EFFECTS OF A DISTANCE LEARNING COURSE FOR TEACHERS ON PROPORTIONALITY ON THEIR PERCEPTION OF SELF-EFFICACY*

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Abstract

With the aim of strengthening the didactic capacity of teachers in the French-speaking Belgium in the teaching of proportionality, we designed a distance training course. The training lasted four weeks and benefited a total of 93 teachers.

To evaluate the effectiveness of this training, we administered a pre-test and a post-test, assessing respectively the teachers' self-efficacy, their feeling of confidence in the didactic field and their satisfaction with the training. The results showed a significant improvement in teachers' confidence and self-efficacy. These positive results underline the importance and relevance of offering further online training courses focusing on the teaching of proportionality, with the aim of optimizing teachers' pedagogical skills in this specific mathematical area.

Key words: *Distance training; Proportionality; Teachers; Didactical confidence level; Self-efficacy.*

1. Introduction

Learners may encounter various difficulties when faced with proportionality, such as recognizing a proportionality situation, identifying linearity relationships between data, choosing the appropriate procedure and many others (Bergeaut, Billy, Cailhol *et al.*, 2013).

At the same time, teachers do not always benefit from adequate training to tackle this mathematical notion effectively. Dragone, Temperman and De Lièvre (2022) have highlighted the challenges teachers face when teaching proportionality.

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They insist on the need to provide teachers with didactic paths adapted to this learning. Tzivinikou (2015) shares this view, highlighting the importance of teachers' sense of personal efficacy (SEP). In his view, appropriate training would not only improve teachers' SEP, but also the quality of their pedagogical interventions with learners.

With this in mind, it's imperative to fill the training gap and equip teachers with the tools they need to tackle proportionality confidently and effectively. With this in mind, the present study focuses on evaluating the effectiveness of a distance learning course dedicated to the teaching of proportionality, specifically aimed at teachers in French-speaking Belgium.

2. Review of the literature

2.1. Continuing professional development for distance learning teachers

In this type of online training, the motivation of participating teachers is mainly found in their desire to develop their professional skills as well as improve their teaching process (Gonçalves & Gonçalves, 2019). The continuing professional development of these teachers can then be defined as a process of acquisition and transformation of the skills and identity of individuals. It aims to improve, enrich and update professional practices, to act effectively as well as to achieve a better understanding of their work while feeling comfortable in it (Mukamurera, 2014). According to Charlier and Charlier (1998, cited by Renard & Derobertmasure, 2019), in-service teacher training is therefore essential. According to them, this type of training makes it possible to introduce innovations in teaching as well as helping teachers to develop their professional skills. What's more, in-service training is an important lever for change.

Distance learning can be organized in a variety of ways. According to Dmitriyeva *et al.* (2020), educational websites, electronic textbooks, audio and video teaching materials are often used. But that's not all: the organization of traditional teaching can be found in distance learning. For example, lectures can be given via videoconferencing or video conferencing.

2.2. Learners' difficulties with proportionality

Proportionality is an essential mathematical concept taught in Belgian schools, from primary to lower secondary level (Dragone *et al.,* 2022). Proportionality refers to a specific relationship between two quantities or sequences of numbers, where one is a multiple of the other. Quantities are characteristics of objects that enable them to be compared with one another (Daro, Geron & Stegen, 2007).

According to Bergeaut *et al.* (2013), students encounter several difficulties when faced with proportionality problems. For example, they have difficulty recognizing a proportionality situation because of the implicit nature of the statements. They also have difficulty identifying the quantities to be related, and sorting the data related to each quantity. What's more, they may have difficulty choosing the right procedure for solving the given problem.

Another frequent difficulty is the incorrect use of an additive procedure, as in the case of Brousseau's puzzle, where learners have to construct an enlargement

of the puzzle. Students are told that a segment 4 units long becomes 7 units in the enlarged puzzle. Some students then add 3 units to each segment (Oliveira, 2008).

These difficulties represent obstacles not only to learning proportionality, but also to teaching it. Indeed, according to Burgos and Godino (2020), teachers need to have the necessary skills to teach the various forms of reasoning applicable in proportionality situations, going beyond the simple application of the rule of three. This will then enable students to acquire a thorough understanding of the fundamental concepts associated with proportionality.

2.3. Challenges for teachers

As mentioned above, teachers face certain challenges when teaching proportionality. In their research, Burgos, Beltrán-Pellicer, Giacomone and Godino (2018) investigated these challenges with young teachers. According to them, most teachers find it difficult to formulate problems involving variations from an initial statement. Moreover, the statements created by young teachers are often too far removed from the initial problem, devoid of meaning or fail to respect the proportionality of the context.

A teacher must therefore possess not only problem-solving skills, but also the ability to select, modify and create problems for didactic purposes. It is also important for a teacher to be able to assess the quality of a learner's mathematical activity in solving a proposed problem and, if necessary, be able to adapt the problem to facilitate deeper mathematical activity on the part of the student (Malaspina, Mallart & Font, 2015).

Furthermore, according to Burgos and Godino (2020), initial teacher training is not sufficient when it comes to understanding mathematical objects. In their view, teacher trainers should therefore enable them to recognize and analyze students' difficulties in solving proportionality problems. Ongoing training would enable teachers to give meaning to the symbolism and mathematical representations involved in problem solving, to develop their rationality and to open up to new solving methods (Bednarz, & Proulx, 2010).

2.4. Self-efficacy

According to Gibson and Dembo (1984), this sense of self-efficacy can be broken down into two dimensions for teachers: the sense of personal efficacy (SEP) and the sense of general efficacy (SEG).

According to Bandura (2007), the concept of a sense of personal efficacy (SEP) refers to a person's belief in his or her ability to succeed at certain tasks and to solve specific problems by finding solutions. In the context of teaching, this SEP corresponds to a teacher's belief in his or her ability to impact learner learning (Gibson & Dembo, 1984).

As for the sense of general efficacy (SEG), this corresponds to a teacher's belief that he or she can bring about change in learners, regardless of external influence. It arises when the teacher believes that all learners are educable (Ross, Cousins & Gadalla, 1996).

Teachers' self-efficacy has a direct and positive influence on their students' motivation and success (Mojavezi & Tamiz, 2012). This conclusion was also found

in a study of 60 secondary school teachers by Shahzad and Naureen (2017). Moreover, it is important to note that a teacher's sense of self-efficacy is correlated with students' attitudes towards school (Al-Alwan & Mahasneh, 2014).

In-service training can be a key element in improving this sense of teacher self-efficacy. Indeed, Tzivinikou (2015) carried out in-service training for teachers and studied its effectiveness on this feeling. This author came to the conclusion that additional training had a positive impact on teachers' sense of self-efficacy, improving their educational interventions with their students.

3. Methodology

As we explained earlier, teachers face challenges when teaching proportionality (Burgos *et al.,* 2018; Dragone *et al.,* 2022). This audience therefore needs to be properly equipped to deal with them, and this can involve participation in in-service training (Burgos & Godino, 2020; Bednarz, & Proulx, 2010). We therefore decided to design an online continuing education course for teachers in French-speaking Belgium.

3.1. Distance learning design

For the purposes of our study, we chose to use Brinkerhoff's model (2005, cited in Duchaine, Gaudreau & Trépanier, 2021) to create and evaluate our distance learning course. This model breaks down into a total of six levels, and enables us to evaluate the effects of continuous training. The first level of this model consists in identifying the needs of the participants in our study. This first level has already been partially implemented in a previous study (Dragone *et al.,* 2022).

The second level of this model corresponds to the development of training using activities and tools adapted to the needs of the participants. Joyce and Showers (2002) carried out an analysis of the results of 200 studies on the effects of continuing education on teaching practices. According to these authors, an effective training program aimed at introducing a new method into the classroom should take 5 factors into account:

1. *Give explanations and information on the theory of the proposed method.*
2. *Provide a demonstration of the method by the trainers.*
3. *Offer participants the opportunity to implement the method during training.*
4. *Provide feedback to participants on their performance in the exercises.*
5. *Provide direct classroom support when applying the method.*

Taking these factors into account, we have meticulously designed our online training course. With regard to the first two factors, we opted for the use of video capsules to present the essential theoretical points clearly and in detail each week of the course. As for the other factors, we designed specific tasks to be carried out each week. This enabled participants to put their knowledge into practice and receive personalized feedback from tutors.

In one of their studies, Manasrah, Masoud and Jaradat (2021) investigated the ideal length of a video capsule in an online course. These authors were able to demonstrate that short videos were significantly more entertaining and enabled learners to perform better. Manasrah *et al.* (2021) concluded that the optimal length

of an instructional video is between 6 and 10 minutes. This length is confirmed by several other studies where this duration enables better concentration, motivation and attention on the part of learners (Harrison, 2019; Goopio & Cheung, 2020; Pfennig, 2022). Moreover, learning is more effective when the speech is delivered with a human voice rather than a computer voice (Mayer, 2017; Mayer & DaPra, 2012). We therefore took these various recommendations into account when creating our different video vignettes.

Our distance learning course on teaching proportionality for teachers in French-speaking Belgium took place over 4 weeks, from March 20 to April 16, 2023. This meant that participants had the opportunity to complete the activities each week, when they had the chance. We used the Moodle platform to support our online training. To do this, we created four tabs corresponding to each week. At the start of the course, only the first week was visible to learners, so content was made available as the course progressed.

For the first week, we administered a test to our participants to gather certain demographic information (years of seniority, type of study, gender...) as well as to determine their level of confidence and sense of self-efficacy prior to the training. Participants were also asked to watch an introductory training video. They then introduced themselves via a Digipad and completed an analysis activity. In the latter, teachers had to analyze the answers of six students to a proportionality problem, and determine the most appropriate solving strategy.

In the second week, participants were invited to view two video vignettes presenting students' difficulties with proportionality. They were then asked to identify a YouTube video on solving a proportionality problem. The teachers then had to present their video in the form of an infographic, identifying the students' difficulties as well as possible avenues for improvement.

In the third week, participants were asked to watch two videos dealing with possible ways of overcoming students' difficulties. Next, teachers were asked to produce a reflective account of their experience. They could either recount a real-life experience, or choose an exercise from a teaching pack. Participants then posted their work on a Digipad and were asked to comment constructively on another participant's production. We created this exercise with the aim of accentuating collaboration between the various participants in our training course. This collaboration was also present through the use of forums, as teachers were able to respond to each other. This collaboration between teachers in virtual environments has an impact on their professional learning. In fact, according to García-Martínez, Tadeu, Rueda and Batanero (2020), this collaboration between teachers during a training course has a significant impact on their professional learning.

For the final week of distance learning, teachers watched a final video presenting the didactic principles and learning methodology for teaching proportional problem solving. As a final activity, the course participants were then asked to create slides presenting a teaching sequence on proportionality. To do this, they had to identify the target audience, the general objective and write a short summary of the chosen sequence. Teachers were also asked to imagine two solved

examples and a solution by analogy for their teaching sequence. Finally, the teachers were asked to complete an end-of-course questionnaire. This measured the level of satisfaction with the training, the teacher's evaluation of the training, the participant's level of confidence and sense of self-efficacy.

We also provided tutoring throughout the course, with a team of three tutors. The latter acted as resource persons in the event of technical problems, as well as providing personalized feedback. According to Janson, Siebert and Dickhäuser (2022), receiving appropriate feedback improves learners' perseverance and learning performance. This is in line with Park, Johnson, Moon and Lee (2019), who demonstrate that specific feedback is more effective than global feedback. Touron and Hertzog (2014) concluded that timely and accurate feedback had a positive impact on learning, so we made sure to give accurate feedback to each learner as soon as possible after completing a task.

What's more, when an activity was correctly completed, a badge was assigned to the participant. For example, when a video was viewed by a teacher, he or she automatically received a badge associated with that activity. At the end of the training, each person who had completed all the tasks proposed received a "performance" badge to indicate their complete success. By using badges in this way, we wanted to give the teachers taking part in our training a clear idea of their progress, as well as offering them instant feedback.

Based on the Blank and De las Alas (2010) model, we can say that we have respected all the characteristics of a quality in-service training course. Indeed, this model includes five key criteria: training content that is clearly explained and adapted to participants' needs, active behavior on the part of participants, tools that are consistent with what is used in the classroom (e.g. the Digipad), duration and frequency of training, and collaboration between participants and with training tutors.

3.2. Sample

In order to invite teachers to take part in our online training course, we contacted school principals. They then informed the teachers wishing to take part in the training course about its organization. Our sample is therefore an occasional one, based on the availability of subjects.

In the end, our sample comprised a total of 93 teachers (11 men and 82 women). With regard to the seniority of our participants, our sample is mainly made up of teachers with over 20 years' seniority (N = 37). The other teachers are fairly evenly distributed between the different levels of seniority.

We can also classify the teachers taking part in our training according to their initial training. The majority are teachers with a bachelor's degree in primary education (70.968%). The remaining 29.032% are teachers with an AESI or a master's degree in didactics.

3.3. The measurement scales used

Still based on Brinkerhoff's model (2005, cited by Duchaine *et al.,* 2021), we assessed teachers' post-training satisfaction (level 3), the knowledge they were able to acquire (level 4), the transfer of this knowledge to their profession (level 5) and, finally, the impact of training on student results and achievement (level 6).

First, we used the teacher self-efficacy scale developed by Dussault, Villeneuve and Deaudelin (2002). This scale was designed to assess a teacher's degree of self-efficacy in relation to his or her profession. It asks teachers to position themselves in relation to fifteen propositions, using a Likert scale. The scale ranges from "strongly disagree" (1) to "strongly agree" (6). This scale by Dussault et al (2002) is used to assess teachers' self-efficacy by measuring two dimensions: sense of personal efficacy (SEP) and sense of general efficacy (SEG). We therefore used this scale to measure teacher self-efficacy as a pre-test in the first week of training and as a post-test in the final week. Similarly, we measured teachers' confidence levels before and after participating in the training. To do this, we simply asked the question "How confident are you in your didactic approach to proportionality? Participants could answer from 1 ("very little confidence") to 4 ("very much confidence").

Next, with regard to level three of Brinkerhoff's model (2005, cited by Duchaine *et al.,* 2021), we used Gaudreau's (2011) satisfaction questionnaire to assess teachers' satisfaction with our training. This was also presented in the form of a Likert scale ranging from "strongly disagree" (1) to "strongly agree" (6). At the end of the training course, teachers were asked to rate themselves on a total of eight statements.

For the last three levels (4, 5 and 6) of Brinkerhoff's model (2005, cited by Duchaine *et al.,* 2021), concerning the acquisition of new knowledge as well as its transfer and the impact of training on student results and success, we used the scale for evaluating training, called "Q4TE", developed by Grohmann and Kauffeld (2013) and translated into French by Chochard (2013). This scale aims to measure the effectiveness of training from the teachers' point of view, by exploring six dimensions with regard to training: satisfaction, usefulness, knowledge acquired, the application of this knowledge, work performance and the organizational results that this training was able to generate. Participants can then position themselves on a Likert scale according to twelve statements at the end of our training.

The Likert scale ranges from "strongly disagree" (0%) to "strongly agree" (100%).

Using these measurement scales, we were able to collect quantitative data on teacher self-efficacy, as well as teacher evaluation and satisfaction with our online training course on teaching proportionality.

3.4. Research questions

To study the impact of our training, we established various research questions based on Brinkerhoff's model (2005, cited in Duchaine *et al.,* 2021).

Table 1 presents each research question associated with each level of this model.

Table 1. Summary of research questions

Brinkerhoff's model	Research questions
Level 1	What training needs do teachers have?
Level 2	What activities and tools are available to meet teachers' needs?
Level 3	How satisfied were teachers with the training?
Level 4	To what extent did the training enable teachers to acquire new knowledge?
Level 5	To what extent will teachers transfer their new knowledge to their classrooms?
Level 6	What impact has the training had on student results and success?

4. Results

Thanks to the quantitative data we collected using the measurement scales of Dussault et al. (2002), Chochard (2013) and Gaudreau (2011), we were able to carry out descriptive and inferential analyses. To do this, we used JASP software and checked, for each procedure, that the postulates for applying a parametric test were respected; when this was not the case, we applied a non-parametric test to our data.

The presentation of our results follows the structure of Brinkerhoff's model (2005, cited by Duchaine *et al.,* 2021). However, it is not possible to present all the results, due to writing constraints.

Level 3: How satisfied were teachers with the training?

Table 2. Gaudreau's (2011) assessment questionnaire

	$\bar{x}$ (/6)	$\bar{x}$ (/100)
The content of this training course met my expectations.	3.906	65.100

This statement is taken from Gaudreau's appraisal questionnaire (2011). Teachers responding to the questionnaire were asked to rate themselves on a scale of 1 (strongly disagree) to 6 (strongly agree). We can see from Table 2 that the average is close to 4, so we can say that teachers' satisfaction with this distance learning course is quite good.

Table 3. Descriptive statistics Q4TE

	Valide	$\bar{x}$ (/100)
Q4TE satisfaction	32	66.875
Q4TE usefulness	32	69.688

In Table 3, we look at the descriptors relating to the "Q4TE" training evaluation questionnaire (Chochard, 2013). In this, the evaluation of the perceived usefulness of the training is at an average of 69.688%. Regarding satisfaction, the score is similar to the previous item in Gaudreau's questionnaire (2011).

Level 4: To what extent has the training enabled teachers to acquire new knowledge?

Table 4. Gaudreau's (2011) assessment questionnaire

	$\bar{x}$ **(/6)**	$\bar{x}$ **(/100)**
This training has enabled me to develop my knowledge of the teaching of proportionality	4.438	73.967
This training has enabled me to develop my intervention skills with students regarding the teaching of proportionality	4.156	69.267
This training has enabled me to reflect on my teaching practices and their influence on the teaching of proportionality to students	4.688	78.133

As a reminder, these three statements are taken from Gaudreau's (2011) assessment questionnaire. Table 4 shows that the degree of agreement regarding the development of intervention skills is close to 70%. In fact, 74% of teachers felt that the training had enabled them to develop their knowledge of the topic covered. In addition, 78% felt that the training had enabled them to reflect on their teaching practices and their influence on the teaching of proportionality to pupils.

The average SEP score in the post-test was higher than in the pre-test. This result is confirmed from an inferential point of view using the Wilcoxon signed rank test ($W = 79.5$; $p < .001$).

We find that teachers gain in didactic confidence after participating in our online training. Indeed, the average score at the start of training is 2.5 on a scale of up to 4, and increases to 3.031 after training.

The Wilcoxon signed-rank test shows a significant result ($p < .001$). We can therefore conclude that the overall impact of the training is significantly positive on participants' level of didactic confidence.

In addition, we observe a link between changes in didactic confidence and initial confidence. Since these results were statistically significant and negative (Spearman's Rho = -0.499, $p = 0.004$), we can conclude that the less didactically confident the teachers were about teaching proportionality, the more positively their level of confidence evolved at the end of the training.

Level 5: To what extent will teachers transfer their new knowledge to the classroom?

Table 5. Gaudreau's (2011) assessment questionnaire

	$\bar{x}$ (/6)	$\bar{x}$ (/100)
As a result of this training, I intend to modify some of my teaching practices for the teaching of proportionality.	4.719	78.65

Table 5 shows that the degree of agreement among teachers to change their teaching practices is close to 80%.

Level 6: What impact does training have on student results and success?

Table 6. Gaudreau's (2011) assessment questionnaire

	$\bar{x}$ (/6)	$\bar{x}$ (/100)
Following this training, I believe I have the necessary skills to effectively teach proportionality to students.	4.531	75.517

On the other hand, teachers feel they have the necessary skills to teach proportionality effectively, with 75% agreement.

5. Discussion

Learners can experience a variety of difficulties with proportionality in mathematics (Bergeaut *et al.,* 2013). For their part, teachers are not always sufficiently trained to teach this mathematical notion optimally. Dragone, Temperman and De Lièvre (2022) have highlighted the obstacles faced by teachers in this area, and stress the importance of providing them with suitable didactic tools. Teachers should be equipped with the skills required to teach the different forms of reasoning relevant to proportionality. This approach will foster a deeper understanding, enabling students to fully grasp the essential concepts of proportionality (Burgos and Godino, 2020). This research falls within this framework and aims to study the impact of an online training course on teachers' pedagogical practices towards proportionality.

As a reminder, our training took place over a total of four weeks and we were able to welcome a total of 93 participants. Before and after the training, these participants were asked to complete a questionnaire measuring their level of didactic confidence, their satisfaction with the training and their sense of self-efficacy.

To do this, we used three previously validated scales. The first assesses teachers' self-efficacy in relation to their profession, measuring two dimensions: SEP (sense of personal efficacy) and SEG (sense of general efficacy) (Dussault et al., 2002). The second measures the effectiveness of the training from the participants' point of view and is called the "Q4TE" (Chochard, 2013). And the last quantifies teacher satisfaction and was established by Gaudreau (2011).

Based on Brinkerhoff's (2005, cited by Duchaine *et al.,* 2021) six criteria for evaluating in-service training, we can highlight some positive results of our distance training on teaching proportionality.

Concerning the first level of this model, we studied teachers' training needs with regard to the teaching of proportionality by measuring their level of didactic confidence (Dragone *et al.,* 2022) and their sense of self-efficacy prior to our training. We planned our distance training taking into account the needs of the teachers as well as the various recommendations for creating quality training according to Joyce and Showers (2002) and the Blank and De las Alas (2010) model (second level).

For the third level, concerning teacher satisfaction (content presented, Q4TE satisfaction and usefulness), the content presented in this training seems to meet teachers' expectations, who also perceive it as relevant. This result can be related to the fourth level of Brinkerhoff's model (2005, cited by Duchaine *et al.,* 2021) concerning the acquisition of new knowledge by teachers who participated in in-service training. Indeed, our results indicate that the level of didactic confidence in teaching proportionality has evolved significantly and positively. In this distance learning format, participating teachers are mainly motivated by the desire to strengthen their professional skills and optimize their teaching methods (Gonçalves & Gonçalves, 2019). Through analysis of the responses to Gaudreau's (2011) satisfaction questionnaire, we note an improvement in intervention skills and pedagogical practices through the development of teachers' knowledge of proportionality teaching. We also observed a significant negative relationship between changes in didactic confidence and initial confidence. In other words, the less didactically confident teachers were at the start of training, the more positively their level of confidence evolved at the end of the course. Furthermore, teachers have a significantly higher sense of self-efficacy with regard to teaching proportionality at the end of this training. Teachers' self-efficacy plays a crucial role in their students' motivation and academic success (Mojavezi and Tamiz, 2012; Shahzad and Naureen (2017).

The fifth level focuses on teachers' transfer of new knowledge into their classrooms. For this level, we studied the modification of teachers' pedagogical practices (Gaudreau, 2011). Almost 80% of teachers agree that they will modify their teaching practices as a result of this training. This result is in line with Tzivinikou (2015), who believes that appropriate training can improve the quality of pedagogical interventions with learners. We have tried to meet the criteria defined by Joyce and Showers (2002) and the Blank and De las Alas (2010) model as closely as possible, in order to create an effective, high-quality training program. Finally, the last and sixth level investigates the impact of training on student results and achievement. At the end of this training, teachers show a degree of agreement of 75% concerning the skills required for effective teaching of proportionality. Ongoing professional development for teachers is an opportunity not only to enrich and update their teaching practices, but also to enable effective action while fostering a better understanding of their profession and a sense of comfort in their role (Mukamurera, 2014).

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