Introduction to the concepts of area and volume in light of the teaching guidance activity: possibilities for teaching mathematics

PEDAGOGICAL PRODUCT

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Abstract
This text presents a proposal for an Educational Product designed for high school students. The objective is to present SDA involving the concepts of area and volume, using GeoGebra software, based on the concept of Teaching Guiding Activity. For this purpose, Teaching Trigger Situations were developed that address the need for packaging, the delimitation of land portions in ancient times and the storage of agricultural production. Themes were problematized based on emerging situations from everyday life and the virtual history of a fictitious company. The integration of Geogebra can allow reviewing concepts, exemplifying, illustrating, manipulating and testing hypotheses, providing support for the creation of a conceptual model of the final solution to be defined collectively with the class. The proposal presented is yet another possibility that can help mathematics teachers in their teaching practices regarding the concepts of area and volume in the classroom.
Keywords: Teaching Guiding Activity. Learning Triggering Situations. Area. Volume.

Introdução aos conceitos de área e volume à luz da atividade orientadora de ensino: possibilidades para o ensino de matemática

Resumo
Este texto traz uma proposta de Produto Educacional elaborado para estudantes do Ensino Médio. O objetivo é apresentar Situações Desencadeadoras de Aprendizagem envolvendo os conceitos de área e volume, com o uso do *software* GeoGebra, fundamentada no conceito de Atividade Orientadora de Ensino. Para isso, foram elaboradas Situações Desencadeadoras de Ensino que abordam a necessidade das embalagens, a delimitação da porção de terra na Antiguidade e o armazenamento da produção agrícola. Temáticas foram problematizadas a partir de situações emergentes do cotidiano e da História virtual de uma empresa fictícia. A integração do Geogebra pode permitir revisar os conceitos, exemplificar, ilustrar, manipular e testar hipóteses, fornecendo subsídios para a criação de um modelo conceitual da solução final a ser definida coletivamente com a turma. A proposta apresentada é mais uma possibilidade que pode auxiliar professores de

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matemática em suas práticas docentes no que tange aos conceitos de área e volume em sala de aula.
Palavras-chave: Atividade Orientadora de Ensino. Situações Desencadeadoras de Aprendizagem. Área. Volume.

1 Introduction

The understanding of teaching and learning processes, as well as the forms of organization of pedagogical activity, is fundamental to teacher education, as it directly influences the construction of reflective and inclusive pedagogical practices. Furthermore, it enables teachers to develop intentional teaching strategies aligned with students' needs, thereby promoting more meaningful education.

The teaching model based solely on abstract rules and mechanistic methods tends to promote a reductionist view of the curriculum (Albino; Silva, 2019). Corroborating this position, Mascarello (2019, p. 71) states that such "[...] reductionism creates a one-dimensional world in which citizens, in favor of the utility of all human activity, have become slaves of the market, cloned by the same standard, without thought and without being."

The maintenance of this perspective, especially in mathematics teaching processes, may cause learning impairments. Educational perspectives that follow this approach often produce information disconnected from reality, resulting in knowledge without meaning for students. Moreover, they may foster an environment that does not favor learning, particularly concerning mathematical concepts.

Based on this perception, it is evident that it is necessary to reframe the ways of teaching and learning, which are often based only on the transmission of knowledge. This bias mainly favors operational procedures to the detriment of the formation and development of the subject's critical thinking within the sociocultural environment. As an alternative, the critical pedagogical approach is proposed, in which both teacher and student take on an active and collaborative role in the teaching and learning process. This approach can stimulate students' active participation in educational processes, creating

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more meaningful educational environments that facilitate learners' understanding (Skovsmose, 2007).

For this to effectively occur in classrooms, teachers must not only be reflective about their individual actions but also critical of their practice within a learning and reflective school. However, in order to promote the unity between theory and practice in teacher education programs, the courses must offer practice opportunities involving lesson planning and simulation for the collective reflection of future teachers.

In this context, during classes of the curricular component *Fundamentos em Matemática* (*Foundations in Mathematics*) of the Mathematics Teacher Education Program at a public university in the interior of Bahia, the proposal emerged to develop a training itinerary for high school students in the state system, regulated by the Base Nacional Comum Curricular – BNCC (*National Common Curricular Base*) (Brasil, 2018). To this end, theoretical discussions were held on lesson planning aimed at understanding the socio-historical movement in the formation of a mathematical concept.

The concepts of area and volume were chosen for introduction, as they emerge from everyday situations and have been developed by humanity through various peoples in different social contexts. To support the proposal, the concept of Atividade Orientadora de Ensino – AOE (*Teaching Guiding Activity*) was used as a theoretical-methodological reference for the intentional design of Situações Desencadeadoras de Aprendizagem – SDA (*Learning Trigger Situations*) (Moura, 1996; Moura et al., 2016) in the digital environment through the GeoGebra software.

The integration of Tecnologias Digitais da Informação e Comunicação – TDIC (*Digital Information and Communication Technologies*) into the proposal can be justified by considering that, since the implementation and experience with Remote Learning during the pandemic caused by COVID-19 (Brasil, 2020), the various subjects that make up the educational system had to adapt to the new interaction scenario, including, and especially, teachers and students. From then on, academic discussions increased regarding the importance and necessity of expanding the teaching repertoire through TDIC (Freitas, 2020).

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The GeoGebra software has an interface with multiple tools that may foster the understanding of area and volume concepts through the simulation and representation of mathematical objects in the digital environment. In addition, it is a free application that can be run on major operating systems such as Android, iOS, and Windows, for instance. It can also be used directly in a web browser, which differentiates it from other dynamic geometry software.

In light of the challenge of planning a teaching proposal in this environment, the following question arose: how can SDA be developed from the perspective of AOE, involving the concepts of area and volume, using GeoGebra software? Thus, the aim of this article is to present SDA involving the concepts of area and volume, using GeoGebra software, grounded in the concept of AOE.

In the following sections, the concept of AOE according to Moura et al. (2010) will be presented, which guided the proposal of this investigation; the description of the methodological path of the study; the SDA developed; and, finally, the concluding remarks.

2 The concept of Teaching Guiding Activity (AOE)

The role of the school is of utmost importance for society, as it is within it that the appropriation of theoretical knowledge developed and refined by humanity over time should occur, with the aim of contributing to the process of humanization. In the school environment, there is a teaching plan in which the activity designed by the teacher reveals the educational aspirations of a particular social group (the curriculum), aiming at students' learning. Thus, the teacher's action, coordinated with the school's guidelines, becomes essential to influence and guide teaching with students (Moura; Araújo; Serrão, 2018).

Considering the intentional organization of teaching, Moura (1996) formulated the concept of Teaching Guiding Activity – AOE (*Atividade Orientadora de Ensino*) based on Leontiev's (1978) concept of activity and on the principles of historical-cultural theory, namely, "collectivity, logical-historical movement, pedagogical intentionality, and the role of mediation in the educational process" (Souza; Aguiar; Oliveira; Batista, 2021, p. 5).

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Human activity "[...] only acquires meaning under the conditions of collective work. It is these conditions that give this action its human and rational sense" (Leontiev, 1978, p. 78), which consists of "motives, needs, actions, and operations, among others." The concept of human activity is a psychological process directed toward the object, coinciding with the objective that stimulates the activity, that is, the motive. In this sense, the following aspects are highlighted:

> 1. For an action to have meaning for the subject, it must be produced by a motive; 2. For actions to shift to a lower place in the structure of activity, becoming operations, new needs or motives must require more complex actions; 3. For the subject to subjectively feel new needs or motives that encourage acting at a higher level, it is necessary that he or she be inserted in a context that objectively produces the need for new actions; 4. For an operation to be consciously automated, it must initially be structured under the condition of an action (Sforni, 2004, p. 8).

Building on the structure of activity proposed by Leontiev, Moura (1996) presented the concept of AOE as "a general mode of organization of pedagogical activity, understood as a unit between the teaching activity carried out by the teacher and the learning activity of the student" (Souza; Aguiar; Oliveira; Batista, 2021, p. 5). In the school environment, Moura et al. (2016, p. 110 [our emphasis]) related the need for cultural appropriation, a real motive for the appropriation of knowledge, the objectives to the act of teaching and learning, and proposed actions that consider the objective conditions of the school.

Figure 1, originally proposed by Moraes (2008, p. 116), summarizes the relationship between the central components of teaching activity and learning activity, as well as the structural elements of the AOE (Moura, 1996).

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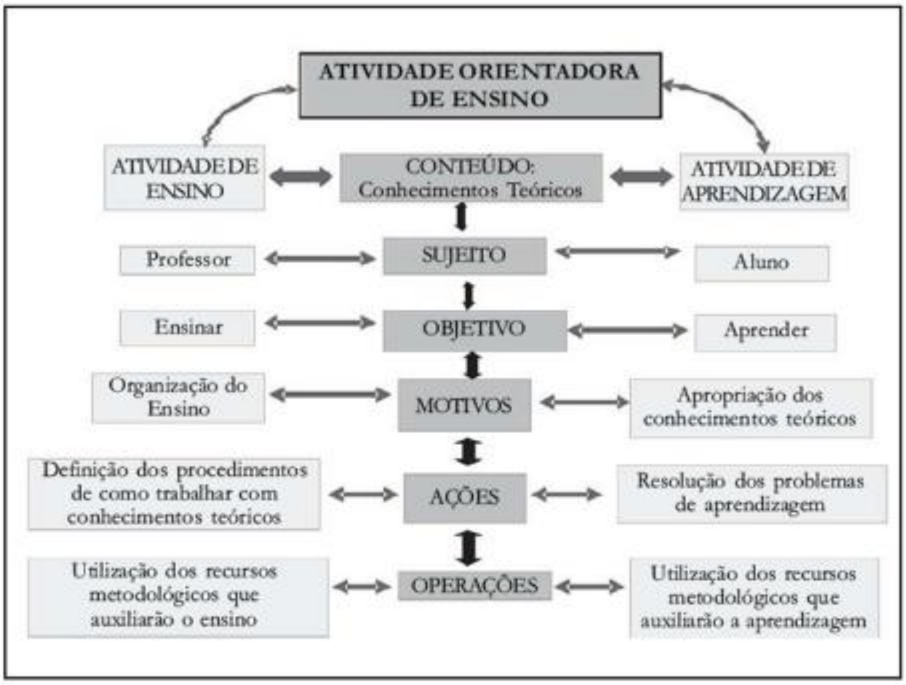
Figure 1 – Systematization of the Teaching Guiding Activity (AOE)



Source: Moraes (2008, p. 116)

The diagram in Figure 1 shows the relationship between the subjects—teacher (teaches, organizes, defines procedures, selects resources) and student (learns, appropriates knowledge, solves problems, uses resources)—involved respectively in the teaching activity and the learning activity, which encompasses content, objectives, motives, actions, and operations. In AOE, the following elements must be present: the educational intention; the SDA (*Situação Desencadeadora de Aprendizagem* – Learning Trigger Situation), as the materialization of the activity; the fundamental core of the mathematical concept; teacher mediation; collective work; and, finally, the transformation of the student's action (Moraes, 2008).

To ensure the effectiveness of AOE, it is essential to address the following dimensions: (i) the *Historical Synthesis of the Concept*, that is, the genesis of the concept, highlighting the necessity that led humanity to construct it and enabling the comprehension of the synthesis from a logical-historical perspective; (ii) the *Learning Trigger Situation (SDA)*, which may be proposed through various methodological resources, such as games,

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situations emerging from daily life, or narratives of virtual history related to the concept; and (iii) the *Synthesis of the Collective Solution*, in which the teacher acts as a mediator during the students' discussion (Moura et al., 2010, p. 225).

However, for these resources to be regarded as effective in creating SDA, it is necessary that they place the student in the face of a problem situation similar to that experienced by human beings when dealing with mathematical concepts. Moreover, the resolution of this problem must occur collaboratively with the group, enabling the joint construction of the solution. The teacher's mediation—that is, the way in which he or she guides the SDA—will be decisive for the achievement or not of its objective (Souza; Aguiar; Oliveira; Batista, 2021, p. 8).

3 Methodological Procedures

Considering the objective of this study, a bibliographic research was conducted, "[...] developed from previously prepared material, consisting mainly of books and scientific articles" (Gil, 2008, p. 50). After analyzing the bibliographic references related to the object of study (concepts of area and volume) in order to compose our collection and expand the range of possibilities that could contribute to this work, the second stage was initiated.

This stage consisted of deepening the theoretical framework of the works and theoretical research that underpin the concept of Teaching Guiding Activity – AOE (*Atividade Orientadora de Ensino*) (Moura, 1996; Moura et al., 2010, 2016; Souza; Aguiar; Oliveira; Batista, 2021; Moraes, 2008). The aim was to understand the organization of teaching that fosters the formation of theoretical thinking through the logical-historical movement of concept formation.

In the third and final stage, Learning Trigger Situations – SDA (*Situações Desencadeadoras de Aprendizagem*) were developed, addressing the concepts of area and volume, using the GeoGebra software for high school students under the theoretical-methodological perspective of the history of the concept. The SDA were designed with high

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school students in mind, aiming to engage them in the activity through the GeoGebra Android version for smartphones.

Based on the concept of AOE, three SDA were elaborated with the general theme "Exploring Commercial Packaging," addressing the following subthemes: the necessity of packaging, the demarcation of land in Antiquity, and the storage of agricultural production. The theme was chosen for its integration into students' daily lives and its potential to explore the involved concepts. For the implementation of these activities, the teacher may divide the class into pairs or trios, requiring a minimum of six class hours. The Applets used can be accessed on the GeoGebra platform[1].

Each SDA aimed to encompass a social need, discussion and understanding of the problem (hypothesis formulation), hypothesis testing (using the software), solution definition (choosing the hypothesis most appropriate to the problem), and solution application (which generates the "answer" and the creation of a conceptual model). The following section presents the organization of AOE supported by the SDA.

4 Learning Trigger Situations – exploring commercial packaging

The Learning Trigger Situations (SDA) were planned with the aim of understanding the concepts of area and volume through the historical process of humanity. They present the historical, geographical, social, and cultural context through *situations emerging from everyday life* and *virtual history*, addressing the necessity of packaging, the demarcation of land in Antiquity, and the storage of agricultural production.

For SDA 1, a documentary on the history of packaging in Brazil is initially presented in order to promote reflections on this topic, as well as to problematize it and relate it to global discussions involving, for example, the socio-environmental perspective. Finally, the concepts of area and volume intended for this study are brought to light in the critical debate.

[1] Available at: https://www.geogebra.org/m/aw8zmqge. Accessed on: 8 May 2025.

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With the objective of fostering initial reflections among students, the class is divided into pairs to discuss and record responses to the following questions: (i) according to the documentary, what are the contributions of packaging to humanity?; (ii) what can be highlighted regarding the relationship between packaging and mathematical concepts?; (iii) which mathematical concepts are mobilized in this documentary?

Next, each pair shares their responses with the class, and the teacher intervenes, guiding the collective synthesis. To better contextualize and provide meaning for subsequent activities, the teacher may refer to the history of Egyptian civilization and its land disputes. The historical narrative then illustrates the use of mathematical concepts by humans in ancient civilizations:

> The Nile River experienced flooding, and after its waters receded, the lands along its banks were left with nutrients suitable for planting. The fact that floods destroyed the demarcations of that region required the "rope stretchers," trained men who used knotted ropes as units of measurement, to make new demarcations, reestablishing the areas cultivated by farmers (Silva; Santos; Brito, 2018, p. 15).

Thus, SDA 1 is formulated with the problem: calculate the area of the right-hand region of the Nile River bank and present the procedures used for its resolution. For this purpose, the teacher presents an illustration (Figure 2) previously created in GeoGebra containing the necessary information to achieve this goal. This teaching proposal was designed to allow students to explore the software tools on their smartphones and mobilize mathematical concepts. Similarly, the class can be divided into pairs or trios to solve the proposed problem (hypothesis testing). Subsequently, the teacher guides the discussion of the solutions proposed by each group (verifying each group's conjectures) and collectively defines the most viable one.

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Figure 2 – Illustrative image of the Nile River

Source: Prepared by the authors (2025)

The second SDA (SDA 2) addresses the necessity of using packaging through a narrative presenting the historical fact involving the production of cachaça and sugar in Brazil, as follows:

> [...] Brazil, the colony of continental dimensions of the Portuguese Crown, comes into play. When the sugarcane cycle began for the export of sugar and cachaça, packaging was needed. Cachaça naturally went into barrels, and sugar was exported in wooden boxes. In Portugal, this wood was reused, so much so that a furniture style emerged using the wooden boxes, called "box furniture" (A HISTÓRIA da embalagem no Brasil, 2015, 4min30s).

In light of this historical fact and aiming to provide meaning for the concepts in question, a graphical and algebraic representation (Applet) of the sugarcane box was created in GeoGebra (Figure 3). This allows the student, with teacher mediation, to investigate the geometric solid (parallelepiped) in question to solve the SDA: find the volume of the box used to export Brazil's sugar production to Europe.

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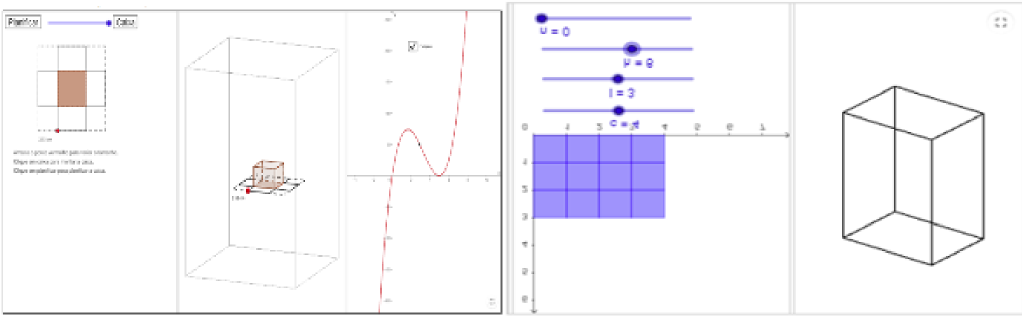
Figure 3 – Illustrative representation of the sugar packaging

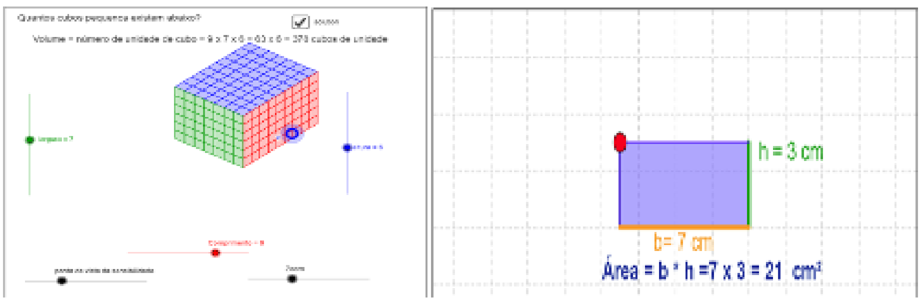


Source: Prepared by the authors (2025)

The experimentation with the GeoGebra Applet was planned for the visualization of mathematical entities, allowing students to understand the relationships between their representations and, above all, to appropriate the investigated concept. After presenting the SDA, the teacher can systematize the concepts worked on through collective discussion with the class.

At this point, the teacher can also work on units of area and volume measurement, formally presenting these concepts as well as the notation of their respective units: m² (square meter) for area and m³ (cubic meter) for volume. To better understand these concepts using GeoGebra, a geometric representation of the solid (Figure 4) is illustrated, which can be investigated through the manipulation of the software's tools.

Figure 4 – Illustrative representation of the geometric solid



Source: Prepared by the authors (2025)

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SDA 3 can be proposed from a virtual history of the concept—a fictional narrative involving a food company, specifically in the condensed milk sector:

> Suppose that you currently work in a food company in the condensed milk sector called “Green,” where we are part of the transport and logistics department. This department wants to minimize costs related to logistics and transportation. For this purpose, the department proposed an assessment of two packaging types: the first (Package A) made of metal, and the second (Package B) made of cardboard, polyethylene, and aluminum. Each packaging has its advantages, and from a financial point of view, both packages have the same cost for the company. It will be our responsibility, then, to choose the packaging that, from a transport and logistics perspective, is most advantageous to ensure the profit of company Green (Santos Filho; Peixoto; Eça, 2025).

In this activity, the triggering problem proposed is to investigate for this fictional company which packaging would ensure profit from a transport and logistics perspective. Students may be asked in advance to bring packages from home to explore their measurements. Initially, the teacher can present or request that students create a visual identity for the fictional company, the packaging models (Figure 5), and then their respective technical sheets containing the information “description, packaging, storage, and transportation” (Figure 6).

Figure 5 – Visual identity of the fictional company

Source: Prepared by the authors (2025)

At this stage of investigating the packaging, differences in measurements may arise, as each student may have brought different packages. The purpose of this activity is

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to guide the investigation of standard units of measurement and lead to the use of a measuring instrument, such as a ruler. It is suggested that the teacher mediates this stage by introducing error calculation, since the ruler is not the most precise tool for investigating packaging. Approximations between the students' packages can be established.

To organize the investigation, the class can discuss the need for adopting standardized measurements presented in each packaging's technical sheet (Figure 6), allowing students to investigate and relate the shapes of these packages to geometric solids.

Figure 6 – Technical Sheet of Package A and Package B

Source: Prepared by the authors (2025)

Once the technical sheets are defined, the shapes of each package can be related to geometric solids so that students perceive that Package A resembles a cylinder and Package B resembles a rectangular prism. At this moment, the teacher can ask: "After reading/defining the technical sheet and based on the knowledge acquired from previous activities, could the investigated packages be classified as geometric solids?" The class can then discuss the lateral and total area of the packaging, as well as the volume of each.

To enhance this discussion and provide students with support on the concepts to answer the initial triggering problem, a GeoGebra Applet (Figure 7) was created. This Applet can be used to examine the elements composing the cylinder and the prism. By

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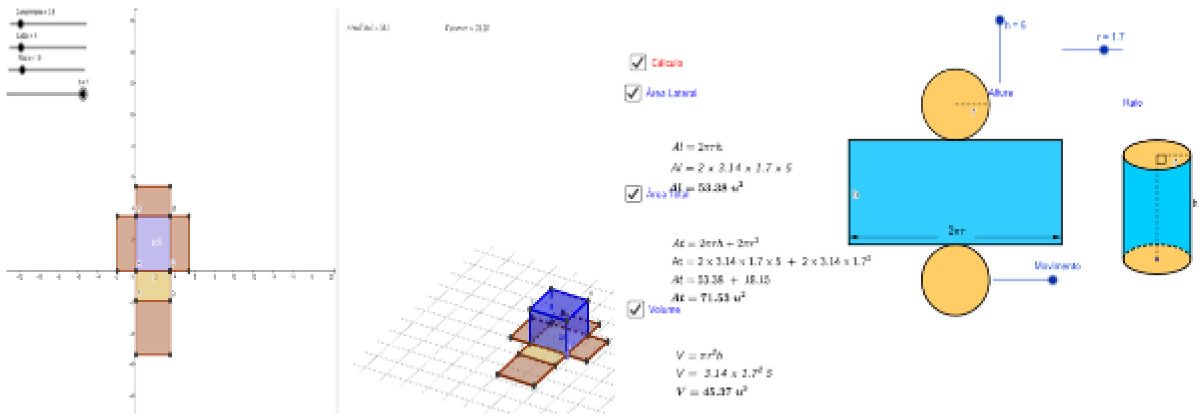
manipulating these elements (height, length, radius) in the software, students can begin to discover how to calculate the lateral area and volume of each package investigated in the proposed activity.

Figure 7 – Elements composing the rectangular prism and the cylinder



Source: Prepared by the authors (2025)

Once the areas and volumes of each package have been investigated with the aid of GeoGebra, the teacher can contextualize the operation of a transport department in a real company, using a video (Avelar, 2020) that references the characteristics and functionalities of the packages (Figure 8). The objective is to provide a theoretical/practical foundation so that students can discern which package (A or B) would be most advantageous for the investigated fictional company.

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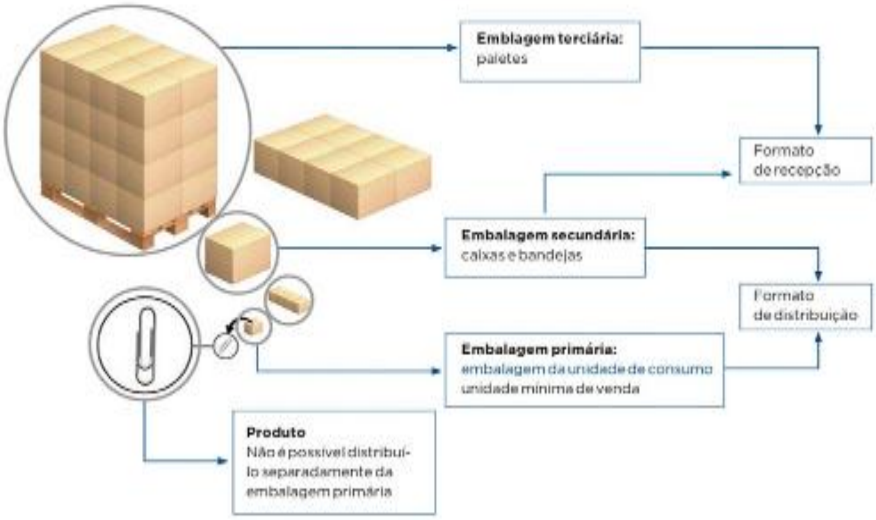
Figure 8 – Primary, secondary, and tertiary packaging



Source: Mecalux website

After presenting the primary, secondary, and tertiary packaging, as well as the transport and logistics department illustrated in the video (Avelar, 2020), the planning shifts to understanding the strategies of the fictional company's department explored in SDA 3. For this purpose, the teacher, with the collaboration of the class, can present the packaging management strategies of the fictional company Green:

> Packaging management strategies at Green Company: To optimize space utilization, the department standardized its measurements using PBR palletization. PBR pallet dimensions, following the construction criteria for these supports established by the standard, are 1,200 × 1,000 mm. The maximum allowed weight for a PBR pallet is 42 kg, and its load capacity ranges from 2,500 to 3,000 kg (Santos Filho; Peixoto; Eça, 2025).

Subsequently, the teacher can provide the class with representations of the PBR pallet and the secondary packaging to determine how many primary packages fit into the secondary packaging (Figures 9 and 10). Then, students must calculate how many Packages A and B can be stored in this secondary packaging. After solving this question, students need to determine how many packages (A and B) fit into the tertiary packaging (PBR pallet).

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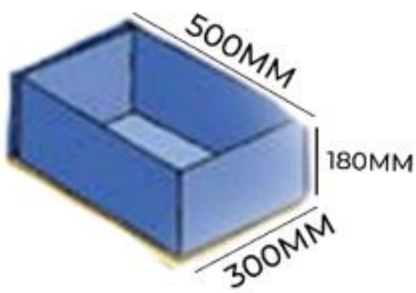
Figure 9 – Tertiary packaging

Source: Prepared by the authors (2025).

Figure 10 – Secondary packaging



Source: Prepared by the authors (2025)

The results obtained in this activity should be shared among students to support discussion and identify which packaging and model would yield the highest profit. At this point, the dimensions of the vehicle used by the company, a box truck, are considered, with the following characteristics: its platforms can accommodate a maximum of 26 pallets measuring 1,000 × 1,200 mm, arranged as illustrated in Figure 11:

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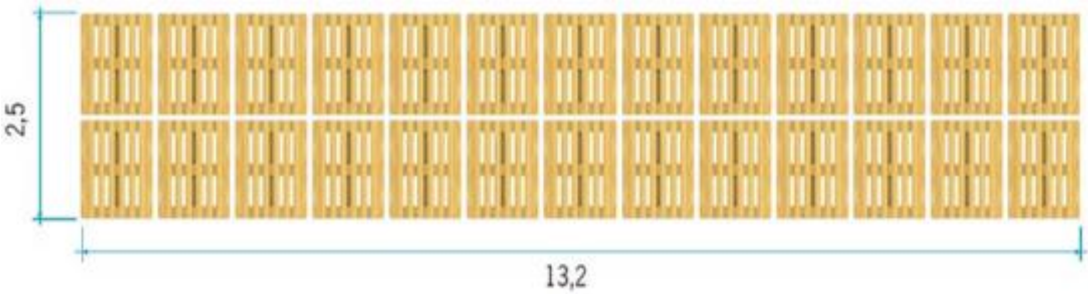
Figure 11 – Organization of pallets in the truck



Source: Prepared by the authors (2025)

After presenting the vehicle's dimensions and the results obtained in previous activities, students are equipped with data that allow them to decide which packaging is most advantageous for the fictional company Green. With teacher mediation, students can present their results and, collectively, reach a common solution for SDA 3. In the collective synthesis, the teacher can revisit the questions: (i) Which package would be most advantageous for the company?; (ii) What strategies were used to reach the answer to the previous question?; (iii) Were the mathematical concepts used in the activities fundamental to solving the proposed activity?; (iv) In your opinion, could this activity happen in real life, or is it only a conceptual exercise?

Each teaching moment was planned to underpin and stimulate the mathematical concepts through manipulation and illustrations in the GeoGebra Applets, allowing each student to interact and develop their reasoning to solve the SDA.

5 Final considerations

The objective of this study was to develop Learning Trigger Situations (SDA) from the perspective of Teaching Guiding Activity (AOE – *Atividade Orientadora de Ensino*), involving the concepts of area and volume using GeoGebra software. To this end, the SDA were elaborated under the theme "Exploring Commercial Packaging," addressing three subthemes: the necessity of packaging, the demarcation of land in Antiquity, and the

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storage of agricultural production. These themes were explored/presented through situations emerging from everyday life and the virtual history of a fictional company.

The need for measurement has existed since Antiquity, especially when dealing with the concepts of volume and area, which required the creation of units of measurement, i.e., measurement standards to enable comparison between objects. Thus, the proposal was intentionally structured to stimulate reflection across history, connecting aspects of the past and the present.

When addressing the necessity of packaging, the aim was to promote observation, experimentation, testing, and measurement, aiming at a broader understanding of the evolution of practices related to conservation, transport, and commercialization. Moreover, the use of everyday situations and the simulation of virtual history in the activity planning sought to make learning more meaningful, engaging the class in finding solutions. The planning of these SDA aimed to involve students in learning activities, thereby transforming them into active participants in the process.

The incorporation of Applets in GeoGebra allows students to test hypotheses, compare, measure, review concepts, exemplify, illustrate, and manipulate mathematical objects, providing the basis for creating a conceptual model of the final solution to be collectively defined with the class. It is important to emphasize that the mere use of games, emergent situations, or virtual stories does not, by itself, constitute an SDA. It is essential that these resources present a problem-situation similar to that faced by humans when dealing with mathematical concepts in real-life contexts.

For instance, it is necessary to store production both to prevent losses and to enable transportation to more distant locations. Furthermore, the solution must be collaborative, allowing for the joint construction of knowledge, and the success of the SDA will depend on the quality of teacher mediation. The proposed learning situations can engage students in challenges that generate cognitive tensions, especially through the use of digital technology. The goal is to promote the appropriation and construction of knowledge, providing theoretical, methodological, and ethical support that encourages critical and full participation in society.

Thus, the proposal presented in this pedagogical product falls within the field of Mathematics education, constituting one of various possibilities for organizing pedagogical activity aimed at approaching the concepts of area and volume. Furthermore, the intentionality of the teacher in consciously and structurally planning actions to bring the student closer to the object of knowledge is highlighted. This classroom development promotes a process of mutual formation, fostering, on one hand, the student's appropriation of knowledge and, on the other, the reflection of the novice teacher on the meaning of their actions in the exercise of pedagogical practice.

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