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THE USE OF TECHNOLOGY IN THE MATHEMATICAL PRACTICES OF THE MONTESSORI METHOD

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Lázaro Nogueira Pena Neto[1].

ABSTRACT

The present work is an experimental, comparative study, based on two strands of teaching and learning in Early Childhood Education. Result of experiments and comparative analysis of this experience report, of good practices in the classroom. The first strand was carried out based on the preparation and elaboration of pedagogical activities with children from Kindergarten II in the standards of the Montessori Method, addressing the fundamental concepts of Geometric Mathematics. Later, the implementation was carried out using technological equipment (tablets) to carry out the same lesson plan, making the adaptation through the electronic device. The different behaviors, execution times of the activities, integration and behavior among the students and the degree of assimilation by recognition of visual and tactile patterns were studied and related.

Keywords: Mathematics, Montessori, Technology.

[1] UFU
Email: lazaro.nogueira@ufu.br

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PRESENTATION

This text presents a proposal and explanation about the work method and activities based on Maria Montessori's theory, focused on her teaching method, and later an adaptation with the use of technological material. From working with 4-year-old children (Kindergarten III) within the traditional classroom, then involving them in an activity totally based on the information and communication technology model.

It is known that the Montessori Method aims at the education of will and attention, with which the child has the freedom to choose the material to be used, in addition to providing cooperation. This pedagogy is part of the New Schools movement, an opposition to traditional methods that do not respect the needs and evolutionary mechanisms of the child's development. As most of the procedures are based on observation and style of activities carried out with the little ones, it is possible to carry out through direct or indirect experimentation, proposals that involve attention, discovery and free choice.

When presenting this work, relevance will be given to the study and practical application of the Method, created from the teaching-learning processes of a group of early childhood education students. With this, discovering the advantages of this process from the beginning of their studies. In this way, integration with the digital resource can be carried out if the principles of sensory education and the use of its development materials are considered, recognizing that:

> "Sensory material is constructed by a series of objects grouped according to a certain quality of bodies, such as color, shape, dimension, sound, degree of roughness, weight, temperature, etc. Thus, for example, a group of bells that give the musical tones; a set of tablets of various colors; a set of solids that have the same shape, but of graduated dimensions, other objects that differ from each other by their geometric shape, and others, still of equal size and different weights, among others. (...). This generic criterion should be subject to a practical determination that depends on the psychology of the child. Only material that effectively interests the child will be experimentally chosen as being likely to educate and entertain the child with a spontaneously chosen and repeated exercise." (MONTESSORI, 1965, p. 103)

Specifically in Montessori Education, it is not the philosophy or methodology treated individually that will give us the possibility of understanding it. Because they are made up of parts, they are hierarchically ordered. The main defined characteristic is Self-Construction: that the formation of the structure of the human being would be the result of an inner force; which would be carried out under the influence of the environment and the periods of development. (OMB, 2019) These periods, with their own characteristics, were defined by her as follows:

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1st Period – From birth to 6 years old - The child performs his own construction through the exploration and absorption of the environment that surrounds him (Figure 03). Its intelligence works as a function of the "external" and the superficial relations between objects and their qualities. It is an essentially sensory period.

2nd Period – From 6 to 12 years old - In this phase, the young person is able to relate the facts in the light of reason, worrying about the "how" and the "why" of things. It is the entrance into the world of abstraction.

3rd Period – From 12 to 18 years old - The world starts to interest him from a different point of view: he looks for what he should do, that is, he wakes up to the problem of causes and effects.

In Education as Science, he argued that this would result from a scientific pedagogy that was capable of respecting the laws of the child's development and its evolutionary phases. And, finally, in Cosmic Education he made reference to respect for the laws established in the close relationship between nature and life and human society; recognizing that it is the "cosmic task" of each being, which maintains the harmony of life and makes evolution possible. (OMB, 2019)

Maria Montessori believed that her work was not finished, on the contrary, she expressed the expectation of seeing it continued and increased. According to her , *"If science were to begin to study men, it would succeed not only in providing new techniques for the education of children and youth, but would arrive at a deep understanding of many human and social phenomena which are still shrouded in astonishing obscurity. The basis of the educational and social reform, necessary in our day, must be built on the scientific study of the unknown man."*element. (OMB, 2019)

Maria Montessori not only put into practice a systematic method of developing the perceptual faculties, but also elaborated a theory of perception that has many points in common with Pestalozzi's approach. Thus, with regard to the didactic material, she noted that it is not necessary for "the children's attention to be retained by objects when the delicate phenomenon of abstraction begins" (Montessori, 1965, p. 80). She wanted her teaching material to be designed in such a way as to allow for the concrete and immediate situation and to favor abstraction. (Montessori, 1965, p. 80)

We have long known about the use of technologies in education. Aligning an effective pedagogical proposal with such resources enables the teacher to improve his teaching practice and enrich his approach in the treatment of the contents to the students.

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To carry out this integration based on Montessori's approach in the digital environment, consider the following reflection according to the author:

> "The objects that present themselves to the eye, in greater number in the external environment, are comparable to our flat fittings: the doors, the framing of a window, the square formed by a blackboard, the flat surface of a table; They are solid objects, but with a predominance of two dimensions that determine the shape of the plane. It is the knowledge of the forms presented in the flat fittings that will be for her a kind of magic key for the interpretation of the entire external environment and that can provide her with the comforting illusion of knowing the secrets of the world" (MONTESSORI, 1965, p. 159)

PROBLEMS

Information is everywhere. Creating a valid and useful information process is what enables the individual to change and transform attitudes. Studying with the teacher is just one of the different work proposals that are presented to the child and/or adult. That is why it is important that the activity to be developed is thought of as neutral elements, but without losing the change in sight. The process of using technology is very much related to the point that how does the teacher deal with it? What are the best procedures and proposals that meet the correct functioning? What are the situations involved? Is it possible to expand the Montessori approach to the digital format? What fundamental procedures can I adapt in my practices?

Many ways of teaching today are no longer justified. We waste too much time, learn too little, and continually become demotivated. Both teachers and students have the clear feeling that many conventional classes are outdated. But where to change? How to teach and learn in a more interconnected society? (Moran, 2019, p. 1)

The Montessori methodology is based on the process of teaching from the concrete so that the student can carry out his abstractions, that is, from macro to micro knowledge. It is based mainly on the observation capacity that children have and that can provide better learning by providing motivating experiences to children through discoveries and concepts that they can elaborate (OLIVEIRA, 2010, p. 17). In fact, all kinds of resources that can be inserted into the process of literacy, assimilation, and accumulation of knowledge are valid. Allied to this, the appreciation of the child as a human being and the enhancement of their qualities.

In each historical moment, some aspect of knowledge served as a basis for decision-making and the elaboration of teaching proposals that were of interest to one or another educational model of that time. For the individual to be considered a citizen, it is necessary

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that he participates and acts as such, giving subsequent return to the state he is linked to as a person.

From the development of their skills such as: language (writing and reading, initial concepts, improvement of speech, enriched vocabulary, expression and free narrative) the child is through a constant wave of information and assimilation of things and facts in the environment that surrounds him. First at home with family, then at school and interaction with classmates and adults and again with both situations, until your learning is more dense.

From the exhibition carried out so far, we thought about carrying out activities in which tactile sensory perception was considered. The use of tablets was the closest to this situation.

OBJECTIVES OF THE RESEARCH

GENERAL OBJECTIVE: To carry out activities in the area of Mathematics (plane geometry) using the application of the Montessori Method in the initial grades of Early Childhood Education through applications of digital technological resources.

SPECIFIC OBJECTIVES: To present the application of the Montessori Method in Early Childhood Education; Verify the teaching practice proposed by the authors in this method and digital context; describe a form of sequence of works to be used combining the two content approaches, enabling a history of practices.

METHODOLOGICAL APPROACH

The present study is based on the methodological model of qualitative research, exploratory experimental with a bibliographic approach within the educational practices in the daily teaching and learning process. Qualitative due to the proximity between the object of study and the researcher in search of a significance of the context. Exploratory because it is in search of the identification between the connection of the proactive activity of the classroom by the Montessori method and the standard based on technology. And with that, carrying out the experiment with children in different environments and pedagogical proposals.

"The balance between individual freedom and the need of the group is another special feature of social education in the Montessori Method. One can speak of a true group only when each of its members feels free enough to be himself, while at the same

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time adjusting his own freedom for the sake of the general welfare. It is in this search for balance between independence and dependence on the group that social behavior is formed. Excessive individual freedom leads to chaos. The excessive uniformity imposed by adults leads to impersonal conformism or rebellion. " (LIMA, 2019, p.15). The child understands and defines himself based on what he interacts with in a greater search for learning, thus creating a mental state of absorption of the content already really learned and consolidated.

Montessori created a range of materials, which she called "materialized abstractions", as they contain playful and didactic characteristics, but are different from toys and pedagogical material. Much more than elaborating the pieces, he created criteria for their construction, which allows the continuity of creations by his followers. Human ingenuity creates new needs, and if the "Montessori materials" were restricted to those made by Montessori, his educational system would run serious risks of inadequacy over time. Thinking and creating materials is a requirement of the grouped room, instruments that are coherent with the group that is being worked with, with the culture where the room is inserted and with social and individual needs. " (LIMA, 2019, p.18)

The issue of content always provokes controversy, because in most Brazilian and foreign educational networks polyvalence is admitted in part of the elementary course – in Brazil Elementary I or the so-called initial grades, first to fifth grade. The licensed teacher already has his characteristic in his name, he obtains a "license" to teach, although his training has been restricted to the teaching practice. The vast majority of undergraduate courses last one semester and leave something to be desired in the construction of a teaching way of thinking. (LIMA, 2019, p.21)

The use of games and play in the classroom can help children explore the world around them, build new knowledge and motivate themselves for their learning. It is important to remember, however, that these games and games should be incorporated into the school routine, treated not as a form of relaxation, recreation, where the child's energies are simply spent, but as a source of knowledge, of aid to the learning of contents, where children find different possibilities of interpreting and interacting with people, objects, cultures, knowledge, emotions, among other issues (KISHIMOTO, 2006, p. 10).

Piaget's theory of development and learning highlights the importance of the constructive character of play in the child's cognitive development. According to Piaget (1971), "there are three basic forms of playful activity that characterize the evolution of play

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in the child, according to the stage of development in which they appear: Sensorimotor Exercise Games, Symbolic Game and Rules Games ".

In the scenario in which these studies are being carried out, the last type of game is addressed in which the pedagogical proposals carried out are contextualized. Rule games are sensory-motor combinations (races, ball games) or intellectual combinations (cards, chess) in which there is competition between individuals (without which the rule would be useless) and regulated either by a code transmitted from generation to generation, or by momentary agreements. (PIAGET, 1976, p. 75).

The game as a pedagogical resource should be considered taking into account: the child's mental age, motivations, execution time, place of performance, items to be worked on in the activity and a set of predefined guidelines to be executed.

In our experiment, the time factor is very important. The child's interest time is very short in relation to the content that is absorbed in practice. In the same way that a motivating interest arises, it also disperses easily. So it is necessary that the Montessori material activity can be carried out in the technological environment in order to be used in all its integrity and student motivation.

Mobile learning is an emerging pattern that brings together three paradigms that are in high demand by the current generation of students: flexible learning model; pedagogical standard supported by wireless technological devices; guidelines aimed essentially at student-centered learning. (WOLYNEC, 2010, p. 1).

Playful classes must be well designed, with defined guidelines and specific objectives. If the teacher only "plays" with these students, he will not transmit content and possibly lose the direction of the class. Intellectual activity cannot be separated from the total functioning of the organism. The body and intellectual learning are part of a whole, through which the student will understand the environment, exchange information and acquire experiences. Classroom games should serve as guidance for behavioral postures, for example. We play by teaching values and, afterwards, this quieter moment is used to explain the content that we will study in this class and the relationship between this and the previous game. The student relates, sets up schemes, forming his own files, which as they develop, become more generalized and more mature. (ROLOFF, 2019, p. 4)

The student is evaluated through an "evaluation worksheet", that is, it is through notes and observations that the teacher monitors and records the student's development (Figure 6). The proof that the work is flowing lies in the relationship with the school activities

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and behavior of the children/young people, their happiness, maturity, kindness, the taste for learning, and the level of the work. (ESCOLA, 2019, p. 17)

Mathematics already naturally has a high amount of symbology and quantifiers. In this way, the introduction of geometric concepts enriches the understanding and interpretation of objects, and three-dimensional and two-dimensional aspects can be worked on. The interesting thing is to be able to work on the sense of touch to 'feel' the volume of objects. Thus, the child experiences touch in the sense of the space occupied by the object, and in digital activity, the transformation in the plane of that same object. Leaving the 3D view and entering the 2D plan.

Teach your child simple math concepts through games and hands-on learning materials. Learning to count by rote memorization is the easiest activity to perform in your daily life. (SELDIN, 2018, p.188)

Based on what is intended and the educator's attitude towards the child: "to create conditions that would allow children to manifest their actions according to their internal needs; He scientifically analyzed the child's personality, his ability to experience the possibilities of his psychic and intellectual development, his nature and the period of the absorbing mind. ”

With the children in the classroom using the material "Solid Fittings", it was proposed to use the initial concepts of geometric shapes in a proactive activity of execution. Based on synesthetic learning of the senses. The activity elaborated (Figure 5) was conceived and carried out on the premises of Colégio Nossa Senhora das Dores, from June 25 to July 5, 2019 with the regent participation and with the authorization of the coordinator of early childhood education.

According to their theories and experiences, it is important to remember that the focus of Montessori Education is always indirect and never direct, unlike traditional education. The respect of Dr. Montessori for the child's formation, from conception, took care not to interfere directly in his development

Mathematics is developed in the sense of touch, that is, with concrete materials and with distinct and colorful shapes. In the case of the activity proposed in this work, the students are arranged in a circle and seated, interacting with the solid fitting (sensory material) and the environment prepared for the activity. The teacher explains once in a collective way what will be done (how the material will be worked) and from there the students come into contact with the method. The activities are carried out leaving the

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children free to carry out what was proposed. Subsequently, individually, the teacher removes any doubts.

Segundo Montessori (1965, p. 59):

> "When we speak of 'environment,' we refer to the total set of those things which the child can freely choose and handle to satiety, according to his tendencies and impulses of activity. Children have disparate preferences: one is occupied with this while the other is distracted by that, without disagreements occurring."

PROCEDURES

In a first phase of explanation with the children, using the cosmic approach of geometric integration of the world, later the activity of the Montessori practice was followed, as can be seen in Figure 01. The proposed activity was carried out in a class with 17 children, in a standard room, followed by the use of tablets in the laboratory, and the activity was defined and created specifically for the class.

It is important to recognize that the information model worked on in Montessori can be added to a visual approach and based on digital games. One can use games aimed at the student's experiential learning aspect. The proposal of an activity experienced by the game allows learning to be spontaneous and occur in a dynamic way. With this, it allows the student an experience that integrates him with the entire collective in which he is involved. The following sequence of work was adopted:

1. The activity of geometric fittings was developed in the classroom;
2. Carrying out the task adapted to digital resources;
3. Observation of concepts learned through post-digital (written) activity;
4. Development of the sensory aspect of children with complementary tasks.

This digital activity was possible from the construction of the respective work object in virtual format. For this purpose, it was built using Adobe Flash technology (graphic tool for building animations and interactions), where the application for the simulation of the online activity was developed. Later it was inserted into a web portal so that it could be executed on the tablets prepared for the students. New programming-based techniques such as HTML5 and other similar languages that offer graphical availability for different platforms are being tested when necessary.

The interaction between children is important at this time, as it strengthens the bonds of friendship and at the same time, they share the learning moment. From there, with the

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simulation on the devices, it was possible to verify the participation and involvement of the children also in the activity in digital format.

Possible technological strategies of software to be used or even built by those who have this need are presented. One of the tools is the learning of Adobe Flash, currently known as Animate, which is a primarily vector graphics software - although it supports bitmap images and videos - generally used for the creation of interactive animations. These work embedded in a web browser (Figure 07) and also through desktops, cell phones, smartphones, tablets, and televisions.(FLASH, 2019)

Even if the teacher does not have technical knowledge, but wants to provide interactivity and speed, he can request the development of his project to a responsible team that develops information technology applications on a digital platform. If you still prefer to use other tools, you can work with third-party websites that may enable the enrichment of activities with the use of the websites. Websites can be used to be adapted according to the pedagogical and curricular context (e.g., Smartkids, Jogos360, EscolaGames, among others).

CONSIDERATIONS

What happens in practice is a junction between Montessori and technology. There is no vision of outdated or unnecessary innovation. Which could lead to a discussion about a superficial class in terms of content. It is understood in this way that one methodology completes the other.

Based on this type of proposal, it was possible, through planning and an exploratory approach, to make use of the instruments that the school offered, so that what was initially projected was obtained. With this, it was realized that when the contents are worked on by more than one approach, the teacher's work becomes more complete. Even though it was a work developed in a 'laboratory-exploratory' way, it was possible to observe and prove, through the time tables and tasks, how much the children were involved. In addition to being a professionally enriching and collaborative process.

As an initial source of study, it is verified in (Figure 8), the average times between the proposed activities, by different means. It is perceived that with each new activity on this theme, there is an absorption/apprehension of knowledge more quickly and with fundamental concepts, deeply absorbed. The activities within the Montessori Model require a longer preparation time, but the execution is very fast if we consider the execution by

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each child, in their cognitive development. This measurement, or metric, considers a time set by the teacher from the moment the activity is distributed to the students in the classroom; in the digital laboratory, once the activity is on "screen", each child receives a "START" instruction and from there they begin to perform it. A predetermined time pattern is not required of the child. As they finish, the time is completed and entered in the comparative table presented. (Figure 9)

Certainly one of the benefits of using the Montessori methodology combined with the world of information technology is the sum of the set of good classroom practices that promote learning in the student. A much more universal and cosmic vision is required of the professional educator, contextualizing it with the daily lives of children, and in a more complete way in the set of school routines.

Future studies based on this proposal evolve in a detailed approach to the use of other devices, being used together with the Montessori material, using virtual objects, in the elaboration of the concepts of numbers, algorithms of mathematical operations and recognition of orders and magnitudes.

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ILLUSTRATIONS

Figure 01 – Students in Montessori activity using geometric fittings

Figure 02 – Representation of the iron fittings (Hand training)

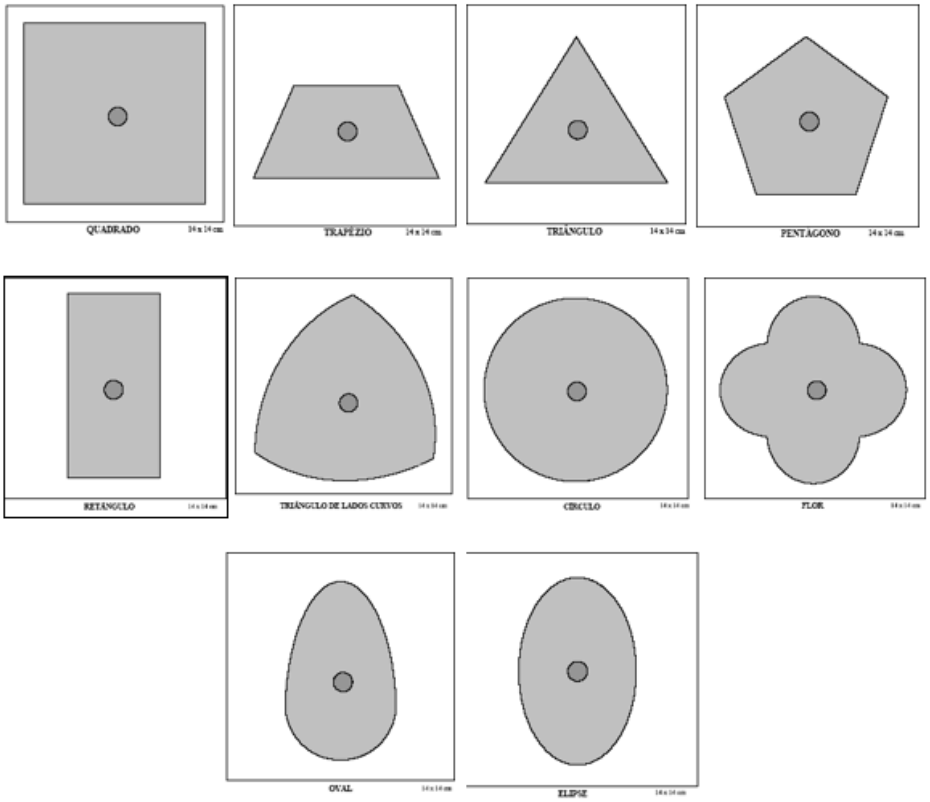

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Figure 03: Development of articulated and graphic language – Practical Scheme

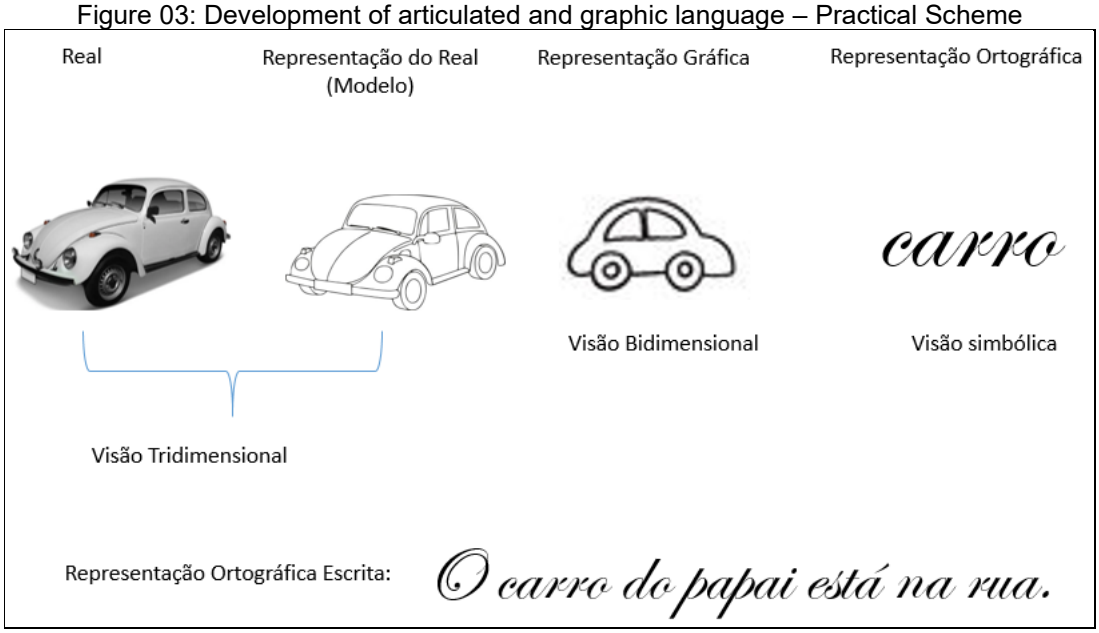

Figure 04 - Development of articulated and graphic language – Synthetic diagram

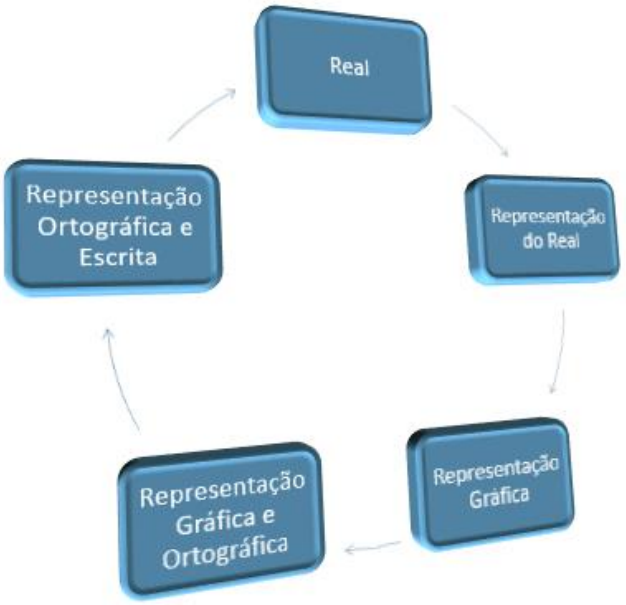

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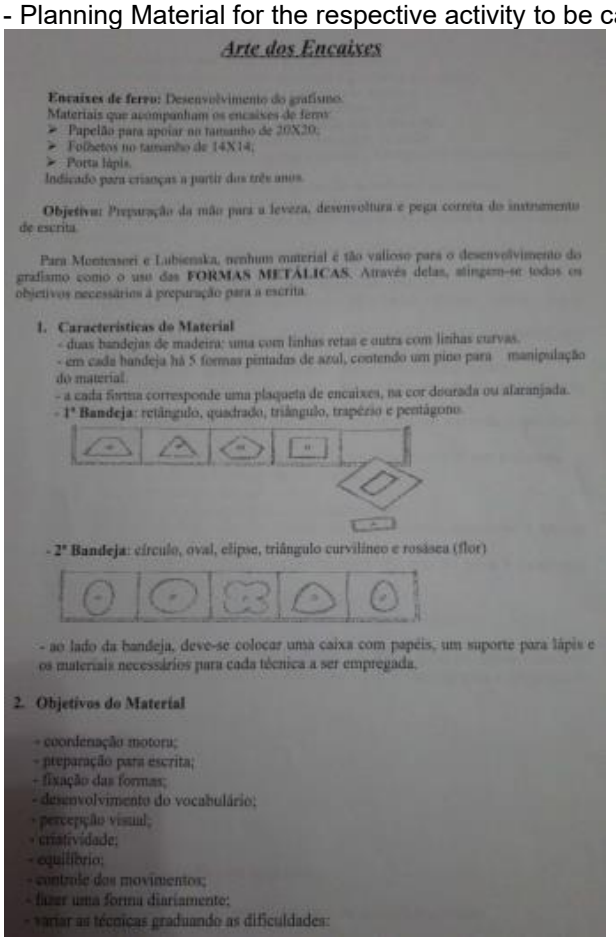
Figure 05 - Planning Material for the respective activity to be carried out



Arte dos Encaixes

Encaixes de ferro: Desenvolvimento do grafismo.
Materiais que acompanham os encaixes de ferro:
- Papelão para apoiar no tamanho de 20X20;
- Folhetos no tamanho de 14X14;
- Porta lápis.

Indicado para crianças a partir dos três anos.

Objetivo: Preparação da mão para a leveza, desenvoltura e pega correta do instrumento de escrita.

Para Montessori e Lubienska, nenhum material é tão valioso para o desenvolvimento do grafismo como o uso das **FORMAS METÁLICAS**. Através delas, atingem-se todos os objetivos necessários à preparação para a escrita.

1. **Características do Material**
   - duas bandejas de madeira: uma com linhas retas e outra com linhas curvas.
   - em cada bandeja há 5 formas pintadas de azul, contendo um pino para manipulação do material.
   - a cada forma corresponde uma plaqueta de encaixes, na cor dourada ou alaranjada.
   - **1ª Bandeja**: retângulo, quadrado, triângulo, trapézio e pentágono.

- **2ª Bandeja**: círculo, oval, elipse, triângulo curvilíneo e rosácea (flor)

- ao lado da bandeja, deve-se colocar uma caixa com papéis, um suporte para lápis e os materiais necessários para cada técnica a ser empregada.

2. **Objetivos do Material**

- coordenação motora;
- preparação para escrita;
- fixação das formas;
- desenvolvimento do vocabulário;
- percepção visual;
- criatividade;
- equilíbrio;
- controle dos movimentos;
- fazer uma forma diariamente;
- variar as técnicas graduando as dificuldades.

Figure 06 - School Performance Evaluation

MATEMÁTICA	*1º bimestre*	*2º bimestre*	*3º bimestre*	*4º bimestre*
Reconhece e escreve o traçado dos numerais corretamente.	EP	EP	S	S
Faz a relação e registra número quantidadè.	EP	S	S	S
Vivencia com interesse as atividades concretas e sensoriais (relatando a noção de cores, sabores, odores, texturas, temperatura e valores).	EP	EP	S	S
Compara e ordena coleções pela quantidade de elementos (noção de igualdade e diferença de conjunto)	EP	S	S	S
Reconhece e nomeia as formas geométricas (quadrado, retângulo, triângulo e círculo)	EP	EP	EP	EP
Utiliza vocabulário específico da disciplina (maior/menor, alto/baixo, grande/ pequeno, leve/ pesado e outros)	EP	EP	S	S
É capaz de reconhecer e nomear os sólidos geométricos (cubo, prisma, cilindro, esfera, cone, pirâmide e ovóide)	EP	EP	EP	EP

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Figure 07- Virtual activity proposed for the class in the laboratory (Source: https://www.aprendizagemaberta.com.br/infantil/content/full_screen.php?url=https://www.universoneo.com.br/ativ//games/sombra01.swf&id=95)

Figure 08-A-Comparison of the execution time of activities in the classroom

Estudante	Sala Montessori
Criança1	01:20
Criança2	01:40
Criança3	00:50
Criança4	01:50
Criança5	00:50
Criança6	01:05
Criança7	01:30
Criança8	01:25
Criança9	02:00
Criança10	02:40
Criança11	02:20
Criança12	01:40
Criança13	01:30
Criança14	02:00
Criança15	02:00
Criança16	01:40
Criança17	01:40

Figure 09 - Photos of the children in activities in the technology laboratory accompanied by the teacher