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USE OF CONCRETE MATERIALS IN TEACHING CALCULATION OF AREAS AND VOLUMES OF PRISM AND CYLINDER

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ABSTRACT
Spatial Geometry, in its Position and Metric aspects, is fundamental for the development of spatial skills and mathematical reasoning. With the aforementioned facts, we sought to create a challenge for students, in which they would identify in these geometric solids what are the faces and edges of a prism and cylinder, using concrete material, calculating areas and volumes of prism and cylinder. Therefore, by changing this reality, bringing concrete

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examples from the day-to-day of local construction and architecture to the classroom, contextualizing the teaching and making it more practical and relevant, we hope to awaken the interest of students, facilitating the assimilation of concepts, and above all, better preparing them for the challenges they will face in their careers. It is concluded, therefore, that the use of concrete materials is a valuable tool for promoting meaningful learning, contributing to the unrestricted education of students and preparing them to face future challenges.

Keywords: Spatial Geometry. Concrete Material. Areas and Volumes.

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INTRODUCTION

Spatial Geometry, in its Position and Metric aspects, is fundamental for the development of spatial skills and mathematical reasoning. However, there is a significant gap in the textbooks available in the library of the Instituto Federal do Piauí, Floriano campus, especially regarding the practical application of these concepts in the daily lives of students. This deficiency is particularly notable in the technical course in building integrated into high school, where understanding calculations of areas and volumes of geometric solids is essential for the professional training of students. Recognizing this need, an innovative pedagogical intervention was proposed in the Mathematics III discipline.

By integrating concrete examples and problem situations inspired by the students' reality, the hope was to stimulate students' interest and facilitate their understanding of the relevance of this knowledge for their future professional performance. This strategy not only enriched the teaching-learning process, but also prepared students to face real challenges in their technical careers.

According to Souza and Rendeiro (2023), teaching spatial geometry is a key part of students' mathematical education, offering essential tools for understanding and interpreting the three-dimensional world around us. It goes far beyond simply memorizing formulas to calculate areas and volumes - it is a journey of discovery that stimulates creativity and critical thinking.

For Silveira, Novello, Laurindo (2011), the use of tangible, concrete materials not only improves the conception of abstract concepts in mathematics, but also promotes deep and lasting learning, encouraging the development of critical reasoning in problem-solving.

When students explore geometric shapes with their own hands, build models, or use computer programs to visualize objects in 3D, these practical/and/or manipulative, and interactive experiences are essential to spark interest and make concepts more tangible. When students can "see" and "touch" geometry, it ceases to be something abstract and becomes a concrete part of their learning. Teaching spatial geometry plays a fundamental role in the development of mathematical reasoning and in understanding the three-dimensional world that surrounds us.

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RESEARCH PROBLEM

Due to the difficulties students have in identifying the faces and edges of a prism and cylinder in geometric solids such as prisms and cylinders, and consequently calculating the areas and volumes of these geometric solids, the following guiding question arose.

Is it possible to associate the concepts of faces and edges of a prism and cylinder, working with concrete materials, in spatial geometry classes, to solve exercises related to the areas and volumes of the two spatial solids, in the 3rd year of the Technical Course in Buildings Integrated with the High School of the Campus of the Federal Institute of Education, Science and Technology of Piauí-Floriano Campus-IFPI?

JUSTIFICATION

The proposal for an innovative approach to teaching spatial geometry in the technical course in construction arose from the need to fill an important gap in students' education. We observed that the teaching materials available in the library of the Instituto Federal do Piauí, Campus Floriano, do not always manage to establish clear connections between theoretical concepts and practical applications in the field of civil construction.

In view of the facts mentioned above, we sought to create a challenge for students, in which they would identify, in these geometric solids, what are the faces and edges of a prism and cylinder, using concrete material, and therefore, facilitating problems in calculating the areas and volumes of prisms and cylinders. Therefore, by changing this reality, bringing concrete examples from the day-to-day construction and local architecture to the classroom, contextualizing the teaching and making it more practical and relevant, we hope to arouse the interest of students, facilitating the assimilation of concepts, and above all, better preparing them for the challenges they will face in their careers.

THEORETICAL FRAMEWORK

Connecting spatial geometry with students' daily lives is another crucial aspect, such as calculating the volume of a water tank for a project, or determining the amount of paint needed to paint the walls of a building. These practical applications not only make learning more relevant, but also prepare students for real challenges in their future careers.

That said, we need to be careful with digital tools, because although they can facilitate the understanding of complex mathematical concepts, they can also promote excessive dependence, reducing students' ability to solve problems mentally. The

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increased integration of technology with human beings, while helping, also contributes to a series of additional challenges. According to Nogueira; et al (2021), finding a balance between the effective use of technology and traditional teaching methods becomes essential to face the current challenges of teaching mathematics.

Souza, (2019) reports that well-planned spatial geometry teaching goes beyond the traditional classroom. It develops skills such as spatial perception, logical reasoning, and the ability to solve complex problems. These are valuable skills not only for mathematics, but for many areas of knowledge and professional life.

For Silva (2015), teaching spatial geometry using concrete materials is an approach that promotes the understanding of abstract concepts through the manipulation and visualization of three-dimensional components. By using physical geometric shapes, such as cubes and cylinders, students can discover the properties and relationships between various geometric solids in a tangible way. This procedure allows students to understand the dimensions and characteristics of the figures in a more vivid way, promoting a more expressive and time-consuming exercise.

In addition, direct interaction with the materials awakens curiosity and interest in the subject, making the study of geometry more engaging and dynamic. Manipulable resources such as blocks, spheres, prisms and other materials, educators provide students with a practical and visual experience that simplifies the visualization and manipulation of objects in space, still according to Turrioni, Perez (2009) concrete materials fulfill a fundamental function in student learning, promoting analysis, in the development of logical, critical and scientific reasoning, fundamental for experimental teaching, becoming highly beneficial to help students in the construction of their knowledge.

> Geometry is a thematic unit of fundamental importance in the mathematics curriculum, as it involves the study of a broad set of concepts and procedures necessary to solve problems in the physical world and in different areas of knowledge (BRASIL, 2018, p.267)

According to Costa (2023), over time, we have noticed that many students face challenges in identifying and understanding the properties of basic geometric shapes, even those that surround us in our daily lives. However, mastering Spatial Geometry is essential for interpreting three-dimensional objects. In addition, this knowledge stimulates abstract thinking, improves our perception of the physical environment, and enables us to solve practical issues in our daily routine.

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METHODOLOGY

Below is a step-by-step description of the proposed pedagogical intervention, with the aim of developing and implementing a sequence of activities using concrete materials such as prisms and cylinders to teach metric calculations of solids, presenting their elements, faces, edges and then defining areas and volumes of the solids mentioned above, together with 27 students from the 3rd year class of the Technical Course in Buildings Integrated with High School at the Campus of the Federal Institute of Education, Science and Technology of Piauí-Campus Floriano-IFPI, morning shift.

In the presentation of the content, issues present in the student's daily activities will be highlighted. The students will be assessed through their participation in class with concrete materials and by solving exercises on the proposed theme, identifying the faces and edges of a prism and cylinder in the objects. During the intervention, concrete materials were presented as a teaching-learning tool, defining the concepts of areas and volumes, and then we calculated areas and volumes using concrete materials, since these, according to the authors cited above, are essential in learning spatial geometry.

The development of the proposal was carried out in the Interdisciplinary Laboratory for Teacher Training (LIFE) and in the mathematics teaching laboratory, which are interconnected, where the concrete materials are stored. The theme was chosen because I have been working for 13 years with the 3rd year of high school integrated with the technical course in building, and sometimes with the 3rd year of high school integrated with the technical course in electromechanics, and I have observed that the students have great difficulty in assimilating the concepts of areas and volumes of these geometric solids, because they are unable to visualize these materials when working only with the theoretical part. Of the 27 students in the class, all chose to participate. These contents (prisms and cylinders) were indicated, justifying that they had difficulties in solving the issues present in everyday problems.

The proposed activities, the workload and the period are detailed in the table below. The invitation to participate in the research was made through the presentation of the objective of the study, and after the acceptance of the research, where the meetings that would occur were defined according to the table below, and filled out by the researcher and author of the research, forwarded to each student in the class. The research protocol is explained in the Free and Informed Consent Form (FICF) and provides a place to accept or decline the invitation to participate. A total of 27 students participated in the research.

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Table 1: Pedagogical intervention activity

Meeting	Duration (hours)	Activities
1	2	Presentations of concrete materials such as prisms and cylinders.
2	1	Application of activities related to the elements of prisms and cylinders Appendix A
3	2	Definition of areas and volumes of prisms, using concrete materials.
4	1	Application of exercises related to areas and volumes of prisms Appendix B.
5	2	Definition of areas and volumes of cylinders, using concrete materials.
6	1	Application of exercises that relate areas and volumes of cylinders Appendix C, and later a semi-structured questionnaire will be applied Appendix D, to ascertain the students' opinion regarding the use of concrete materials.

Source: Researched Author

DETAILS OF THE INTERVENTION PROPOSAL

In the first meeting, the concrete materials prism and cylinder were presented, and then the definition of prism and cylinder will be made, through an expository and explanatory class giving names to the elements of the prism and cylinder, which will be used concrete materials available in the interdisciplinary laboratory for teacher training - LIFE.

In the second meeting, the elements of the prism and cylinder were identified through practical activities, using appendix A. In the third meeting, the area and volumes of the prism will be defined using the concrete materials, available in the interdisciplinary laboratory for teacher training - LIFE.

In the fourth meeting, appendix B related to the area and volumes of the prism was applied. In the fifth meeting, the definitions of areas and volumes of cylinders will be presented, using the concrete materials, available in the interdisciplinary laboratory for teacher training - LIFE.

In the sixth and final meeting of the intervention, appendix C related to areas and volumes of the cylinder was applied, followed by a semi-structured questionnaire appendix D, to ascertain the students' opinions regarding the use of the study materials used.

INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria for participation in the research would have to be a student enrolled in the 3rd year of the technical course in building integrated with high school, class 2301, and as for the exclusion criteria, they would be excluded if they belonged to other 3rd year technical courses integrated with high school at the Instituto Federal do Piauí, Campus Floriano, or did not accept the provisions of the free and informed consent form provided by the researcher.

RESULTS

During this pedagogical intervention, it was believed that the students would engage in discussions, obtaining potentially significant results in learning the spatial geometry content presented in the introduction. At the same time, it was expected that the students would expand their capabilities to carry out the proposed activities in spatial geometry. In this way, the students understood that it is possible to self-regulate their studies and become protagonists of their own learning.

The mediating teacher asked the students to form nine (09) groups, with 3 members in each group, totaling 27 members. During the formation of the groups, it was noticed that the groups were composed of students who sat close together in the classroom, or among members who already had coexistence in the school environment.

In view of this formation, some students suggested "teacher! We can join groups of 03 members, with another group with 03 members, because the tables and materials such as prisms and cylinders available in the laboratory are not enough to serve the 09 groups separately". The teacher accepted the idea and created a new arrangement, requiring that each group or table should have one of the solids or cylinders. In this way, the groups that worked on the work were formed.

After this new group formation, the material (appendices) was handed out, as well as the geometric solids, and the steps for solving the mathematical activities were explained. Corroborating the proposal of the work, Marques, Fonseca and Mendes (2018) report the importance of looking for tactics that also bring the student closer to the content worked on, which can improve learning difficulties in the classroom, not only by presenting it in an expository format, but also by working with tangible materials, breaking with the stigma of presenting Mathematics as something difficult that cannot be solved.

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DISCUSSION

Below, some of the students' statements and solutions that were recorded in the researcher's field notebook were highlighted.

> "Professor, do you mean that every time you spoke about the lateral edge of the pyramid, it is this same lateral edge of the prism, which we are now having contact with for the first time in practice with these concrete materials"?
> "Do you mean that the edge of the base is this that I am having contact with"?
> "The questions will be asked in groups, if one does not know, the other can find out".

These comments encouraged me, as the first meeting encouraged the class to participate.

The solutions below concern the elements of the prism and cylinder, the area and volume of the prism, the area and volume of the cylinder and the use of concrete material, as per appendix A, B, C and D.

Image 1: Student 1

Source: Research author

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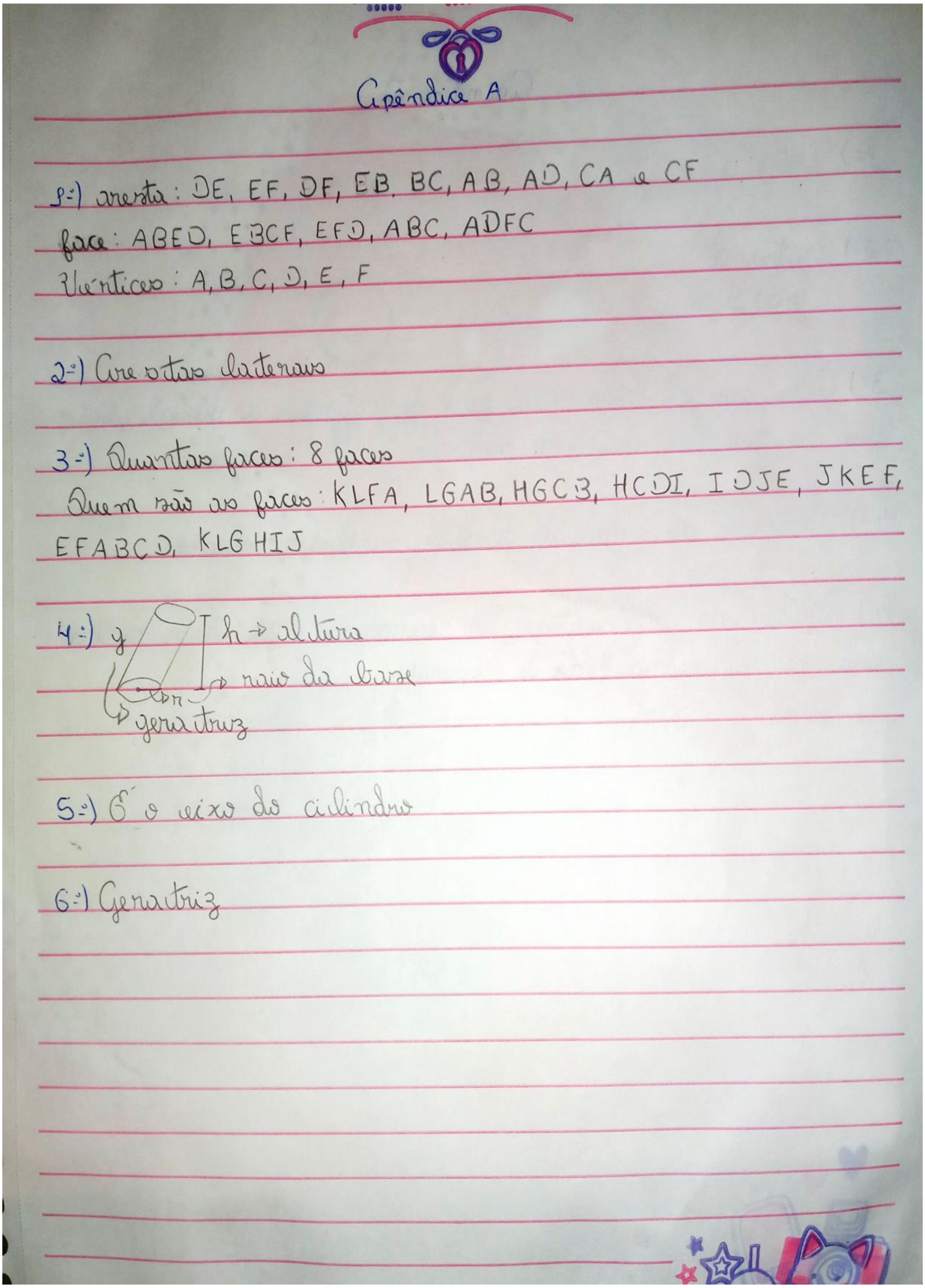

Apêndice A

1º) aresta: DE, EF, DF, EB, BC, AB, AD, CA e CF
face: ABED, EBCF, EFD, ABC, ADFC
Vértices: A, B, C, D, E, F

2º) Arestas laterais

3º) Quantas faces: 8 faces
Quem são as faces: KLFA, LGAB, HGCB, HCDI, IDJE, JKEF, EFABCD, KLGHIJ

4º) y
h → altura
→ raio da base
r
→ geratriz

5º) É o eixo do cilindro

6º) Geratriz

Source: student 1's notebook

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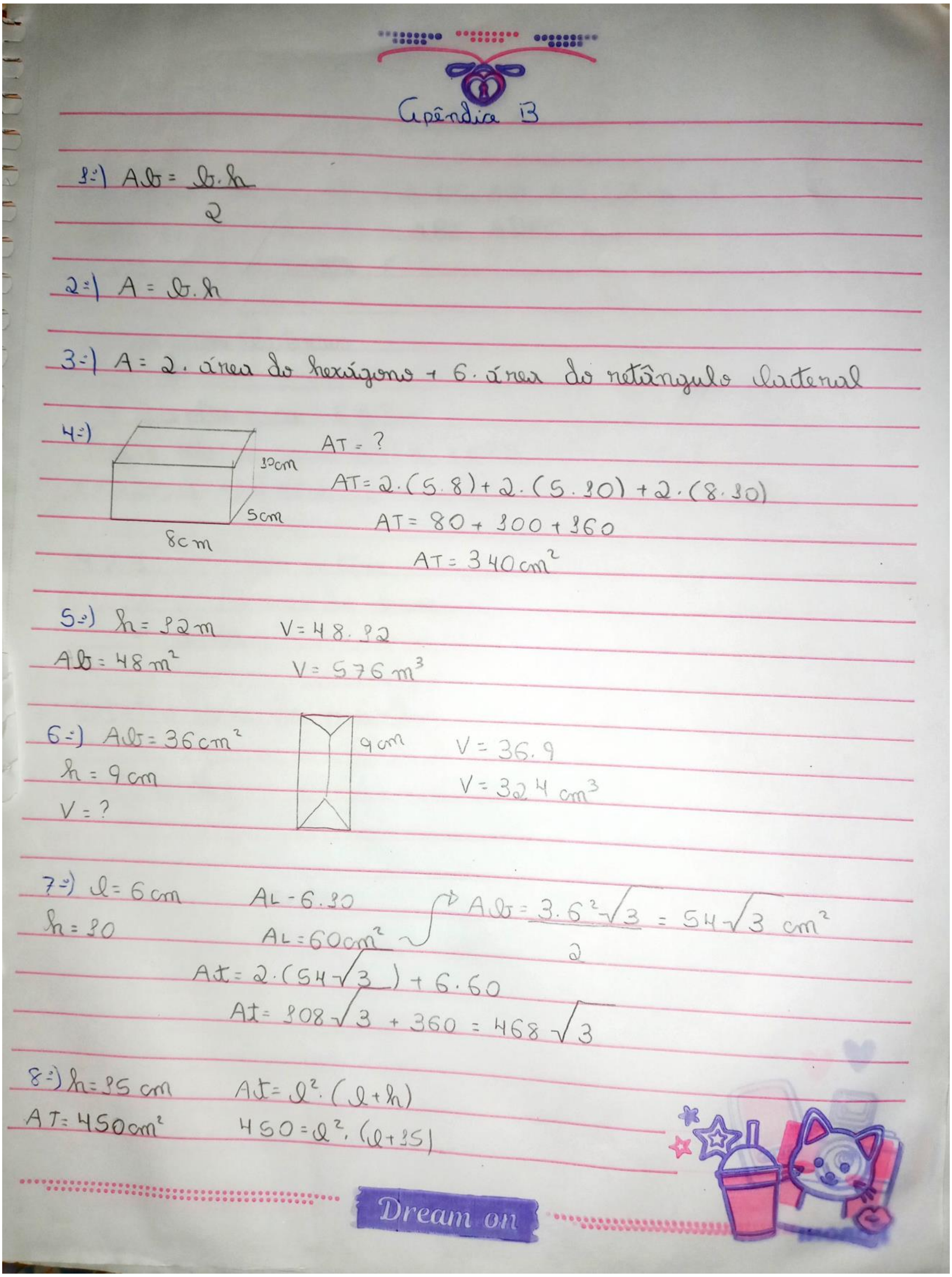

Source: student 1's notebook

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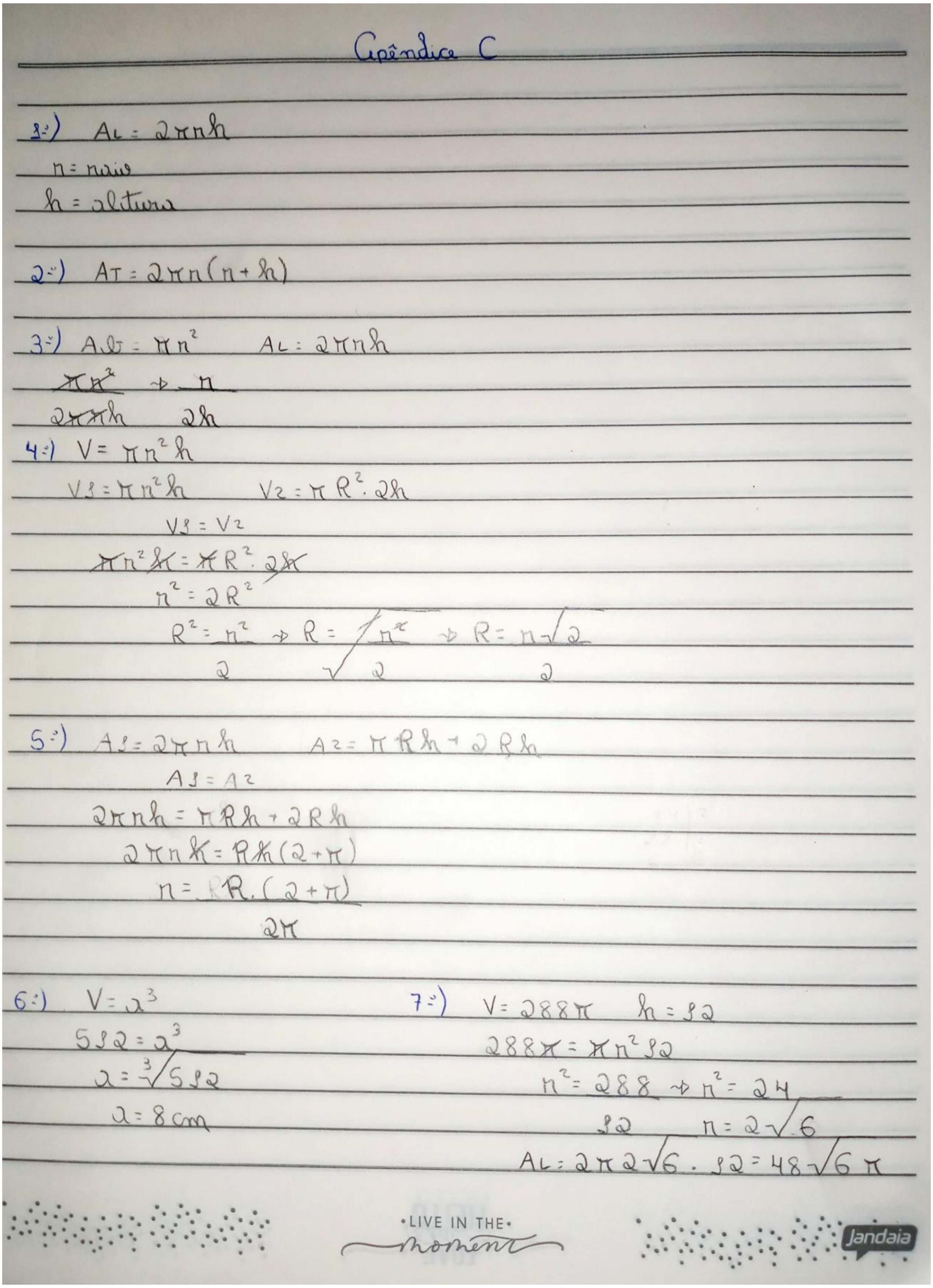

Source: student 1's notebook

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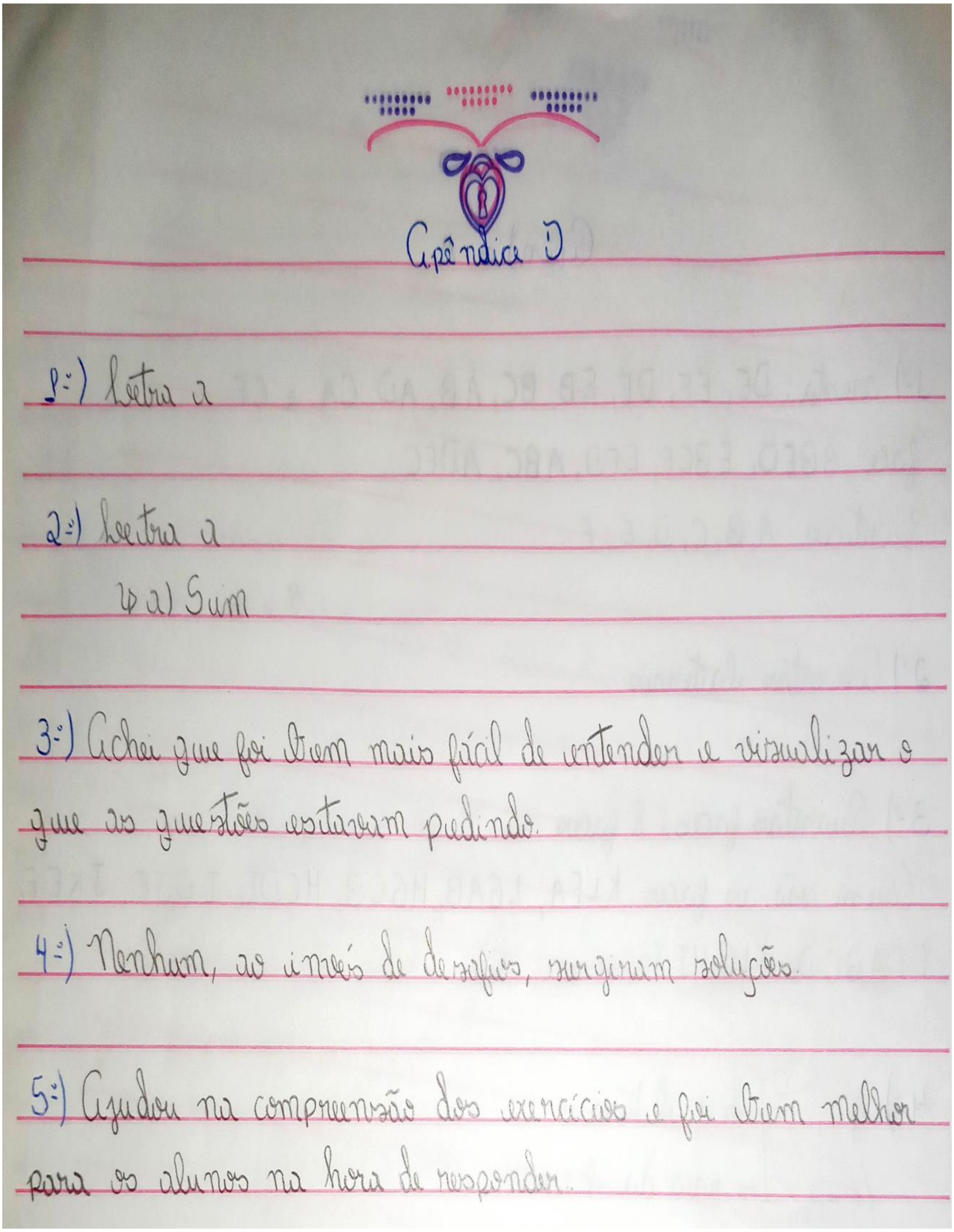

Source: student 1's notebook

The solutions presented above by student 1, although he/she did not answer all the questions correctly, when asked about how many faces a triangular and hexagonal prism

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has, student 1 did not have enough knowledge to give the correct answer, but he/she has mastered the other questions related to calculating the areas and volumes of the two solids studied, in relation to appendix D item 5 which describes the use of concrete material, the student presents the following solution: "It helps in understanding the exercises and was much better for the students when it came to answering"

The solutions below concern the elements of the prism and cylinder, areas and volumes of prisms, areas and volumes of cylinders and the use of concrete material, as per appendices A, B, C and D.

Image 2: Student 2

Source: Research author

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Apêndice A

1. Arestas: AB, BC, AC, AD, BE, EF, FC, FC, ED.

Faces: (DEF) e (ABC), (ADEB), (ADFC), (BEFC)

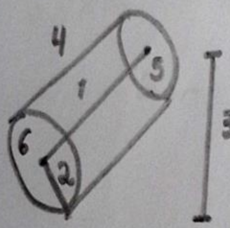
Vértices: A, B, C, D, E, F

2. Arestas laterais.

3. Quantas faces: 8

Indique que são faces: (EJKF), (FKLA), (ALGB), (BGHC), (CHID), (DIJE), (A,B,CDEF), (LGHIJK)

4.



4 - Geratriz
2 - Raio da base
3 - Altura

1 - Eixo
5 - Base
6 - Base

5. Eixo

6. Geratriz

Source: Student's notebook 2

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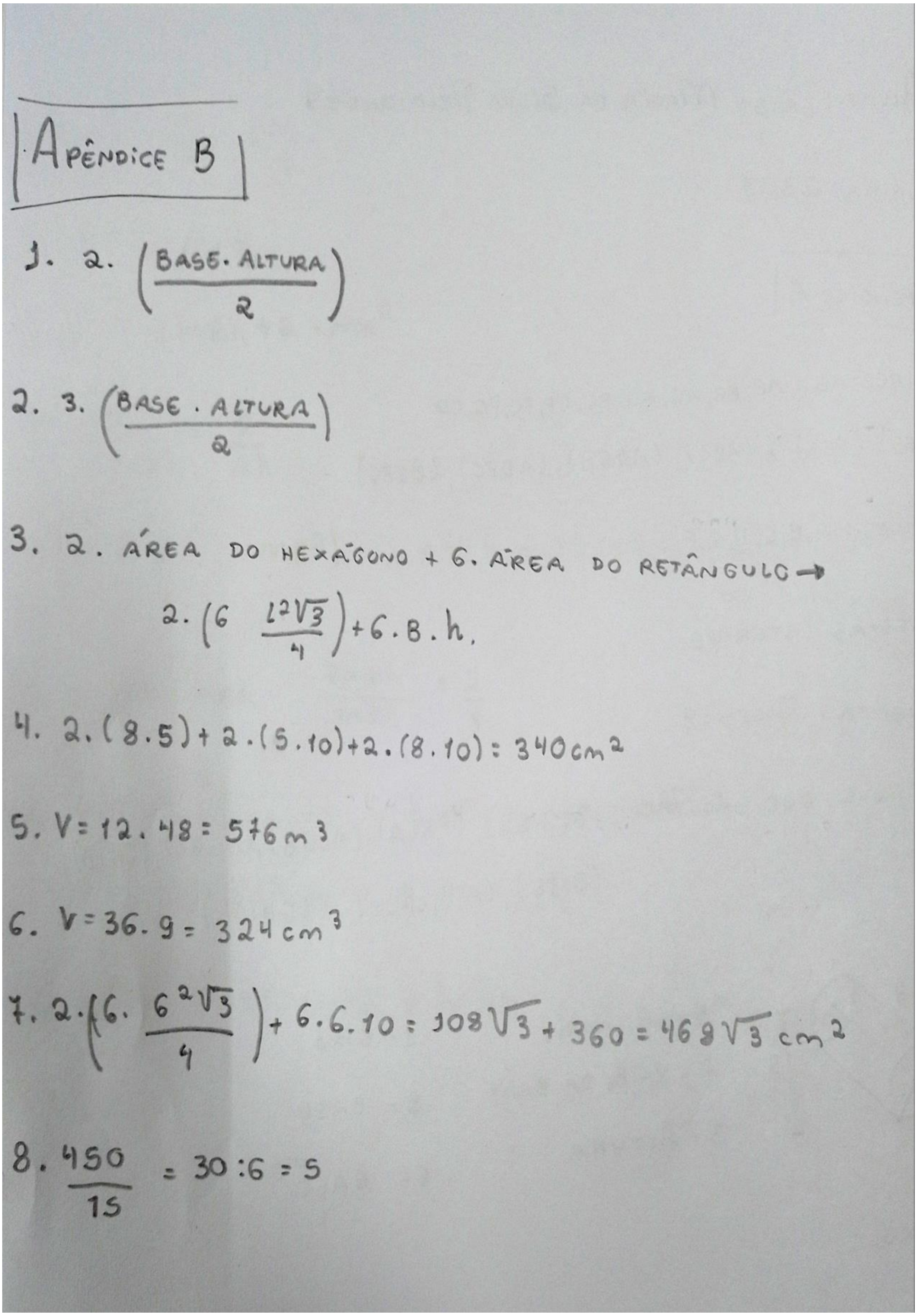
Apêndice B

1. $2 \cdot \left(\frac{BASE \cdot ALTURA}{2}\right)$

2. $3 \cdot \left(\frac{BASE \cdot ALTURA}{2}\right)$

3. 2. ÁREA DO HEXÁGONO + 6. ÁREA DO RETÂNGULO →

$2 \cdot \left(6 \frac{l^2\sqrt{3}}{4}\right) + 6 \cdot B \cdot h.$

4. $2.(8.5)+2.(5.10)+2.(8.10) = 340\,cm^2$

5. $V = 12.48 = 576\,m^3$

6. $V = 36.9 = 324\,cm^3$

7. $2.\left(6.\frac{6^2\sqrt{3}}{4}\right)+6.6.10 = 108\sqrt{3}+360 = 468\sqrt{3}\,cm^2$

8. $\frac{450}{15} = 30 : 6 = 5$

Source: Student's notebook 2

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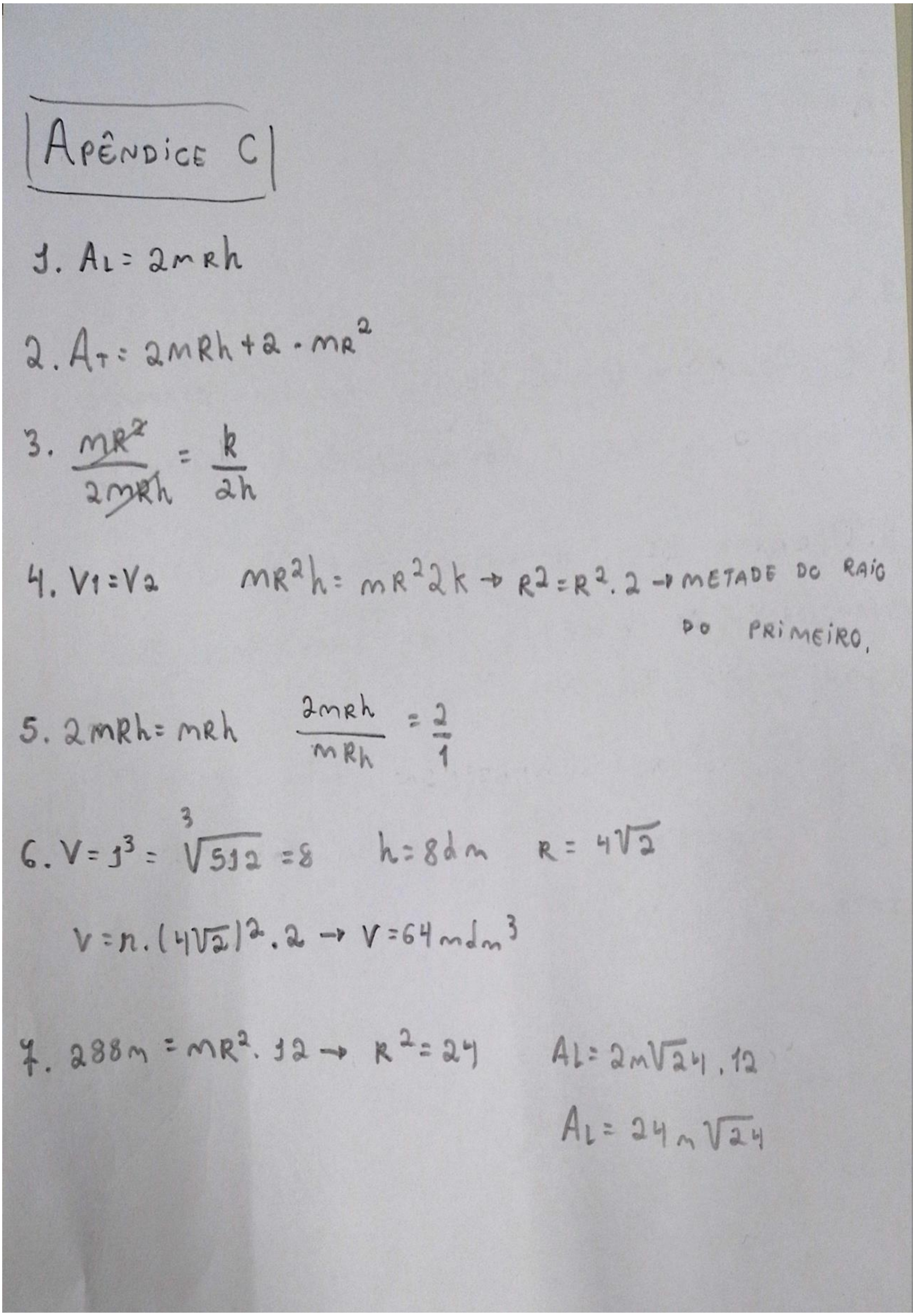

Apêndice C

1. $A_L = 2\pi R h$

2. $A_T = 2\pi R h + 2 \cdot \pi R^2$

3. $\frac{\pi R^2}{2\pi R h} = \frac{k}{2h}$

4. $V_1 = V_2$ $\pi R^2 h = \pi R^2 2k \to R^2 = R^2 . 2 \to$ METADE DO RAIO DO PRIMEIRO.

5. $2\pi R h = \pi R h$ $\frac{2\pi R h}{\pi R h} = \frac{2}{1}$

6. $V = 1^3 = \sqrt[3]{512} = 8$ $h = 8 dm$ $R = 4\sqrt{2}$

$V = \pi . (4\sqrt{2})^2 . 2 \to V = 64\pi dm^3$

7. $288\pi = \pi R^2 . 12 \to R^2 = 24$ $A_L = 2\pi\sqrt{24} . 12$

$A_L = 24\pi\sqrt{24}$

Source: Student's notebook 2

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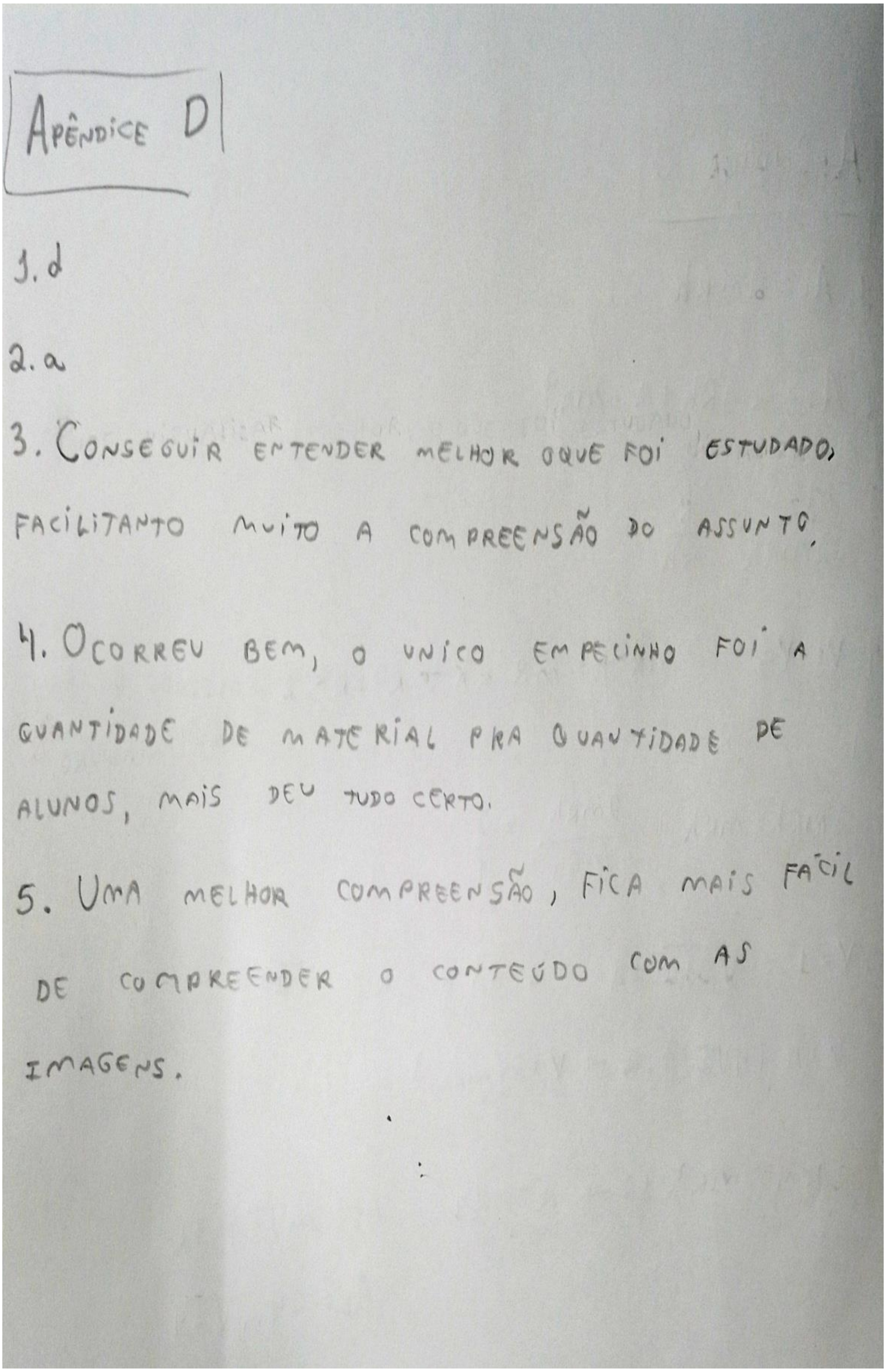

Apêndice D

1. d

2. a

3. Conseguir entender melhor oque foi estudado, facilitanto muito a compreensão do assunto.

4. Ocorreu bem, o unico empecinho foi a quantidade de material pra quantidade de alunos, mais deu tudo certo.

5. Uma melhor compreensão, fica mais fácil de compreender o conteúdo com as imagens.

Source: Student's notebook 2

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Again analyzing the solutions presented by student 2, although he/she did not answer all the questions correctly when asked about the faces of the triangular and hexagonal prism, student 2 demonstrated mastery in solving the other questions related to calculating the areas and volumes of the two solids under study, and in relation to Appendix D, item 5, which describes the use of the material, student 2 made the following statement.

"Better understanding and it is easier to understand the content with the images"

CONCLUSION

The pedagogical intervention using concrete materials provided remarkable results in the students' learning process. It was observed that, when handling physical objects, students were able to better engage abstract concepts, promoting the assimilation of content previously considered complex. This teaching methodology allowed for more active and engaged interaction, generating a dynamic and collaborative learning environment.

In addition, the use of concrete materials contributed to the development of fine motor skills and logical reasoning. By participating in practical activities, students had the opportunity to explore different strategies to solve problems, which stimulated critical thinking and creativity. This approach also proved to be inclusive, meeting the needs of different learning styles and providing equal opportunities for participation for all students

Finally, the pedagogical intervention with concrete materials highlighted the importance of diversified teaching methodologies. Incorporating tangible resources into the educational process resulted in an increase in students' motivation and interest in the content presented. It is therefore concluded that the use of concrete materials is a valuable tool for promoting meaningful learning, contributing to the unrestricted training of students and preparing them to face future challenges.

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I would like to thank my fellow teachers for their contributions to improving my research, as well as for their understanding during this time of pedagogical intervention.gradeço ao Instituto Federal do Piauí for welcoming me and supporting me in carrying out this research, which were the best moments of my life.

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