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# **Introducing preservice primary teachers to socioscientific activism through the analysis and discussion of videos**

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## **Introducing preservice primary teachers to socioscientific activism through the analysis and discussion of videos**

Complexities of social problems in our globalised world pose new educational challenges, including how to empower citizens for active engagement with socioscientific issues. This study describes the analysis and discussion of an activist video as the first phase in an activist education programme. Participants were 104 preservice primary teachers from the University of Malaga (Spain). Their task was to watch a video about illegal mining in the Venezuelan Amazon and, using the CoAnnotation tool, to annotate the video so as to indicate: the problem they saw as most important, the best solution, and ways in which the video could be improved. Students were subsequently shown all the annotations that had been made by the group as a whole so as to facilitate discussion. The content of their annotations was analysed and described using a category system developed by consensus among the research team. The problem most commonly referred to by students was environmental damage. In terms of solutions, the main focus was on raising awareness, although mention was also made of government intervention and both citizen-led and school-based initiatives. As for how the video might be improved as a tool for raising awareness, students made several suggestions regarding its content.

Keywords: pre-service teachers; visual < media; socioscientific activism

## **Introduction**

We live in an increasingly globalised world (Carter, 2008) in which profound scientific, technological, social, economic and cultural changes have taken place. Citizens are thus confronted with important and complex socioscientific issues, what Sadler (2004) refers to as social dilemmas with conceptual or technological links to science and which affect people's lives. Analysing and explicitly acknowledging the social injustices that follow from these socioscientific issues therefore becomes crucial, as does the resulting need for sociopolitical action (Reis, 2014a). Bencze and Carter (2011) suggest that sociopolitical action by students has the power to improve: a) their knowledge about these issues, b) their competences in terms of research and citizenship, and ultimately c) the wellbeing of individuals, societies and environments. However, in order to develop these competences in students, it is first necessary to introduce activism into teacher training programmes. Indeed, it is only by engaging in sociopolitical actions themselves that preservice teachers will acquire the skills needed to engage their students in activism initiatives aimed at transforming society and the environment (Linhares & Reis, 2018). Video podcasting, or *vodcasting* (Gkatzidou & Pearson, 2007), is one of the tools (Brown & Green, 2007) that may be used to carry out these kinds of social transformation, especially if it is students themselves who produce and disseminate the videos as a form of sociopolitical action (Marques & Reis, 2017a). In this paper we report the first phase of a broader project and explore how the analysis and discussion of a video about a socioscientific and sociopolitical problem may be used as a way of introducing preservice primary teachers to inquiry-based collective activism.

## **Literature review**

The present study is inspired by two bodies of literature that address: 1) the engagement

of teachers in activist education about socioscientific and sociopolitical controversies; and 2) the use of instructional videos and annotations as a tool for introducing students to activism. Accordingly, we aim to contribute to the current line of inquiry into activist science and technology education (Bencze & Alsop, 2014) from which projects such as ‘We Act’ (Reis, 2014b) have emerged.

### ***Activist education about socioscientific and sociopolitical controversies***

During the 1980s and 1990s it began to be argued that inquiry-based collective action should be considered an important aspect of citizens’ scientific literacy (Hodson, 1998, 2003). For proponents of activist education, science and technology education is both a context and a pretext for “[bringing] about change, whether it is social, political, economic or environmental” (Alsop & Bencze, 2009, p. i), and this view was subsequently manifested in a series of publications with three unifying objectives: to contribute to the growing number of educators who are seeking to be more politically and ethically engaged with social and environmental issues; to offer a more radical complement to existing science and technology education; and to promote more thoughtful and collaborative action by bringing together people with the openness and courage to share and explore their political and educational commitments (Bencze & Alsop, 2014). The STS(E) approach allows the promotion of a scientific literacy both considering the relevance of social context in the mobilization of scientific knowledge and innovation and stressing the importance of science education for citizens’ emancipation and social involvement in the resolution of the societal problems they consider relevant (Bencze, Pouliot, Pedretti, Simonneaux, Simonneaux & Zeidler, 2020). This approach according to Hodson (2021) was expanded “to include the provision of opportunities for students to confront socioscientific issues (SSI), often of a controversial and certainly of a topical nature”. Hodson (2003) proposes a curriculum

for science education that focuses on four main components: a) learning science and technology; b) learning about science and technology; c) learning by doing science and technology; d) engaging in sociopolitical action. On the contrary, some STEM (Science, Technology, Engineering and Mathematics) initiatives seem to prioritize a science education strongly focused on the core knowledge and skills of these disciplines, compromising students' understanding about the importance of social context in the construction and mobilization of scientific knowledge (Bencze, Pouliot, Pedretti, Simonneaux, Simonneaux & Zeidler, 2020; Bencze, Reiss, Sharma & Weinstein, 2018; Bogdan-Toma & García-Carmona, 2021; Levinson, 2019).

Introducing research-based collective activism into the classroom has a number of educational advantages: 1) it promotes active, research-based education on real issues of controversy; 2) it engages students in a collective and democratic approach to solving social problems; 3) it offers a critical understanding of interactions between society, science, technology and the environment; 4) it provides skills needed for social transformation; 5) it boosts students' self-esteem and capacity for action; and 6) it brings together diverse groups with common but divergent ways of thinking so that they can learn together as subjects rather than objects of educational processes (Alsop & Bencze, 2014; Marques & Reis, 2017a; Reis, 2014a, 2020).

### ***Engaging teachers and students in activist education through consideration of socioscientific problems***

One way of facilitating this step towards action involves consideration of socioscientific problems, which Zeidler (2014) defines as “relevant, controversial and ill-structured problems that require scientific, evidence-based reasoning, [have] social ramifications that require students to engage in dialogue, discussion, debate and argumentation, integrate [...] ethical components that require some degree of moral reasoning, [and

which] emphasise the formation of virtue and character as long-range pedagogical goals” (p. 699). From an educational perspective, socioscientific problems can offer a real-life forum for democratic dialogue and, as a result, shift educational institutions away from an emphasis on exam-based teaching, social conformity and competition between individuals and societies (Kellner & Kim, 2010). In this respect, approaches such as ‘STEPWISE’ (Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments) seek to promote students’ critical thinking and active engagement in socioscientific problems (Bencze et al., 2019). However, as Reis (2014b) points out, supporting activism by addressing socioscientific and socioenvironmental problems in the classroom is not an easy task, since schools, communities and society must first be prepared to accept a change in the education system so as to empower both teachers and students as active citizens and agents of change. A first step to achieve this is to ensure that preservice teachers develop their pedagogical skills within the science, technology, society and environment framework (STS(E)) (Bencze et al., 2009), with the aim of empowering them to address socioscientific problems through sociopolitical action (Hodson, 2021).

In this context, a number of studies involving preservice teachers have examined ways of promoting behaviour change with regard to health or environmental issues. For example, in a pro-environmental initiative, Carter and Martin (2017) set preservice teachers the challenge of reducing their ecological footprint in terms of food and energy consumption and their production of waste, asking them to evaluate and explain their success or failure in doing so. More recently, Amos and Levinson (2019) described a variety of ways in which teachers might use socioscientific inquiry-based learning to engage students with the 2030 Sustainable Development Goals, in which health and environmental issues feature strongly.

Efforts to introduce changes of this kind need, however, to be aimed not only at preservice teachers but also qualified teachers and students at various stages of education (Chen & Liu, 2020), and this is reflected in the literature. Reis (2014b), for example, describes a project aimed at promoting students' collective socioscientific activism and discusses secondary education teachers' motivations for participating in such an initiative, as well as the difficulties they face when seeking to engage their students in activism on social and environmental issues. For their part, Baptista, Reis, and de Andrade (2018) studied the potential of a collective action initiative with students aged 8-10 years to explore the question of why bee numbers are declining. In a role-play activity, students wrote a letter to the environment minister setting out both the problem and proposed solutions, and they also drew up a manifesto and gathered signatures of support from the local community.

Raising students' awareness of a specific problem is a necessary first step towards engaging them in activism on socioscientific issues (Lester et al., 2006). In this respect, activist videos may be a useful starting point, for two reasons: 1) they can function as a good catalyst for discussion about the issues, calling attention for different perspectives and interpretations between students and 2) they serve as an example which students can use as a guide to create their own activist videos. During this process, teachers tried to enrich the discussion through the introduction of some comments about the intricated net of interactions between science, technology, society and environment (e.g. the influence of specific groups of individuals and of capital in scientific and technological endeavours).

### ***Educational videos and annotations as an introduction to activism***

Video streaming accounts for 72% of internet data traffic (Cisco, 2017), which in part reflects the popularity of platforms such as YouTube, Vimeo and Dailymotion. This

potential can be tapped within education, since as Jaramillo-Hoyos (2005) points out, the dramatic qualities of argumentative videos draw viewers in, and thus they are a resource for engaging students and raising their awareness about socioscientific problems. Activist videos may also provide students with a model which can inspire them to develop and disseminate their own initiatives within the context of an activist education project. It should be noted that what students produce in projects of this kind may be shared not only in the form of videos but also through PowerPoint presentations, posters or displays, etc. (Bencze et al., 2012).

The literature contains several examples of the use of video in activist education projects. For instance, Marques and Reis (2017a, 2017b) asked 12-13-year-old students to produce vodcasts aimed at raising awareness about environmental pollution, while Cebrián-Robles and España-Ramos (2018) worked with preservice teachers to produce activist videos about local socioscientific problems. Other studies have focused on the analyses of videos already available at the internet, using tools such as annotation software to encourage students to collaborate and engage with the video content and to discuss shared points of interest (Vieira et al., 2014).

Video annotation tools allow comments to be added to specific fragments of video, and collaborative annotation platforms such as *CoAnnotation*, developed and used by one of the present authors (Cebrián-Robles, 2017), are designed with the express purpose of fostering interaction and a sharing of ideas, while also enabling a detailed analysis of content (Cebrián-de-la-Serna et al., 2015; Johnson et al., 2010; Vieira et al., 2014). However, we believe that after the video analysis through on-line individual annotations, it is important to have a general discussion with all the students in presence in order to avoid any minimization of many human interactions, such as gestures, eye contact, speech variations, etc.

Drawing together these developments, the present authors decided to use video annotation technology in the context of an activist education project. The idea was to show students an activist video about a socioscientific problem that would serve as an example and which they would then analyse and comment on using annotation software, after which they would produce their own activist videos about a local socioscientific problem. In the present study we focus on analysing students' annotations of an activist video of this kind.

### ***Research questions***

As part of a broader research project exploring an instructional intervention, the present study examines the annotations made by a sample of preservice primary teachers when viewing and analysing a video about illegal mining in the Venezuelan Amazon. The specific research questions were as follows:

- (1) What problems and solutions related to illegal mining in Venezuela do the students identify when analysing the video?
- (2) In which fragments of the video do students identify these problems and solutions?
- (3) What links do the students make between the problems and solutions they identify in the video?
- (4) In what ways do the students think the video could be improved so as to have a greater impact in terms of raising awareness about the problem?

### **Methods**

#### ***Research context and participants***

The sample for this study comprised 104 preservice primary teachers who were enrolled

(during the 2017-18 academic year) in a compulsory ‘Teaching science’ module that is offered in year 3 of the teacher training programme at the University of Malaga (Spain). The majority were aged 20 or 21 years.

***Source of the video and its content***

The video used in this study was created as part of a joint project between the University of Malaga (Spain) and the Central University of Venezuela in Puerto Ayacucho (Amazonas State, Venezuela), and it was titled “Rural development, management of nature reserves, and promotion of environmental education in town and city councils of Amazonas State”.

The video begins by showing and describing the landscape of the Amazon rainforest, including its fauna and flora. It then goes on to explore the problem of gold mining and the presence of illegal mining companies, with various experts, including geographers and educators, describing the damaging impact this activity is having on the environment, on people’s health and on a social level. The video ends with a number of proposed solutions to this problem.

***Instructional intervention***

The present study forms part of a broader activist education programme (Figure 1).

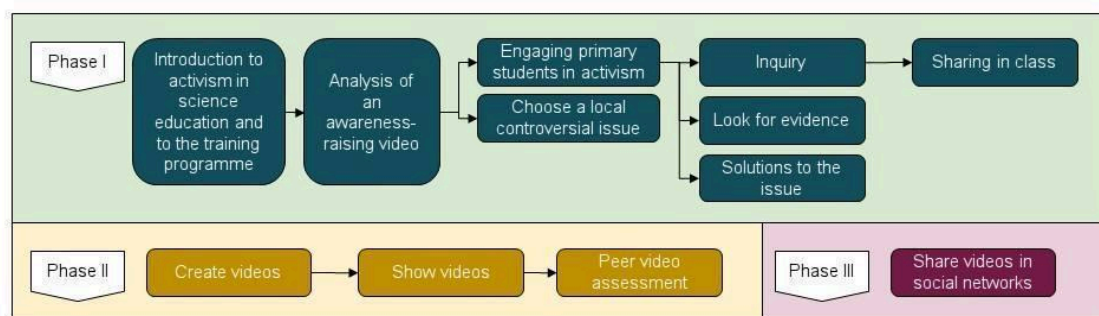


Figure 1. Phases of the activist education programme

The present study focuses on the first activity of phase 1, where students were introduced to the notion of activism in science through the analysis of an activist video about a socioscientific problem illegal mining in the Venezuelan Amazon.

### ***Classroom instruction***

The material used was a video about illegal gold mining in the Venezuelan Amazon.

The video explains that the main environmental problem associated with this activity is mercury pollution, due to the use of this element to extract gold from ore as an amalgam. Other environmental impacts include deforestation, diverted river courses and habitat loss. Reference is also made to health problems, due mainly to the presence of mercury, as well as to a number of social issues such as prostitution, drug addiction, alcoholism, the flight of capital and smuggling. The video ends by considering a number of possible solutions to the problems: a people's task force to develop environmental education and communication campaigns, promoting sustainable development through civic engagement, and raising public awareness through schools and the media.

The activity involved three sessions lasting approximately one hour each, although students could choose to spend additional time on the task between sessions two and three, either at home or in class. In the first session, students were introduced to the idea of activist education and to various activist projects. In order to accomplish this, socioscientific issues were defined as open-ended problems that are controversial in nature with no clear solution (Zeidler, 2014). Several examples of socioscientific issues were presented - the disappearance of bees, climate change, genetic cloning, etc. - and possible commitments of teachers and students in tackling these problems were discussed. Finally, several examples of activist initiatives conducted by students from different countries were presented (Baptista, Reis y Andrade, 2018; Conceição, Baptista

& Reis, 2019; Sperling, Wilkinson & Bencze, 2014). In the second session, which took place in a computer lab, students watched and annotated the aforementioned video using *CoAnnotation* (Cebrián-Robles, 2017), an open-access tool designed to promote self-regulated learning and critical thinking through collaboration and the analysis of online multimedia content. Students were already familiar with this tool from other course activities. Here they began by working individually to annotate the video in relation to three categories: problems, solutions and ways of improving the video. The annotations involved highlighting and labelling a fragment of the video with one of these categories and adding an explanatory text (an example is shown in Figure 2).

- **Problem:** Select one problem from among those which the video mentions as being caused by illegal mining. Choose the one you consider to be the most serious and explain the reasons for your choice in the annotation. (One annotation per student).
- **Solution:** From among the proposed solutions to the problem you have chosen, select the one you consider to be the best. If no solution to your chosen problem is proposed in the video, suggest your own solution when annotating a fragment of the video. (One annotation per student).
- **Improving the video:** Identify fragments of the video which, in your opinion, could be improved so that it would have a greater impact in terms of raising public awareness about illegal mining in Venezuela. (One or more annotations per student).

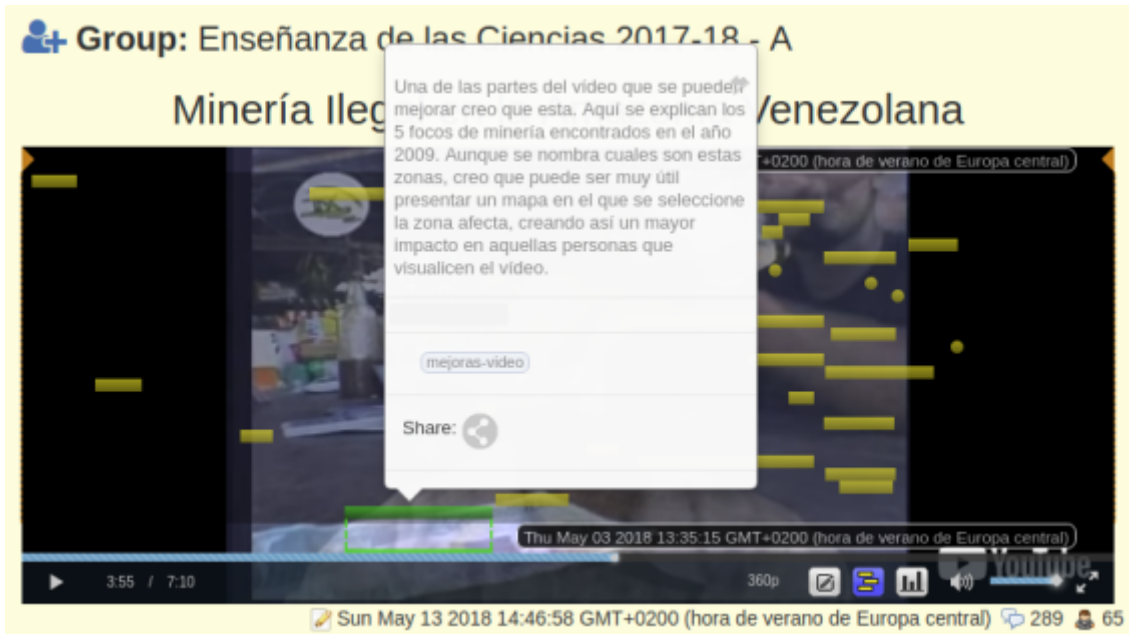


Figure 2. Example of an annotation in which a student highlights and labels a fragment of the video as an aspect that could be improved. The English translation of the Spanish text inside the panel is as follows: *This is a part of the video that I think could be improved. Here they refer to the five mining sites that were discovered in 2009. Although they name these locations, I think it would be really helpful to include a map showing the affected area, as this would have a greater impact on people who watch the video.*

The screenshot in Figure 2 shows a point in the video which one of the students highlighted and labelled as an aspect that could be improved. In the annotation panel the student explains why and suggests a way of improving the content. The yellow bars in the background correspond to annotations (under different categories) made by other students for the same fragment.

The annotation task was proposed to be done in class for one hour. However, this time was not enough to complete the task. So, students were given the opportunity to continue it at home for a week. This way, the students spent about an hour viewing and annotating the video at home and completing the task. In addition, and due to students' interest, the discussion ended up occupying several free times between classes.

In the third and final classroom session, the teacher showed students all the annotations that had been made using the *CoAnnotation* tool, thus facilitating discussion of different problems, solutions and suggested improvements to the video. This also served: 1) to illustrate how the tool could offer an instantaneous analysis of the annotations made by the group as a whole across the duration of the video; and 2) to show students where in the video their annotations for each of the three categories (problems, solutions and suggested improvements) were concentrated.

The annotations on video done by the students allowed a first individual analysis, catalyst for the discussion about the addressed socioscientific problem. This process was followed by an all-class discussion at the university, where the teacher tried to bring to discussion some more complex aspects that have not been addressed individually -- e.g. related to the root of the problems -- and some alternative arguments. Furthermore, this analysis through the annotations on the video allowed the development of a map of the controversy described in the video: a map similar to the one proposed by the actor-network theory (Latour, 2005), establishing connections between different dimensions: politics and science; nature and society.

### ***Data collection and analysis***

To address the first and fourth research questions (i.e. problems and solutions related to illegal mining in Venezuela, and ways of improving the video), we analysed the content of students' annotations; to facilitate this analysis the annotations were first exported from the *CoAnnotation* tool to spreadsheets. After first grouping the annotations according to the three broad categories (i.e. problems, solutions or suggested improvements to the video) we then, through an iterative series of meetings, reached a consensus regarding the specific type of problem, solution or suggested improvement that was referred to in each annotation, thus producing a list of sub-categories for each.

For example, an annotation in the problem category could refer to an impact on the environment, on people's health or of a sociocultural nature. Depending on its content, an annotation could be assigned to more than one sub-category within its corresponding broader category.

In order to classify the fragments of video in which students identified problems and solutions (the second research question), we divided the video into four chapters, based on the core focus of each:

- (1) Introduction and description of the Amazon rainforest as a natural area of critical importance.
- (2) A second chapter focusing on the problem of illegal mining in the Venezuelan Amazon and sites where this is occurring.
- (3) A third chapter exploring consequences of this illegal gold mining.
- (4) The final part of the video, in which possible solutions to the problem are proposed.

By dividing the content of the video into four chapters we were able to link students' annotations to them. This enabled us to analyse the spread and concentration of annotations across the video as a whole.

Finally, we used the Gephi software (<https://gephi.org/>) to map the relationships between the problems and solutions that students referred to in their annotations (the third research question). Gephi is free open-source software for visualising and exploring relationships between data, which has been used in other studies in science education (Fitzgerald, Danaia & McKinnon, 2019). To answer the third research question on what relationships the preservice primary teachers establish between the problems and solutions they place in the video, an analysis of the relationships between

the different response categories that were chosen and the labels was carried out. Gephi was used for this purpose, as it allows us to visualise the associations between the annotations and their connection with the 4 questions posed (labels), taking them two by two. For this purpose, the relationships of the annotations between problems and solutions have been analysed thanks to the visual representation in Gephi. On the one hand, each problem and each solution is represented by a circle whose size is proportional to the number of students who make that annotation in the video. On the other hand, the circles are connected with arrows of a thickness proportional to the number of students making a given problem-solution connection.

## **Results**

In this section we begin by presenting the results for the three aspects that students were asked to identify when annotating the video, namely problems, solutions and suggested improvements. We then examine the links they made between the problems and solutions they identified.

### ***Problems and solutions identified by students when analysing the video on illegal mining in the Venezuelan Amazon, and their proposals for improving the video***

Across the video as a whole, the 104 students made a total of 369 annotations. Figure 3 shows the number of annotations corresponding to each of the three categories that students were asked to consider (problems, solutions and suggested improvements to the video). There were also thirteen annotations (i.e. a highlighted fragment and accompanying text) which students did not label with one of these three categories (shown as 'Not categorised' in Figure 3).

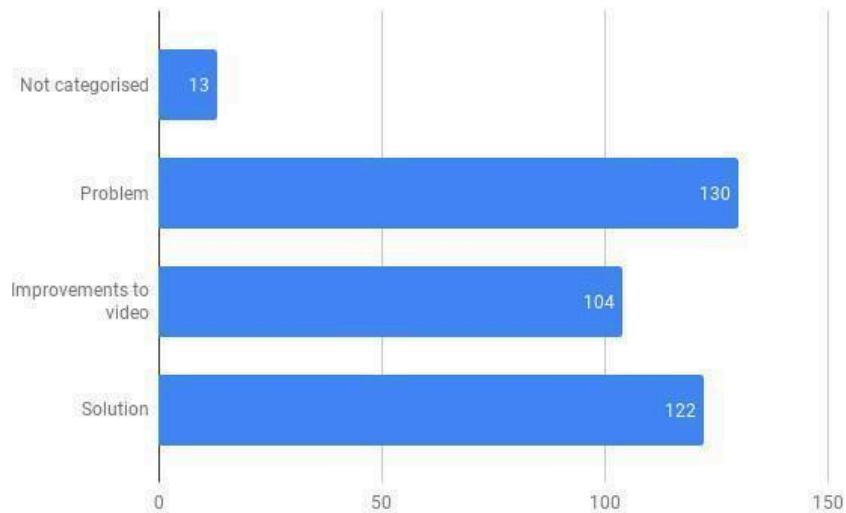


Figure 3. Frequency of annotations in each of the categories across the video as a whole.

Of the 369 annotations, 130 (35.2%) corresponded to problems, 122 (33.1%) to solutions and 104 (28.2%) to ways of improving the video. In their annotations most of the students referred to specific statements made in the video, which at times they quoted almost word for word.

Figure 4 shows the spread and concentration of annotations across the video as a whole (chapters I-IV) for each of the categories considered, as described in the “Data collection and analysis” section. An annotation could, in theory, cut across chapter divisions, although this was not generally the case. Each of the four graphs (a-d) in Figure 4 has two dimensions: the timeline of the video (abscissa axis) is shown from left (start of the video) to right (end of video), while the height of the plot (ordinate axis) represents the concentration of annotations at any given point along the timeline. The number of annotations in brackets refers to the concentration of annotations in that video chapter.

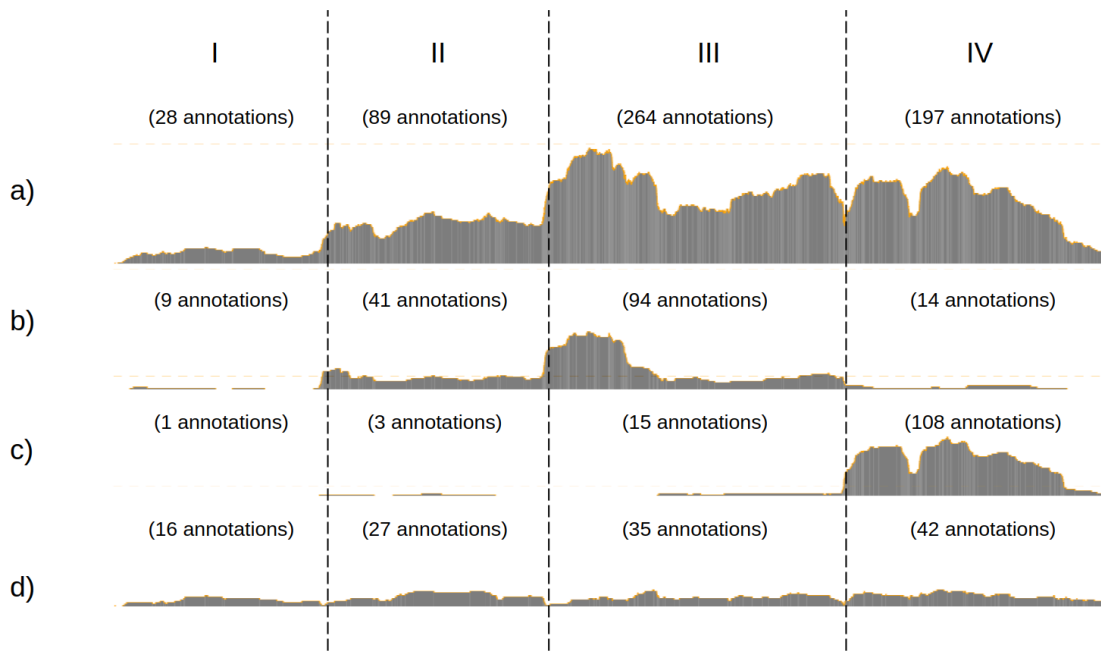


Figure 4. Graphical representation of the spread and concentration of annotations across the four chapters of the video (I-IV): a) all categories combined; b) problems; c) solutions; d) suggested improvements to the video

Figure 4a shows the spread and concentration of annotations for “all categories combined”. It can be seen that the large majority of annotations are concentrated in chapters II, III and IV, which is consistent with the fact that chapter I was merely a descriptive introduction to the Amazon rainforest and did not refer to problems or solutions related to illegal mining. Figure 4b represents the frequency of annotations in which students identified a “problem”. These annotations are concentrated in chapters II and III of the video, which is indeed where problems and their causes are described. Consistent with the fact that possible “solutions” were discussed in the final part of the video, it can be seen in Figure 4c that the large majority of annotations in which students identified a solution are concentrated in chapter IV. Finally, Figure 4d shows that annotations in which students suggested ways of “improving the video” are spread much more evenly across the video as a whole.

### *Analysis of annotations in which students identified a problem*

Many of the annotations in which students identified a problem are concentrated in a fragment of the video in which the narrator explains the following:

Illegal gold mining has disastrous consequences for both natural and cultural biodiversity. Hundreds of hectares of forest have been destroyed and unknown quantities of mercury have built up in the soil and water, causing irreparable damage to nature and the health of thousands of people, to the extent that it also poses a threat to future generations (minute 03:06 of the video).

Figure 5 illustrates graphically how this section of the video accounted for a large proportion of ‘problem’ annotations.



Figure 5. Concentration of annotations in which students identified a problem.

In terms of their content, the ‘problem’ annotations made reference to three kinds of impact. The first, which featured in 89 annotations, concerned harm to the environment, nature or the ecosystem, and in particular the effects of deforestation, such as the loss of forest mass, of biodiversity or of wildlife in general. The second impact, mentioned in 41 annotations, was that on people’s health, with students either referring directly to mercury as the causal agent or more generally to the various diseases that people may develop. Finally, reference was made in 29 annotations to sociocultural

problems, primarily threats to future generations (10 annotations) and the repercussions of illegal mining in terms of prostitution, drug addiction, alcoholism, flight of capital and smuggling (9 annotations).

In Table 1 we indicate the specific issues mentioned by students under each of the three kinds of impact. In some cases, students referred to more than one kind of impact when describing the problem of illegal mining. Although they had been asked to choose only the problem they considered to be the most important, 16 students mentioned more than one problem in their annotations.

Table 1. The specific issues under the three kinds of impact that students referred to in their annotations of the video about illegal gold mining.

Problems caused by illegal gold mining	Total
<b>Impact on the environment</b>	89
Pollution	37
Loss of wildlife	36
Deforestation	21
Destruction of the landscape	17
<b>Impact on people's health</b>	41
Harm caused by mercury	26
May cause diseases	5
<b>Sociocultural impact</b>	29
Threats to future generations	10
Prostitution, drug addiction, alcoholism, flight of capital and smuggling	9
Lack of cultural awareness	2
Exploitation of Venezuela's resources by other countries	1
Forced and poorly paid labour	1
Harm to local tribes	1

Note. Some annotations did not refer to a specific sub-type of problem and merely used the generic term (e.g. health problems). Consequently, the sum of annotations referring to specific types of a problem does not necessarily correspond to the total shown for that problem.

The most important problem identified by over a third of the students (39.42%) was the contamination of rivers by the mercury used to extract gold from ore, and its resulting impact on nature and people's health. For example, one student wrote:

Mercury is a major pollutant, and in countries such as ours, Spain, its use in thermometers has been banned due to its harmful effects on health. This illegal mining produces enormous amounts of mercury waste that remain in the soil and water, damaging the environment and people's health.

A smaller proportion of students (22.12%) considered that the most serious problem caused by illegal mining was destruction of the ecosystem. For example:

The most serious problem is that the amount of mineral reserves in this area is affecting the conservation of biodiversity in this habitat, since these reserves are not being properly managed, as illustrated by the increase in illegal gold mining.

Another group of students (17.31%) also mentioned loss of wildlife and deforestation (e.g. "Hundreds of hectares of forest have been destroyed..."), while 4.81% of them referred specifically to destruction of the landscape (e.g. "The minerals that are present in this reserve are a problem, because the whole landscape is damaged and destroyed."). Finally, 13.46% of students focused on the social impact in terms of drug addiction and prostitution, etc. ("It's also causing serious social problems such as prostitution, drug addiction and alcoholism. This poses a threat to future generations in this area."), and one student mentioned the exploitation of workers.

#### *Analysis of annotations in which students identified a solution*

In the final part of the video there are two key sections in which possible solutions to the problem of illegal mining are proposed. The first involves a female narrator who says:

The increasing impact of illegal mining means there is need for a people's task force that can develop environmental education and communication campaigns so as to ensure that nature is fully respected and to promote sustainable development through effective civic participation (minute 05:15 of the video).

This is followed by a fragment of an interview with a Venezuelan academic:

On this issue of mining, real efforts need to be made to raise people's awareness. This has to start in schools, and then through the media, targeting two sectors of the population. On the one hand, younger generations need to be informed about environmental conservation and why it matters, to understand what it means, not just locally but for the rest of the country and the planet. And then there's the community as a whole, public opinion, because often one of the reasons why mining projects, illegal mining occurs in these communities or regions is because people are unaware of the impact that mining will have on the land and on their health and lives (minute 05:48 of the video).

Most of the solutions proposed by the students reflected those mentioned in the video, for example: "Providing information and raising awareness among all sectors of the population (children, teenagers, adults and older generations) about the harmful impact of illegal mining activities. Using the media, or places like schools to promote and build a movement that leads to respect for the natural world".

Only 7 annotations featured original proposals by students, an example of which was: "The solution should involve strict control and severe punishment for those who carry out illegal mining. And so there needs to be close collaboration between the authorities of the country that is affected and the UN".

Table 2 shows details of the different solutions that were proposed by students in their annotations.

Table 2. The four kinds of solutions that featured in students' annotations of the video about illegal gold mining

Proposed solutions to the problem of illegal mining	Total
<b>Raising awareness</b>	84
Unspecified approach	26
Through schools	36
Through the media	22
<b>People's task force</b>	19
<b>Education/training</b>	19
<b>Action by different groups</b>	34
Not specified by whom	1
Civic engagement	26
Government intervention	6
School-based initiatives	1

The most common kind of solution proposed by students involved raising awareness, either generally or specifically through the media or schools. Reference was usually made here to people's lack of information about the problem:

One solution is to raise public awareness through education and/or the media. People need information about conservation of the environment so that they are aware of the damage that illegal mining causes.

Nineteen students quoted almost word for word the reference made in the video to a people's task force:

The enormous impact that illegal mining has had means there is a need for a people's task force to develop environmental education and communication campaigns, and thus try to promote respect for nature and enable sustainable development through civic participation.

Other proposed solutions made reference to action by governments or citizens. Regarding the former, this involved either new laws or a combination of stricter sanctions and direct government intervention:

[...] New laws could be drawn up to protect trees, and ideally whole forest areas so that they are respected.

As regards action by citizens, this usually involved some form of civic

engagement:

A movement of people brought together by the serious problem they are facing due to this illegal mining. If a community cooperates in the struggle towards a common goal that benefits everybody, then eventually it will be listened to and understood, and little by little the situation will improve.

Students' proposed solutions were often related directly to one of the three kinds of impact they had identified (environmental, health, social), although more general suggestions were also made:

Awareness needs to be raised among the population as a whole as to why it is important to conserve the Amazon rainforest, beginning in schools and then through the media and public opinion.

#### *Analysis of annotations in which students suggested ways of improving the video*

Although only 33 annotations concerned technical improvements to the video, suggestions for improving its content featured in 83 annotations. Table 3 lists the suggestions that students made under each of these categories: technical and content.

Table 3. Suggested technical and content-related improvements to the video as a tool for raising awareness about illegal mining

Technical improvements	Total no. of annotations
The overall quality of the video could be improved	8
The sound quality is poor	8
The video is a little boring and not very dynamic	7
The music interferes with or masks what the narrator is saying	7
Other	3

Improvements to content	Total no. of annotations
It would be good to replace certain images or fragments of the video or add new ones	53
It would be good to add more information about some issues	13
Better solutions than those proposed in the video could be offered	10
The video needs a tighter focus, avoiding information that is not relevant to the problem	2
Include experiences or opinions of those affected	2
Include more children in the video	2
Add subtitles or an on-screen signer	1

The suggested technical improvements focused on the sound and image quality, the use of music and the need for a more dynamic presentation. For example: “What the university professor says is really important, because he’s talking about different kinds of solution that have been proposed. But the music in the background is too loud”.

In terms of content, the most commonly suggested improvement concerned replacing certain images or fragments of the video or adding new ones so as to make clearer the impact of illegal mining, for example, using before-and-after images: “The video could include images that show the devastating impact in terms of destruction of ecosystems”.

Similarly, some students mentioned adding more information about the specific effects of illegal mining, for example:

I would talk more about the species that have died as a result of all this, about the diseases that have been and are being caused, about the number of habitats that have been destroyed, etc. Figures and data to raise public awareness.

Another suggestion was to mention the contribution that more international initiatives could make, alongside those proposed in the video, for example, highlighting similar situations in other countries or organising larger-scale public awareness campaigns.

Finally, it was suggested that whereas the video should avoid information that is not relevant to the problem, it would be useful to include more children and also the experiences and opinions of those affected by the problem: “In my view, and in terms of solutions, they should include a section where we hear from those who are directly affected by this environmental damage, and where we see what they are trying to do about it”.

***Links made by students between the problems and solutions they identified in the video***

In this section we present the results obtained when using the Gephi software to explore links between problems and solutions, as identified by the students. Figure 6 shows relationships between the three kinds of problem (environmental, health and sociocultural) and the four types of solution (raising awareness, people’s task force, education and training, and action by different groups) that featured in students’ annotations. Problems are represented by the three green circles in the centre of the figure and solutions by red circles to either side. In both cases the size of the circle is proportional to the number of students who referred to this problem or solution. The lines which connect circles represent the relationships found in students’ annotations, and here the thickness of the line is proportional to their frequency.

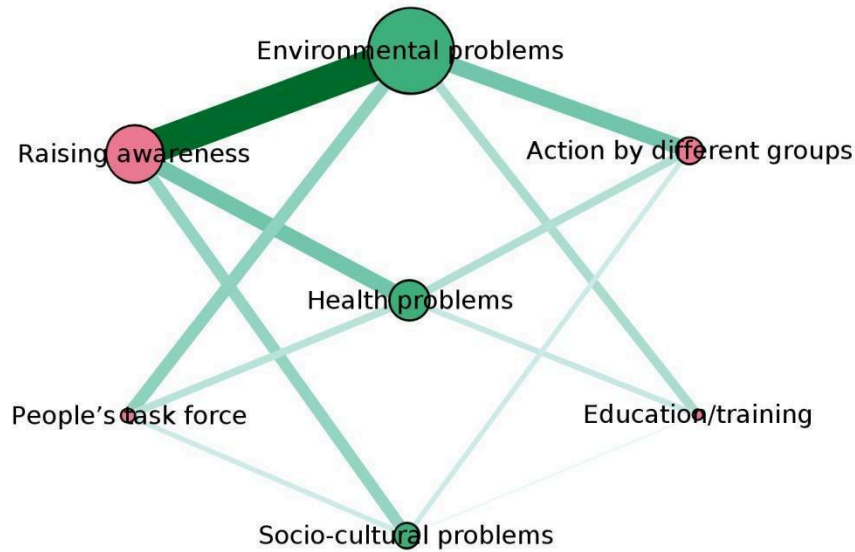


Figure 6. Relationships between the three kinds of problem and four types of solution that were referred to in students' annotations of the video about illegal mining

It can be seen in Figure 6 that students most commonly referred to environmental problems, for which the principal solution was raising awareness, followed by action by different groups, the creation of a people's task force and, finally, education and training.

Figure 7 shows a more detailed analysis of these relationships by considering the specific kinds of problems and solutions that were referred to in students' annotations.

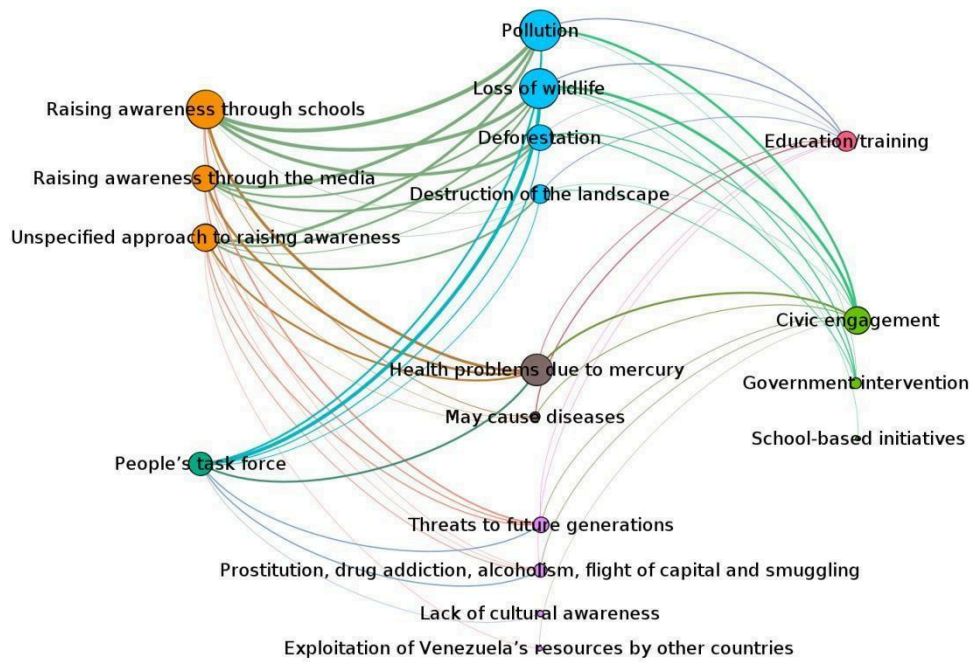


Figure 7. Relationships between the specific kinds of problems and solutions that were referred to in students' annotations of the video about illegal mining

Here it can be seen that government intervention and school-based initiatives were only proposed as solutions to the different kinds of environmental problems. Thus, while some students suggested that the state should be directly involved in tackling the environmental impact of illegal mining, this was not the case for the health and social problems associated with this activity.

Figure 7 also shows that the main health problem referred to by students was the harm caused by mercury. In addition, it can be seen that this problem was linked to various kinds of solution, namely the three sub-categories of awareness raising, civic engagement, a people's task force, and education and training.

Finally, we grouped the different solutions mentioned by students according to their proposed target problem (i.e. environmental, health or sociocultural). In Figure 8, the three broad kinds of problem are shown on the left, represented by red circles, while on the right the green circles correspond to solutions for each of these problems. As in

the previous two figures, the size of the circles and the thickness of the lines that connect them are proportional to the frequency with which they are mentioned in the students' annotations.

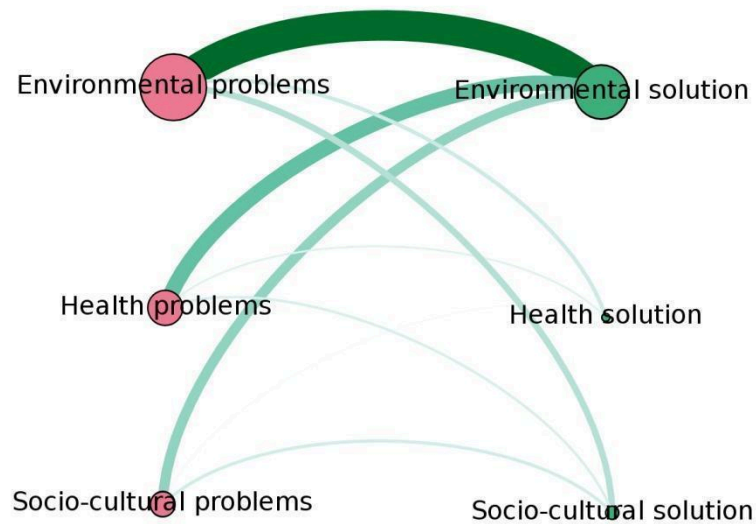


Figure 8. Relationships between the three kinds of problem and their corresponding solutions

As one would expect, a given type of solution is most commonly proposed for a problem of the same kind, for instance, an environmental solution for an environmental problem. Interestingly, however, what Figure 8 also shows is that all three kinds of solution were primarily proposed as a way of tackling an environmental problem (the thickest line from each kind of solution links to the circle representing environmental problems). For example, one student described the problem as follows: “This mining not only has an impact on the natural world but also on a cultural level, creating serious health problems, as well as a rise in prostitution, drug use, alcoholism, flight of capital and smuggling. This has a major social impact”. However, despite referring here to health and social impacts, the solution proposed by this student focused solely on the

environment: “The solution lies in building a people’s task force to develop environmental education and communication initiatives so as to ensure that nature is fully respected and promote sustainable development”.

### **Discussion, Conclusions and Implications for Teaching**

Overall, the results obtained suggest that the task of annotating the video and identifying problems, solutions and possible improvements encouraged our preservice primary teachers to analyse and reflect more closely on the environmental and social issues that were addressed within the short film. Because the *CoAnnotation* tool records the annotations made by all users, it facilitates subsequent group discussion, allowing participants to see the extent to which their own ideas and comments overlap with or differ from those of others. In the case of our students, this sharing and discussion of ideas enabled them to develop a richer understanding of the problem of illegal gold mining and possible solutions to it.

Regarding the annotations in which students identified a problem, most of these were concentrated in the chapters of the video where the nature of the environmental and social problems is discussed (chapter II) and where possible consequences are explained (chapter III). In terms of the type of problem, students most commonly highlighted the environmental damage caused by illegal mining, followed by the impact on people’s health and, to a lesser extent, social problems.

Annotations in which students identified a solution were almost entirely located in the final chapter of the video, which again is consistent with its content. The primary solution referred to by students was raising awareness through schools and the media, although mention was also made of citizen-led initiatives and/or government intervention; it is worth noting that the latter was not proposed in the video and was

only suggested by a few students. Overall, these results suggest that most of the students identified the main problems and solutions that are discussed in the video.

In terms of the main problem and preferred solution identified by individual students, by far the most common pairing was raising awareness about the environmental impact of illegal mining. This suggests that they saw raising awareness as a necessary first step in tackling the problems described in the video. Other possible solutions to the environmental problems caused by illegal mining were action by different groups, a people's task force and, finally, education and training, although these were mentioned by a smaller number of students. On a more specific level, government intervention and school-based initiatives were proposed as possible solutions to environmental problems, but they were not mentioned in relation to health or sociocultural problems. Another finding is that while some students referred in their annotations to all three types of impact (i.e. environmental, health and social) their preferred solution was focused solely on the environmental level. This leads us to believe that this activity could contribute to the development of an environmental citizenship focused on pro-environmentally responsible behaviours in which citizens act and participate in society as agents of change in the private and public sphere, at local, national and global scales, through individual and collective actions in the direction of solving contemporary environmental problems, preventing the creation of new environmental problems, achieving sustainability and developing a healthy relationship with nature (Hadjichambis et al., 2020).

Regarding how the video might be improved so as to increase its impact as a tool for raising awareness and the learning from action, students' suggestions fell into two broad groups: technical improvements (e.g. concerning the sound quality, the use of music and the need for a more dynamic format) and improvements to the content, such

as adding new images or fragments in order to make clear the impact of illegal mining. Within the context of the activist education programme as a whole, the task of suggesting ways of improving the video primes them for the subsequent activity, where they have to create their own videos of a similar kind.

Video annotations allow for the mapping of the controversy associated with socioscientific problems, through the identification of those problems, possible causes, groups of citizens involved and potential solutions. This method can be useful and complementary to other strategies such as controversy mapping (Latour, 2007), where the relationships between actants are analysed according to actor-network theory (Latour, 2005). Both the video and the video annotations are relevant for teacher education as they contribute to what Hodson (2021) proposes: learning about action, learning through action and learning from action. In this research, students began viewing an activist video in order to learn about action, through the identification of skills and strategies necessary for an activist video. In a second moment, they analyse the content of the video in depth with the aim of reflecting on how to improve its activist dimension. This moment develops students' competences regarding the production of activist videos with stronger potential impact on its viewers. These skills can empower students both as video makers and potential activists, preparing them for action (e.g. through the dissemination of videos on social media) (Cebrián-Robles, España-Ramos & Reis, 2021). In the case of video annotations, preservice teachers can evaluate the results of activist projects carried out by themselves or others, allowing them to learn from action.

In conclusion, our experience with this group of preservice primary teachers suggests that asking them to watch and annotate an activist video, identifying the main problem and proposed solutions to it, is an effective way of engaging them with a

complex socioscientific problem and preparing/instigating them for action about such issue. These annotations on videos hosted on the internet allow for an in-depth collaborative analysis of media content, encouraging science teachers to use video annotations as a resource for the identification and understanding of problems, consequences, possible causes, preconceptions, opinions, involved actors, arguments and counter-arguments, fake news and possible solutions for those problems. The annotations provide teachers with a better knowledge regarding students' perspectives, allowing for the identification of aspects and voices ignored by the students and, consequently, for the preparation of more complete, rich and in-depth final all-class discussions.

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