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Seeds that germinate, sprout, grow and develop in their own time: productions of educational actors inserted in different spaces

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Abstract: As part of the "Digital Videos in Mathematics Education" extension course, we aimed to understand how the discourse of a teacher combines semiotic resources in the video production entitled "About the sphere and the cylinder". The research approach is qualitative, and the data produced in the investigation is based on the video, on interviews, and on discussion forums. We reflect on spontaneity, the classroom, and the use of digital technology, creating a link between the spreading of seeds and the possibility of exploring this technology in public schools to stimulate students to produce mathematical knowledge through videos. In this sense, when we became aware that our reflections touched the sensibility of the teacher, we oriented the investigation to the product of his experience in the light of multimodality. We conclude that this educational actor, guided by "playfulness" and "valid information", harmonizes semiotic resources of language, mathematical symbolism, and visual demonstration when producing meanings in his discourse.

Keywords: Digital Video Production. Mathematical Discourse. Multimodality.

Semillas que germinan, brotan, nacen y se desarrollan a su tiempo: producciones de actores educativos insertados en diferentes espacios

Resumen: En el marco del curso de extensión "Videos digitales en la Educación Matemática", buscamos comprender cómo el discurso de un profesor combina recursos semióticos en la producción titulada "Sobre la esfera y el cilindro". El enfoque de la investigación es cualitativo y los datos producidos en la investigación se basan en esa producción, en entrevistas y foros de discusión. Así, reflexionamos sobre la espontaneidad, el aula y el uso de la tecnología digital vinculando el lanzamiento de semillas con la posibilidad de usar la tecnología en la escuela pública para estimular a los estudiantes a producir conocimiento matemático a través de videos. En ese sentido, al tomar conciencia de que nuestras reflexiones afloraron la sensibilidad del referido profesor, dirigimos la investigación para el producto de su experiencia a la luz de la multimodalidad. Concluimos que este actor educativo, pautado por lo "lúdico" y por la "información válida", armoniza recursos semióticos del lenguaje, del simbolismo matemático y de la exhibición visual al producir significados en su discurso.

Palabras clave: Producción de Videos Digitales. Discurso Matemático. Multimodalidad.

Sementes que germinam, brotam, nascem e se desenvolvem a seus tempos: produções de atores educacionais inseridos em diferentes espaços

Resumo: No âmbito do curso de extensão "Vídeos digitais na Educação Matemática",

buscamos compreender como o discurso de um professor combina recursos semióticos na produção intitulada “Sobre a esfera e o cilindro”. A abordagem da pesquisa é qualitativa e os dados produzidos na investigação se baseiam nessa produção, em entrevista e fóruns de discussão. Assim, refletimos sobre espontaneidade, sala de aula e uso da tecnologia digital vinculando o lançamento de sementes a possibilidade de explorá-la na escola pública para estimular estudantes a produzirem conhecimento matemático por meio de vídeos. Nesse sentido, ao tomarmos consciência de que nossas reflexões afloraram a sensibilidade do referido professor, direcionamos a investigação para o produto de sua experiência à luz da multimodalidade. Concluímos que esse ator educacional, pautado pelo “lúdico” e pela “informação válida”, harmoniza recursos semióticos da linguagem, do simbolismo matemático e da exibição visual ao produzir significados em seu discurso.

Palavras-chave: Produção de Vídeos Digitais. Discurso Matemático. Multimodalidade.

1 Introduction

Driven by the need to perform actions, human beings produce technologies. For a long time, his perception capacity has made him improve methods, techniques, and creative resources that, in a given moment, made possible the emergence of digital technologies. Somehow, the result of this effort has benefited the creation and implementation of educational policies that seek to promote people's social and digital inclusion. In this context, we notice the “timidity” with which digital technologies have been explored in schools, which signals the need to structurally advance in aspects such as University-School integration, quality internet access, equipment acquisition, and teacher training. However, we cannot wait for ideal conditions to implement what is already part of the social life of teachers and students. It is time to sow seeds and work for them to bear fruit in the different educational spaces.

In this way, we understand that thinking is reorganized with the use of technologies. Thus, supported by experiences of educational actors linked to the public schools, we developed the extension proposal “Digital Videos in Mathematics Education” aimed at teachers of Basic Education with the objective of producing and socializing mathematical, artistic and technological knowledge through digital videos, as well as consolidating the sharing of experiences between university and society. To wit, this proposal sowed seeds of knowledge through discussion of texts, teaching activities, and digital video shows that germinated, sprouted, were born, and developed in their own time with the production of teachers and students inserted in different contexts. In particular, due to space limitation (in this article) we will address only the analysis of the video “About the sphere and the cylinder”, produced in the scenario of the mentioned proposal. In this context, we reflect on the following question: How does a mathematics teacher express mathematical content through digital video? Thus, we seek to understand how this professional combines semiotic resources to produce meaning in his discourse, based on his choices.

2 Literature review

In this section, we present a literature review on works that address the theme “digital videos in Mathematics Education” in order to bring our study closer to research conducted in other contexts. We begin with Souza and Oliveira (2021) who conducted a study on publications dated between 2015 and 2020, which used videos in mathematics education, as well as their potential for practice and teacher training. These authors note, in their analysis, three strands that involved: lesson recording, video production, and videos as a teaching resource. As a conclusion, they register that still “there are gaps regarding research on teacher training for the use of vídeos” (Souza & Oliveira, 2021, p. 229), and that it is essential to think of formative

actions to meet demands and promote mathematical, pedagogical and technological training in a joint, not in a segmented way.

In another study Canedo Jr. (2021) uses digital video in the continuing education of teachers who choose a problem and produce videos as answers, in an activity focused on teaching mathematics. In this opportunity, the referred author lists the following themes to analyze the data: "between problematization and the game of questions and answers"; "the domestication of the multimodality of videoproblems"; "the notion of problem reconsidered"; and "Empiricism in, and with, digital vídeo". In view of the above, he concluded that some research participants replicated excerpts of video problems in their productions, while others suggested the need to perform experiments, in other words, there was empirical influence, which corroborates the understanding that "different media have shaped the nature of the data used by students in their modeling practices" (Canedo Jr, 2021, p. 127).

Vieira (2017), meanwhile, investigates how the production of digital videos can contribute to the construction of contextualized knowledge in science education. At the time, the author offered workshops on the creation and planning of digital videos for students from Elementary School II, who were divided into teams to address the following themes: sexually transmitted diseases; evolution of diversity; reproduction of living beings; and sound and electromagnetic waves. The workshops foresaw the production of digital videos on these themes, which could be explored through short films, documentaries, series, and talk shows. According to the author, the results show that these students "achieved the construction of contextualized knowledge in science education [...] promoted articulations through the knowledge revealed in the production of the digital vídeo" (Vieira, 2017, p. 145).

In turn, Fontes (2019) investigates different factors that influenced the communication of Mathematics undergraduates characterized in seven videos: "signal game"; "limit"; "percentagem"; "Fibonacci sequence"; "behavior of the quadratic function graph"; "symmetry"; and "school of little ants". In search of understandings, the author resorts to interviews and analysis of these productions supported by the documentary method to value atheoretical knowledge and the "meanings given by the members of a social group, who are inserted in a specific context, from a series of interconnected lives and experiences that pervade that group" (Fontes, 2019, p. 88). The author infers that mathematical communication is linked to these students' understandings of that science and "their teaching and learning processes, as well as [to] the technological knowledge they had at the time of the videos' production and the context in which they were embedded" (Fontes, 2019, p. 143).

In her instance, Oliveira (2018) explored this theme with the aim of understanding different dimensions that emerged from the I Festival of Digital Videos and Mathematics Education held in a public school. The author takes on aspects of Paulo Freire's theory and multimodality to glimpse subjects' world readings in the video production process. Her study is composed of scripts and student productions, interviews with managers, teachers, and parents. The author admits that the dimensions apprehended in the research material present: the student subject and the video as a response to curiosity; the importance of the cell phone, the computer and fast internet for mathematics research and teaching; the mathematical content of the videos produced by students; the digital video festival and Mathematics Education at school; and the public image of mathematics. Finally, she concludes that "producing video with mathematics is a path that expands through dialogue" (Oliveira, 2018, p. 89).

In another research, Simonetti and Moretti (2021) analyze the Common National Curricular Base (BNCC) that defines the guidelines related to student learning and teaching work. The authors address competence four that deals with an important element for their

reflections, which approach the theory of semiotic representation registers. In particular, they illustrate some classroom situations to explore skills related to this theory and realize that, although there are approximations between BNCC and the mentioned theory, there are some conceptual distortions that can compromise the role of mathematical learning in the intellectual formation of students. In this sense, the authors show concern about the conflict of interests between economic and educational organizations that make them reflect on the role of mathematical learning in Basic Education associated with the reasoning, analysis and visualization skills of these students.

Our last research explored is by Neves (2020) who seeks understandings of how mathematics undergraduates combine semiotic resources when producing digital videos. The author adopts a theory for multimodal discourse analysis and produces data embedded in the context of two courses. In the process, she admits to having selected five videos based on repetitive viewing and comparison of critical events. Furthermore, she points out that forums, scripts, and student reports also composed the *corpus* of the research, and after analyzing this material, she suggests that the producers resort to verbal language, mathematical images, and mathematical symbolism to express ideas through semiotic combinations. Supported by the videos, the researcher exemplifies that the gesture materialized the mathematical discourse, the music served as a motivating element, and the image situated the mathematical problem. She then concludes that the multimodal nature of the video enabled its producers to perform combinations between elements of traditional mathematical discourse and cinematic language, which enhanced semantic expansions.

In view of the researches in question, it is possible to expose that they show that when using mathematical videos for teaching, learning or teacher training, we can understand how the authors (re)elaborate their knowledge supported by multimodal/semiotic resources, as well as the gaps and possibilities that this theoretical-methodological strategy underlies. Furthermore, we understand that there is a fertile field for working with digital videos in Mathematics Education when we consider the resources that can be employed in their production and analysis. Thus, in the next section, we address the theoretical framework that underlies our study.

3 Theoretical framework

Due to the need for communication, the human being uses several forms of discourse. According to Souza (2021, p. 82), “a discourse is any communicative action integrated into a given context that relates the sender (producer of meaning), the audience (assignor of meaning) and the message (set of codes)”. In this sense, the digital video content constitutes a type of discourse loaded with meanings that can be used as a seed in the (re)construction of mathematical knowledge. But, how can we understand this theoretically?

If we look at the socialization of mathematical knowledge (ideas, impressions, signs) present in the discourse of the sender - semiotic product of (communicative) action - we have a combination of language, mathematical symbolism and visual display. Thus, if these semiotic resources are distinct their grammars are specific in the context of the Systemic Functional Multimodal Discourse Analysis theory (O'Halloran, 2005), which can be translated as Systemic Functional - Multimodal Discourse Analysis (SF-ADM).

This SF-ADM perspective derives from Functional Systemic Theory (FTS), which after Halliday's (1978) linguistic studies on language use and function establishes three metafunctions, namely: *(i)* ideational; *(ii)* interpersonal; and *(iii)* textual. In TSF, the author in question refers to discourse content in *(i)*, the representation of that content in *(ii)*, as well as

the organization of content and representation in *(iii)*. In the case of SF-ADM, there is plurality in (communicative) action and the analyst's look at "multimodal discourse is concerned with the theory and analysis of semiotic resources and semantic expansions that occur as semiotic choices combine into multimodal phenomena" (O'Halloran, 2011, p.121). The distinguishing feature of SF-ADM is that it considers language, mathematical symbolism, and visual display as semiotic resources in addition to their specificities. That is, the use and function of language, mathematical symbolism, and visual display are addressed from this perspective.

In this sense, in relation to the semiotic resource of language, Halliday (1978) guides the need to observe that the discourse analyst needs to consider the grammar of language. For example, in a digital video the nomenclature used by the producer of meanings is aligned with a grammatical structure in which the use of verbs, conjunctions, and nouns that condition the reading of the discourse predominates. In this perspective, according to O'Halloran (2015), the use of these elements reveals the sender's strategies and highlights the audience's difficulties regarding the grammatical use of language (Chart 1).

Chart 1: The grammatical use of language

Strategies and difficulties		Meanings and examples
a	Interconnected Definitions	The theoretical framework of mathematics has well-defined, chained structures. Example: the "area of the parallelogram" represented by the "modulus of the vector product of two vectors".
b	Technical Taxonomy	Regarding item (a), there is a classification of mathematical concepts that relies on common characteristics. Example: vectors with "representatives in the same plane".
c	Special expressions	Regarding item (b), a specific nomenclature of mathematics is used. Example: the "geometric interpretation" of the modulus of the vector product of two vectors.

Source: Adapted from O'Halloran (2015, p. 65)

O'Halloran (2015) argues that grammatical strategies and difficulties related to language can transform discourses of meaning producers, unattractive, in view of the audience's unfamiliarity with certain concepts, classifications, and specialized vocabulary. On the other hand, the grammatical strategies of these meaning producers incorporate logical arguments and reveal the semiotic choices in their discourses. Chart 2 discusses the metafunctions of language that are used by the sender in the elaboration of mathematical discourse.

Chart 2: The metafunctions and systems of language analysis

Metafunction	Analysis System	Description (Language)
Ideational	Participants, Processes, and Context.	Socialize mathematical participants and processes that ensure logical coherence and characterize the nature of action supported by world experiences or occurrences of physical events.
Interpersonal	Discourse Function.	Use patterns, conventions, statements, and questioning in an effort to position mathematics through dominant relationships that originate in logical reasoning.
Textual	Relevance of the topic.	Textually organize the socialized message to highlight certain passages in light of mathematical ideas and arguments.

Source: Adapted from O'Halloran (2000, 2015)

It is important to note that the grammatical strategies of the meaning producer with the use of language enable the realization of (new) semantic expansions when other semiotic

resources such as mathematical symbolism and visual display are incorporated into his discourse. In general, these realizations generate an explosion of meaning in the audience, which contributes to the understanding of the discourse. O'Halloran (2015) emphasizes that mathematical symbolism developed supported by language, something that brought functionality to the particularities of its grammar and that made it possible to combine linguistic and symbolic elements in the sender's discourse. Chart 3 systematizes strategies of the meaning producer and difficulties of the audience regarding the grammatical use of mathematical symbolism.

Chart 3: The grammatical use of mathematical symbolism

Strategies and difficulties		Meanings and examples
a	Special symbols	The convention of special symbols associated with the grammar of mathematical symbolism enables different combinations in discourse. Example: the representation of vectors.
b	New grammar strategies	Because of item (a), in (re)encoding meaning the grammatical strategies of mathematical symbolism differ from the grammatical strategies of language. Example: the sequence of algebraic operations that result in an equality.
c	Implicit chains of reasoning	The logical meaning of mathematical processes involving implicit reasoning relies on prior knowledge. Example: the height of the parallelogram.

Source: Adapted from O'Halloran (2015, p. 65)

In particular, the grammatical strategies of mathematical symbolism that encompass different combinations, (re)codification of meanings, and logical reasoning highlight the distinction between language and mathematical symbolism used in the sender's discourse. According to Souza (2021, p. 100-101), the use of "mathematical symbolism eliminates a number of processes, synthesizes the codification of experiential meaning, and fulfills functions that do not belong to language". The author points out that this "form of expression reveals a connection between concepts that is used to textually organize mathematical discourse and make possible the realization of new kinds of processes" (Souza, 2021, p. 101). In this direction, Chart 4 elucidates characteristics of the metafunctions of mathematical symbolism that help the discourse analysis, when in the production of meaning the sender uses this semiotic resource.

Chart 4: Metafunctions and systems for analyzing mathematical symbolism

Metafunction	Analysis System	Description (Mathematical symbolism)
Ideational	Participants, processes, context, and logical reasoning.	Recognize patterns, elect references, and constitute mathematical processes that provide a means to describe physical events, as well as enable relational, spatial, and temporal interpretations to be made in mathematical processes.
Interpersonal	Information and conventions.	Establish relationships between participants and mathematical processes, considering the rigor of mathematical laws.
Textual	Relationships and operations.	Display results of mathematical processes organized according to conventional patterns.

Source: Adapted from O'Halloran (2000, 2005, 2015)

O'Halloran (2005) emphasizes that mathematical symbolism emerges from pattern recognition and the constitution of mathematical processes related to problem solving. In this sense, the sender's discourse establishes codes that make it possible to compile its ideational meaning, institutes an operational relationship between participants and processes that

highlights its interpersonal meaning, and organizes the results of mathematical processes into its textual meaning. Souza (2021, p. 103) notes that combining language and mathematical symbolism "propitiates the reader's involvement and helps in the understanding of the linguistic text that is not always linear".

Along these lines, (Souza, 2021, p. 104) maintains that "although mathematical symbolism is the main semiotic resource for constructing logical meaning in mathematics", the advancement of technology has made it possible to associate linguistic, symbolic, and visual patterns through representations. Specifically, with regard to the semiotic resource of visual display, this advancement has expanded meanings from geometric interpretations that rely on discourse. Chart 5 exposes the grammatical strategies of the sender when the semiotic resource of visual display is used to produce meanings.

Chart 5: The grammatical use of visual display

Strategies and difficulties		Meanings and examples
a	Special Conventions	The relationships that are configured between spatial representations and symbolic descriptions are established using patterns of visual display. Example: the three-dimensional Cartesian coordinate system.
b	Density of visual interaction	Based on item (a), various mathematical information of a given content can be visualized. Example: the symbolic equation and the geometric representation.
c	Implicit reasoning	Based on item (b), prior knowledge enables the exercise of implicit reasoning. Example: the geometric interpretation of the modulus of the vector product of two vectors.
d	Incorporation of symbolic and linguistic elements	The mathematical representation contains symbols and/or linguistic elements. Example: the combination of mathematical symbolism and language in an image.

Source: Adapted from O'Halloran (2000, 2005, 2015)

In accordance with O'Halloran (2015), the grammatical strategies associated with the semiotic resource of visual display integrate logically after processing elements that make up the discourse of the meaning producer. In other words, the specificities of this semiotic resource (image, video clipping, and representation) intersemiotically relate to each other in a single representation, but with its particularities and intrasemiotically harmonize with the specificities of the semiotic resources of language (gesture, music, orality, and signal) and mathematical symbolism (mathematical symbolism). These grammatical strategies exploit spatial representations, symbolic descriptions, visualization, and implicit reasoning. Chart 6 illustrates the metafunctions of visual display that are used by the sender to produce meaning in his discourse.

Chart 6: The metafunctions and systems for visual display analysis

Metafunction	Analysis System	Description (Visual Display)
Ideational	Processes, participants, and imaginary contexts.	Visually map the organizational aspects that relate mathematical processes and participants.
Interpersonal	The focus turns to the composition of the visual elements.	Characterize the mathematical components displayed in the visual representation considering factors such as size, proportion, and density.

Textual	The representation is considered a single component.	Elaborate interpretations about the mathematical components represented visually in order to relate them.

Source: Adapted from O'Halloran (2000, 2015)

O'Halloran (2005) notes that the semiotic resource of visual display, present in the sender's discourse, enables the visual mapping of mathematical participants and processes (ideational meaning), the characterization of their mathematical components and how they relate (interpersonal meaning), as well as, the interpretation of these components (textual meaning). This possibility extends the interpretation of the meaning of the visual form being (re)encoded using language. In the sequel, we devote attention to the investigative context and the stages of our study.

4 Methodology

Supported by Borba, Almeida, and Gracias (2018), we opted for the qualitative research approach and the extension course "Digital Videos in Mathematics Education" served as the research scenario. In the opportunity, we made 20 openings available for teachers who teach mathematics in public school in an environment for sharing experiences. However, to our surprise, only one teacher adhered to the proposal, attended the face-to-face meetings, and carried out the activities. In our understanding, this justifies the choice of sowing seeds (in the teacher's reflections) regardless of the number of participants, in order to carry out mathematical activities and offer protagonism to the students to create movements in the public school classroom.

Particularly, in this course we defined 20 hours for online activities (participating in discussion forums, reading texts, building prototypes, writing a script, producing a digital video) and three face-to-face meetings that took place at the university in a three-week interval. We emphasize that the purpose of this extension course was not to teach participants how to produce digital videos, but to show possibilities of teaching mathematics with other technological resources that differ from the board and brush, for example.

In this path, in search of finding elements that would later help the data analysis focused on the production of the referred teacher (the digital video) - associated with the seed sowing in the public school classroom - and to understand how he combines semiotic resources, as well as produces meanings in his discourse, we conducted an interview divided into two parts that lasted about 30 minutes. In the first part, we addressed issues related to the extension course, the didactic materials and the proposed activities. In the second part, we dealt with his production to get to know details about the choice of theme, the use of semiotic resources, the target audience, the editing work, among other specificities.

Regarding the interview, we shared with the teacher participating in the course the initial (open) questions to facilitate his reflections that, after the beginning, led us to the elaboration of other questions. Before that moment, we watched the video several times in order to make notes regarding the mathematical content, the semiotic resources and its running time to then elaborate its timeline, separate it into planes and cut excerpts in the analysis supported by the SF-ADM approach (O'Halloran, 2005) with emphasis on the semiotic resources used in the production. In particular, these resources were identified and separated for the visualization of their combinations present in the teacher's speech.

We emphasize that this movement of watching the video, as well as identifying and separating its semiotic elements enabled the representation of records in its timeline. Moreover,

this movement made it possible to elaborate understandings, from the data analysis, to describe how the teacher uses grammatical strategies of the semiotic resources of language, mathematical symbolism, and visual display to produce meaning in his discourse.

5 Data Analysis

In order to understand how teacher Tenório combines semiotic resources in his discourse, we consider it important to recall moments before the production of the video "About the sphere and the cylinder"[1] which record his participation in forums of doubts and in the three face-to-face meetings held throughout the extension course. In addition to these records that we used in our investigation, the data analysis is based on the video sent by the teacher in attendance to the (final) activity of the course, as well as the interview he gave on that occasion. In particular, when living this experience of producing mathematical content with the help of digital technology, the author assumes a well-defined role, facing the camera, marked in the initial and final parts of his production. In this path, in order to situate the reader in the process of analyzing this production, we elaborated Chart 7 to illustrate that the discourse of the referred author combines semiotic resources of language, mathematical symbolism and visual display (O'Halloran, 2005).

Chart 7: The composition of the video plans

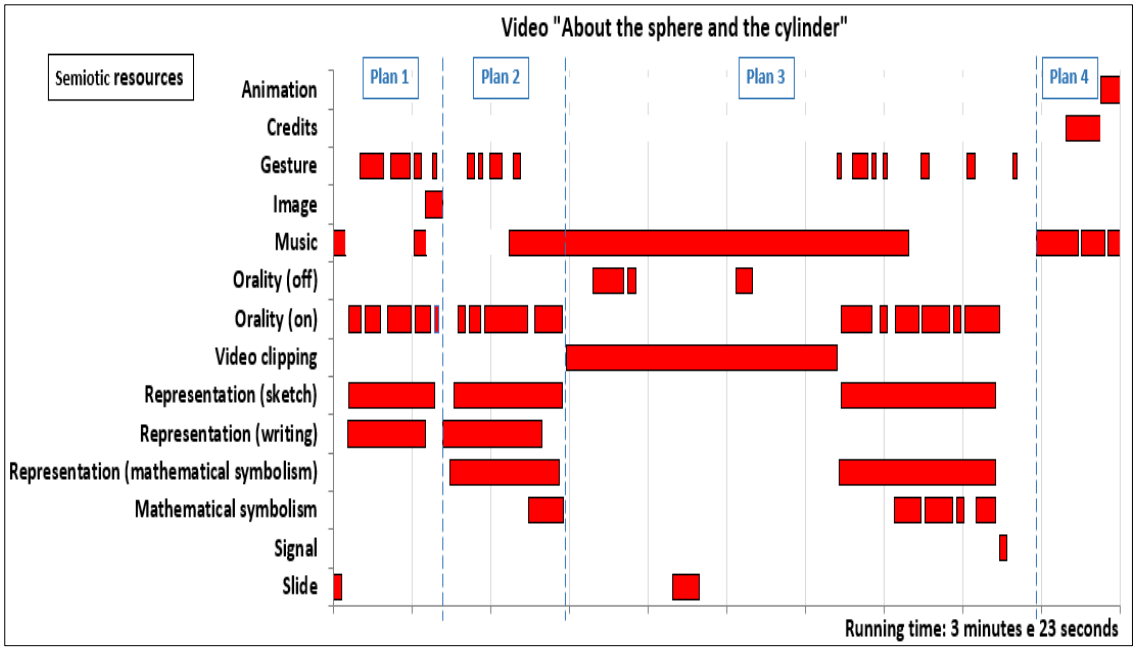
<table>
<tr><th></th><th>Plan 1: opening</th><th>Plan 2: development</th><th>Plan 3: conclusion</th><th>Plan 4: closing</th></tr>
<tr><td>Situation</td><td>Digital/Internal</td><td>Digital/Internal</td><td>Digital/Internal</td><td>Digital</td></tr>
<tr><td>Description</td><td>Identify the title of the video. In the sequence, a classroom is used as a backdrop. The teacher looks/speaks into the frame and says that he will address the concept of volume of the sphere.</td><td>Identify the flag of the state of Roraima. In the sequence, a classroom is used as a backdrop. The teacher looks/speaks into the frame and explores what they set out to do.</td><td>A laboratory experiment is presented. In the sequence, a classroom is used as the setting. The teacher looks/speaks into the frame and conceptualizes the volume of the sphere.</td><td>Identifies the title, author and credits of the video, and acknowledgments.</td></tr>
<tr><td>Duration</td><td>26”</td><td>34”</td><td>129”</td><td>13”</td></tr>
<tr><td>Semiotic resources</td><td colspan="4">Animation, gesture, music, orality (on and off), representation (sketching, writing, and mathematical symbolism), mathematical symbolism, signal and slide.</td></tr>
<tr><td>Camera Movements</td><td colspan="3">Handling done with the hands supposedly supported by a tripod.</td><td>There is no use of a camera.</td></tr>
<tr><td rowspan="2">Field Character</td><td colspan="3">The teacher stands, makes light movements, facing forward.</td><td>-</td></tr>
<tr><td>-</td><td colspan="2">The teacher turns to the board, writes, with his back turned.</td><td>-</td></tr>
<tr><td rowspan="2">Sound</td><td colspan="4">Use of illustrative music (background).</td></tr>
<tr><td colspan="3">Presence of speech.</td><td>-</td></tr>
</table>

Source: Own Elaboration

[1] Archimedes, in his work "About the sphere and the cylinder", demonstrated the following theorem: The volume of a sphere is equal to four times the volume of a cone that has the maximum circle of the sphere as its base and the radius of the sphere as its height. Source: https://www.rpm.org.br/cdrpm/58/3.htm. Accessed on: Dez. 11 2022.

O Chart 7 brings elements related to the timeline of the video "About the sphere and the cylinder" which has a total of 3 minutes and 23 seconds. In particular, in this production, the author announces at the same time explores the concept of volume of the sphere. In this vein, after watching the video several times, we noticed the semiotic resources identified in Figure 1 to illustrate how, and at what moments, these resources are combined in the mathematical discourse.

Figure 1: Semiotic resources combined in the video "About the sphere and the cylinder"



Source: Own Elaboration

In our understanding, this diversity of semiotic resources associated with the author's creativity enriches the production of meaning in his discourse. According to Fontes (2019), the capacity for expression is a factor that shapes mathematical communication. Just observe that if teacher Tenório was only talking about the concept of volume of the sphere, his speech might not make any sense to the audience. Thus, the meaning produced in his speech could be impaired, for example, because the algebraic and geometric representations of the mathematical object were not employed in his production. Thus, we reinforce that, in his discourse, the combination of elements from geometry and algebra, technologies of intelligence (Lévy, 1993) and semiotic resources of language, mathematical symbolism and visual display (O'Halloran, 2005) makes emerge, in this production, a multiplier effect that points to "the old maxim" that no technology is isolated and that the practice of meaning production is realized from the choices made by its producer to combine semiotic resources. Neves (2020, p. 29) maintains that these choices "aggregate characteristics of each resource [...] so that their particularities are extended [...] so that the meaning [...] is reformulated, enabling a better understanding of the phenomenon".

We clarify that the producer of the video "About the sphere and the cylinder" is not a professional in the area of communication and, therefore, we do not see him prevented from developing this activity freely without the rigor of the profession. In any case, what he does as a teacher-author-producer is: appropriating technological resources (which he had available at that opportunity); exploring technical knowledge (concept of volume of the sphere); prioritizing a combination of semiotic choices (meaningful to him); and producing meanings in his discourse. Based on Souza (2021, p. 82), this relationship between signifiers and meanings

leads to the production of signs as elements of "human representations that have form and content, namely, they are present in discourses that aim to produce meaning".

With that, we asked the said producer how he defined the theme to produce meanings in the video "About the sphere and the cylinder" and he replied as follows:

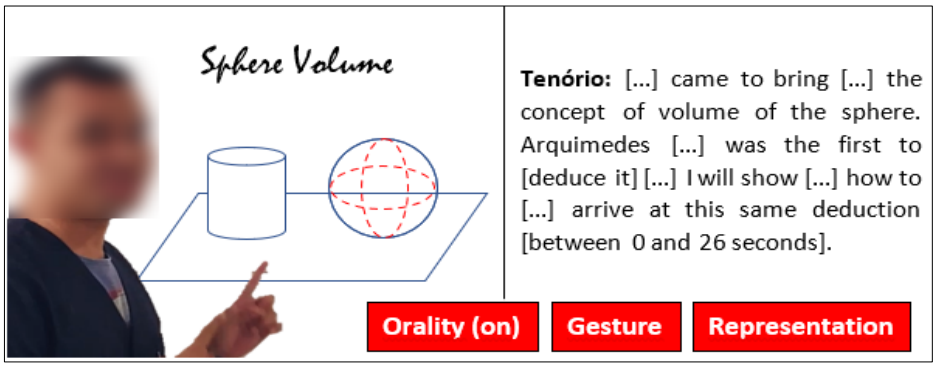
> Teacher Tenório: *[...] I wanted to pass something playful that my high school students could retain for them as valid information [...] so there are many demonstrations of the volume of the sphere interesting and not so complicated, but I thought that for my students would be a thing not yet to reach [...] demonstration of Cavalieri which is from 1500 or so [...] but Archimedes was the first to do it [...] and it was much earlier [...] 212 BC [...] a pioneer guy [...], ahead of his time [...] so I wanted to show that it is possible [to use] these ideas of dipping things in water [...] he [here a reference to Archimedes] was phenomenal. And he has several stories related [to] [...] deductive method to find the volume of the sphere [...] I wanted to show them in a more playful way involving mathematical knowledge already acquired [...] in the case there would be the calculation of volume and cylinder [...]* (Tenório, 2022, excerpts from the interview transcript).

With this excerpt from the interview, we infer that teacher Tenório recognizes that it is not attractive enough to use only board and brush to explore the concept of volume of the sphere, even based on previously studied knowledge. In this regard, Vieira (2017, p. 118) suggests that the production of videos supported by "curriculum content expands contextualized knowledge in view of the fact that the combination of images presented in the footage with the text greatly facilitates the understanding of the subject studied, making it explicit and easy to understand". At the same time, we notice what the course participant considers significant when he prioritizes "ideas of immersing things" so that his "high school students" retain "valid information".

In this sense, Simonetti and Moretti (2021, p. 102) emphasize that the register of semiotic representation "is an important element for the teacher's teaching activity" and, for this reason, they consider it necessary for the intellectual development of the student. On the other hand, there are also clarifications on choices that the participant made to characterize what he called "playful thing" and thus produce meanings in his speech. According to Souza and Oliveira (2021, p. 269), "using videos in mathematics classes [...] embraces the perception that it is necessary to develop activities with them [...]" to stimulate them to reflect on mathematical concepts.

Figure 2 is a representation of plan 1 (introductory part of the video) in which its producer elects as signifying elements semiotic resources of language [orality (on) and gesture] and visual display (writing and sketch), in view of the goal of announcing the "concept of volume of the sphere" by "Archimedes". It is worth noting that the approach present in this production differs from the content-example-exercise model, usually used in traditional teaching methodologies (Neves, 2020). In particular, the grammatical language strategy chosen by the video producer, with the use of orality (on) and gesture, covers *interconnected definitions* that connect the volumes of the sphere and cylinder. This evidences a *technical taxonomy* existing between (these) concepts that rely on common characteristics and are part of a list of specific nomenclatures in mathematics, called *special expressions* (O'Halloran, 2005). In this view, the video "About the sphere and the cylinder" offers conditions to signify teacher Tenório's opening speech in which the use of language [orality(on) and gesture] is shaped by the visual display (writing and sketching) and vice versa.

Figure 2: The combined use of gesture, orality (on) and representation



Source: Own elaboration with adaptations from the video

In view of this, we took the opportunity to find out more details about the influence of his choices and he highlighted the following:

> Teacher Tenório: *[...] I decided to draw on the board to show [the students] that it is not impossible to do [even though the teacher recognizes his limitations when saying], but I also had difficulty. [And adds] it was a barrier that I had to overcome. Interesting! [...] we make a relationship between the calculation of the volume [of the sphere] and the cylinder [...] [And emphasizes that it is necessary] the student already [...] have this knowledge that the area of the cylinder is the area of the base times [its] height and that [in this approach] it is not just any cylinder [...] [since] the height has to be equal to the diameter of the sphere [...]* (Tenório, 2022, excerpts from the interview transcript).

Nesse In this interview excerpt, we infer that the video producer uses visual representations of the "sphere" and the "cylinder" without hiding that he has some "difficulty" with geometric sketches. Oliveira (2018, p. 18) argues that "communication and dialogue present themselves during the expression of ideas and mathematical content that take shape through the produced vídeo". In any case, he considers it "interesting" to relate the calculation of their volumes from a specific (previous) knowledge. Following this bias, we also wanted to know if the author of the video had developed a script to produce it, supported by the resources available in the virtual room of the course and he expressed himself like this:

> Teacher Tenório: *In Folder 1 - Script - I find very interesting the exemplified way of making it, besides the direct approach about the schematization in a narrative structure. [I would also like to highlight the part where the author says: "It doesn't matter how you prepare the script, as long as it contains the necessary information for filming and that it is understood by everyone involved in the work". I found this part very interesting because it does not bind the idea of the video to a ready-made pattern, a fact that would hinder the creative part of the author. In folder 2 - Recording - The filming tips, positions for framing and applications for screen capture are very important points, especially for teachers who are total strangers to this universe of technology. This exchange of experiences is fundamental, making the folder extremely important to improve the quality of productions* (Tenório, 2022, excerpts from the transcript of the discussion forum).

In this opportunity, the video producer mentions Folder 1 when he considers "interesting the exemplified way of making it" and the "direct approach" that this material suggests for the construction of a "narrative structure". This statement is consistent with the script of the video in which the author prioritizes objectivity, and does not frame his choices "to a ready-made pattern" that would compromise his freedom of creation. In turn, when he refers to Folder 2 to highlight "the filming tips" related to the moment of recording (framing and applications), we infer that this objectivity is associated with improving the "quality of Productions". In this

direction, we emphasize the way the message is addressed to the audience in the moments of "framing the vídeo", as well as observing that the recording scenario used in the classroom does not have adequate acoustics to capture audios (openly), besides the fact that teacher Tenório does not have the best equipment to do the takes. Perhaps, this experience is a demonstration that producing videos with limited resources offers conditions to engage students in activities that enable different modes of mathematical expression. In view of the above, it is worth mentioning Fontes (2019, p. 61), because among "the possibilities that exist to promote an environment that provides the student with intellectual development, autonomy, self-evaluation, and responsibility, the video production activity is an option that should be considered".

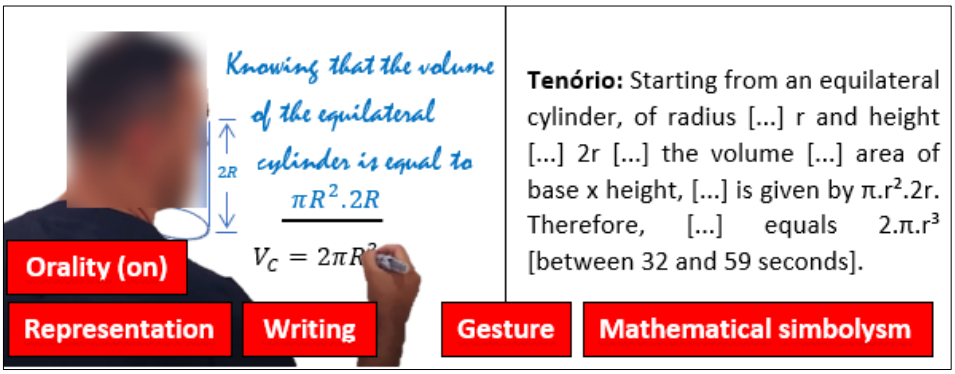
In this excerpt of the production, orality (on) brings life to the use of the representations of the sphere and cylinder sketched on the board. However, we observe that the semiotic language resource used by the producer does not turn to explore participants (numbers, terms, operators) and processes (operations, deductions, volumes of the sphere and cylinder). Thus, associated with the grammar of visual display, we notice the absence of the ideational metafunction in his discourse, since this semiotic resource was not used in any algebraic manipulation in the referred plan 1.

In relation to the use of language combined with representation, we understand that the same situation occurs in this excerpt of the discourse, although we recognize that there is production of meaning when teacher Tenório announces the concept of volume of the sphere. In this way, we emphasize that the mathematical components of the representation outlined in the table signal a complementary relationship between sphere and cylinder, characterized by the use of the interpersonal metafunction in the discourse. In particular, we justify our interpretation based on the passage: "I came to bring [...] the concept of volume of the sphere. Archimedes [...] was the first to [deduce it] [...] I will show [...] how to [...] arrive at this same deduction".

On the other hand, in the sequence referring to the development of the deductive approach to the concept of volume of the sphere (in plane 2 of the video) there is a combination of semiotic resources of language (gesture, music, orality (on)), of mathematical symbolism (symbol, sentence, property, concept) and of visual display (framing, camera movement, sketch, writing and mathematical symbolism). Figure 3 illustrates an excerpt in which some of these semiotic resources are employed.

In this excerpt of the video, we notice the conventional use of *special symbols* that O'Halloran (2015) highlights in his work, because the interpersonal meaning of the discourse denotes that its producer follows strict mathematical laws to institute relationships between participants (numbers, terms, operators) and processes (operations, deductions, volumes of the sphere and cylinder). Moreover, in seeking to deduce the concept of volume of the sphere inspired by Archimedes, we note that he recognizes mathematical operations and develops them in the context of mathematical processes, something that characterizes the ideational meaning of his discourse. We also observe that teacher Tenório adopts a mathematical pattern to perform these operations and display the resulting element of the mathematical processes, for example, the concept of the volume of the sphere, which highlights the textual meaning of his discourse associated with mathematical symbolism.

Figure 3: The combined use of writing, gesture, orality (on), representation, and mathematical symbolism



Source: Own elaboration with adaptations from the video

In particular, in this excerpt from the video, the use of orality (on) combined with mathematical symbolism underscores that its producer: incorporates *interconnected definitions* (volumes of the sphere and cylinder) and of *special expressions* (equalities, notations, operations, terms) as grammatical language strategies; institutes ideational meaning (of discourse) by manipulating participants and mathematical processes to employ a strategy in view of his goal; highlights interpersonal meaning (of discourse) from statements that rely on *logical reasoning*, for example, when he states that: "starting from an equilateral cylinder, of base radius equal to *r* and height equal to *2r*. And knowing that the volume of the cylinder is equal to area of the base times height [...]"; and, right after that, he socializes the textual meaning (of the discourse) that is shared from his mathematical arguments, employed in the manipulation of mathematical operations to state that "[...] the volume of the equilateral cylinder is [...] equal to $2\pi r^3$ [...]". This is an example that "the written text [...] gives way to the filmic text, so that other multimodalities, besides writing itself, become possible" (Canedo Jr, 2021, p. 78).

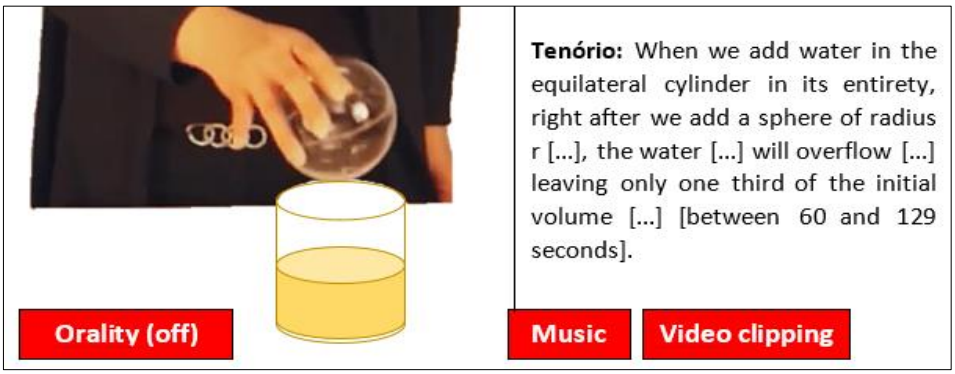
Regarding the grammatical strategy of mathematical symbolism, the use of elements (notation, numbers, operators) enables the algebraic development based on the logical coherence of Mathematics and, thus, we understand that there is an exposure of the ideational meaning of the discourse at times when its producer demonstrates knowledge to operate participants (the radius of the base *r*, the height of the cylinder *2r*) and mathematical processes (the calculation of the volume of the cylinder). In particular, he relates these elements supported by mathematical laws in order to enhance interpersonal (discourse) meaning. Moreover, the producer uses board and brush to organize the result of these mathematical processes and embed their textual meaning (in the discourse) that is configured by the use of mathematical symbolism. In particular, this is how the author uses: *special symbols* combined in this excerpt; *new grammatical strategies* in recoding the concept of volume of the sphere; and *implicit reasoning chains* to produce logical meaning supported by prior knowledge.

In turn, the grammatical strategy of visual display used in this excerpt of the video offers conditions for the audience to broaden their understanding of the topic, as it enables the elaboration of interpretations between the visually represented mathematical components (volume of the sphere and the cylinder), something that characterizes the interpersonal meaning of the discourse and highlights: the *special conventions* represented spatially and described symbolically; the *density of visual interaction* that make it possible to explore mathematical information; the *implicit reasoning* from a previous mathematical knowledge; and the *incorporation of symbolic and linguistic elements* made explicit through algebra and geometry.

In the sequence of the video, the author is heading to conclude his speech. Figure 4

illustrates a cut of this production, taken from plan 3, between moments 60 and 129 seconds.

Figure 4: The combined use of music, orality (off), and video clipping



Source: Own elaboration with adaptations from the video

At the time, this excerpt led us to the initial question of the interview that involved the choice of the topic, because we considered (interestingly) the origin of the equation and the sphere immersed in the cylinder had been explored. On that path, the said author added the following:

> Teacher Tenório: *[...] I can ask something else without mentioning the name of the sphere [...] I can ask how much water came out of the cylinder [...] some [students] will associate [...] some will calculate [...] [or they will say] this here is a cylinder [...] this here is 2/3 of the cylinder [...] will calculate [...] without even realizing [...] so I think this is interesting [...] I wanted to talk about the story of Archimedes [...] [in the sequence he makes reference to the time of the video that we stipulated up to 5 minutes when saying] [but,] there was no time [...] [for this reason, he adds] I had to cut there [...]* (Tenório, 2022, excerpts from the interview transcript).

We support the idea that this excerpt from the video reveals a significant element among his choices, the so-called laboratory experiment that teacher Tenório used to enrich his production, based on a video cut (available on the Internet). During the interview, we also manifested his resourcefulness in his speech, which brought some comfort to the approach of the chosen theme, and we also highlighted the practical application as a (real) laboratory experiment, with the use of water and concrete material, to emphasize that in current times this physical space present in public schools and universities seems to be in disuse due to the inattention of its managers (lack of investment and maintenance), as well as the advancement of digital technology. And when we asked if this material was part of the school's laboratory, teacher Tenório said:

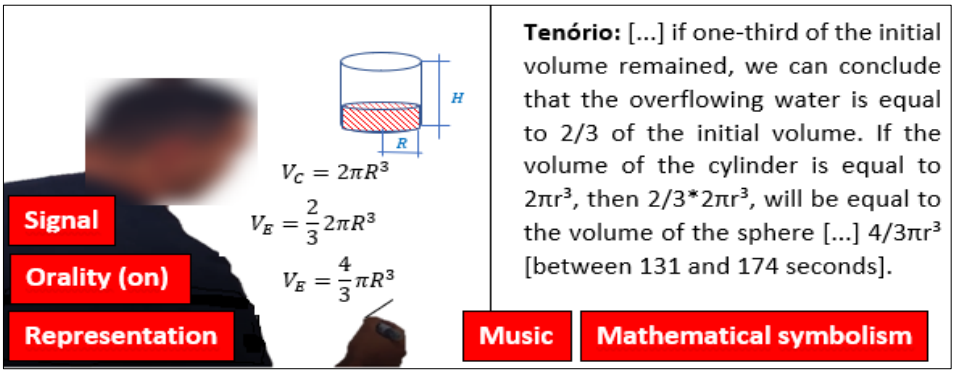
> Teacher Tenório: *No, this material I had already seen [...] I took a video already made [...] the voice is mine [...] [in the opportunity, when asked who had made the video cut he showed the original video in which he downloaded from the Internet] [...] [what I did] I removed the audio [...] put a song [...] was [...] just comments [...] I tried to do the subtitles on YouTube [...] [from that moment on, he didn't hold back, he opened the video on his cell phone and explained step by step how to introduce the resources] I tried to put all the videos [...] I didn't have that many resources [...] of the Inshot application [...] I found it very interesting [...] I edited it on the cell phone [...] very easy [...] cut, stop [...] these transitions I wanted to round off more [...] I used the Roraima flag just to say that the video is from here [...] as if it were [...] a vignette [...] [at this moment of the interview he points to the beginning of shot 3 and says] then [...] I put the animation [of the video cut] [...] this audio is not mine [...] and I put the animation [... ...] this audio is not mine [...] I did not record an audio [...] I extracted it from the video I was explaining and realized that it would not be interesting [...] [showed the original video he produced] [...] I did not like it [...] I just took the audio and threw it there [...]* (Tenório, 2022, excerpts from the interview transcript).

These two interview clippings help explain some semiotic choices present in the video "About the sphere and the cylinder". In particular, in a reciprocal way, its producer prioritizes the use of semiotic resources of language and visual display in order to harmonize them in a multimodal combination, known as intersemiosis (Neves, 2020), which highlights the individual potentialities of orality (off), music and video clipping, as well as produces meanings in his speech when he explores mathematical demonstration without restricting it to the use of board and brush, for example. In this opportunity, the teacher uses these semiotic resources that shape each other to accentuate the concept of volume of the sphere, deduced with the help of a laboratory experiment.

Regarding the grammatical strategy of the language, we realize that there was no use of *special symbols* in this part of the production. However, we understand that the orality (off) and the background music support the representation in the moments when the video producer says: "When we add water in the equilateral cylinder in its entirety, right after we add a sphere of radius *r* [...], the water [...] will overflow [...] leaving only one third of the initial volume [...]", which in our conception evidences the use of *new grammatical strategies* and *reasoning chains implicit* in this approach. For this reason, in this excerpt of the video, when considering the grammatical strategy of visual display used by the author, our gaze turns to the laboratory experiment that makes it possible to re-signify the concept of volume of the sphere, as well as to observe elements incorporated to the *density of the visual interaction* and to the *implicit reasoning*.

In the sequence (still referring to plan 3 of the video), the author combines in his speech semiotic resources of language [music, orality (on), signal], of mathematical symbolism (mathematical symbolism) and of visual display (representation). Figure 5 illustrates a clipping extracted between instants 131 and 174 seconds of that plan.

Figure 5: The combined use of music, orality (on), representation, mathematical symbolism, and signal



Source: Own elaboration with adaptations from the video

In our understanding, this video clip has similarities with what we consider in our analysis of plan 2, regarding the use of grammatical language strategies, mathematical symbolism and visual display, as well as regarding the production of meanings. In any case, we emphasize that the mathematical discourse is strengthened in this section of plan 3, supported by the laboratory experiment (video clipping used by the author in the previous plan). In this direction, we emphasize that this script (construction, choice) led the author to the following reflection: "[...] if 1/3 of the initial volume was left, we can conclude that the water that overflowed is equal to 2/3 of the initial volume. If the volume of the cylinder is equal to $2\pi r^3$, then $2/3*2\pi r^3$, will be equal to the volume of the sphere [...] $4/3\pi r^3$", which highlights the harmonization of semiotic resources in mathematical communication and emphasizes the co-participation of technology in the production of knowledge.

6 Conclusions

In society, the digital age has influenced the spontaneous use of technologies in different spaces of socialization, in particular, if we observe the human being in the search for services, leisure, entertainment, among others, we have some condition to perceive this behavior. Given this scenario, we consider - in an extension project - reflections about spontaneity, mathematics classroom and possibilities of using digital technology. Purposefully, these reflections led to the launching of seeds that surprised us by germinating, sprouting, being born and developing in such a short time, after we offered the extension course "digital videos in Mathematics Education" directed to public school teachers. This observation is based on the reports of a participant who experienced the course and chose to insert the production of digital videos in his teaching methodology.

In particular, this was the reason why we need to extend our perceptual registers to enjoy the details that led us to the meanings produced in the video "About the sphere and the cylinder". Following this understanding, when we analyze the video we understand that teacher Tenório chose and combined several semiotic resources: orality (on), orality (off), gesture, video clipping, mathematical symbolism, signals, among others, which enabled the production of meanings in his speech. Thus, we observe that his choices relate to his professional performance, in the sense of promoting learning and sowing seeds (of knowledge) supported by playfulness and spontaneity, instead of opting for a ready-made script.

Moreover, the seeds sown by teacher Tenório resulted in 13 videos produced by (approximately) 90 students from three high school classes and by their participation in a Mathematics Week and a Science and Technology Fair, events in which these productions were exhibited. We recognize that this experience with the extension course "Digital Videos in Mathematics Education" has produced fruits that make us glimpse, savor, and believe, like Freire (2023), that education is an act of hope.

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