The issue of didactical suitability in mathematics educational videos: experience of analysis with prospective primary school teachers

La cuestión de la idoneidad de los vídeos educativos de matemáticas: una experiencia de análisis con futuros maestros de educación primaria

María BURGOS, PhD. Associate Lecturer. Universidad de Granada *(mariaburgos@ugr.es).*
Pablo BELTRÁN-PELLICER, PhD. Associate Lecturer. Universidad de Zaragoza *(pbeltran@unizar.es).*
Juan D. GODINO, PhD. Professor. Universidad de Granada *(jgodino@ugr.es).*

Abstract:

The number of educational videos available on the internet on the most varied topics is rapidly increasing. These include mathematics videos that cover virtually any type of curriculum content. However, their quality as a learning resource varies greatly. As a result, it is necessary to provide teachers with tools to enable them to analyse the appropriateness of using educational videos, considering the various aspects involved. This paper describes the design, implementation and results of an educational intervention with 93 prospective primary school teachers, focussed on developing their ability to analyse the educational suitability of videos about proportionality. Preliminary analysis of the video revealed significant errors and inaccuracies in the definitions, propositions, and procedures, as well as shortcomings and inaccuracies in the arguments, and so its level of epistemic suitability is rated as medium. However, the majority of the prospective teachers rated its degree of suitability as high in almost all components.

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Students regard studying didactic suitability and implementing it through components and indicators as positive, believing that this activity facilitates professional reflection. However, mastering this tool requires analysing a greater number and variety of videos and further collective discussion of the results of the analyses performed by the students.

Keywords: teachers' education, onto-semiotic approach, didactical suitability, educational videos, proportionality.

Resumen:

La cantidad de vídeos educativos disponibles en Internet sobre los más variados temas está aumentando a un ritmo acelerado. Así, nos encontramos vídeos de matemáticas que cubren prácticamente cualquier tópico curricular, aunque su calidad como recurso didáctico es muy desigual. En consecuencia, es necesario proporcionar a los profesores herramientas que les permitan analizar la pertinencia del uso de estos vídeos, teniendo en cuenta los diversos aspectos implicados. En este trabajo se describe el diseño, implementación y resultados de una acción formativa con 93 futuros maestros de educación primaria, orientada al desarrollo de la competencia de análisis de la idoneidad didáctica de vídeos sobre proporcionalidad. El análisis *a priori* del vídeo reveló errores e imprecisiones significativas en las definiciones, proposiciones y procedimientos, así como carencias o inexactitudes en los argumentos, por lo que el nivel de idoneidad epistémica se valora como media. Sin embargo, la mayoría de los futuros docentes valoraron su grado de idoneidad como alto en casi todos los componentes. Los estudiantes consideran positivo el estudio de la idoneidad didáctica y su implementación a través de componentes e indicadores, considerando que esta actividad facilita la reflexión profesional. No obstante, el dominio de esta herramienta requiere incrementar el número y variedad de vídeos para analizar y mayor discusión colectiva de los resultados de los análisis que realizan los estudiantes.

Descriptores: formación de profesores, enfoque ontosemiótico, idoneidad didáctica, vídeos educativos, proporcionalidad.

1. Introduction

The use of educational videos from YouTube and other platforms has increased dramatically in recent years, offering a promising learning resource for students and the general public (Azer, AlGrain, AlKhelaif, & AlEshaiwi, 2013).

These educational resources and the pedagogical models that use them, such as *flipped learning* (Bergmann & Sams, 2012), should be the subject of educational research as it is not clear how possible it is to achieve meaningful learning by watching recorded classes. Indeed, several researchers discuss the role that the use of YouTube and other social media might play in formal education, analysing how online resources are organised and how they can be inserted

as informal tools in specific educational settings (Borba et al., 2016; Dabbagh & Kitsantas, 2012; Duffy, 2008; Portugal, Arruda, & Passos, 2018; Ramírez, 2010). It is widely regarded as necessary for the field of educational studies to investigate the adequacy of online educational resources to ensure that technology is in accordance with learning objectives (Turney, Robinson, Lee, & Soutar, 2009).

Research in mathematics teaching regarding the use of educational videos emphasises the importance of the teachers themselves evaluating and recommending suitable videos for their pupils (Beltrán-Pellicer, Giacomone, & Burgos, 2018; Ruiz-Reyes, Contreras, Arteaga, & Oviedo, 2017; Santos, 2018). This is because some of these videos show formally incorrect procedures, not all of them indicate the educational level for which they are intended, and the meanings they raise might not be relevant to what is being covered in class. Accordingly, there is a clear need to design and implement training processes that make it possible to promote teachers' professional growth and develop their knowledge and competences (Chapman, 2014; English, 2008; Mason, 2016; Ponte & Chapman, 2016; Sadler, 2013).

In view of this issue, the aim of this research is to design, implement, and evaluate a training activity for future primary school teachers, focussing on developing knowledge and competences, relating to the analysis of the epistemic suitability of educational videos about proportionality that are available on the internet.

The work is based around the following sections. Section 2 outlines the theoretical framework and specific research problem. Section 3 describes the design of the training process implemented. Section 4 includes a preliminary analysis of the video about proportionality, which is used as an instrument for evaluating the competences achieved by the future teachers. Section 5 shows in detail the results of the experiment, analysing qualitatively and quantitatively the reports drawn up individually by the future teachers. The final section includes a summary of the research and discussion of its implications, and limitations.

2. Theoretical framework and research problem

In the field of research into training mathematics teachers, different theoretical frameworks are used to categorise and promote different types of professional knowledge and competences (Pino-Fan & Godino, 2015). We consider that the didactic–mathematical knowledge and competences (DMKC) model (Godino, Giacomone, Batanero, & Font, 2017; Breda, Pino-Fan, & Font, 2017), developed within the framework of the onto-semiotic approach to mathematical knowledge and instruction (OSA) (Godino, Batanero, & Font, 2007), provides suitable tools for approaching our research problem. This model emphasises the importance of designing and implementing training resources that promote teachers' competence in

analysing educational suitability. *Didactical suitability* is understood as the degree to which an instructional process combines certain characteristics that mean it can be described as appropriate or adequate, the main criterion being the fit between the personal meanings students construct (learning) and the institutional meanings, whether these are intended or actually implemented (teaching), taking into account the influence of the environment (Godino, 2013). This involves coherently and systematically articulating six criteria relating to the facets that affect a training process (Godino et al., 2007): epistemic, ecological, cognitive, emotional, interactive, and those relating to media.

We consider that a mathematics training process is more epistemically suitable the better the institutional meanings implemented (or intended) represent a reference meaning. The reference meaning will relate to the particular educational level and should be drawn up, taking into account the different types of problems and contexts for use of the content taught, as well as the operational and discursive practices required (Godino, 2013). Consequently, it will be necessary to take into account the degree of adequacy of the situations–problems and it will also be necessary to consider the variety and adequacy of the representations, definitions, procedures, and propositions, as well as the arguments supporting them. High suitability from an epistemic perspective requires the situations–problems proposed to involve a variety of representations, to offer students a variety of ways of approaching them, and to require students to interpret, generalise, and justify the solutions. Furthermore, the different partial meaning of the mathematical objects that appear must be connected and defined (Godino, Font, Wilhelmi, & Lurduy, 2011).

Using didactical suitability enables teachers to reflect systematically on their own practice (Aroza, Godino, & Beltrán-Pellicer, 2016; Beltrán-Pellicer, Godino, & Giacomone, 2018; Posadas & Godino, 2017) and it can also be applied to analyse partial aspects of the instructional processes, such as the use of technological resources. Specifically, Beltrán-Pellicer, Giacomone, and Burgos (2018), using the theoretical–methodological tools from OSA, analysed the degree of epistemic suitability of a selection of the educational videos viewed most frequently by users of YouTube™, relating to problems of proportional sharing. On the one hand, they found a wide variety of focuses and methods for solving this type of problem, which can interfere with the teaching and learning process in the classroom if the teacher does not previously select or record these videos. On the other hand, the epistemic suitability of the sample of videos analysed was very diverse, with videos that contained errors and inaccuracies as well as many of them offering an unrepresentative or poorly defined treatment of the mathematical content. Finally, they noted that the videos with the metrics reflecting the greatest popularity were not the most suitable ones. This work is the main antecedent of the present paper.

We consider that it would be desirable for teachers to understand the didactic

suitability of the tool and acquire the necessary competence to use it to analyse educational resources critically, particularly in the use of videos available online.

Furthermore, various pieces of research show that teachers, both in their initial training and in service, show difficulties with teaching concepts relating to proportionality (Bartell, Webel, Bowen, & Dyson, 2013; Ben-Chaim, Keret, & Ilany, 2012; Berk, Taber, Gorowara, & Poetzl, 2009; Hilton & Hilton, 2018). Teacher training must take into account the development of mathematics teaching knowledge and competences relating to this topic by designing and implementing specific training interventions. This is why the trainee teachers were asked to analyse a video on proportionality.

3. Design of the training process

The training experience was carried out during the 2018-2019 academic year in the framework of the Curriculum Design and Development in Primary Education module with ninety-third year students from the Primary Education degree.

During their degree studies, future teachers receive specific training about epistemic (mathematical content), cognitive (mathematics learning, errors, and difficulties), instructional, and curricular aspects, so that when carrying out their school placements, they should be able to put into practice the knowledge they have acquired to analyse, design, and support teaching-learning according to specific content (in our case, proportionality).

Furthermore, before carrying out this research, and in line with the chosen DMKC model, we carried out training workshops with the group of students focussing on developing the competence of analysing global meaning (based on identifying situations-problems and the operational, discursive, and normative practices involved in solving them), and onto-semiotic analysis of the practices (description of the framework of objects and processes involved in the practices) used in the mathematical activity of solving problems involving proportionality.

The first session comprised a two-hour workshop where the characteristics of the theory of didactical suitability were presented, as well as how the different epistemic, cognitive, affective, interactional, media related, and ecological dimensions of a given study process relate to each other. The aim was to involve future primary school teachers in a reflection on the need to have a system of specific indicators that make it possible to evaluate teaching practice systematically.

In the next session, also lasting two hours, the future teachers worked in teams to analyse the epistemic suitability of online educational videos on proportionality. The initial group work enabled the students to compare, discuss, and improve their proposals for evaluating the epistemic suitability of different educational videos relating to proportionality.

In the third phase, the students individually completed the tasks described in

the following section as a final evaluation instrument, the results of which are analysed in this work.

4. Preliminary analysis of the epistemic suitability of the video

In this section we analyse the epistemic suitability of the video, that is, the mathematical knowledge brought into play in it. This analysis will serve as a benchmark for interpreting the students' answers when they evaluate the suitability of the educational video. The researchers performed the analysis and preliminary evaluation independently. They then compared them to decide on a common evaluation.

The educational video analysed[1] covers the topic of direct arithmetic proportionality from the perspective of presenting the notions of ratio and proportion (Ben-Chaim, Keret, & Ilany, 2012). The idea is that the future teachers will watch the video closely and critically assess its degree of suitability, in line with the epistemic suitability components and indicators (Godino et al., 2007; Godino, 2013).

In general, the situations-problems proposed in the video are presented in context and the mathematical ideas are connected. Various ways of approaching the problems are proposed, but we consider that the sample of the problems is not sufficiently representative or defined. The solution methods proposed are only applied to problems with a missing value, in which the condition of regularity is assumed in advance, and problems involving comparing ratios, for example, are not considered. The video features a great variety of linguistic registers and representations: natural registers (oral and written), symbolic (numerical and algebraic), tabular, and graphic ones.

Furthermore, we have identified some errors and inaccuracies in the presentation of rules (definitions and propositions) and arguments:

— Error of expression in the handling of simplifications of fractions. To simplify, the numbers that appear in the numerator and denominator are crossed out, leaving as superscript the factors that remain when canceling terms.

Graph 1. Screenshot from minute 7.

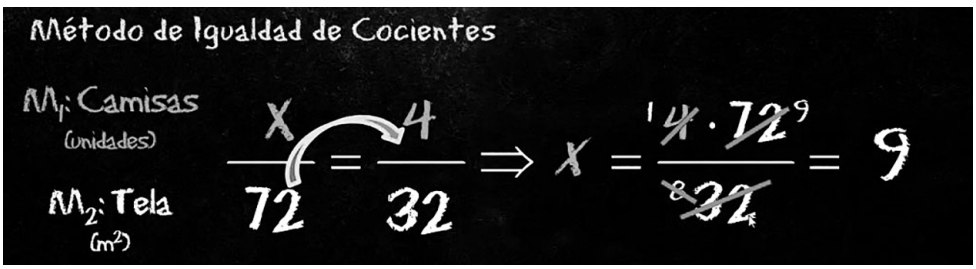

Image text: Quotient Equality Method. M_1: shirts (units) M_2: fabric (m^2)

Source: Clasemáticas, 2012.

— Error in the definition of ratio and proportion.

(1:00) «Ratio, mathematically speaking, means quotient. The proportion, the ratio, the quotient between these two magnitudes is always the same.»

Here we see incorrect use of the concepts of ratio and proportion. A ratio is not always a quotient and a ratio is not the same as a proportion, a confusion found with some frequency in teaching practice.

— The doubling rule does not necessarily denote a relationship of direct proportionality.

(3:20) The narrator presents a «trick» to find out whether two magnitudes are directly proportionate: «To find out if two magnitudes are directly proportionate, all you have to do is check that doubling one is the same as doubling the other, tripling is the same as tripling.»

This is a necessary but not sufficient condition for two magnitudes to be directly proportionate. The proportionality of magnitudes is a linear function established between the values of the magnitudes.

— When the relation of direct proportionality is justified, this is based on the relationship that doubling one magnitude corresponds to doubling the other.

(4:30) Next, the narrator tells the students the question they should ask after finding the magnitudes: «Will twice as many shirts need twice as much cloth?»

(4:43) «If the answer is yes, and in this video it obviously will be, because if not, we would be looking at another type of proportionality … then we are looking at a problem of direct proportion.»

This is incorrect. The answer to a question like the one he asks might be no and it might be that no other situation of proportionality is involved.

— Neither the operations in a proportion nor the reason for using cross multiplication are explained.

We consider that the degree of suitability regarding relationships between objects, on a low-medium-high ordinal scale, is medium, as not all of the propositions and procedures have an associated argument. Furthermore, the various meanings of the objects that appear in the exercises are sometimes but not always identified, and so the degree of suitability is medium in this aspect.

GRAPH 2. Screenshot from minute 8:15. General method.

Image text: General Method of Proportionality. M_1: shirts (units) M_2: fabric (m^2)

Source: Clasemáticas, 2012.

(8:15) «In other words, the quotients are equal between the magnitudes, within them, or comparing one with the other magnitude, so this quotient is also correct.»

In the first method he presents, the «equal quotients» one, he uses external ratios. Here, in what the author calls the «general proportionality method», he uses internal ratios, without appropriately explaining the relationship between the two proportions. Furthermore, he uses the term proportion instead of ratio to refer to the fractions that appear on screen.

The final procedure for solving proportionality problems that the author of the video presents is the rule of three:

(11:35) Put the magnitudes in a column; «we put x is to 72 as 4 shirts is to 32.»

GRAPH 3. Screenshot from minute 11:47. Rule of three method.

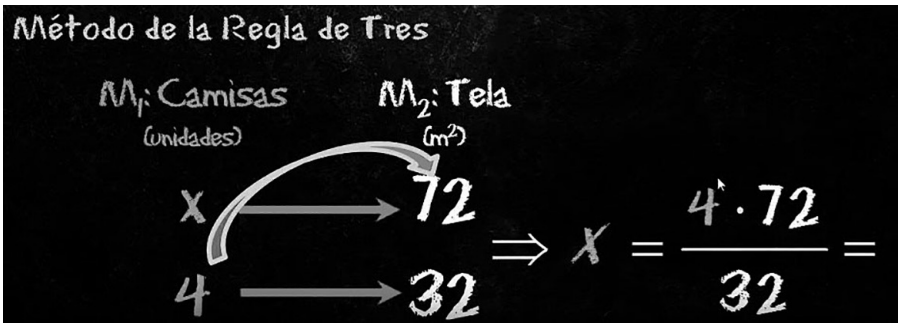

Image text: Rule of three method. M_1: shirts (units) M_2: fabric (m^2)

Source: Clasemáticas, 2012.

(11:47) «And this, in reality, if you rewind the video, is the general method. The thing is I don't know why you love putting arrows on it. The general method has a mathematical explanation and this one doesn't really.»

He relates the rule of three method, which he solves by cross multiplication, to the general method. Thus, he is referring to to a «debased rule of three», that is to say, he does not present the proportional equation, which he distinguishes as another method. Therefore, what he calls «the rule of three» is, in the diagram (using arrows), accompanied by cross multiplication, which is not justified in the video.

Based on these analyses, the researchers quantitatively evaluated the video's degree of epistemic suitability in each of the six components, scoring each indicator according to whether its contribution to the suitability is low, medium, or high (0, 1, or 2 points, respectively). The total maximum score will, therefore, be 12. Table 1 shows the marks given by the research team.

TABLE 1. Evaluation of epistemic suitability by components.

Component	Score given to the video
Situations-problems	1
Language	2
Rules	1
Arguments	1
Relationships between objects	1
Articulation of meanings	1
Final score	7

Source: Own elaboration.

5. Results

For the second working session, we asked the students firstly to watch at home three videos[2] about directly proportional distributions which had different degrees of suitability. Individually, they had to decide on the greater or lesser degree of suitability of the videos as well as their level of use of algebra, taking into account the type of solution developed. Afterwards, in class, they were asked to discuss their evaluations with the work group and then prepare a group opinion about the degree of suitability of the different videos. The instructions given to the students for analysing the videos are the same as the ones proposed in the final task. That is to say, should consider: a) the variety of situations-problems presented; b) the presence of different registers of representation; c) the clarity and correctness of the definitions, propositions, and procedures; and d) the argumentation of the propositions and procedures.

As a result of this session, we saw that the future teachers overlooked the errors in definitions, propositions or procedures present in the videos and that in the idea-sharing in the working group, they found it hard to agree on the degree of suitability of the different videos. Discussing the individual positions in many cases led them to modify their preliminary analyses, identifying new elements of analysis that had gone unnoticed.

In this section, we analyse the answers the students gave in the final evaluation task (third working session), which consequently reflect what these students have learnt. We then analyse the answers given to the quantitative evaluation instruction for each of the six components of suitability, as well as the overall adequacy of the video.

Table 2 shows the frequencies and percentages of the answers given regarding the characteristics of the situations-problems presented in the video.

TABLE 2. Variety of situations-problems proposed (n = 93).

Characteristics of the situations	Frequency (%)
A representative and defined sample of problems is presented	83 (89.25)
The situations appear in context	83 (89.25)
The mathematical ideas are connected	87 (93.55)
Various ways of tackling the problems are suggested	89 (95.70)

Source: Own elaboration.

We can see that the majority of the students adequately recognised that the situations are presented in context in the educational video being analysed, the ideas are connected, and various ways of approaching the problems are provided. The majority of them (89.25%) also accepted that the videos show a representative and defined sample of problems.

In relation to the presence of different representations and language registers, the students have no difficulty in identifying the natural register and the symbolic register. However, they identify the tabular and graphic registers to a lesser extent. Other students, to a lesser extent, identify animation and other different types (Table 3).

TABLE 3. Identification of linguistic representations (n = 93).

Type of language	Frequency (%)
Natural (oral)	92 (98.9)
Natural (written)	93 (100.0)
Symbolic (numerical)	89 (95.7)
Symbolic (algebraic)	83 (89.2)
Tabular	74 (79.6)
Graphic	28 (30.1)
Animation	49 (52.7)
Others (iconic, multimedia, diagrammatic, etc.)	10 (10.8)

Source: Own elaboration.

The majority of the future teachers have difficulties locating the errors or inaccuracies in the definitions, propositions or procedures, as well as in the arguments given for the transformations, or when the relationship of direct proportionality in the situations presented is justified (Table 4).

TABLE 4. Clarity and correction of definitions, propositions, procedures, and arguments.

Errors and inaccuracies in the rules and arguments		Frequency (%)			
		Not stated	Explicitly states there are none	Yes but does not specify what	Yes and describes it
Rules	Errors in arithmetic-algebraic treatment	63 (67.7)	21 (22.6)	2 (2.2)	7 (7.5)
	Errors in definitions	51 (54.8)	22 (23.7)	2 (2.2)	18 (19.4)
	Errors in propositions or procedures	51 (54.8)	21 (22.6)	5 (5.4)	16 (17.2)
Arguments	Error or inaccuracy when justifying a relationship of proportionality	45 (48.4)	20 (21.5)	6 (6.5)	22 (23.7)
	Error or inaccuracy when justifying an arithmetic-algebraic transformation	54 (58.1)	20 (21.5)	4 (4.3)	15 (16.1)
	Other errors or inaccuracies	52 (55.9)	20 (21.5)	2 (2.2)	19 (20.4)

Source: Own elaboration.

When the future teachers identify errors of arithmetic or algebraic processes, some mention that the author of the video does not explain some of the symbols used, including subscripts, or that simplifying the results of the operations might confuse the students.

With regards to errors or inaccuracies the students recognise in definitions, we find the following categories of answers:

— Error in the definition of ratio. This is the category with most answers that identify conflicts in the definitions.

For example, E50 said: «Ratio: the video defines this as the proportion of the quotient between both magnitudes. This could cause confusion; one alternative would be "link between two magnitudes that can be compared to each other."»

— Inaccuracy in the definition of direct proportionality.

— Confusing definitions or ones that are inappropriate for primary school.

— As well as these categories, some students include as errors in the defini-

tions descriptions that are not relevant in relation to procedures or modes of expression. For example, E84 notes that: «The names used for the methods for calculating the proportion could cause confusion as in different places different names might be used for these methods.»

The future teachers show difficulties assigning errors to the appropriate categories and providing relevant descriptions. They refer to «confusing explanations» in «Errors relating to definitions». For example, E54 identifies as an error in definitions:

> In the explanation of the proportionality method (in the exercise with the shirts) he isolates «x» as if it were an equation. He should have found the proportion between the shirts and the metres of cloth (how many times bigger the metres of cloth are than the number of shirts) and then divided the metres of cloth to get «x».

Then adds regarding «Errors in propositions or procedures»: «In procedures, I would put the same error as in "Errors in definitions"».

Most of the students who identify conflicts in procedures refer to the rule of three: «He crosses out numbers and isolates «x» in the rule of three confusingly, writing small numbers next to big ones might give the impression they are powers (E52)».

Other students identify procedural errors: «In the equal quotients method, putting the unknown quantity «x» in the numerator, it is easier for the student to place it in denominator of the left fraction (E26).»

Or they feel that the explanations that accompany the procedures are complex or insufficient.

Only one student (E83) refers to the error in the proposition: «To find out wether two magnitudes are directly proportionate or not, all you have to do is check that doubling one is the same as doubling the other, tripling is the same as tripling …»

No student mentions as an inaccuracy the fact that the argumentation of the relationship of direct proportionality is only based on the proposition that «doubling one magnitude corresponds to doubling the other». Most of the students who place an error in this category do so incorrectly, either because they indicate «confusing explanation» or «limited argumentations» or because they refer to inaccuracies in the explanation of transformations and not in the relationship of proportionality.

Only six students make any reference to the lack of argumentation of the operations. For example, E67 states that: «The only problem I can see with this video is that when simplifying he does not explain this process, it is true that the video is not about simplification but it could mean students get lost when solving problems.»

In relation to other errors, the future teachers fundamentally identify:

— Errors or inaccuracies in the expression (oral) or language used.

— Unsuitable presentation for primary-school pupils.

— Difficulties understanding the differences between the methods for solving the problem.

— Insufficient arguments for arithmetic transformations.

Regarding the «trick» the author of the video presents, E68 includes the following as an error:

> Trick: «To find out whether two magnitudes are directly proportional, it is enough to establish that the double of one of them corresponds to the double of the other». Although this is a quick way of seeing if there is direct proportionality or not, it seems imprecise as it only mentions doubling. He should mention «halves match», «sums match», «differences match», in other words, using all four operations.

Table 5 shows the frequency of errors detected by the future teachers. We distinguish between answers that mention an error in a somewhat relevant way in the appropriate category and answers that are not relevant because they are not in the appropriate category, because the description of the error is not conclusive or is subjective, or because what they include cannot be regarded as an error or inaccuracy. In general, the percentages of students who recognised errors and inaccuracies were low. The highest related to the justification of the relationship of proportionality, mentioned by 22 students (23.7%).

TABLE 5. Errors identified by the students.

Errors and inaccuracies in the rules and arguments detected by the future teachers		**Frequency**				
		Relevant answer	Irrelevant answer			Total (%)
			It is an error but not in the category identified	Inconclusive or subjective description	Not an error	
In rules	Arithmetic-algebraic treatment	1	1	1	4	7 (7.5)
	In definitions	7	3	5	3	18 (19.4)
	In propositions-proportions	4	3	5	4	16 (17.2)
In arguments	When argumenting the relationship of proportionality	3	8	4	7	22 (23.7)
	When argumenting transformation	5	3	3	4	15 (16.1)
	Others	5	2	7	5	19 (20.4)

Source: Own elaboration.

Section d) of the instructions asked the trainee teachers to identify whether the mathematical objects and the meanings are presented in connection in the video. Apart from two students who did not answer this section, 73.12% of the future teachers believed that the mathematical objects are related in a relevant way and that, as such, the degree of suitability of this aspect is high (Table 6). Furthermore, 63.44% said that the different meanings of the objects involved are always connected.

TABLE 6. Relationships between objects and meanings.

Relationships between mathematical objects		Suitability	Frequency (%)
Relationships between objects	All of the propositions and procedures have an associated argument	High	68 (73.1)
	Some of the propositions and procedures have an associated argument	Medium	23 (24.7)
	None of the propositions and procedures have an associated argument	Low	0 (0.0)
The meanings of the objects that appear are identified and interwoven	Always	High	59 (63.4)
	Sometimes	Medium	30 (32.3)
	Never	Low	2 (2.2)

Source: Own elaboration.

According to the results obtained in the preliminary analyses (variety and representativeness of the situations-problems proposed, variety of representation systems, clarity and correctness of the rules and arguments, connection between objects and meanings), the future teachers had to quantitatively evaluate the degree of didactical suitability of the video. They had to assign a score of 0, 1, or 2 depending on whether they regarded its suitability as low, medium, or high, respectively.

TABLE 7. Frequency (%) of evaluation of epistemic suitability by components.

Components	Evaluation of the video		
	0	1	2
Situations–problems	1 (1.1)	40 (43.0)	52 (52.9)
Language	3 (3.2)	37 (39.8)	53 (57.0)
Rules	3 (3.2)	33 (35.5)	57 (61.3)
Arguments	1 (1.1)	42 (45.2)	50 (53.8)
Relationships between objects	4 (4.3)	22 (23.7)	67 (72.0)
Articulation of meanings	2 (2.2)	37 (39.8)	54 (58.1)

Source: Own elaboration.

Table 7 shows that over half of the students gave the highest mark for relevance in each of the epistemic suitability components. The aspect with the highest valuation is the relationship between objects (72.0% indicated high suitability here) followed by correctness of rules (61.3%).

We can see that the highest score that can be assigned to the video is 12 points. The minimum score assigned was 4 points (one student) and the mean was 9.5 points. The most common score (in 29% of cases) was 10 points. Furthermore, 9 students (10%) gave the video the maximum score.

The future teachers were asked to explain the reasons for their epistemic suitability scores. Analysing their answers has enabled us to identify the categories in Tables 8 and 9, where we distinguish arguments for a positive evaluation and arguments for a negative evaluation.

TABLE 8. Arguments for giving a positive evaluation (n = 93).

Indicator	Frequency (%)
Attractive presentation	8 (8.6)
Adequate language	43 (46.2)
Varied language	21 (22.6)
Variety of examples (representative and articulated sample of situations-problems)	26 (28.0)
Everyday situations-context/connection with real life	27 (29.0)
Appropriate arguments/clear explanations	38 (40.9)
Enough arguments	17 (18.3)
Varied and adequate procedures/methods	23 (24.7)
Coherent/adequate definitions	19 (20.4)
Articulated meanings	17 (18.3)
Favours reasoning or that pupils construct, perfect, and use their own representations to organise, record, and share ideas	14 (15.1)
Appropriate relationships between objects (propositions with associated argument; related methods)	15 (16.1)
No error in rules or arguments	7 (7.5)

Source: Own elaboration.

The future teachers gave a positive valuation to the language used and to the arguments used being appropriate and the explanations clear. For example, E14 gave 2 points to the language component, saying:

The language used is varied: natural (oral and written), symbolic (numerical and algebraic), tabular (using tables), animation (a child thinking and asking a question, a gif with movement in the result of the problem), and with arrows establishing relationships of proportionality.

> ... Also, the level of language is clear and simple suitable for the Primary Education level it is aimed at.

E22 gives the arguments component 2 points: «I did not think there were any notable errors regarding the arguments and the procedures used in the video. The arithmetic operations are always accompanied by an argument and justification. The arguments and procedures are clear.»

However, these components are where negative evaluations are most often given, referring both to errors in expression and language and to unclear or confusing arguments (Table 9). E38 said: «Sometimes it uses language that is a bit technical for a primary-school child. I think the arguments are good, but they could be a bit clearer in some of the 4 methods it explains for direct proportionality.»

TABLE 9. Arguments for giving a negative evaluation (n = 93).

Indicator	Frequency (%)
Situations-problems not adequate for primary level	3 (3.2)
Errors in expression/language	11 (11.8)
Language not suitable for primary level	11 (11.8)
Poor representations (little connection, lack of graphic or visual language)	3 (3.2)
Difficulty distinguishing methods	4 (4.3)
Excessive arguments	3 (3.2)
Unclear, confusing or fast arguments	19 (20.4)
Propositions with no connected argument	1 (1.1)
Incorrect or insufficient definitions	2 (2.2)
Definitions not adequate for primary level	4 (4.3)
Procedures not adequate for primary level	3 (3.2)
Procedures unclear or fast	4 (4.3)
Errors in procedures (simplification in rule of 3)	5 (5.4)
Arguments not adequate for primary level	4 (4.3)
Unconnected meanings	12 (12.9)
Lacks situations of meaning construction or own representations	3 (3.2)
The author includes ideas out of context or that might cause confusion (for example, inverse/compound proportionality)	3 (3.2)
Situations contextualised poorly or only in a mathematical context	4 (4.3)

Source: Own elaboration.

The analysis as a whole should lead future teachers to decide whether the video seems suitable to them, explaining their decision. In this case, we have classified the students' responses into «yes», «yes, but …» when they make some kind of objection, and «no». Table 10 includes the frequencies and percentages of each of these options.

TABLE 10. Adequacy of the video in the final reflection (n = 93).

In your opinion, is this video adequate?	Frequency (%)
Yes	48 (51.61)
Yes but…	38 (40.86)
No	7 (7.53)

Source: Own elaboration.

Of the future teachers, 51.61% consider the video to be adequate, and they valued most highly the presence of various ways of solving the problems and the degree of adequacy of the argumentation. Table 11 summarise the different explanations the students used to evaluate how adequate the video is.

TABLE 11. Arguments when they believe the video is totally adequate (n = 48).

Indicator	Frequency (%)
Various ways of solving problems	46 (95.8)
Variety of examples	22 (45.8)
Adequate and detailed explanation	42 (87.5)
Simplifies definitions/presents the most relevant and representative information	13 (27.1)
Adequate representation/language	26 (54.2)
Useful/motivational	7 (14.6)
Includes tricks/advice	12 (25.0)
Relatable context	10 (10.8)
Inspires reflection on most adequate method	6 (12.5)

There are no errors	7 (14.6)
Adequate length	2 (4.2)
Attractive presentation, informal tone	5 (10.4)

Source: Own elaboration.

Of the future teachers, 40.86% did not believe that the video was wholly adequate (Table 10). They identify as drawbacks the length, the language, and some of the methods used being inadequate for primary-level, or it potentially being boring for the pupils.

TABLE 12. Arguments that indicate drawbacks («yes but ...») (n = 38).

Indicator	Frequency (%)
Language not adequate for primary level	11 (28.9)
Arithmetic procedures not explained	4 (10.5)
Excess length	6 (15.8)
Boring or causes pupils to switch off, lacks animations or visual resources	19 (50)
Causes confusion among the students	6 (15.8)
Lacks variety of contexts	3 (7.9)
Incorrect explanations	5 (13.2)
Too long and dense for primary school	11 (28.9)
Not all situations/concepts/methods are adequate for primary level	12 (31.6)
Does not take into account prior knowledge or problems with learning	4 (10.5)
Contains errors	7 (18.4)

Source: Own elaboration.

Finally, only 7.5% of the students did not believe the video was adequate. They state that the explanations are not very accurate or not at all accurate and the arguments are inadequate or confusing for primary level.

Analysing students' answers has enabled us to detect some conflicts relating to the identification of components and descriptors in the analysis of epistemic suitability, essentially relating to rules and articulation of meanings. For example, E32 identifies rules with ways of solving a problem and states: «I have given the rules a mark of 2 because they do display a wide variety of ways of solving the problem.»

Similarly, E56 noted that:

> For the rules, I have given a score of 2 (high) for suitability because I agree with how he does the operations in each case where he solves the problems and because I do not think he makes any errors when doing them.

Some students consider that the meanings are articulated when various methods are used or what is being done in the video is justified. For example, E41 said: «I think that the definition of concepts has a high level, because it uses various methods to solving the problems.»

E30 added: «Regarding the articulation of meanings, the suitability is high as it constantly explains what each thing being done means.»

6. Summary, implications, and limitations

The aim of this work was to design, implement, and evaluate a training activity for future primary school teachers focussed on developing the knowledge and competence to analyse the epistemic suitability of educational videos on proportionality. We started by stating why the topic is of interest, given the abundance and availability of videos that are offered as resources to help teach mathematics. However, given the inconsistent quality and variety of meanings in the educational videos (Beltrán-Pellicer, Giacomone, & Burgos, 2018), there is a need to train teachers in how to evaluate these resources and use them suitably.

The training activity focusses on providing future teachers with a theory-based tool for analysing epistemic suitability, that is to say, the mathematical content presented in a video about proportionality. Preliminary analysis by the researchers of the video revealed errors and inaccuracies in definitions, propositions, and procedures, as well as shortcomings or inaccuracies in the explanations used to justify the procedures and propositions. Also, the presentation and treatment of a variety of situations-problems and the articulation of meanings of proportionality have major shortcomings, and so we rated its level of epistemic suitability as medium on the low-medium-high ordinal scale. However, the majority of the future teachers, after the training process had been applied, ra-

ted the degree of suitability of the video as high in almost all components.

The evaluation instrument used, based on epistemic suitability components and indicators, considers the variety of situations-problems posed, the presence of different registers of representation, the clarity and correctness of the definitions, propositions, and procedures, and the justification for procedures and propositions using arguments that are relevant and adapted to the corresponding educational level. Failure to recognise the absence of some important indicators led a high percentage of students (51.6%) to regard the video as an adequate teaching resource without identifying its shortcomings.

We also observed a degree of inconsistency in the allocation of scores by the participants, finding some evaluations with the maximum score where students identify more drawbacks than in others with lower scores. While these variations keep the overall evaluation coherent, they do indicate that it is perhaps necessary to define the criteria more, in order to achieve greater uniformity between participants. Nonetheless, we have to take into account that this is a qualitative evaluation of suitability and that the final number, within certain margins, is only the summary result of a more complex process in which the different components of suitability are identified.

These results suggest there is a need to consider in greater depth the development of future teachers' specialised content knowledge, in this case regarding proportionality, increasing the training time allocated, analysing a larger variety of educational videos, and increasing group discussion of the results of the analysis phase.

This type of training action, focussing on the content of the discipline but with a clear orientation towards knowledge and didactic competences, aligns with works by other authors such as Davis (2015), where he notes the impact of his concept study, both when revealing the complexity of the underlying mathematical ideas and when developing the mathematical ideas necessary for teaching.

Furthermore, in addition to the epistemic element, the didactical suitability theoretical tool includes the cognitive, emotional, interactional, media, and ecological aspects, which are not considered in this piece of research. Although it is not relevant to apply some of these aspects to the case of using didactic resources, in particular the aspect of learning achieved, the other aspects could be the subject of analysis and reflection by the teachers who use these resources.

Notes

[1] The video from the *Clasemáticas* channel can be viewed at https://www.youtube.com/watch?v=o1Mu-lkgv-o

[2] The videos suggested can be viewed at:
https://www.youtube.com/watch?v=0Z5DejetHR8
https://www.youtube.com/watch?v=v8KN44iNPIs
https://www.youtube.com/watch?v=1uAbIb-McLo

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Authors' biographies:

Maria Burgos is an Associate Lecturer in the Department of Didactic of Mathematics at the Universidad de Granada. She has a doctorate in Mathematics from the Universidad de Almería and a master's in Didactic of Mathematics from the Universidad de Granada. She is a member of the FQM-126 Teoría de la Educación Matemática y Educación Estadística (Theory

of Mathematics Education and Statistics Education) group.

https://orcid.org/0000-0002-4598-7684

Pablo Beltrán-Pellicer is a Associate Lecturer in the Didactic of Mathematics area of the Universidad de Zaragoza and a Compulsory Secondary Education and Spanish Baccalaureate Teacher at the CPI (Integrated Public School) Val de la Atalaya (María de Huerva, Zaragoza). He has a doctorate in Mathematics Teaching and is a member of the S36_17D Investigación en Educación Matemática (Mathematicas Education Research) group.

https://orcid.org/0000-0002-1275-9976

Juan D. Godino is a retired Professor of Didactics of Mathematics, Extraordinary Collaborator of the Department of Didactics of Mathematics and professor of the Doctoral Program in Education of the University of Granada. Member of the FQM-126 Group, Theory of Mathematical Education and Statistical Education. Since 1993 he has been developing the onto-semiotic approach to mathematical knowledge and instruction, a specific theoretical framework for mathematical education.

http://orcid.org/0000-0001-8409-0258

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