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EURASIA Journal of Mathematics, Science and Technology Education, 2018, 14(11), em1573
ISSN:1305-8223 (online)
Research Paper https://doi.org/10.29333/ejmste/92022

Exploring the Effectiveness of Video-Vignettes to Develop Mathematics Student Teachers' Feedback Competence

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Received 10 October 2017 ▪ Revised 20 February 2018 ▪ Accepted 25 March 2018

ABSTRACT

The ability to give constructive, purposeful and timely feedback is essential to the teaching profession. Research indicates that this competence remains underdeveloped during initial teacher education. This paper focuses on the design, implementation, and evaluation of a competence development intervention with secondary mathematics student teachers. The intervention builds on videotaped response-based simulations. A pre-test/post-test design was used. Mathematics student teachers were invited to respond to open-ended questions while watching a series of video-vignettes which focused on providing feedback to students in different real-life classroom situations. Content analysis of student teachers' answers helped us map changes in their feedback competence development. A scale was developed to capture their related feedback self-efficacy. The results indicate that the intervention had a positive impact on the development of mathematics student teachers' feedback competence. Implications and directions for future research are discussed.

Keywords: feedback, initial teacher education, mathematics education, student teachers, teaching competences

INTRODUCTION

The theory-practice gap is a contentious problem in initial teacher education (ITE) and is consistently reported in the literature (Allen & Wright, 2013; Korthagen & Kessels, 1999; Loughran, 2012). Although ITE programs typically comprise theoretical and practical components, they do not necessarily complement each other effectively. Often the development of teaching competences is left almost entirely to field experience, which is the curriculum component less easily controlled or monitored (Jordan, Schwartz, & McGhie-Richmond, 2009). Consequently, certain teaching competences remain undeveloped throughout ITE programs. Indeed, Korthagen and Kessels (1999) criticize ITE programs for the impracticality of their training approaches, indicating that they leave teachers unsure about their readiness for the profession (see Loughran, 2002). Recent research supports this criticism (Gelfuso & Dennis, 2014; Goodnough, Falkenberg, & MacDonald, 2016; Hatch, Shuttleworth, Jaffee, & Marri, 2016; Korthagen, 2017).

In Spain, ITE programs offer student teachers the chance to gain field experience in secondary schools. This fieldwork includes two phases: observation and intervention. During the observation phase, student teachers spend a short period of time observing professionals in their day-to-day teaching activities. During the intervention phase, student teachers demonstrate their micro-level teaching competences. Previous studies on Spanish ITE programs indicate that student teachers feel that they have insufficient practical experience to prepare them for real-life classroom situations (e.g., for participating in school research and innovation, or informing and advising families) (García, Pascual, & Fombona, 2011; Zagalaz et al., 2015). Likewise, a recent study involving secondary school mathematics student teachers in Spain identified significant problems in relation to competences around *giving and*

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Contribution of this paper to the literature

- This study contributes to the literature by demonstrating that mathematics student teachers' ability to 'notice' can be influenced by video-based intervention programs.
- This study presents the design, implementation and evaluation of an intervention that fosters the acquisition of mathematics student teachers' feedback competence during ITE.
- This intervention moves towards a more student-centered environment and provides an opportunity to integrate theory and practice into ITE.

seeking constructive, purposeful and timely feedback to/from students, their families, and colleagues (see Muñiz-Rodríguez, Alonso, Rodríguez-Muñiz, & Valcke, 2016, 2017; Muñiz-Rodríguez, 2017).

). In this respect, Spain is not an exception. Mathematics student teachers' difficulties in providing feedback to students has been identified in other countries (see e.g., Helgevold & Moen, 2015; Jakobsen, Mellone, Ribeiro, & Tortora, 2016; Kögce, Çalik, Aydin, & Baki, 2008). This suggests that there is a pressing need to develop training in this domain.

Simulation-based training has emerged as an alternative approach to developing teaching competences during ITE programs. Such strategies aim at bridging the theory-practice gap by digitally simulating real-life classroom situations without putting students, families, colleagues, or student teachers at risk (Cioffi, 2001; Dotger, 2013). Simulation-based activities can differ substantially. Cioffi (2001) distinguishes between response-based simulations, where the learner is a passive onlooker and has no control over the data presented, versus process-based simulations, where the learner is an active agent and can control the information and its sequence over time. The present study focuses on the efficacy of videotaped clinical simulations as a type of response-based simulation. This tool is currently employed in teacher education (Dotger, Masingila, Bearkland, & Dotger, 2015; Hatch et al., 2016; Herbst, Aaron, & Chieu, 2013; Koc, Peker, & Osmanoglu, 2009). The video-vignettes reflect realistic clinical cases and help to contextualize learning and assessment (Finch, 1987). They are particularly interesting since they increase the reliability and validity of the instructional approach and related assessment (Lievens & Sackett, 2006). Large scale studies – pointing at a positive differential impact - have been reported by e.g., Aper and colleagues while comparing their efficacy and efficiency with real life simulations and traditional instructional methods (see e.g., Aper et al., 2012).

The present study examines the design, implementation, and evaluation of a simulation-based competence-development intervention for secondary school mathematics student teachers. The research question that guided this study is as follows: to what extent are video-vignettes an effective tool for developing competence in *giving and seeking constructive, purposeful and timely feedback to/from students, their families, and colleagues* during ITE programs? To this end, a pre-test/post-test design was set up, involving secondary mathematics student teachers from a Spanish university.

Below, we outline the theoretical framework. Secondly, we explain the qualitative research methodology. Finally, the results are presented, followed by a discussion and related implications.

THEORETICAL FRAMEWORK

This study builds on Blömeke, Gustafsson and Shavelson's (2015) integrated perspective on teacher competences. On the basis of a critical review of the literature, the authors place competences along a continuum that evolves from cognitive and affective-motivational dispositions to observed behavior. Cognition, affect-motivation and behavior are connected through an analysis of situational specific demands. This requires three types of skills – Perception, Interpretation, and Decision (PID) (see also Sherin & van Es, 2002). Teachers have to be 1) aware of what is important in a concrete situation (Perception), 2) able to interpret the situation, drawing on their knowledge and experiences (Interpretation), and 3) make relevant decisions (Decision).

In view of the development of feedback competences, this model has clear implications. Firstly, cognition has to be developed by introducing specific knowledge and skills. From an information processing perspective, student teachers have to acquire "scripts." According to Geen and Donnerstein (1998, p. 80) "A script serves as a guide for behavior by laying out the sequence of events that one believes are likely to happen and the behaviors that one believes are possible or appropriate for a particular situation." Scripts are thus cognitive schemas that have to be internalized (Duran & Kelly, 1985). In this study, we use the feedback model of Hattie and Timperley (2007) as a cognitive schema to provide feedback (see below). More specifically, we include an explicit instructional process to introduce a cognitive schema to develop this feedback behavior.

The PID model of Blömeke et al. (2015) also implies that the affective-motivational dimension must be tapped into. This brings together affective, cognitive and motivational resources. The use of video-vignettes helps us to operationalize this dimension as video-vignettes present an authentic experiential setting that activates these

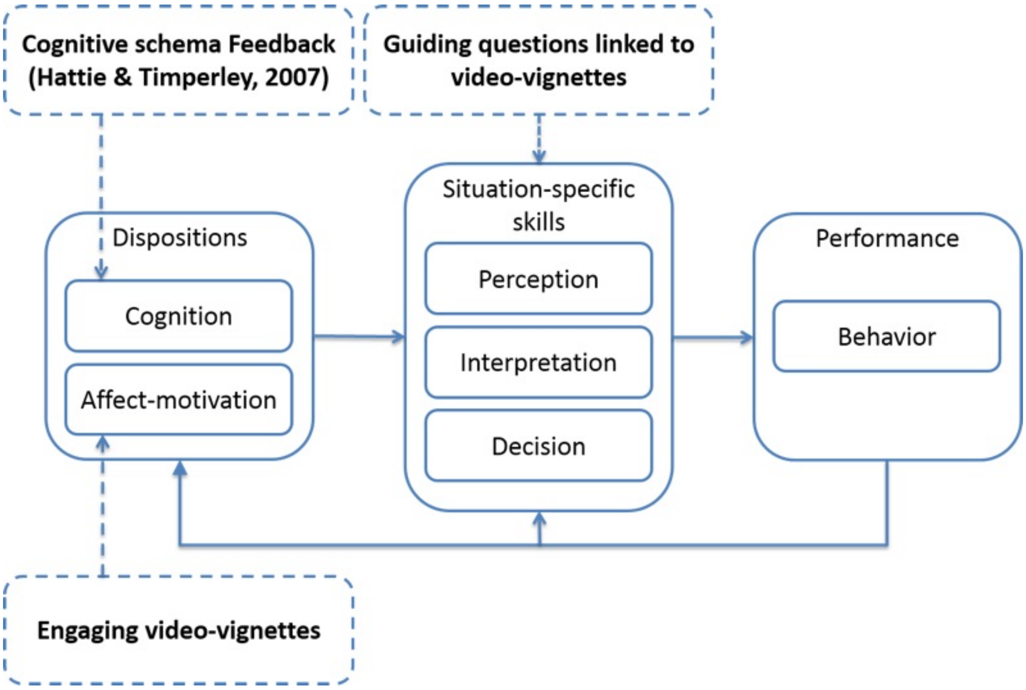

Figure 1. Integrated perspective on teacher competences and how they are influenced by the use of video-vignettes (based on Blömeke et al., 2015, p. 9).

resources. Indeed, several authors stress how instructional video-vignettes boost students' motivation and engagement (see Bryan & Recesso, 2006; Choi & Johnson, 2005; Tripp & Rich, 2012).

Next, the model indicates that we have to boost Perception, Interpretation and Decision making to invoke behavior. The PID approach is central to many teacher education models that aim to prompt reflection (Korthagen, 2004), pedagogical thought models (Shavelson & Stern, 1981), as well as studies involving novice and expert teachers. The latter indicates that expert and novice teachers differ in their PID skills (Livingston & Borko, 1989; Sherin & van Es, 2002). In our intervention, the video-vignettes and accompanying open-ended questions invite student teachers to respond to complex situations. Video-vignettes have proven to be effective in fostering the reflection cycle needed to learn from practice, and then apply to real-life problems (Cherrington & Loveridge, 2014; Moon, 2013; Seidel, Blomberg, & Renkl, 2013; Siry & Martin, 2014). Such reflection is difficult to invoke in traditional teacher education approaches (Zeichner & Liston, 2013). Video-vignettes are expected to invoke practice-related experiences that are sufficiently profound to invoke in-depth reflection (Bogo et al., 2013; Dieker et al., 2014). In mathematics education, invoking reflection has been referred to as "noticing" (Jacobs, Lamb, & Phillip, 2010).

There is a variety of approaches used to map student teachers' "noticing" or PID activities. Reflection is noted by many as a visible outcome: For example, some authors employ a framework to analyze written student reflections and develop a rubric to screen the output (Hatton & Smith, 1995; Ward & McCotter, 2004). Since we focus on a cognitive schema for giving feedback, this rubric can link this cognitive dimension to indicators that reflect levels of PID. In view of the latter, we build on Bloom's revised taxonomy to distinguish between levels of remembering/perception and understanding/interpretation (Anderson & Krathwohl, 2001).

Figure 1 gives a graphical representation of the theoretical framework used in this study. Because of the interconnectedness of all elements in the model, we added arrows to illustrate reciprocal connections. The figure also incorporates intervention design characteristics.

A Model of Feedback

Hattie and Timperley (2007) emphasize feedback as one of the most powerful instructional strategies influencing learning performance. Feedback is conceptualized as information provided by an agent (e.g., a teacher, peer, book, parent, or one's self) about aspects of one's performance or understanding (Hattie & Timperley, 2007). Research shows some types of feedback are more powerful than others, such as providing cues or reinforcement (Hattie, 2009; Hattie & Gan, 2011; Kluger & DeNisi, 1996; Li, Cao, & Mok, 2016). Moreover, feedback can be given in different ways: computer-generated feedback (Adesina, Stone, Batmaz, & Jones, 2014; Fyfe, 2016; Panaoura, 2012; van der Kleij, Feskens, & Eggen, 2015), formative versus standardized or interim assessment (Konstantopoulos, Li, Miller, & van der Ploeg, 2016; van den Berg, Harskamp, & Suhre, 2016), feedback on students' homework, workbooks or notebooks (Núñez et al., 2015), text- versus video-based feedback (Adiguzel, Varank, Erkoç, & Buyukimdat, 2017), process-oriented versus social-comparative feedback (Rakoczy, Harks, Klieme, Blum, & Hochweber, 2013), individual versus collective feedback (Roschelle et al., 2010), or immediate versus summative feedback (Fyfe & Rittle-Johnson, 2016). To structure this variety, Hattie and Timperley (2007) propose a model of feedback building on three perspectives:

- Feed-up – Where am I going? This stresses the learning goal related to the task or performance.
- Feed-back – How am I going? This gives information about – successful or unsuccessful – progress in view of the learning goal.
- Feed-forward – Where to go next? This provides information about greater possibilities for learning, such as enhanced challenges, more self-regulation, greater fluency and automaticity, more strategies and processes, or deeper understanding.

The same authors stress that these questions can be answered at four levels:

- The task level: distinguishing correct from incorrect answers, acquiring more or different information, and building surface knowledge.
- The process level: information about the learning processes needed to understand or perform the task.
- The self-regulation level: the student's monitoring of his/her learning processes, implying autonomy, self-control, self-direction, and/or self-discipline.
- The self-level: invokes personal evaluations and affects about the students.

In this study, the aforementioned feedback model is used as an action framework (script) for teachers to work in real-life classroom situations when giving and seeking feedback to/from students. Specific situations were filmed to develop the video-vignettes for the current study. This model is also used as a framework for the content analysis of student teachers' reactions to the video-vignettes in order to map their feedback competence development.

Mapping Student Teachers' Feedback Competence Development

A key outcome of ITE programs is the development of teaching competences, reflected in changes in student teachers' knowledge, skills and attitudes. Recent research supports the idea of building on Bloom's taxonomy (Bloom, Krathwohl, & Masia, 1956) to map teacher education outcomes (Szabo & Schwartz, 2011). The revised version of the taxonomy distinguishes six behavioral mastery levels: remembering, understanding, applying, analyzing, evaluating, and creating (Anderson & Krathwohl, 2001). In this study, we focused on the two founding levels:

- Remembering, which means recognizing or recalling knowledge from memory to produce or retrieve definitions, facts, or lists, or to recite previously learned information. This taxonomical level maps student teachers' Perception skill.
- Understanding, which means constructing meaning from different types of functions be they written or graphic messages or activities like interpreting, exemplifying, classifying, summarizing, inferring, comparing, or explaining. This taxonomical level maps student teachers' Interpretation skill.

Both taxonomical levels helped us to develop questions invoking specific reflection skills (PID) in student teachers when watching the video-vignettes. Questions concerning what student teachers "would do" in each real-life classroom situation (Decision skill) were considered at the understanding level because student teachers' decisions did not prompt an actual action and, consequently, could not directly affect their teaching behavior. Both taxonomical levels were used as a framework for the subsequent content analysis of student teachers' reactions to the reflection questions in order to score their feedback competence development.

Likewise, self-efficacy – as a key element of social cognitive theory – appears to be related to knowledge acquisition and competence development (Pajares, 1996). Self-efficacy refers to "beliefs in one's capabilities to organize and execute courses of action required in managing prospective situations" (Bandura, 1997, p. 2). The strength of self-efficacy is therefore measured by the degree of certainty with which one can perform a given task (Zimmerman, Bonner, & Kovach, 1996). In this sense, previous studies note the correlation between student teachers' sense of self-efficacy and their competence development (Malushko, 2015; Markauskaite, 2007; van Dinther, Dochy, Segers, & Braeken, 2013). Thus, it is important for ITE research to draw attention to student teachers' self-efficacy within the learning process.

Video-Vignettes to Develop Feedback Competence

Researchers have sought new learning experiences that might enhance future teachers' readiness to teach. To this end, technology has become a useful proxy (Georgouli, Skalkidid, & Guerreiro, 2008; Szabo & Schwartz, 2011), particularly the adoption of online environments. In this context, video-vignettes have become a popular way of engaging students in real-life classroom contexts (see Jeffries & Maeder, 2004). Video-vignettes present student teachers with a hypothetical scenario, to which they respond by expressing their perceptions, values and/or impressions. They are also considered an effective way of assessing student teachers' competences (Borko, Jacobs, Eiteljorg, & Pittman, 2008; Koc et al., 2009; Santagata & Guarino, 2011). Few studies have investigated how video-vignettes foster mathematics student teachers' feedback competence, yet those that have suggest their effectiveness (Benton-Kupper, 2001; Wiens, Hessberg, LoCasale-Crouch, & DeCoster, 2013).

Although watching a video-vignette is quite different from engaging in a real-life classroom context, the literature points towards the benefits for ITE. Video-vignettes are a valuable way of addressing difficult-to-explore and sensitive topics (Jeffries & Maeder, 2004; Shen, Gromova, Zakirova, & Yalalov, 2017). They also facilitate understanding of the complexity of teaching (Koc et al., 2009), boost motivation and self-efficacy (Herbst et al., 2013; Sancar-Tokmak, 2013), and help connect theory to practice (Hatch et al., 2016). Video-vignettes can be re-watched and are therefore a good basis to reflect from multiple perspectives (Seidel et al., 2013). They facilitate collaboration between student teachers, and between student teachers and teacher educators (Hess, 2004; Sherin, 2004). Nevertheless, some authors stress weaknesses in the use of instructional videos, claiming they might interfere with desired learning outcomes and reinforce conventional preconceptions of teaching (Beitzel & Derry, 2009; Brophy, 2004).

Video-vignettes can be classified as one of the response-based simulations mentioned above. Involvement requires an action framework that describes the steps teachers can take to tackle a specific situation (see Chaplain, 2016; James, 2016). This action framework is considered a cognitive schema or script. Student teachers elaborate and organize this schema in their cognitive system as a guide for action. Using a series of video-vignettes is expected to consolidate and refine this schema/script, which then becomes part of the professional behavioral repertoire. Research emphasizes three factors that influence learning via video-vignettes (see Hatch et al., 2016): (1) the characteristics of the materials and resources, such as the content, length, quality, authenticity, degree of uncertainty, and/or level of relevant information; (2) the social and educational background of participants, i.e., the knowledge, experiences, and/or conceptions; and (3) the nature of the activities: online or offline, individual or in groups. We will return to these factors below.

The present intervention focuses on the use of video-vignettes through an online environment to immerse secondary mathematics student teachers in real-life classroom situations in which feedback is provided. As a course assignment, participants were required to react via short- or mid-term action plans. They entered a description of these actions in the online environment.

METHODOLOGY

Hypotheses

Building on the theoretical framework outlined above, we put forward the following hypothesis: "Studying clinical simulations will boost the development of the feedback competence in mathematics student teachers, as reflected in their responses to questions and their related self-efficacy."

Research Sample

The target population was mathematics student teachers enrolled in the Master Degree in Teacher Training for Secondary Education in the academic year 2016-2017 at the University of Oviedo (Spain), where some of the authors served as teacher educators. Prior to participating in this study, participants completed twenty-one weeks of their ITE program. There were 15 mathematics student teachers enrolled in this program. One participant dropped out during the intervention due to personal circumstances, resulting in data collected from 14 mathematics student teachers (mean=25.93 years old, SD=3.54): 7 women, 7 men. Sample size is critical in research; also in qualitative research. Building on Malterud, Siersma, & Guassora (2016) we (a) paid sufficient attention to develop a clearly defined aim of the study grounded in a clear terminological framework; (b) we can guarantee the sample was very specific and fits the population specifications; in this context we stress that 14 out of 15 students enrolled for this program participated in the study; (c) we built on an established theoretical feedback framework (see below) defining the coding categories; (d) we were in control of the dialogue because we collected answers from individual students for each specific question and (e) our interpretative analysis strategy was guided by operational indicators

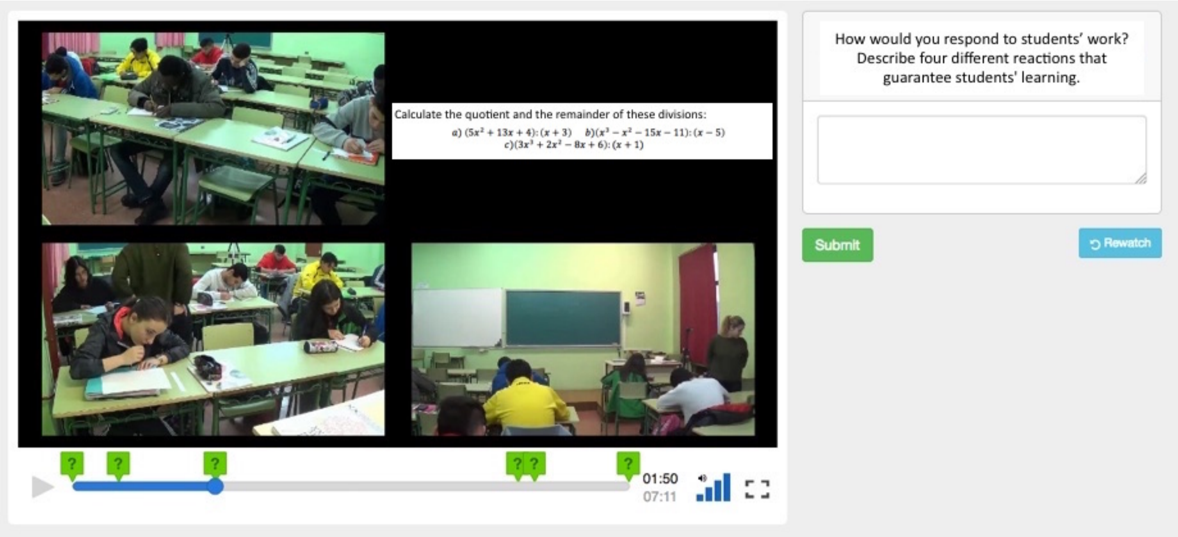

Figure 2. Example of a video-vignette

fitting the theoretical feedback framework. Nevertheless, we will return to the issue of sample size in the discussion section since it is a limitating factor in view of generalizing our specific results to the larger population of students.

Research Instruments

Data were collected at the time of the pre-test and post-test administration:

- Marking student teachers' feedback competence development was based on an analysis of their responses to questions embedded in the pre- and post-test video-vignettes.
- Student teachers' self-efficacy (SE) to provide feedback to students was measured by means of a SE scale, which follows Bandura's guidelines (1986, 2006). Bandura defines self-efficacy as the perception of one's ability to successfully perform specific tasks. A ten-item self-efficacy questionnaire was developed, using a ten-point Likert scale (see **Appendix 1**). Each item is related to a feedback perspective or level in such a way that the level of self-efficacy in each feedback perspective or level is immediately obtained from the corresponding items. The reliability of this scale was α=.823 at the pre-test, and α=.922 at post-test.

Design of the Video-Vignettes

A total of seven video-vignettes (one for the pre-test, five for the intervention, and one for the post-test) were developed from video-recordings of lessons purposefully designed in collaboration with two secondary education mathematics teachers. Each specific vignette (duration between 7-9 minutes) focused on feedback given during a different real-life classroom situation. Each vignette was based on a different type of learning activity: digital quiz, card game, group work, blended learning, regular lesson, and role play game. The pre- and post-test video-vignettes displayed the same classroom situation and, therefore, the same learning activity. The post-test video-vignette was longer, encompassing additional scenes of the classroom situation. This is because it included two more embedded questions than the pre-test video-vignette. Building on the feedback model of Hattie and Timperley (2007), the teacher and the students were engaged in feed-up, feed-back, and feed-forward interactions providing feedback at the four levels (i.e., task, process, self-regulation, and self). Three cameras were used to videotape each situation. Each video-vignette consisted of a compilation of three shots, giving the viewer a holistic picture of the instructional setting (see **Figure 2**).

Figure 2 shows how, at the start and during regular intervals, the online video-vignette was paused and mathematics student teachers were required to respond – in writing – to an open-ended question. When necessary, the video-vignette included a print of the exercise being focused on. The video-questions focused on student teachers' feedback competence while exploring the two founding taxonomical levels described above: remembering (perception) and understanding (interpretation and decision making). **Table 1** gives an outline of the questions embedded in a sample video-vignette. All video-vignettes were hosted on EDpuzzle, an open-source web application for online video-questionnaire design, delivery, and administration.

Table 1. Structure and content of a sample video-vignette

Progress	Embedded question	Taxonomical level
Start	1. Imagine you have to teach *(content)* at *(grade)*. How would you start the lesson?	Understanding
	2. How did the teacher start the lesson?	Remembering
	3. How would you respond to students' work?	Understanding
	4. How did the teacher respond to students' work?	Remembering
	5. How would you conclude the lesson?	Understanding
End	6. How did the teacher conclude the lesson?	Remembering

Note. Questions 1 and 6 were not included in the pre-test.

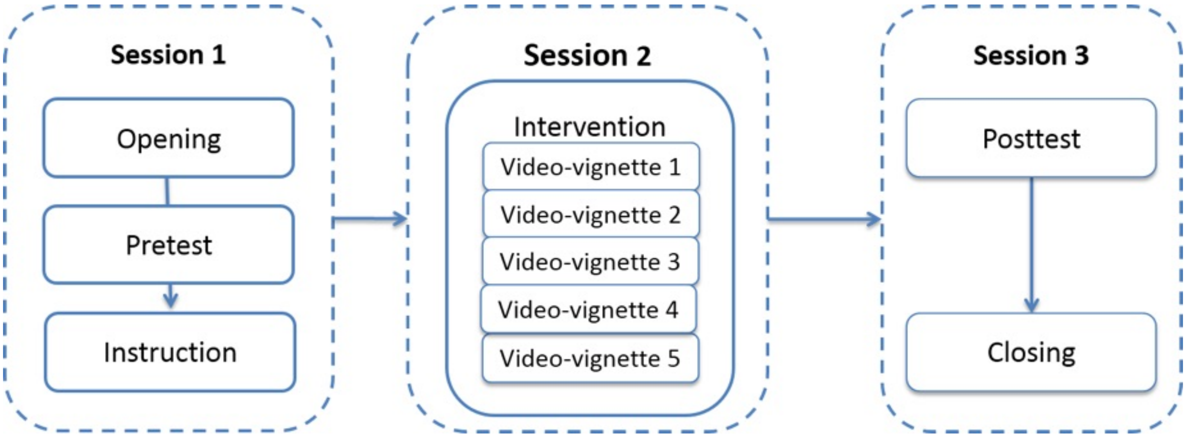

Figure 3. Structure and content of the intervention

Procedure

The intervention consisted of three sessions lasting two hours each, and took place over two consecutive weeks. **Figure 3** gives a graphical representation of the procedure.

All sessions were set up in a computer room. Each student teacher was provided with computer access, an Internet connection, and headphones.

Session 1

- Opening. A presentation about the research project and the intervention was given. At this point, informed consent was obtained from all participants.
- Pre-test. Participants watched the pre-test video-vignette and answered the pre-test questions (see **Table 1**). These questions were embedded in the video-vignette. Next, they filled-out the self-efficacy instrument.
- Instruction. Each participant watched an instructional video-vignette introducing the feedback model explained above. A print handout was provided as additional support. A list of questions was embedded in the video-vignette in order to check participants' understanding.

Session 2

- The intervention consisted of participants watching five consecutive video-vignettes with embedded questions (see **Table 1**).

Session 3

- Post-test. Participants watched the post-test video-vignette and answered the embedded questions (see **Table 1**). Next, they filled out the post-test version of the self-efficacy scale.
- Closing. Participants and researchers summarized and discussed key concepts of the feedback model. Participants were acknowledged for their participation and interest.

Data Analysis

The data analysis focused on mathematics student teachers' answers to the pre- and the post-test video-vignettes. Responses to each embedded question were considered as units of analysis. Each unit of analysis was screened following a directed content analysis technique (Hsieh & Shannon, 2005). Building on the aforementioned theoretical framework (i.e., the feedback model and Bloom's revised taxonomy), a coding rubric was developed.

Table 2. Coding matrix to map student teachers' feedback competence development

Coding category	Indicators
Feedback perspective	(1) Feed-up, (2) Feed-back, (3) Feed-forward
Feedback level	(1) Task, (2) Process, (3) Self-regulation, (4) Self
Taxonomical level	(1) Remembering, (2) Understanding

Table 3. Pre-test and post-test results relative to student teachers' feedback (FB) competence development and related self-efficacy (N=14)

	Pre-test				Post-test			
	R	**U**	**R+U**	**SE – M(SD)**	**R**	**U**	**R+U**	**SE – M(SD)**
Feed-up	4	-	4	7,47(2,167)	8	8	16	7,79(1,424)
Feed-back	10	8	18	7,23(1,959)	13	12	25	8,07(1,762)
Feed-forward	-	13	13	7,07(1,837)	13	13	26	8,07(1,676)
FB perspective total	14	21	35		34	33	67	
Task	2	3	5	8,17(1,949)	9	10	19	8,11(1,707)
Process	13	12	25	8,53(1,407)	12	12	24	8,21(1,369)
Self-regulation	3	4	7	7,86(1,460)	2	5	7	8,07(1,385)
Self	5	8	13	7,40(1,805)	1	7	8	8,07(1,940)
FB level total	23	27	50		24	34	58	

Note: R = Remembering. U = Understanding. SE = Self-efficacy. M = Mean. SD = Standard Deviation. At the time of the pre-test, the feed-up perspective was only analyzed at the remembering level and the feed-forward perspective at the understanding level.

Three coding categories were considered: feedback perspective, feedback level, and taxonomical level. Operational definitions for each category were developed, building on the theory. Each category was further broken down into a list of indicators in order to define differences in feedback competence development, and as such between the pre- and the post-test responses (see **Table 2**). Within each feedback perspective the rubric allows us to consider feedback at each of the four different levels. Similarly, the rubric allows for feedback to be coded from the three different perspectives (feedback, feed up and feed forward), without considering a particular focus at the four levels.

Coding began by reading participants' responses and highlighting all text that on first impression appeared to represent a feedback reaction. Next, all highlighted passages were coded using the former coding rubric (focusing on levels and perspectives). This strategy increases coding reliability (Hsieh & Shannon, 2005). Weft QDA(cc) was used to manage the data and coding. After coding, frequencies were calculated for each indicator to compare pre-test and post-test results. The sample size limits the capacity of the quantitative analysis. While handling binary data (1=feedback is identified, 0=other), only a non-parametric test could be used for the analysis. However, as this type of statistical analysis has insufficient power with small sample sizes, we made the decision – as recommended in the literature - to build on descriptive statistics only. Data for participants' sense of self-efficacy to provide feedback to students were examined through descriptive statistical analyses.

RESULTS

Table 3 summarizes the descriptive results for mathematics student teachers' development of feedback competence and related self-efficacy[1].

Overall, the results indicate that the intervention had a positive impact on the development of mathematics student teachers' feedback competence. Differences in student teachers' responses before and after the training could be identified. We follow the structure of **Table 3** in the discussion of the results.

Before the training, student teachers were able to perceive and interpret feedback in relation to feed-forward (n=13) better than feed-up (n=4) or feed-back (n=18). This notable difference became smaller after the training, especially in terms of feed-back. A modest increase was observed at the feed-up (n=16) and feed-back (n=25) components, while the feed-forward (n=26) remains upwards. In terms of feed-up, before the training, few participants (n=4) perceived how the teacher started the lesson by stressing the learning goal(s) of the unit to ensure that students focus on the content related to this goal. After the training, although a higher number of student teachers perceived the feed-up intervention performed by the teacher, the results are rather modest at both taxonomical levels (n=8). Regarding the feed-back perspective, despite a general awareness (n=10), the level of understanding attained before the training was low (n=8). After the training, student teachers were better able to perceive (n=13) and interpret (n=12) actions containing information about students' progress, such as "I would

[1] Since we are describing overall results for each feedback perspective (i.e., remembering plus understanding), we put total frequencies into brackets (R+U) for each perspective.

provide students information about their progress during the lesson" or "The teacher asks students what they have been learning up to this lesson in order to check what students know." The feed-forward component appears to have been grasped well both before and after the training. Student teachers' responses seemed adequate in relation to both taxonomical levels, see for instance, "I would ask students to design a similar activity for the next lesson including the concepts they consider more difficult about this unit" (pre-test) or "The teacher concludes the lesson using the information she gathered from the activity to decide which concepts need to be reviewed and reinforced in order to improve students' learning" (post-test).

Regarding the four levels, we found the highest number of indicators in relation to feedback about the process both before (n=25) and after (n=24) the training. Before the training, this is second by a moderate focus on feedback related to the self (n=13). This focus shifts towards feedback at the task level after the training (n=19). Nevertheless, few student teachers referred to feedback at the level of self-regulation both before (n=7) and after (n=7) the training. The relevance of this fluctuation is explained in detail in our discussion. When looking separately at both taxonomical levels, slight variation is found at each feedback level due to the training. For instance, for the task level, prior to the training few student teachers were able to perceive (n=2) or interpret (n=3) actions that aim at distinguishing correct from incorrect answers, acquiring more or different information, or building surface knowledge. After the training, there was a substantial increase in both the remembering (n=9) and the understanding (n=10) level. However, most of the indicators related to this level consist of correct/incorrect answer feedback, instead of some other criterion related to task accomplishment. Feedback at the process level was perceived and interpreted to a large extent both before and after the training. Few differences are observed between both taxonomical levels. Student teachers were able to perceive and interpret actions containing information about the learning processes needed to understand or perform the task even before the training period. As mentioned above, self-regulation is the most overlooked feedback level. Before the training, student teachers barely perceived (n=3) how the teacher encourages students to monitor, self-control or self-assess their learning processes. Nor were they able to interpret this feedback level (n=4). After the training, the outcomes remain low at both taxonomical levels (n=2 and n=5, respectively). In terms of the self-level, the overall decrease in the number of indicators is explained by a lighter emphasis on the remembering level after the training (from n=5 to n=1). Small differences were observed at the understanding level (from n=8 to n=7).

Before the training, participants' answers mainly referred to instructional activities, such as content review, encouraging participation, calling attention, or praise, see for instance "The teacher starts the lesson by encouraging students' participation" or "The teacher asks a lot of questions in order to get students' attention and encourage them to focus on the subject." Other answers remained very general: "The teacher starts the lesson by asking questions," redundant: "I would explain why the correct answer is right. I would explain why one of the incorrect answers is wrong," "I would congratulate the students who answer correctly. I would reward the students who answer correctly with symbolic prizes that reinforce their learning," or even irrelevant: "If all the students answer correctly, I would be happy," "I would encourage students to cooperate and help each other" or "I will respond to students' work by making them feel good." Some student teachers shared their personal opinion about the behavior of the teacher, see for instance "The way the teacher starts the lesson is very appropriate" or "The teacher responds to students' work with and open and calm attitude." Respondents also referred to what the learners did instead of adopting the teacher's perspective: "Some students raise their hands. Although not all students responded, it seems that several know the answer."

The nature of student teachers' reactions clearly changed during and after the intervention. Replies were more elaborate and referred to key concepts in the model, for instance "I would start the lesson by contextualizing and recalling the learning goals, evoking students' thinking, in order to know what they remember," "I would ask students about what they remember/know about the metric system in order to gather information about their current knowledge. I would make a scheme from their answers and relate the key concepts with the learning goals of the unit", or

> *"I would respond to students' work by enhancing their confidence about their response (self-regulation level), using questions to check how they came up with the answer and what they should have done (process level), identifying what the correct answer is (task level) and making some comments about their personal work (self-level, the least effective), all through questions, suggestions and directions, not directly."*

Nevertheless, a couple of participants still referred to rather broad actions after the training, such as "I would start the lesson using very graphic and simple materials that serve to call students' attention and strengthen their motivation."

The impact of this intervention was also measured in terms of student teachers' self-efficacy to provide feedback to students. Overall, participants believed they were suitably qualified to provide feedback even before the training. This perception supports the self-efficacy results at the time of the pre-test, but contrasts with the analysis of the responses given to the embedded questions. **Table 3** shows a small increase in student teachers' self-efficacy to give and seek feedback after the training, except at the task and process levels. Possible reasons behind this decrease are explained in the discussion.

DISCUSSION

Our results provide evidence of the effectiveness of video-vignettes on the development of secondary school mathematics student teachers' feedback competence during their ITE. These results corroborate previous findings on the potential for simulation-based activities (Hatch et al., 2016; Herbst et al., 2013). It is hypothesized that through their reflections on simulated practice reality, student teachers come to understand the realities of the future school environment (O'Donoghue & Brooker, 1996).

A clear increase in the number of indicators related to feedback at the feed-up and feed-back perspectives and at the task level was observed after the training. Indeed, given that approximately 90% of teachers' feedback aims at the task level (Hattie & Timperley, 2007), it is surprising that only half of our student teacher sample provided information about whether students' answers are correct or incorrect at the pre-test stage. After the training, feed-forward and feedback related to the process or self-regulation remained invariable, while feedback focusing on the self-level decreased. The latter is of lesser concern; feedback at this this level is the least effective as it is typically unrelated to task performance (Hattie & Timperley, 2007). The low proportion of feedback focusing on self-regulation is noteworthy, since this kind of feedback might be – according to the literature – effective. As learners monitor, control or assess their own learning process, they become more competent in seeking, accepting and accommodating feedback from external sources (Hattie & Timperley, 2007). They also become more proactive and self-motivated (Cleary & Zimmerman, 2004; Nicol & Macfarlane-Dick, 2006). Indeed, Zimmerman (2002) explains that teachers usually expect students to display their self-regulation skills outside the classroom. However, to be able to meet these expectations, teachers need to provide learners with a repertoire of self-regulation and self-assessment strategies. The participants in this study emphasized this level to a very limited extent. This feedback level should be reinforced during the training period, incorporating specific strategies that student teachers can use to boost their students' self-regulation. Examples proposed by Nicol and Macfarlane-Dick (2006) can be adopted in this context.

The video-based intervention clearly resulted in changes in mathematics student teachers' knowledge, skills and attitudes about feedback at the two founding taxonomical levels. For the first taxonomical level 'remembering', we found a higher number of indicators after the training. For the second taxonomical level 'understanding', the post-test results reflect a clear increase in the amount of indicators. In general, slight differences exist between both levels. Indeed, the results suggest that both levels are attained to the same extent. Considering the existence of a sequential, hierarchical link between the taxonomical levels (Anderson & Krathwohl, 2001), the mastery of the two founding levels enables the development of the feedback competence in the higher levels of the taxonomy.

Mathematics student teachers' self-efficacy to provide feedback to students proved to be relatively high. Despite a small increase after the training, in most feedback perspectives and levels, a decrease of self-efficacy was observed from pre- to post-test both at task and process levels. This can be explained by looking at the nature of the intervention: It is to be expected that by using instructional video-vignettes, participants' metacognitive vision of the feedback process has broadened. Also, considering the importance and diversity of feedback at the task and process levels (Hattie & Timperley, 2007), student teachers will also learn how to identify their limitations, which affects their sense of self-efficacy.

Previous research suggests video-based training engages student teachers in their ITE (Herbst et al., 2013). During the intervention, the research team observed an increase in mathematics student teachers' motivation compared to the traditional courses they followed. During the different sessions, all participants seemed focused when watching the video-vignettes, reflecting on the real-life classroom situations, and suggesting solutions about how to move forward. This implies that the affective-motivational dimension – proposed in the model of Blömeke et al. (2015) – has been tapped into. Their engagement was also evidenced by the in-depth, lively discussions that unfolded during each session. This suggests that an online environment can also function as a prompting mechanism (Georgouli et al., 2008; Szabo & Schwartz, 2011).

The design of the video-based intervention combined an instructional video-vignette about the feedback model (Hattie & Timperley, 2007) with a series of practice based video-vignettes. This combination helps to close the gap between theory and practice in ITE (Allen & Wright, 2013; Korthagen & Kessels, 1999). The data collected at post-test reflect this changed reality. Moreover, student teachers participating in the study valued the potential of video-vignettes to link theory to practice.

After the training, student teachers were able to better perceive and interpret core concepts related to the feedback model and about their relevance for the learning process. We therefore believe that this approach expands and deepens student teachers' understanding of the theoretical concepts and improves their ability to appropriately react to feedback situations. According to Schwartz and Bransford (1998), when learners have little familiarity with a theory or concept, providing them with visual or practical illustrations of the theory or concept can facilitate learning. Moreover, in this study, throughout the intervention, participants' perceptions and interpretations became more accurate, i.e., student teachers answered in a more focused, in-depth, and analytical way about specific issues related to feedback.

There were limitations to the present study. First, a small student teacher sample from one Spanish university was used. This limits the generalization of the findings to other settings. A more representative sample, involving student teachers from other universities should be included in future research and the impact of this intervention should be compared to other teaching and learning strategies. For instance, a long-term intervention or a process-based simulation (see Aper et al., 2012) should be explored. In this study the affective-motivational dimension was based on the perception of the researchers who conducted the intervention. This variable could be measured more objectively in future studies by incorporating a learning stimulation scale into the instrument or by recording student teachers during the intervention and analyzing changes in attitude. Moreover, group discussions could be conducted during the intervention procedure as this could, help participants deepen their perceptions and reflections by sharing experiences (Dotger, 2013). Teacher educators also could join in and share their expertise to address issues related to each specific classroom situation. Such discussions would provide a complete portrayal of the ideas generated during the analysis of the video-vignettes. Finally, future research could develop an alternative approach based on the analysis of the PID-levels and explore the impact of feedback competence development during initial teacher education.

This study contributes to ITE policy and practice. The results of this intervention could be used to inform policymakers and teacher educators about specific learning experiences that enhance student teachers' feedback competence development. Many ITE programs still employ traditional teaching methods (Akrawi, 2010). This intervention moves towards a more student-centered environment and provides opportunities to integrate theory and practice in ITE. This study could be extended by implementing alternative interventions in relation to other teaching competences. To this end, the design could be adapted for different classroom situations or teaching disciplines, such as developing aggression management competences, parent-teacher communication competences, management of bullying, etc. The domain of teacher education could as such be compared to the domain of medical education where the use of (online) clinical simulations is an established practice (see e.g., Aper et al., 2012).

ACKNOWLEDGEMENTS

The authors wish to thank Lucía López Álvarez, Juan Francisco Hernández Rodríguez, and Miguel Ángel Luengo García, as well as the teaching staff and students of Fernández Vallín High School (Gijón, Spain) and Colegio Hispano Inglés (Santa Cruz de Tenerife, Spain), for their collaboration and effort to design and implement this intervention. This research has been partially supported by Ghent University BOF grant with code 01DI1516 and by Spanish Ministry of Economy, Industry and Competitiveness grant with code TIN2017-87600-P.

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APPENDIX 1

Self-Efficacy Questionnaire

The following questions are designed to help us gain a better understanding of your competence to provide and seek feedback to/from students. Please rate your degree of confidence in doing the tasks described below, using the following scale:

1	2	3	4	5	6	7	8	9	10
Cannot do at all				Moderately can do					Highly certain can do

	1	2	3	4	5	6	7	8	9	10
Establish specific learning goals	□	□	□	□	□	□	□	□	□	□
Indicate whether students work is correct or incorrect	□	□	□	□	□	□	□	□	□	□
Identify what students understand	□	□	□	□	□	□	□	□	□	□
Detect when students make errors	□	□	□	□	□	□	□	□	□	□
Detect when students have misconceptions	□	□	□	□	□	□	□	□	□	□
Provide praise, rewards, and punishment	□	□	□	□	□	□	□	□	□	□
Provide information about what is or what is not understood	□	□	□	□	□	□	□	□	□	□
Indicate that more information is needed	□	□	□	□	□	□	□	□	□	□
Indicate alternative strategies to complete the task	□	□	□	□	□	□	□	□	□	□
Use assessment data to plan future instruction	□	□	□	□	□	□	□	□	□	□

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