a more flexible understanding of science and a greater confidence from the teachers.

On the other hand, the mostly easily improved characteristics and elements were clarity of explanation and connecting with students' prior ideas or experiences. The improvement was notable and implies that at the end of the intervention, the majority of the participants could clearly explain scientific concepts and design their explanations to closely link with the students' knowledge, ideas or experiences.

In the measurements conducted during the follow-up study, the majority of the participants were able to convey scientific concepts in the classroom using explanations at a high performance level. The scores were slightly improved from the pre- and post-test measurements, and only one teacher scored the same as on post-test, although that score was already high. The average score was the same as the post-test (pretest average = 10.1; post-test average = 14.65; follow-up average = 14.7), since the slight differences between the post-test and follow-up results were not statistically significant.

These findings support the idea that the improvements achieved after the formative peer evaluations could be sustained six months after the intervention, and that the participants were able transfer the lessons they learned for explaining scientific concepts from a simulation (practicing with their peers in a university context) to a real classroom.

The average score for each element was slightly higher for a majority of the criteria evaluated in the rubric. However, the use of metaphors, analogies, experiments or models and the treatment of student mistakes as learning opportunities were not transferred into a real teaching context, and the presence of both elements was even diminished in the various classes observed.

Discussion

The universities that participated in this study were representative of Chile's teacher education programs. Therefore, the results obtained are generalizable to other teacher training programs in similar contexts. These results can be considered significant, both in the statistical and educational sense of the word, since they produced a high effect size (Cohen, 1988) despite that the sample size for the study was not particularly large. There were statistically significant differences when comparing the student teachers' performances (in explaining scientific concepts) before and after they participated in peer assessment. This general improvement was transferred and maintained into a real classroom six months after the intervention, which allows us to conclude that there was a measurable learning outcome.

The above conclusion could be taken to predict that these results will be maintained over a longer time period. However, it must be mentioned that the first years of teachers' work tend to be the most important in shaping teaching practices, as well as the fact that during this time, the teachers and their methods are subject to the influences of colleagues and school authorities (Day, 2008). It would therefore be necessary to continue monitoring the new teachers and, in particular, to give them space and time for critical reflection on their practices, both individually and among peers, to prevent the positive effects of this study from disappearing. In fact, the majority of the teachers who participated in the follow-up study commented on the importance, in their opinion, of colleague peer assessments as a tool to continue improving their pedagogical practices and address teaching challenges in a real world context. This is an interesting proposal that emerges from this study originated from the participants themselves.

Generally, although the improvements in developing conceptual explanations were slightly different among the three participating universities, all three groups improved on their initial skill levels in explaining scientific concepts. In fact, although a better performance was expected from the student teachers with greater science knowledge, the results showed that these factors are not necessarily related. However, significant knowledge of the concepts to be taught is needed—but is not the only thing necessary—in order to develop flexible and conceptually accurate explanations.

This result could challenge the idea that teachers cannot develop pedagogical content knowledge if they are not experts in the subject they teach and, in addition, experts in pedagogy, something which would occur after various years of teaching the same subjects (Shulman, 1986). This study has shown that the foundations of pedagogical content knowledge can be triggered during initial teacher training, when the student teachers possess limited experience teaching the subjects. However, the practice component needed to develop this kind of professional teacher knowledge, as established by Shulman (1986), is in line with the results of this study. Practical experience is necessary to develop the required skills to explain scientific concepts, even during simulations of teaching, as was the case with the formative peer assessments through microteaching and even in the early stages of the student teachers' practical experience.

On the other hand, it is important to remember that studies of peer assessment in initial teaching training generally do not include follow-up work at schools (Sluijsmans, 2002). The present investigation's follow-up study showed that the participating teachers not only transferred the lessons learned during initial teacher training, but also sustained, at a high performance level, eight of the 10 elements treated as important for explaining scientific concepts to students. This shows that peer assessment can be a successful strategy in initial teacher training for the purpose of improving some aspects of how student teachers convey scientific concepts, such as clarity of explanation, coherence and consistency; organization; completeness; connection with previous ideas or experiences of students; the use of examples, images or graphics; and the use of non-verbal language.

However, the use of metaphors, analogies, experiments and models, as well as working with student errors, did not show any substantial improvement after peer assessment. In addition, these two elements did not transfer satisfactorily into real teaching practices; instead, the minor improvements achieved after the intervention dropped back down to the levels initially reported. This could be the case because these elements require a more mature and flexible level of subject knowledge, as other authors have suggested (Davis, 2005; Ogborn & Martins, 1996), but that proposal is still being debated and, in this study, remains as an open question. Another study with student teachers revealed that although the subjects could create and use analogies, they were unable to employ them as tools when teaching unfamiliar concepts (James & Scharmann, 2007). This could be a possible hypothesis for the this study's results,

since the student teachers prepared microteaching lessons on topics they wanted to teach, while in the follow-up study they were teaching topics selected by the national curriculum for that time of year and those might have been less familiar to them. In this sense, this study has helped to clarify which elements are easier to modify through peer assessment and which ones are more challenging, both in terms of improving and transferring the learning from a university context into a classroom.

In connection with the previous idea, the student teachers that participated in the follow-up study offered a severe self-criticism of their teaching abilities, evaluating their own explanations more in terms of the classroom climate they managed to create and maintain during the class than the explanations themselves. As such, this study reiterates the importance of developing skills to analyze practices and identify effective ones for a particular teaching context (Sonmez & Can, 2010). Teachers must be able to analyze the elements of their own practices and isolate the aspects of their performance from those of the teaching situation, which will help them to identify causes and effects and to have the courage to try improving the situation. If not, they will incorrectly judge their performances, which can affect their sense of achievement and professionalism and the decisions they make in the classroom. This is an important point to consider in the functions of teacher education programs.

Finally, it is important to note that, like in all studies with volunteer participants, some self-selection bias could have influenced the results, such as the efficacy self-perception in the creation of conceptual explanations. That issue notwithstanding, since the three participating groups included high, intermediate and low performance levels at the beginning of the intervention, the sample can be treated as representative of the full spectrum of possibilities for this variable. This allows us to predict improvements if the peer assessment methodology were applied again to student teachers with different teaching skill levels.

Conclusion and outlook

The present study was built around three questions, which will be addressed below.

(a) What elements do student teachers use to explain scientific concepts?

To answer this first question, an instrument was developed to identify and evaluate the elements present in the student teachers' explanations—one that proved to be conceptually valid, based on an evaluation by an expert panel, and reliable, based on statistical analyses. The elements identified as strengths—in other words, the ones that participants used most frequently and at the highest levels—were the sequence of the explanations (most of which were logical and progressive) and the use of examples, images and graphs to clarify or illustrate certain parts of the concept being explained. To a lesser extent, the participants used non-verbal language to represent aspects of the concept. Their explanations were not always clear, and several included some inaccuracies or conceptual errors, but in general they cohered with the concept, with their different parts cohesively related. The explanations presented varying degrees of completeness in terms of the lesson goal and their connections with student ideas. In contrast, the least developed elements among this group of student teachers were the use of metaphors, analogies, experiments or models and the treatment of student errors as learning opportunities.

(b) Are all of these elements equally adaptable to formative peer assessments?

This question was explored through an intervention based around formative peer assessments. The aim was to identify if the above described patterns could be modified using this type of performance evaluation. The results showed that the participants improved their explanations for a majority of the elements, and that the difference between their initial and final performance scores was statistically significant. However, the two elements that were the least developed at the beginning of the intervention proved very difficult to affect through formative peer assessment.

(c) Can changes in student teacher explanations be transferred into a real classroom and maintained over the medium term?

To address this question, a follow-up study was carried out with aim of exploring the sustainability and transferability of lessons learned in a university context to a science classroom. The results showed that

eight of the 10 elements were transferred successfully and even strengthened with practice, sustaining the improvements sixth months after the intervention finished.

In summary, this study explored the training of student teachers to communicate scientific concepts through explanations. The study focused on formative peer assessment during initial teacher training and its subsequent transfer from a university context into the classroom. From its results, we can conclude that the majority of the elements behind this teaching practice can be fostered in simulated contexts under carefully prepared conditions.

Given this study's ample scope, it has useful implications for teacher education beyond the context of Chile. Firstly, the rubric designed by the researchers can improve the diagnostic tools and intervention mechanisms used for student teacher skills. In this manner, it could become a model device for designing process and/or progress evaluations of practical teaching skills, thereby contributing to the development of measurable goals in initial teacher education, as well as the monitoring of these goals. The results of this study could help guide decision-making processes for education activities that are intended to help teachers develop these types of practical skills before taking on teaching responsibilities in an actual school. These activities could include, for example, creating study or mentoring groups based on their skill identification. Likewise, the present research could serve as model for the design of other types of innovative methodologies that examine the educational power of peer collaboration.

On broader scale, the results of this study could have implications for or generate debate on rethinking the role of the evaluation tools used for initial teacher training. At present, most of the information gleaned from these tools is used to track compliance (or non-compliance) with the student teacher standards in the countries where these are widely applied. It is thus worth asking whether it would be possible to have tools that serve both educational and informative purposes (i.e., evaluations). Or, on the other hand, one could ask if it would be useful to incorporate peer assessment and feedback methods into the initial years of teacher education. These are new questions that this study leaves open for consideration, since they, as well as the results of this study, could be of value to countries that are currently evaluating or redesigning their standards for initial teacher training — something which is beyond the scope of this study.

Furthermore, this study could stimulate a debate on teacher education policy and a critical examination of the opportunities that it, as a central mechanism of how the educational system operates, provides future teachers to develop their skills. How could this education ensure that teachers, in addition to being able to develop good teaching practices, can transfer and maintain these skills in the actual classroom? It is an interesting question to bring up in the context of Chile's new policies to promote teaching excellence.

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