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Teachers' Reactions to Educational Television Programs during the Pandemic and Their Implied Images of Mathematics Teaching

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Abstract: In this paper, we discuss the images of mathematics and its teaching, as expressed by mathematics teachers, in reaction to educational programs broadcasted by Polish public television channels during the first lockdown in 2020. For our analysis, we deployed a theoretical framework mostly drawn from the work of Paul Ernest. Our data came from a variety of sources such as educational fora, social networks, websites and email exchanges. Our results, based on an interpretative analysis, revealed four overarching images of mathematics and its teaching which, although related to the specificities of television, resembled images found by other relevant studies. The first image of mathematics views it as an unambiguous discipline in which there is no room for more than one point of view. The second image refers to the teacher as a presenter who is expected to possess particular verbal and non-verbal skills, especially given the fact that the television programs did not involve any live audiences. The third image refers to the unappealing nature of the broadcasted lessons, while the fourth image refers to the underlying approach of crude memorization associated with 'traditional' mathematics teaching. Our study's contribution is twofold: in the improvement of televised educational programs (and possibly online courses) and in the improvement of the public's image of mathematics.

Keywords: images of mathematics; educational TV; mathematics teachers

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1. Introduction

The COVID-19 pandemic, which shook the world from 2020 until recently, led many countries to seek alternatives to traditional face-to-face education. This was especially the case during the first lockdown, which included curfews and limitations to people's mobility. In Poland, a series of 'educational television' programs started being broadcast at the end of March 2020. These programs covered all levels and most subjects of primary and secondary education. In this article, we are interested in television lessons on mathematics, which sparked a significant number of negative reactions among in-service and preservice teachers, journalists and parents. These reactions were expressed online and mainly focused on the teacher presenters' performance, but sometimes also referred to the quality of the mathematical content being communicated. Here is a characteristic example from a Facebook group of mathematics teachers:

It's time to die. I was waiting for a completely different level, for added value, for specialists and not somebody who, in the voice of Eeyore on heavy sedative drugs, will tell nonsense with the diameter of a circle being identical to its circumference. . . I'm devastated. (Facebook group).

We found these reactions interesting for two reasons; first, because they expressed the teacher viewers' images of what constitutes 'good' mathematics teaching and, second, because they were indicators of the challenges and limitations of television-broadcasted lessons. Due to the large quantity of data gathered, in this article, we only focus on the

analysis of teacher viewers' expressed images of mathematics, hoping that these could be considered in similar endeavours, especially in situations that do not involve interaction with students, e.g., in modes of asynchronous learning. Additionally, we aim to add to the existing literature on images of mathematics by suggesting a categorisation that contains verbal and non-verbal categories and combines existing theoretical frameworks.

2. Background of the Study

The first cases of COVID-19 were reported in Poland at the beginning of March 2020. The government's decisions that followed resembled those of most European governments: schools at all levels of education (from pre-kindergarten to upper secondary) were closed on March 12, and on March 30, a series of educational programs aired for the first time on four public television channels. These programs were broadcast until the end of May (since on June 1st schools gradually started opening) and were targeted at all grades (1–8) of primary school and the three grades of Lyceum (upper secondary school). These programs were named *School with TVP (Szkoła z TVP),* and a total of 1600 lessons, lasting 1440 h, were broadcasted within these programs. A total of 191 teachers acted as presenters; these included both ordinary general education teachers and mathematics teachers—according to Polish law, general teachers teach all subjects in grades 1–3 and then, from grade four to grade eight, each subject is taught by a specialist teacher. These teachers were recruited by regional television branches in cooperation with regional authorities of the Ministry of Education. A lively online debate among academics and mathematics teachers, as well as other agents including journalists and students, took place during the broadcasting of these programs. Some of the harsh comments referred to the correctness of the mathematical content communicated, while others referred to the teacher presenter's way of conducting the mathematics lesson, including the use (or lack thereof) of resources. There were also references to teaching-as-knowledge-transmitters, as we will show next. We hypothesize that these are associated with particular images of mathematics and its teaching. Therefore, we designed a study to answer the following research question: What are the teachers' implied images of mathematics and its teaching, as portrayed in their reactions to the educational television programs?

In the next section, we present an overview of the literature on the images of mathematics and its teaching.

3. Images of Mathematics and Its Teaching

Images of mathematics in western societies are usually negative and are accompanied by statements on the difficulty or boredom associated with studying mathematics [1] or on women's poor performance [2]. Studies on images of mathematics have investigated both the general public [1] and groups of students [3,4]. The sources of data for such studies have been questionnaires only [5], questionnaires combined with interviews or focus groups [1,3], students' drawn images [4], literature works [6–8] and advertisements in newspapers [9].

For example, Darragh [6] has shown that mathematics in schools is often portrayed negatively in young adult fiction, with depictions of mathematics classes generating literary effects of comedy or tragedy, thus construing mathematics as neither valuable nor useful in the future. This study also found negative positioning of mathematics teachers, with some depicted as villains and extremely stereotyped, which in turn, may reflect societal views and perpetuate stereotypes. The study by Fellus et al. [7] identified four hidden messages contained in children's picture books: mathematical ability is a gift, mathematical ability is like having a magic eye or knowing a secret language, mathematics is about doing calculations quickly and mathematical ability is associated with social awkwardness. As the authors put it: "In some picturebooks, characters find themselves with a choice to make: pursue mathematics or have friends" (p. 7). In the same study, Fellus et al. [7] suggested a way to overcome this:

> When mathematically inclined people are shown over and over to be socially awkward geniuses with near-magical gifts, teachers need to unravel these implications together with students and demonstrate that this is one story, not the only story. Teachers may choose to highlight the literature that emphasizes persistence and iterative understanding [7] (p. 7).

In another study [4], pupils' drawings of mathematicians were examined; the authors found that the drawings tended to fall into two categories: those in which the mathematician was depicted as a teacher and those where the mathematician was shown working in some other capacity. In most of the countries where the study was conducted, the majority of pupils depicted mathematicians in non-teaching roles, indicating a lack of understanding of what mathematicians actually do. When asked to list reasons why someone might need to hire a mathematician, many pupils were unable to provide a response and some even expressed confusion over whether a mathematics teacher is a mathematician. This study found that pupils' drawings generally lacked awareness of what mathematicians actually spend their time doing, with the exception of computer programming and problem-solving. The gender of the mathematicians drawn was primarily male, even in drawings by female pupils. Additionally, in another study, it was found that in many social texts and situations, mathematicians are depicted as "arrogant, elitist, middle class, eccentric, male, social misfits. They lack social antennae, common sense, and a sense of humour" [10] (p. 3).

In [9], the use of mathematical representations in press advertisements was examined by sampling different newspapers and identifying mathematical elements such as symbols, graphs, and equations. The researchers have found that advertisers used mathematics as a referent system to associate with the product and transfer valued characteristics of mathematics like precision and rationality to the product. The advertisements analysed used mathematics as a rhetorical means to persuade, but in most cases, they did not have mathematical content. The simplistic representations of mathematics suggest a low level of mathematical demand made on readers. This study demonstrated that the idea of mathematics as a rational, authoritative and powerful form of knowledge can be used to convey and transfer qualities that 'submit' the reader to the advertisers' control.

The results of these studies converge on the aforementioned stereotypical images, further enhanced by students' feelings of powerlessness in front of authoritarian mathematicians [4]. Another interesting finding was that not being good at mathematics was almost a source of pride for some people:

> Many persons operating at high levels of competency in numeracy, graphicacy and computeracy in their professional life in the UK still say "I'm no good at mathematics, I never could do it". In contrast to the shame associated with illiteracy, innumeracy has been almost a matter of pride amongst educated persons in Western Anglophone countries. In fact, many such persons are not innumerate at all and it is school or academic mathematics, not everyday mathematics, that they feel they cannot do [11] (p. 5).

For the purpose of this study, we follow Lim and Ernest [1], who view an image as consisting of "at least two main components, (i) a cognitive component, including a mental picture, mental representation, an idea or conception, and (ii) an affective component, including attitudes, emotions, feelings, anxiety, enjoyment and fear". (pp. 194–195). In particular, the image of mathematics consists of the following:

1. Stated attitudes.
2. Feelings (choice of emotive descriptors).
3. Description/metaphor for mathematics.
4. Beliefs about the nature of mathematics.
5. Views about mathematicians and their activities.
6. Beliefs about mathematicians' ways of knowing and warranty of mathematical knowledge.
7. Description/metaphor for learning mathematics.
8. Aims for school-based mathematics.

9. Memories of best/worst mathematics lessons.
10. Beliefs about mathematical ability.
11. Beliefs about sex differences in mathematical ability [1] (p. 195).

The above components were complemented with visions of high-quality mathematics instruction [12], which were in turn based on Hammerness's [13] notion of teachers' vision, defined as "a set of images of ideal classroom practice for which teachers strive" (p. 143). Munter [12] suggested detailed rubrics to describe aspects of these visions. For the purpose of our study, we deployed only the 'Role of the teacher's rubric, which consists of four levels based on the sophistication of the instructional vision. These are, in ascending order, the teacher as a motivator, the teacher as a deliverer of knowledge, the teacher as a monitor, and the teacher as a facilitator:

The lowest level of the rubric (Level 0: teacher as a *motivator*) pertains to responses that are limited to asserting that the teacher must be energetic and captivating so that students are sufficiently motivated to learn, with no mention of what the teacher should do with respect to content . . . at Level 1 (teacher as a *deliverer of knowledge*), the participant's description suggests that the teacher has mathematical knowledge that must be imparted unto students and is most effectively accomplished through efficiently structured lessons.

At Level 2 (teacher as a *monitor*), descriptions suggest that students should play an active role in working together on mathematical tasks and that affording time to students to figure out (or, more likely, reproduce) what the teacher has explained or demonstrated is important.

To earn a Level 3 score (teacher as a *facilitator*), the participant must describe the teacher's role in facilitating student discovery during at least part of the lesson. At most, the imagined teacher introduces the day's task and does the first one or two parts of that task with the class before turning it over to the students, and then keeps students on the right path by asking questions (p. 600, emphasis in the original).

4. Methods

We collected data from invitation-only Facebook groups addressed to general and mathematics teachers, as well as from website content. The website content included articles, interviews with teachers and comments on these. We have decided to preserve the anonymity of the Facebook groups. Each article published online, as well as each Facebook post, was counted as one text; the same was the case for each comment that followed—where the same teacher posted more than one comment, these were counted as different texts. We collected 635 texts from the Facebook groups and 289 texts from websites. The texts were analysed using a thematic analysis approach [14]. Having in mind the elements of the images of mathematics described above, we first separated relevant texts from irrelevant texts: in our case, we excluded 273 texts containing criticism of the government's policies. The next step was to assign codes to the utterances contained in the texts (see Table 1) and then combine these codes to establish the emerging images.

Table 1. Data coding.

Code Symbol	Code Name	Code Description
CONTENT	Content knowledge	The teacher does or does not demonstrate knowledge of the content
MATH	Nature of mathematics	Mathematics does or does not allow for multiple perspectives
BODY	Teacher's body position	Teacher's body position in relation to the camera (back/front)
VERB	Teacher's verbal expression	Teacher does or does not articulate all words properly
TOOLS	Teacher's use of tools	Types of tools used by the teacher (whiteboard, marker, ruler, etc.)

Table 1. *Cont.*

Code Symbol	Code Name	Code Description
QUEST	Teacher's questioning	Teacher's use (or not) of questions
CAMERA	Teacher's attitude on camera	The teacher is (or is not) comfortable in front of the camera
ONLINE	Teacher's experience in online teaching	The teacher is (or is not) experienced in online teaching
TALENT	Teacher's talent	The teacher is (or is not) talented in teaching
APPEAL	Lesson's appeal	The mathematics lesson is (or is not) interesting
LEARN	Type of learning	Learning mathematics by only (or not) memorising facts
KNOW	Knowledge transmission	Knowledge is (or is not) transmitted from the teacher to the student
PREP	Lesson preparation	The mathematics lesson is (or is not) thoroughly prepared

5. Results

Our analysis led us to four overarching images of mathematics and its teaching. The first image includes codes on the nature of mathematics (MATH) and the teacher's knowledge of the content (CONTENT):

> Without a doubt, the content that has reached us contains gross errors (CONTENT). Basic mathematical skills and concepts are so clearly defined that there is no doubt that there are no two points of view concerning the correctness of the content contained in the program. (MATH) [15]

Although the teachers' knowledge of content (or lack of it thereof) was mainly demonstrated by their mistakes, the above excerpt also reflects an image of mathematics as an unambiguous discipline in which there is no room for more than one point of view.

The second image includes codes on the teacher presenters' verbal (VERB, QUEST) and non-verbal behaviour (QUEST, VERB, KNOW), their (pedagogical) content knowledge (KNOW), their readiness to teach in such a form (PREP) and some general features of their teaching performance (TALENT), including their attitude towards the camera (CAMERA). The following excerpts are characteristic:

> The lessons are such that there is a person or two in front of the camera and a whiteboard. Some people act as if they stand/sit in front of a normal class, ask questions to non-existing children (QUEST), listen, and then answer by themselves, which is not very good concerning the state of their minds [16].

> Teachers read from a piece of paper, talk in a way that is hard to understand the main point, and articulate each "ę" and "ą", like in a miserable theatrical performance (VERB). In addition, they throw to the audience concepts (KNOW)... (Facebook group)

> I saw a sad lady sitting at a desk (CAMERA) with a textbook and a messy looking notebook; behind her an unused whiteboard (TOOLS)... (Facebook group)

> I did not expect that in a few days we would have been able to create the perfect lessons in a new form (PREP), but if you provide the audience with such a 'product' and you call it educational success, it is a misunderstanding for me... [17]

In the above excerpts, we identified some aspects of the presenters that were deemed negative. However, in other texts, we located descriptions of features of a 'good' mathematics teacher, especially one that would be able to efficiently conduct these programs:

> There are a lot of charismatic teachers (TALENT) who, in addition, are familiar with running distant education courses (ONLINE) or have experience in front of the camera (CAMERA)... [17].

Therefore, based on this image, the teacher presenter—besides being well-prepared—is expected to possess particular aspects of verbal and non-verbal behaviour, especially given the fact that the television programs did not involve any live audiences and there were therefore no opportunities for interactions. We may relate these to the 'Teacher as motivator' role described by Munter [12]. This image is closely related to the next one, in which the focus is shifted from the teacher presenter to the presented lesson itself.

The next image derives from the code APPEAL, which is associated with the extent to which the audience perceived the lesson as interesting. A characteristic excerpt comes from a primary school teacher:

> Based on my experience, I assume that the child will not focus his attention on such a presented lesson for 30 min. It lacks a bit of imaginativeness and creativity (APPEAL). I had a problem myself to watch one lesson to the very end… [18].

According to the above excerpt, the broadcasted lesson lacked the interest its author would expect. The collected data were not sufficient to provide us with more hints on whether the overarching image is that mathematics teaching is expected to be appealing or whether it is usually unappealing. A second excerpt enforced the second option:

> This matter needs to be publicised, because in the worst situation, the Ministry of Education recommends that you watch the program for educational purposes. Therefore, millions of Poles received the information that this content was checked by experts from different fields of education (PREP) [15].

The author of the above excerpt expresses his worry that the audience ("millions of Poles") would consider this a 'standard' mathematics lesson. This implies a view that the television lessons were accurate representations of the mathematical classroom.

The fourth image emerged from the code associated with the way mathematics is learned (LEARN). Here is a characteristic excerpt from an online article:

> In the TVP edition, the school is not a place for learning, which is at the end of a process, but a crude "memorise-pass the exams-forget" (LEARN) [17].

According to the above excerpt, teaching and learning mathematics—as presented in the program—became possible only through knowledge transmitted from the teacher presenter to the student viewer. This knowledge consisted mainly of isolated facts that the student viewer was asked to memorise (usually at a fast pace), without applying any critical thinking. Therefore, we may identify the image that mathematics teaching should not be based solely on crude memorisation.

6. Discussion

The importance of the images of mathematics is acknowledged by many studies and is mostly based on the effects these images have on people's careers or even their everyday lives. For instance, it is posited that mathematical literacy "assists individuals in recognising the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective citizens" [19] (p. 2). Obviously, a negative image of mathematics hinders the individual's path towards mathematical literacy, which, in turn, may affect the person's well-being. Ambrose [20] refers to dogmatic and unethical implementations of mathematics within economics and education; concerning education, he criticizes—among others—the increasing importance of standardized testing. These practices are rooted in particular images of mathematics as being precise, logical and unambiguous. Another effect of the negative image of mathematics is the low enrolment in mathematics and engineering studies [1]. In light of these considerations, we have studied teachers' images on mathematics and its teaching as portrayed in their online interactions. Our aim was not only to enrich the literature on the images of mathematics, but also to

identify the challenges and limitations of television programs and the requirements that they enforce on the designers and the teacher presenters.

Our study has led us to four overarching images. These images were constructed by combining different codes, therefore we did not focus on their quantitative aspects, e.g., whether one image was quantitively more pre-dominant than others. According to the first image, the accuracy of the mathematical content is of the highest importance and, moreover, there is no room for different points of view in mathematics and its teaching. Indeed, our own viewing of the programs led us to identify mistakes in the presented content, some of which were substantial. At the same time, following Hersh [21], we can claim that this image reflects only the 'front mathematics', which is characterized by the following:

> "front mathematics" is formal, precise, ordered and abstract. It is separated clearly into definitions, theorems and remarks. To every question there is an answer, or at least, a conspicuous label: "open question". The goal is stated at the beginning of each chapter and attained at the end (p. 128).

Hersh [21] goes on to describe the mathematics 'in the back' as "fragmentary, informal, intuitive, tentative" (p. 128); this kind of work resembles more closely the work of mathematicians and researchers and is even reflected in contemporary works on vagueness in mathematical discourse [22]. In these approaches, there is room for the student (and even the teacher) to deploy less formal and less absolutist ways of expression while engaging in a mathematical activity.

The second image is implied in the critique of the teacher presenters who were not accustomed or trained to teach on camera, therefore their verbal and non-verbal actions sometimes resulted in awkward results. According to this image, the mathematics teacher is expected to be a motivator of the students [12], by being well-prepared and being able to utilise different resources in her teaching. In a second reading, this image may reflect the social awkwardness which accompanies mathematicians (see, e.g., [7]).

The third image is implied in portrayals of the broadcasted mathematics lessons as boring and without 'energy'. One may claim that this critique is related to the specificities of television. Even if this claim is true, we do believe that for many people (including, presumably, the directors of the programs), the content of the television courses was designed in such a way as to represent the desired (or 'proper') mathematics lesson (cf. [23]). This raises some concerns about the distance between educational theory and teaching practice—even if, in our case, the teaching practice had to be reduced to a performance in front of the camera. According to the words of a prominent Polish professor in mathematics education:

> The harm these broadcasts have done is not that they teach children poorly, but that they send a signal to weak teachers that such teaching is okay. (Anonymous, personal communication, 2 April 2020).

The fourth image describes teaching and learning mathematics as involving inquiry and participation, as opposed to passive receipt of isolated facts that are to be memorised, which seemed to be the case with the television programs. This can be associated with the 'teacher as facilitator' vision [12], according to which the teacher facilitates the students' discovery of new knowledge. One may claim that this is a general issue in online mathematics education. In a recent paper, Bakker and Wagner [24] referred to some researchers' worry that "quick adoption of new technology will lead to falling back to less favorable pedagogy" (p. 2). We found ourselves with the same concerns in our own online teaching during the lockdown and pondered the following: how to ensure a more participatory and less passive teaching and learning, given the technological and time constraints?

One limitation of our study is the sources of our data, especially social media. We acknowledge that the dynamics of online exchanges may lead to polarisation [25]. Actually, one may claim is that our data seem to converge on a polarized and negative view of the television programs. Additionally, by focusing on teachers' images, we were only able to interpret a selection of the vast amount of data available on the topic.

7. Conclusions

In summary, our study's contribution is twofold: towards the improvement of televised educational programs (and, possibly, online courses) and the improvement of the public's images of mathematics. Concerning the first, we believe that thorough preparation, which takes into account contemporary teaching approaches, is necessary; we do acknowledge that in our case, the television lessons had to be designed and conducted in a very short time. Still, we cannot ignore the image that the teacher presenter is expected to have some characteristics associated with keeping the intended audience motivated and engaged. Our study has shown that the risk of switching to transfer-of-knowledge approaches is significant—it was interesting to witness viewers' strong disagreement with this form of teaching. We believe that if such programs are improved, we may expect an improvement in the public's image of mathematics; this in turn may affect student enrolment in mathematics courses. From a research perspective, our study adds to relevant studies that deploy not only the concept of image, but also concepts such as mathematical identity [7], to analyse texts. However, one should be cautious in the case of online texts, because the risk of polarisation is real. Finally, the results of our study may also contribute to future studies aiming to find commonalities in the images of mathematics among different agents or even among different countries and cultures.

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