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Mathematics video classes produced by students: a proposal to enhance learning

Videoaulas de matemática produzidas por alunos: uma proposta para potencializar a aprendizagem

Video clases de matemáticas producidas por estudiantes: una propuesta para potenciar el aprendizaje

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Abstract

This work aimed to analyze whether high school students' production of mathematics video classes enhances their learning. We examined how students learn function concepts when producing video classes. The research was carried out in two classes of the first grade of high school integrated into technical education in the federal network. In one class, students produced video classes, and learning was compared with that of the other class. Qualitative research was adopted, in which data were collected through questionnaires, interviews, field observation, and analysis of video classes produced by students. The video classes students created reproduced the classes they were used to watching, as they did not present innovations and/or different methodologies. Ultimately, we noticed a gain in learning with the video class production process. The students demonstrated the ability to work as a team, gained autonomy in their studies, and presented satisfactory results in the final assessments.
Keywords: Mathematics. High school. Quadratic polynomial function. Video classes.

Resumo

Este trabalho teve como objetivo analisar se a produção de videoaulas de Matemática pelos estudantes do Ensino Médio potencializa sua aprendizagem. Investigou-se como os alunos aprendem os conceitos de função ao produzirem videoaulas. A pesquisa foi realizada em duas turmas do primeiro ano do Ensino Médio integrado ao ensino técnico da rede federal. Em uma turma os alunos produziram as videoaulas, e a aprendizagem foi comparada com a da outra turma. Adotou-se pesquisa qualitativa, em que os dados foram coletados em questionários, entrevistas, observação de campo e análise das videoaulas produzidas pelos estudantes. As videoaulas elaboradas pelos alunos reproduziram as aulas que esses estudantes estavam acostumados a assistir, pois não apresentaram inovações e/ou metodologias diferenciadas. Ao final, percebeu-se que houve ganho na aprendizagem com o processo de produção das videoaulas. Os estudantes demonstraram capacidade de trabalhar em equipe, adquiriram autonomia nos estudos e apresentaram resultados satisfatórios nas avaliações finais.
Palavras-chave: Matemática. Ensino Médio. Função polinomial do segundo grau. Videoaulas.

Resumen

Este trabajo tuvo como objetivo analizar si la producción de video clases de matemáticas por parte de estudiantes de secundaria mejora el aprendizaje de los estudiantes e investigó cómo los estudiantes aprenden los conceptos de función mediante la producción de video clases. La investigación se realizó en dos promociones del 1er año de Enseñanza Media Integrada a la Educación Técnica de la Red Federal. En una clase, los estudiantes produjeron clases en video y se comparó el aprendizaje con la otra clase. Se adoptó una investigación cualitativa, los datos fueron recolectados a través de cuestionarios, entrevistas, observación de campo y análisis de lecciones en video producidas por los estudiantes. Notamos que las video clases creadas por los estudiantes reproducían las clases que estos estudiantes estaban acostumbrados a ver, ya que no presentaban innovaciones y/o metodologías diferentes. Al final, nos dimos cuenta de que había un beneficio en el aprendizaje del proceso de producción de las video clases. Los estudiantes demostraron capacidad para trabajar en equipo, ganaron autonomía en sus estudios y lograron resultados satisfactorios en las evaluaciones al final de la investigación.
Palabras clave: Matemáticas. Escuela secundaria. Función Polinómica de Segundo Grado. Videoclases.

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1. Introduction

In 2017, a video lesson on limits and derivatives produced by students in a third-grade high school class highlighted their mobilization and learning when involved in this type of activity. This fact led us to consider changes in the teacher's teaching methodology. To promote such changes and use digital information and communication technologies (DICT), we envisioned that students' production of video classes could improve their mathematics learning. The above proved crucial for planning the research and led us to design and write the project, which was carried out in 2019 with students in the first grade of technical education integrated into high school in industrial automation at the Federal Institute of Minas Gerais—Campus Betim (IFMG-Betim). The research project aimed to verify whether the students producing the video classes acquired skills in planning, executing, building, and presenting video lessons focused on a quadratic polynomial function to teach their colleagues. In short, the aim was to know whether the students producing video classes become protagonists of their learning and whether they demonstrate a better understanding of the quadratic polynomial function than the comparison class.

The students had already studied this topic in the final years of elementary school. Still, the intention was that after the research process, they would not only understand and synthesize the instrumental aspects but also be creative in understanding the calculations and the central aspects of the content. Finally, students should learn the concepts of quadratic polynomial function, showing that student-student and student-teacher relationships can be mediated. Given the above, throughout this study, we sought to answer the following questions*: What is the evidence of student learning gains when they collaboratively produce mathematics video lessons? What type of learning did the students demonstrate?* Methodologically, a qualitative perspective and several research instruments were adopted for data collection –questionnaires, interviews, notes in the field diary, feedback from students, and video classes produced, among others that generally made up the data.

The article is organized as follows: Section 2 is dedicated to the literature review, which contributed to the deepening of knowledge and the construction of the research methodology. Section 3 describes the methodological paths followed in the development of this study. Section 4 discloses the research results. Finally, Section 5 analyzes the results.

2. Vigotski and mediation

Starting from the questioning above, we grounded the work on Vigotski's (2007) studies and theoretical discussions.

Mediation is one of the prominent concepts in Vigotski's theory, which says that the relationship between human beings and the world occurs through mediation "that manifests itself in the contact between subjects or between a subject and an object mediated by another subject" (VIGOTSKI, 2007, p. 51). Corroborating the author's idea, we consider how important mediation is in the teaching and learning processes. According to Vigotski, there are three main groups of mediation: instrument, sign, and symbolic system. The instrument is an element interposed between the worker and the object of their work, aiming to enhance the subject's action in the world. Therefore, it is a mediating element. The instrument acts as a mediator and provokes thoughts about the object in the other person. The sign is present in the individual's psychological activity, which Vigotski calls a psychological instrument. The sign acts as an instrument of psychological activity, just as the role of an instrument at work. Signs act by activating and controlling other psychological actions, such as memory, because they express or represent facts.

Symbolic systems organize signs into complex and articulated structures. "The use of external brands will transform into internal mediation processes; Vigotski calls this mechanism the internalization process" (OLIVEIRA, 1977, p. 34). Vigotski (2007, p. 58) defines internalization as "the internalization of cultural forms of behavior involves the reconstruction of psychological activity based on operations with signs." For him, this process is one of the main mechanisms to be understood when studying human beings. According to Oliveira (1977, p. 38), it is "as if, throughout their development, the individual 'took possession' of the forms of behavior provided by culture, in a process in which external activities and interpersonal functions transform into internal intrapsychological activities."

Internalization happens when external signs are transformed into internal signs. When the individual transforms knowledge in their mind, they internalize this knowledge. In this sense, the proposal to create video classes produced by the students aims to encourage them to study, learn, and internalize the concepts of a quadratic polynomial function. In this way, we sought to enhance student learning mediated by technology through video class production. Furthermore, interaction between students can promote the acquisition of new knowledge, and they can perform tasks with the help of more capable companions –"the ability to perform tasks independently is defined as a level of real development" (VIGOTSKI, 2007, p. 96). The relationship between development and learning led Vigotski to create the zone of proximal development (ZPD) theory. The ZPD, according to him,

> [...] is the distance between the level of actual development, which is usually determined through independent problem solving, and the level of potential development, determined through problem solving under adult guidance or in collaboration with more capable peers. (VIGOTSKI, 2007, p. 97).

Students are considered capable of independently carrying out tasks related to quadratic functions, as they already have some knowledge acquired from studies done in the final years of elementary school. Vigotski (2007, p. 94) states that "any learning situation that a child faces at school always has a previous history." The next topic discusses the role of digital media in the educational process.

2.1. Digital media and the Internet in education

The role of video in the pedagogical environment can be discussed in several ways. The first approach concerns the role of video from the students' standpoint. This approach states that producing content in digital format (video and video classes) can allow students to develop interaction and autonomy in learning by doing, interacting with others, and analyzing existing and constructed knowledge (BORBA; VILLAREAL, 2005).

The second approach refers to how communication can develop within the classroom through languages, gestures, texts, board and marker, paper and pen, and digital media, among other resources. (WALSH, 2011). The third approach deals with the possibilities and limitations of working with technologies and videos. The possibilities lie in using technologies for Internet research, ease of real-time communication, creation of games, and educational applications. The limitations include few school computer labs, flawed or inexistent Internet connections, machine maintenance, and poor teacher training in digital technologies.

Video production can develop various skills in students, such as critical thinking (SHEWBRIDGE; BERGE, 2004). It can also encourage expression and communication (MORAN, 1995), favor an interdisciplinary vision, integrate different capabilities and intelligence (MARTIRANI, 1998), and value group work (SHEWBRIDGE; BERGE, 2004). By adopting new attitudes to favor their methodology, teachers adapt to the current times, which are full of new technologies. Therefore, the teacher must master digital technologies, obtain pedagogical resources for today's students, and dynamically approach academic knowledge (SILVA, 2011). In this research, we thought about provoking students and motivating them to be the protagonists of their learning to develop autonomy as students and build their own knowledge.

2.2. The concept of function

As mentioned above, the theme chosen for the research and production of the video classes was a quadratic polynomial function, as the concept is usually studied in the first grade of high school. Mathematics in high school has been influenced by what Fiorentini (1995) calls a technicist trend, according to which mathematics is reduced to a set of techniques, rules, and algorithms, disregarding substantiation or justification. This trend was notable in Brazilian mathematics teaching. With the Modern Mathematics Movement (MMM)[2], functions began to be taught to students aged ten and over. In Brazil, this happened between 1955 and 1970. The teaching was very formal, and the reasons that determined the emergence of the concept of function were ignored (TINOCO, 2004).

The concept of function spanned approximately 4,000 years until it was scientifically consolidated at the beginning of the 20th century. In 1673, the concept of function was introduced by Leibniz (1646-1716), a precursor of differential and integral calculus and infinitesimal analysis. He used the concept of function to designate geometric variables associated with a given curve; later, in the 18th century, this concept became less dependent on the curve and began to mean the dependence on a variable expressed by a formula. However, Euler (1707-1793) was responsible for several notations currently used in mathematics, including $f(x)$, used to represent functions. According to Ponte (1992), in the 20th century, following the development of set theory initiated by Cantor –a German mathematician who pioneered the studies and creation of set theory– the notion of function was expanded and began to include everything that was arbitrary correspondences between numerical sets and other sets.

Tinoco (2004) proposed that teaching the concept of function undergoes stages in which students construct the notions of variable, dependence, regularity, and generalization. The notion of variable is considered one of the most difficult for them to grasp: "It is any number from a given set, but it is not specifically any of the numbers in that set" (TINOCO, 2004, p. 5). Students perceive

2 The Modern Mathematics Movement (MMM) was an international movement in mathematics teaching that emerged in the 1960s and was based on the formality and rigor of the foundations of set theory and algebra for mathematics teaching and learning.

the variable as if it were the unknown in an equation and try to find a value for this unknown. For example, in *f(x) = 3x—9*, it is normal for students to assign the value 3 to the variable, considering it an unknown. Regarding the notion of dependence between variable quantities, they realize that one of the quantities is determined by the variation of the other. Many phenomena flow with a certain regularity, and a pattern is created to establish a value for the unobserved stages. This pattern is a generalization for phenomena that occur regularly. Tinoco (2004, p. 7) suggests some care teachers should take with students to help them understand the concept of function. The author states, "flexibility in passing a representation in the current language, orally and in writing, is fundamental for constructing the concept."

As this study is centered on the quadratic polynomial function, we searched in the Curriculum Guidelines for Secondary Education (Orientações Curriculares para o Ensino Médio - OCEM) (BRASIL, 2006, p. 73) the instructions regarding the study of the quadratic function:

> The study of the quadratic function can be motivated by application problems in which a specific maximum point must be found (classic maximum area determination problems). The study of this function –the position of the graph, coordinates of the maximum/minimum point, and zeros of the function– must be carried out so that students may establish relationships between the graph's "appearance" and the coefficients of its algebraic expression, avoiding memorization of rules.

Currently, teaching in Brazil is guided by the National Common Curriculum Base (Base Nacional Comum Curricular—BNCC) (BRASIL, 2018), which prioritizes using problems from everyday situations. In our proposal to produce video classes, students are encouraged to show everyday situations and explore all the properties of the quadratic polynomial function in the videos. Finally, we expect students to move between all representations of the quadratic polynomial function, such as tabular, algebraic, symbolic, and graphic representations.

In the following section, we summarize the project execution.

3. Mathematics video lessons: proposal and execution

The project developed in 2019 was organized into four stages. In the first stage, we searched periodicals and databanks of national theses and dissertations for the topic "video classes in mathematics teaching[3]."

The second stage began on March 19, 2019, with the first meeting between researchers and fellows to establish the development of the work. The scholarship holders were given some articles and research on video classes to learn about the topic and discuss their expectations regarding the project. At the following meeting, we planned the research development and discussed the class choice. Two classes attending the first year of the Automation Technical Course were chosen

3 After studies on the topic, the writing of the project began. It was submitted to IFMG-Betim notice 11/18, and called "A utilização da produção de vídeos/videoaulas feita por alunos visando o favorecimento da aprendizagem matemática" [The use of video production/video classes made by students to promote mathematical learning] and aimed to research the learning gains when students produce mathematics video lessons. The project was approved to start in February 2019 and end in February 2020. It will be collaborated on by two scholarship holders from the Junior Scientific Initiation Institutional Program (PIBIC-Jr) and two volunteer scholarship holders, second —and third-year students of the Institute.

according to their available meeting times. The students were between 15 and 18 years old and residing close to the Institute. The classes were called Team 1 (T1) and Team 2 (T2) to facilitate their identification. T2 was the research object, and T1 was the control class, which continued following the teacher-researcher's methodology .

T2 comprised 32 students, of which 10 were girls and 22 were boys. This class performed well, was participative, completed the proposed activities, had high attendance, and showed interest in mathematics. At the beginning of the research, T2 had 30 students, of which 9 were girls and 21 were boys. The group was participative; they liked mathematics, completed the proposed tasks, and were committed to their studies. A schedule of actions was drawn up with the students to organize the procedures for developing the research, and the choice of the mathematical topic was discussed. The teacher-researcher invited the students and explained the purpose of the research. We created a WhatsApp group with the researcher and fellows for easier communication.

The third stage was with the T2 students. It started only in June 2019 due to the quarterly assessment period in May. The class was divided into five groups of six students according to the working harmony between peers in the room. The themes of the video classes were drawn for each group, and the schedule for their implementation was presented. At another point, the students chose the group's guiding fellow through a draw, and each fellow followed two groups. Then, each scholarship holder started the activities with the group. They suggested bibliographies for studies, video lesson models, and software for editing. We felt it necessary to collect data to analyze students' previous knowledge of the quadratic function and identify gaps in understanding the concept. Therefore, we created instruments to a) measure the degree of mathematical knowledge specific to the quadratic function, b) consolidate knowledge with activities, and c) promote understanding of the topic covered in the video class.

During mathematics class hours, students developed project activities, researched, prepared the activities, the lesson plan, and the script for video production, and clarified doubts with the teacher. During the same period, the control class attended classes on quadratic functions with the teacher-researcher. This content was managed according to the teaching plan from June 27, 2019, to August 6 of the same year. The teacher used the textbook *Matemática: Ciências e Aplicações - Vol. 1* – [Mathematics: Sciences and Applications], by Gelson Iezzi, activity lists, and the Khan Academy platform[4].

The video class presentations began on August 8. Groups A and B presented on August 12, and groups C, D, and E on August 15, as shown in Chart 1.

4 *Khan Academy* is a free online platform that offers exercises, educational videos, and a personalized learning dashboard. It empowers students to study at their own pace, inside and outside the classroom.

Chart 1 – Division of topics between groups of students

WORKGROUP	SUMMARIZED CONTENT
GROUP A **Definition of role** **Aug/08/2019**	Problematization involving quadratic functions; definition of quadratic functions; formation rule; examples of functions in reduced forms https://www.youtube.com/watch?v=YhwgMAXAxps&t=44s
GROUP B **Study of the function sign** **Aug/08/2019**	Construction of graphs; concavity study; denomination of notable points (0, c); X-axis intercept https://www.youtube.com/watch?v=nkfNOTvlWX0&t=102s
GROUP C **Delta study (Δ)** **and sign of the function** **Aug/12/2019**	Deduction and study of the delta; coordinates of the vertex of the parabola; function zeros; vertex deduction methods; maximums and minimums of the parabola https://www.youtube.com/watch?v=nkfNOTvlWX0&t=102s
GROUP D **Study of the roots** **Aug/12/2019**	Interception on the X and Y axes; sum and product of roots; factored form of the equation; equations with two variables. Study of the sign https://www.youtube.com/watch?v=5h7JIE1d-LI
GROUP E **Quadratic inequalities** **Aug/15/2019**	Resolution of inequalities; study of the sign of inequalities; representation of the solution on the real line https://www.youtube.com/watch?v=5h7JIE1d-LI

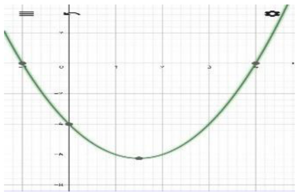
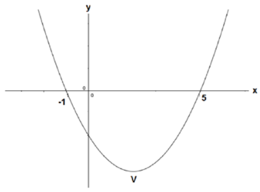
Source: Author's archive from 2019

A panel of classmates, the class teacher, and a guest teacher reviewed the video class presentations. At the end of each presentation, the group gave the class a list of activities related to the video class. Any doubts about the activities were solved in the following class, before the other group's presentation.

Chart 2 lists examples of activities the groups handed the class after presenting the video lesson.

Chart 2 – Some activities developed by the groups

GROUP A	For the functions below, determine: a) the concavity; b) the zeross; c) the vertex coordinates (maximum or minimum); d) intersection with the y-axis; e) the graph sketch; f) the image set; g) the study of the sign. 1st - $f(x) = x^2 - 4x + 3$ 2nd - $y = - x^2 + 6x$ 3rd - $y = x^2 - 2x + 5$ 4th - $y = - x^2 + 2x + 5$

GROUP B	What is the rule that defines the function of the graph below? 
GROUP C	The graph of the function $y = ax^2 + bx + c$ is represented below. Classify the statements as true (T) or false (F):  a) ( ) The real number **c** is negative. b) ( ) The real number **a** is positive. c) ( ) The real number **b** is positive. d) ( ) The abscissa of the vertex **V** is negative. e) ( ) The ordinate of the vertex **V** is positive. f) ( ) The discriminant (△) of the function f(x) is null.
GROUP D	A ball is thrown into the air. Its height **h**, in meters, is related to the time, seconds, of launching through the expression $h(t) = - t^2 + 4t + 5$. a) At what time does the ball reach its maximum height? b) What is the maximum height reached by the ball? c) Make a graphical sketch of the ball's trajectory.

Source: Author's archive from 2019

The students' video classes covering high school functions were the *final product* of this research, which was made available on YouTube through a channel created for the project, "Projeto videoaulas IFMG-Betim" [IFMG-Betim video class project]. This channel aimed to facilitate access to anyone interested. Next, we present some aspects and results of the production of video classes. Chart 3 highlights notes on the presentations of the video classes.

Chart 3 – Some aspects noted in the video classes

VIDEO LESSONS	THEME	NOTES
1st.	Definition of a quadratic function	The video was made with animation and self-explanatory scenes but without audio. Students felt uncomfortable but enjoyed the video lesson.
2nd.	Roots or zeros of the graph function, concavity	The film was not sharp and had not been edited. Students complained that they could not view the images. They asked to explain on the board. The methodology used by the group was very interesting.
3rd.	Coordinates of the vertex of the parabola	Clarity in the explanations: the image was good, but the audio was low. The students liked the video lesson. The students behaved like the teachers lecturing in front of the whiteboard.
4th.	Study of the sign of the quadratic function	The group used the digital whiteboard resource. The explanations and images were clear, but they did not use the resources of the digital whiteboard.

5th.	Quadratic inequalities	The video was carefully edited and scripted. The content was detailed, and the students had difficulty understanding it; they found it too difficult.

Source: Author's archive from 2019

4. Results and discussions

According to the students' procedures, we found they had technological skills while producing the video classes and knew how to use social networks and make films with their mobiles. However, they lacked skills in academic research or typing, formatting, and video editing. Many had more contact with technology at IFMG-Campus Betim.

We tried to observe the main aspects during the presentations somehow, during which we realized the students kept the same format as the video classes they were used to watching to study. Hence, they did not seek creativity or criticize what they were used to watching. In the video classes, students played the role of teachers, usually in front of the board, showing the content of the video class theme. Finally, a preliminary assessment with the scholarship holders and volunteers revealed that the students were not too creative in producing the video classes. They were expected to use other devices in the production, such as songs, dances, performances, etc. However, they repeated the formats of the video classes they are used to watching online to study.

After the analyses, the theme was decided, quadratic inequalities, which resulted from several students' reports that they had not studied inequalities in the ninth grade and expressed difficulties following the presentation. Group E presented the topic. Their idea was to produce a video lesson using techniques different from those of other groups. The content was presented mechanically and linearly. The speaker maintained a slow and too-detailed narrative; as he explained, the students demonstrated doubts and difficulties understanding. The class became restless; some students stopped paying attention, and others complained that it was difficult to follow the explanation and, on several occasions, asked to replay the film.

At the end, a student asked the group to explain how they could get the result of a simultaneous inequality. Chart 4 shows the dialogue and how Student 1 and the Student-presenter explained the theme to their colleagues.

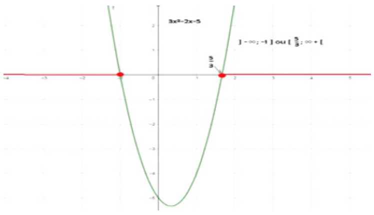
Chart 4 – Student-presenter dialogue and explanation to classmates

Student 1: *It's just that there was a simultaneous inequality, where you separate it into two parts, and then find the value of x and separate the two values. And then, what do you do after that?*
At that moment, we noticed that this student was encouraging an inner dialogue about the solution to the inequality. This seemed to have constructed a question in his mind. To understand, he asked his classmates for explanations.
Student-presenter: *Teacher! Can I go there?*
The student-presenter tried to show his classmates what he had learned through dialogue. He demonstrated autonomy and confidence then. He could share his knowledge with his classmates –according to Vigotski, real knowledge. At that moment, he provoked the zone of proximal development (ZPD) in his classmates.
Professora: *Pode, o pincel está na mesa.*
Teacher: *Yes, the marker is on the tablei.*
He showed it on the screen that was projected on the board.
$2 \leq 3x^2 - 2x - 3 \leq 13$
First, we separated the two inequalities and named them Inequality I and Inequality II according to this here.
The student-presenter was firm in his explanation.

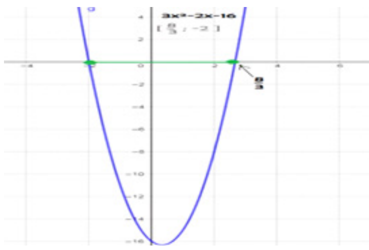
$$2 \leq 3x^2 - 2x - 3 \leq 13$$

Then, we calculated the roots of each inequality and studied the sign. See here how we do it:

Then, he pointed to the projection on the board and showed the study of the sign of each inequality and the representation of the solution on the graph of each one. He showed the figures and spoke about the two inequalities. With each explanation, there were mediating dialogues that provoked the ZPD.
I) $3x^2-2x-3 \geq 2$, *having the roots* $x_1 = -1$ *e* $x_2 = 5/3$*, 5/3, carrying out the sign study, the solution is the interval.*



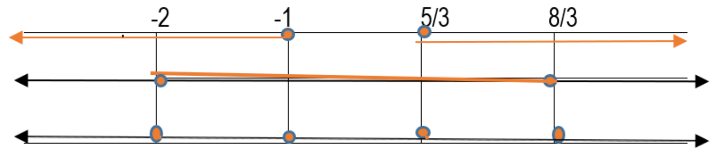
]-∞;-1] ou [5/3,+∞]
Student-presenter: *Then, we do the same thing with Inequality II*
II) $3x^2-2x-3 \leq 13$, *having the roots* $x_1 = -2$ *e* $x_2 = 8/3$*, studying the sign, the result is the interval.*



[-2, 8/3]

Still pointing at the presentation, he showed the representation of each solution on the straight lines and finally showed what the intersection between them would look like. He showed firmness and confidence then and could transmit his knowledge to his classmates.

Student-presenter: *Let's represent these intervals on straight lines and intersect them*



Student-presenter: And then, we have the solution

S= {x ϵ R/-2≤x≤-1 ou 5/3≤x≤ 8/3}

He turned to the class and asked: *Have you followed me*?

Most of the class nodded, showing understanding. Vigotski says that when a classmate verbalizes, explains, and shares in various ways, they provoke knowledge in the other, and the other can understand, so what the author defined as a zone of proximal development occurs.

Source: Author's archive from 2019

This presentation aligns with Vigotski (2007), who argues that we learn from each other when we are in society or a group. A classmate was teaching other classmates, which constituted a moment of interaction and learning. It is important to note that the video class alone does not give results; just watching it was not enough for learning to occur. Furthermore, the teacher's mediation in these moments was essential. When the student-presenter stood in front of the room and explained the topic to his classmates, he mediated between what was presented in the video class and his knowledge.

At each video class presentation, the groups handed out lists of activities that covered the theme of the video class to the whole class. Some students showed difficulties interpreting and understanding the resolution of problems involving maximums and minimums, algebraically representing the function represented by the graph, and solving problems that included the roots of the function. These doubts were resolved by their pals in the classroom before the video class presentation.

5. Final considerations

The general objective of this research was to analyze, discuss, and reflect on whether students' production of video classes favors learning. To this end, we conducted observations and analyses of the production process, video class presentations, and assessments. We noted that during the research development, these young people moved around to solve their doubts with the fellowship holders and the teachers. A relevant consideration was the students' movement in the classroom to clarify doubts with each other. When someone doubted an exercise, another classmate quickly sat down next to the pair and discussed the activity with them –they felt free to share their knowledge without being shy. This interaction favored the consolidation of learning.

T2 did not have classes on quadratic function content with the teacher-researcher. This class studied the content alone, using the textbook and the Internet as tools, and the teacher-researcher solved any doubts that arose. T1 had classes with the teacher-researcher and used the textbook, lists of activities, and other resources.

The fact that these students learned the content without participating in the teacher's classes indicates that they were autonomous and became protagonists of their own learning –and, therefore, we can infer that producing the video classes promotes learning. According to Oliveira (1977, p. 57), learning

> is the process by which the individual acquires information, skills, attitudes, values, etc., from contact with reality, the environment, and other people. It is a process that differs from innate factors, [...] and the organism's maturation processes, independent of information from the environment [...]. Vigotski's idea of learning includes the interdependence of the individuals involved in the process precisely because of his emphasis on socio-historical processes. The term he uses in Russian (obuchenie) means something like "teaching-learning process," always including the one who learns, the one who teaches, and their relationship.

The students had prior knowledge of the quadratic function, which is, according to Vigotski (2007), real learning. They needed to study, on their own, definitions, concepts, symbolic and graphic representations. Furthermore, they needed to know all this to transmit this knowledge through video classes. We also found that interactions between group members made them more independent of the teacher. In face-to-face moments, they shared their ways of understanding the content studied, contributing to constructing knowledge, which aligned with what Vigotski teaches: that social interactions promote knowledge acquisition.

Regarding knowledge gains, students felt confident and independent and discovered they could learn any content mediated by technology and teachers. They said the most significant difficulty they encountered was learning to teach, i.e., recording the video class. They said completing the steps to produce the video class was very laborious and difficult. Some students felt that getting good scores in the subject in a normal class and assessment would be easier.

In this research, students indicated that the video class production has great pedagogical potential and is worthy of being reported. The reasons that led to this statement are highlighted here:

a) Students actively participate in the learning process when producing video classes. They had to research, organize information, and clearly and concisely explain the concepts. This helps to consolidate knowledge and understanding of the topics covered.

b) Each student has a unique way of understanding and explaining concepts. When producing video classes, students can share their perspectives and approaches, which can help other students better understand the content.

c) Creating the video lessons required students to review and organize the information logically. This review and synthesis process helped reinforce information retention and made students more likely to remember the concepts.

d) The production of video classes promoted collaborative activity, in which students worked as a team to create educational content. This promoted teamwork, communication, and collaboration skills, which are important in the workplace and life in general.

e) Students' video lessons were shared with classmates and other students from other schools to facilitate access at any time for review and further study.

It is important to highlight that teachers must guide and supervise video class production. Teachers can provide guidelines and feedback and ensure that the content produced is accurate and of quality.

For future work, this study aims to reformulate and adapt the instruments used to construct the video classes and knowledge –not only concepts of functions and quadratic functions but the knowledge that educates one to understand the world.

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