Development of an investigative teaching sequence as learning tools of the anatomy and physiology content of the human nervous system

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ABSTRACT

The search for quality in education involves the study, analysis and reflection of pedagogical strategies such as the Sequence of Teaching by Inquiry (SEI), leading the student to the critical development of the contents worked. This work aims at the application of a CES focused on the teaching and learning of the content of the Human Nervous System. Didactic strategies and educational games are methods that can involve the student in a new learning experience and that have been increasingly used in different areas of Education, favoring teaching compared to the more traditional method. This work was carried out with students of the 2nd year of a high school, located in the municipality of Tianguá, where semi-structured questionnaires were applied, dynamics, classes and a sequence of teaching by investigation (SEI) were carried out in the search for a greater interaction of students with the content and the promotion of a more interesting and investigative study. It is worth noting that the content of Anatomy and Physiology of the Human Nervous System is considered complex for students, with regard to the relationship between structure and functioning, and that the search for resources that promote learning is important. In addition, the questionnaires were analyzed in order to identify whether there was progress in the students' learning.

Keywords: Learning lab, Investigative teaching sequence, Learning tool, Nervous system.

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INTRODUCTION

To meet the learning needs of students, due to the COVID-19 pandemic, many schools have adopted the remote teaching modality. A new reality was found by the teachers, with different demands when compared to face-to-face teaching, especially in the pedagogical part. The moment is challenging, and why not say innovative, as there has been an increase in the use of digital technologies in order to improve teaching in this modality. The Objective, in remote teaching, is an alternative to offer students access to content that would be presented in person. (RONDINI, *et al*, 2020).

Thus, as a result of the pandemic, emergency remote teaching has become the main alternative for educational institutions at all levels of education, characterized as a temporary change in crisis circumstances.

It is not easy to make classes more attractive and hold students' attention to the content worked, or to encourage students to understand what is taught in the classroom. In the search for new strategies where the student finds himself as a participatory individual and trainer of his conceptions, the Sequence of Teaching by Inquiry (SEI) emerges as systematized teaching practices, relating the knowledge that the student has with what he will learn (CARVALHO, 2013).

It is understood that the teaching of Human Anatomy is recognized by the need for memorization, which needs to be reevaluated because it should be focused on the development of competencies that facilitate meaningful and continuous learning, with the teacher as a mediator of this process (RAMOS; TEIXEIRA; BELÉM, 2020).

To this end, we can emphasize the importance of using playful activities, such as games, for students to learn something in a more fun and reflective way. The educational game is a playful activity that offers the teacher the opportunity to work and reinforce the content, promoting a more effective and active participation of the student and always seeking the best performance of teaching and learning (PARREIRA JÚNIOR, 2016).

Educational games and SEI are tools that guide innovative paths in the search for investigative teaching that can and should be used by teachers. It is necessary that the teacher seeks to make his classes dynamic and attractive, so that the student understands it as a moment in which he is learning and living something new, not separated from his reality. It is essential to use activities that deviate from the traditional scheme of theoretical classes, among these activities can be used those that have a playful character (KNECHTEL; BRANCALHÃO, 2008).

Therefore, a more expressive teaching for the student should be considered, even considering the different characteristics present in each being, both in emotional and cognitive matters. Learning is more meaningful as new content is incorporated into the student's knowledge structures and acquires meaning for them from the relationship with their prior knowledge (KLAUSEN, 2015).

Lectures, which are too teacher-centered, do not contribute to students being protagonists of learning, not considering previous conceptions, do not enable interactions between subject and object of knowledge, nor interaction between peers. It is necessary for teachers to reflect on their practice and develop didactic strategies that allow this displacement, this change of function (SCARPA; CAMPOS, 2018).

This work aims to develop a Sequence of Teaching by Inquiry (SEI), making the classroom an investigative, dynamic and reflective environment on the part of the students, in order to favor scientific literacy and the understanding of the contents worked for the Human Nervous System, since it is usually presented in a complex and traditional way.

METHODOLOGY

This research had an investigative character with a quantitative and qualitative approach, accompanied by the application of semi-structured questionnaires, where the interviewee was free to use his words on the subject addressed, allowing the grouping of the statements into categories of information, having as advantages details of their conceptions, having the questionnaires and the analysis criteria validated by the qualification team having, Also, considering the experience of the applicator.

The research was carried out in a Full-Time High School, located in the urban area of the city of Tianguá – CE. The has been authorized by the Ethics Council of the Centro Universitário Inta – UNINTA of the city of Sobral - CE, with opinion nº: 4.776.699.

The research population belonged to the full-time classes of the 2nd year of high school, which totaled 146 students enrolled in the grade, but the sample consisted of only 32 students, considering the remote access to classes synchronously, once a week, lasting 50 minutes, which is one of the inclusion criteria. in addition to the signing of the Free and Informed Consent Form (TALE) and the Free and Informed Consent Form (ICF) that were made available to the students for the appropriate signatures, respecting the social distancing guidelines guided by the Government of the State of Ceará. The students were instructed to be very comfortable about filling out and signing the terms or not, so as not to feel pressured to participate in the research.

Students who did not have access to remote (synchronous) moments were excluded from the research due to constant internet connection problems. However, the students who fit this profile and who could not participate in the research were not harmed in terms of the content worked, because with the help of classmates and the school's support team, they had access to the information with recorded classes and the delivery of teaching materials to their homes.

OVERVIEW OF METHODOLOGICAL ACTIONS

The activities carried out remotely took place in seven weeks, considering that in each week there was 1 (one) hour of 50-minute class and were as follows: Application of a motivational video, guiding and problematizing questions, asynchronous moment in the *WhatsApp application* with suggestion of materials for study and completion of questionnaires for follow-up, suggestion for the elaboration of models, expository and dialogued class, resumption of the hypotheses elaborated by the students with analysis and corrections made by the students, application of questionnaire and the card game *Fisiocode* in the remote modality.

In the first motivational moment, a video was made available to the students with parts of the film known as "Lucy", by Luc Besson, Universal Pictures, (2004). In addition, guiding questions and three problematizations were made available for the collection of hypotheses related to the human nervous system (Appendix A). To continue the research, in a second moment, the students were instructed to carry out research on the functioning of the nervous system and its structures, which occurred asynchronously with the use of the WhatsApp messaging application; the students had total freedom to research and answer their questions. During the asynchronous moment, study materials were made available with guiding questions to follow the students' studies (Appendix B). In a third moment, remote meeting, a part of the content of anatomy and physiology of the human nervous system was addressed, and the students were instructed to produce didactic models, models for example, representing the neuron and the reflex arc, in addition to the application of a diagnostic questionnaire (Appendix C), used to accompany the students in their asynchronous activities. In the fourth moment of the remote meeting, contents related to Anatomy and Physiology of the Human Nervous System were worked on and the participants were asked to make a resumption of hypotheses analyzing what they wrote initially so that, later, a learning gain could be verified.

DATA ANALYSIS

The data were presented and analyzed in the form of tables and graphs built with *Excel* 2019. Qualitative analyses were performed with the analysis of the hypotheses of the problematizations, the guiding questions, the questions of the asynchronous moment and the diagnostic questionnaire. The student registrations took place with the use of *Google forms*, with the links made available in the *Google Meet* chat, during remote or synchronous classes and in the *WhatsApp group*.

RESULTS AND DISCUSSION

ANALYSIS OF THE HYPOTHESES OF THE PROBLEMATIZATIONS

The research began with the sensitization of the students in a presentation of excerpts from the movie "Lucy", the character has contact with a certain chemical substance and ends up

developing powers linked to the development of the human mind, as her brain is able to perform numerous actions, highlighting the increase in intelligence, as she starts to use more than 10% of her brain, highlighting the development and importance of the human nervous system. After the moment of motivation, guiding questions and problematizations were sent through a link, from *google forms*, attached to the chat of the class held on *Google Meet.* This moment was very important because with the *forms* tool it was possible to follow the completion of the form by the students immediately.

The problematizing questions, presented to the students, were carried out through three situations below that presented drawings related to them.

1. Have you ever hit your elbow and felt that shock? Do we have any electrical current running in our body?
2. Sometimes we "pull" our arm or hand when we unknowingly touch hot or sharp places, how can this happen without us being prepared for it?
3. In some MMA fights, we see some fighters fainting at a certain point in the fight. What could have happened?

During this first moment, the students elaborated their hypotheses in the form *Forms* available in the chat *Google Meet*, where the teacher was careful to encourage and praise the students' participation. It is noteworthy that the students had in the projection of the screen of the *Google Meet* the presentation of the questions, making it even easier to visualize the figures and questions present in the questionnaire.

Teaching by Inquiry, especially in Science classes, represents a possibility of overcoming the propaedeutic education model, that is, a school culture historically centered on the transmission of scientific content, disconnected from the lives of students (SILVA et al., 2022). According to Carvalho (2018), two concepts are essential for the teacher to establish investigative situations in the classroom, namely: problem development and intellectual freedom, that is, "creating conditions in the classroom for students to be able to participate without fear of making mistakes".

Authors such as Silva et al. (2022), using the same theme, developed manipulative experiments with didactic scripts in the application of the SEI, in order to gather statements of the concrete situation on the Density of Bodies, and were later evaluated. In general, the development of the SEI allowed us to identify, in the students' statements, voices of the school scientific culture.

ANALYSIS OF THE REPORTS OF THE FIRST PROBLEMATIZATION

For an analysis of the first problematization about the existence or not of electric current working in our body, we can organize this moment into categories, according to the students' hypotheses, aiming at a better qualitative analysis.

The first category is the report of the ***presence of electric current in the human body***, the second category is the ***understanding of not having, or knowing, what electric current is in the human body*** and, finally, ***distorted explanations or explanations with apparent research by the participant.***

AS FOR THE PARTICIPANTS WHO CONSIDERED THE PRESENCE OF ELECTRIC CURRENT IN THE HUMAN BODY

Let's look at some of the hypotheses, *ipsis litteris,* described by the participants.

> **Participant 4 –** "*Yes, sometimes I feel some shock and we can have an electric current in our body*."
>
> **Participant 7 –** "*yes and very... I think we do have electrical currents in our body that give this lack of pain or shock sensation I think NN I have CTZAA*"

It is identified, in most cases, that students understand the existence of electric current in the human body, even if they do not make a more elaborate explanation at that time. Based on the result, it was observed that the students had a very concrete idea that the human body was strongly influenced by electric currents, which was explained by their own empirical experiences. Another interesting factor is that the students had the ability to explain phenomena related to electric current on a personal and external level, such as the danger that strong electric currents can cause damage.

Taking into account what has been mentioned, it is important to emphasize that teaching by inquiry seeks to propose actions that allow the construction of explanatory models based on interactions between people and/or study materials. According to Piaget (1975), the process of knowledge construction is characterized by the search for equilibrium, which occurs when we are faced with a new situation, for which we do not have an explanatory model, that is, an existing structure of understanding. Therefore, the student will go through imbalance, a temporary moment of adaptation to the presented reality that culminates in a new balance, that is, in a new understanding of reality.

AS FOR THE PARTICIPANTS WHO UNDERSTAND THAT *THERE IS NOT, OR KNOWS, WHAT IS AN ELECTRIC CURRENT IN THE HUMAN BODY*

Let's see, below, some of the hypotheses of the participants described *ipsis litteris,* who did not present clear arguments about electric current in the human body. **Participant 2 –** "*not an electric current but a flow of the nervous system that can give us involuntary impulses of "energy*". 🐕🦺👌 "

> **Participant 20 –** "*Should the psychological shock because it is a muscular vein that can cause this*"

It can be seen from these statements that some participants present a distant understanding of a more scientific explanation, or even with basic concepts. In view of this, it is a consensus that we all learn without truly worrying about the nature of the process and we all teach without seeking a theoretical support that explains the teaching-learning process.

In the context of learning theories, it is evident that they arose for the reason highlighted by Bigge (1977), in which "man not only wanted to learn, but also often his curiosity impelled him to try to learn how one learns". Thus, in a behaviorist perspective of learning, the student is passive, uncritical and a mere reproducer of information and tasks. The student does not develop his creativity and, although individual rhythms can be respected, not enough emphasis is given to his intrinsic curiosity and motivation. The student may even run the risk of becoming apathetic because he or she is excessively dependent on the teacher.

AS FOR PARTICIPANTS WHO PRESENTED DISTORTED EXPLANATIONS OR WITH APPARENT RESEARCH ON ELECTRIC CURRENT IN THE HUMAN BODY

Finally, we verified, below, the hypotheses of the students who presented less clear statements about electric current or with research expressions at the beginning of this SEI, see below the explanations described *ipsis litteris.*

> **Participant 30 –** "*This happens because of the nerves we have in our arms, their function is to transmit messages such as pain to the brain, etc. when we hit the elbow, stimulating the ulnar nerve, which causes a discharge and generates false information about pain*."
>
> **Participant 31 –** "*Paresthesia, which can also simulate stings, burns and other sensations*"

In the reports, it is verified that the participants carried out quick searches on the internet to formulate their hypotheses to consider the presence of electrical correction in the human body. However, we can consider the action of research or consultations as being important, even if it is in the formulation of hypotheses. The participants' concern to provide information shows interest in collaborating with the research.

For a quantitative view, we can summarize this first moment in terms of the percentage of participants within each criterion elaborated by the author in Table 1 below.

From the data analyzed, it was observed that the construction of concepts and theories gains quality according to the deepening of knowledge. Thus, the formulation of hypotheses also gains contours of better structuring as the cycle of formulation-analysis-refutation-proof becomes more common and recurrent. Authors such as Lawson and Toulmim (Locatelli & Carvalho, 2007) present forms and patterns to analyze the structure of hypothetical-deductive thinking, especially in the

elaboration of the argument in science classes. On the other hand, in a broader context, Lakatos and Marconi (2003) present aspects related to the structure of hypotheses and their characteristics according to the structure formulated. The search for the qualitative advancement of argumentative constructions in science classes necessarily requires a modification of the structure of the class, seeking approaches that contribute to such transformation.

Table 1. Quantitative analysis of the criteria of the first problematization

Established criteria of the first problematization	**% criteria**
Presence of electric current in the human body	*62,5%*
Understanding of not having, or knowing, what electric current is in the human body	*18,8%*
Distorted explanations or explanations with apparent research from the participant	*18,7%*

Source: Author

The table shows the percentages of the participants' perceptions regarding the criteria established about the electrical impulse of the human nervous system from the first problematization of the participants.

ANALYSIS OF THE REPORTS OF THE SECOND PROBLEMATIZATION

The second hypothesis, presented to the students, seeks to understand the action of the reflex act by the human nervous system.

The participants answered the problem situation with their previous knowledge. To analyze this problematization about the involuntary response of the reflex act of the human body, we can elaborate three categories according to the students' hypotheses, aiming at a qualitative analysis.

The first category, for this second situation, is related to the student's report on the ***existence of a defense control by the human reflex,*** the second category is a ***non-reflex response of the human organism***, and the third category is for the non-reflex ***response of the human reflex.***

Cruz (2019), with the general objective of discussing the potential of an investigative teaching sequence on the theme of Sense Organs, found that the use of semiotic resources, intentionally inserted in the activities of the sequence, enhanced the investigation process, as they triggered investigative aspects such as problematizations, investigations to test hypotheses and helped in the construction of arguments. Thus, it was observed that the teaching sequence developed has investigative potential that collaborates with the learning of the theme and that the semiotic modes contributed to its development.

AS FOR THE REPORTS ABOUT THE EXISTENCE OF A DEFENSE CONTROL BY THE HUMAN REFLEX

Below are some hypotheses of the participants, *ipsis litteris,* who expressed an idea of defense that comes from a reflex act.

Participant 1 – "*this happened because our nervous system activates a function in our brain that causes us to have certain reflexes at the same time*"

Participant 7 – "*Our nervous system alerts us that we are in danger and sends a "message to the brain" to get out or stop doing something that puts us in danger*."

Participant 16 – "*This occurs through reflexes commanded by our brain, so we pull our hand when we feel something hot, for example*"

Taking into account the data analyzed, it was observed that the students' explanations were incorrect, in some aspects, they were only incomplete or partial. Based on this, it is important for the teacher to plan the teaching in such a way that students can become aware of their ability to understand that some of their explanations can be complemented by others (Solsona et al., 2003).

AS FOR THE REPORTS OF THE PARTICIPANTS WHO REFLECTED ON A NON-REFLEX RESPONSE OF THE HUMAN ORGANISM

Some reports from the students, *ipsis litteris,* who understood that there were other means of rapid response to something that could threaten the human body.

Participant 2 – "*The skin refuses when it touches something that can burn the skin*"

Participant 23 – "*At the same time we feel a thermal shock and we get scared when we touch it*."

For some students, the available situation has as its response a non-reflex action, many understand it as a local or punctual action of the human nervous system. The students' explanations were not erroneous, but only incomplete or partial, so the teaching should not reflect the human organism in such a way as to favor the relationship of complementarity of the explanations.

Students' recognition of their own ideas has been pointed out as an important factor for learning scientific concepts. In the model of Posner et al. (1982), one of the conditions for conceptual change is related to the learner's dissatisfaction with his or her existing conceptions.

AS FOR THE REPORTS OF THE PARTICIPANTS WHO DID NOT SHOW UNDERSTANDING OF THE HUMAN REFLEX

Finally, some explanations of the participants, *ipsis litteris,* who did not present an understanding of the human reflex act.

Participant 11 – "*Sometimes I don't think where I put my hands because I don't pay attention*"

Participant 21 – "*It can cause an astonishment in our bone system*"

When analyzing the students' hypotheses, the lack of understanding about the human reflex act was verified, or the absence of a more explanatory answer to the second problematization of the questionnaire.

Table 2 shows a quantitative analysis of the established criteria regarding the hypotheses elaborated by the participants in the second problematization of the human reflex act.

Table 2. Quantitative analysis of the criteria of the second problematization

Criteria established for the second problematization	% criteria
Existence of a human reflex defense control	*50%*
Non-reflex response of the human organism	*21,9%*
They did not report understanding of the human reflex	*28,1%*

Source: Author

The table shows the percentages of the participants' perceptions regarding the human reflex act of the second problematization, it is identified that only 50% of the students present an idea of defense of the human organism in the face of a situation where there is the action of the human reflex act.

With regard to the nervous system, the focus of teaching is on the memorization of anatomical structures and functions (RODRIGUEZ, 2003). This shows how challenging it has been to propose ways to articulate the epistemic and social domains of scientific knowledge to its conceptual domain (DUSCHL, 2008), especially in contents whose emphasis is memorization. Authors such as Matos et al. (2021) developed a set of materials organized from a sequence of classes involving the investigation of a phenomenon related to the nervous system of the human being, the pain of the "phantom limb", in which the proposal was to make such knowledge be articulated seeking the engagement of students in practices such as: elaboration of hypotheses, interpretation of data, argumentation among peers and construction of conclusions.

ANALYSIS OF THE REPORTS OF THE THIRD PROBLEMATIZATION

In the third problematization we find hypotheses elaborated by the students and described in *Google forms* where the problem situation asks about fainting of people who suffer blows to the head and its consequences on the human nervous system.

Considering the previous knowledge presented by the students in the third problematization, a teaching strategy was sought to connect the theoretical activities to the applicability of situations that require reasoning in favor of solving problem situations, inciting the curiosity of the students, and, mainly, using their primary knowledge as foundations for the construction of new knowledge. Carvalho (2016) emphasizes that the "sequence of activities that brings a specific theme, where each planned activity seeks the interaction of the student's previous knowledge with the new knowledge", enables a foundation on the already existing knowledge, resulting in scientific knowledge.

Thus, three categories were elaborated for this problem situation. The first category is considered that the student has a ***perception of alteration in the nervous system due to a brain concussion***, in the second criterion ***explanations about fainting not linked to brain concussion*** were considered and as a last criterion the students presented ***hypotheses without information about brain concussion***.

AS FOR THE STUDENTS' NARRATIVES ABOUT THE STUDENTS' PERCEPTION OF CHANGES IN THE NERVOUS SYSTEM CAUSED BY A BRAIN CONCUSSION

The following are the students' narratives, *ipsis litteris,* alluding to alterations in the nervous system due to a brain concussion, let's look at some of these hypotheses.

> **Participant 5 –** "*You may have hit one side of the brain where the body's nervous system is and the blow may be very strong and you may faint, others may even lose the movement of the leg, or cause failure in some part of the body*"
>
> **Participant 12 –** "*The wrestler may have applied the blow to his opponent, causing him to lose his senses and just fainting and causing a brain injury*."

It is possible to observe, in the hypotheses, that the students perceive some alteration in the human nervous system, due to a blow to the head. Even if they did not use a more elaborate language, their hypotheses allow this understanding. Table 3 shows some words referring to the situation, such as collapse or fainting, for example.

The true emphasis of the student as a constructor of his own knowledge arises with the cognitive-constructivist theories of learning, which imprint a determinant character on the students' previous conceptions. This cognitive-constructivist perspective of learning is due to the Piagetian model and that of Ausubel et al. (1981), in which learning to think and learning to learn are taken into account, and not with the attainment of observable behaviors.

AS FOR THE STUDENTS' NARRATIVES THAT PRESENT EXPLANATIONS ABOUT FAINTING SPELLS NOT LINKED TO BRAIN CONCUSSION

Below are arguments from participants, *ipsis litteris,* who presented information about fainting that has no direct link to cerebral concussion.

> **Participant 11 –** "*The celebrus shakes causing dizziness, or the ear fluid (I don't know what it calls it) is stirred causing an imbalance*"
>
> **Participant 32 –** "*Occur when blood pressure drops and there is no oxygen*"

The students' hypotheses present information linked to possible fainting, with no link to brain concussion. The interesting thing is that the students' hypotheses, for this problematization, the students' attempt to explain fainting with technical arguments, from the baggage of knowledge

acquired by them throughout their school life. However, it is observed that it is necessary to make students aware of their findings about the problem studied, only then would they be able to understand that some of their explanations can be complemented by others (Solsona et al., 2003).

AS FOR THE NARRATIVES OF STUDENTS WITHOUT INFORMATION ABOUT BRAIN CONCUSSION,

Some participants demonstrated that they did not have knowledge in the arguments described on the subject, which is observed, *ipsis litteris,* down:

Participant 9 – "*Eli can date a blow from the head*"

Participant 26 – "*I don't know*"

Participant 28 – "*By the blows of rivals*"

In these hypotheses, a small part of the participating students lacked information about brain concussion.

Below is table 3, which presents a quantitative analysis of the established criteria of the hypotheses described by the students focused on the third problematization.

Table 3. Quantitative analysis of the criteria of the third problematization

Criteria established for the third problematization	% criteria
Perception of a change in the nervous system due to a brain concussion	*71,9%*
Explanations of fainting spells not linked to brain concussion	*15,6%*
Hypotheses without information on brain concussion	*12,5%*

Source: Author

In the table, we can see the percentages of the participants' perceptions of brain concussion in the third problem. It can be seen that 71.9% of the students attributed the fainting, linked to blows to the head, to changes in the nervous system.

It is important to emphasize that students' prior knowledge should be considered in the implementation of educational practices, with the purpose of contributing to the construction of new knowledge, promoting the transformation and improvement of the quality of learning, including in public education (SANTOS; ROSSI, 2020).

After the remote moment, where the motivation and application of the questionnaire containing the problematizations and guiding questions took place, the students were instructed to research about the AFSNH.

ANALYSIS OF THE GUIDING QUESTIONS

For the asynchronous moment, a WhatsApp group was created so that students had access to materials to assist in the research, at this time it was advised that students carry out their studies on AFSNH through websites, books and videos, according to the possibilities of access of each one. To

assist the participants, two links were forwarded, with content on the theme, with access to *Google Forms* with reading material, videos and guiding questions.

This material was suggested to assist the research by the participants and that they would be comfortable using the material according to their needs.

ANALYSIS OF THE QUESTIONS USED TO MONITOR THE PARTICIPANTS' STUDIES

The students who accessed the material and answered the questions had an understanding in part of the basic concepts presented in the material as they answered the questions. The students' questions and answers, *ipsis litteris*, are listed below:

First Google Forms Link Questions

1. What did you understand about synapse?
2. Explain in your own words what action potential is?

For a better follow-up of the study routine of the participants, listed below are some of the answers, *ipsis litteris,* on the first question that seeks the meaning of synapse nervosa.

> **Participant 11 –** "*The synapse is an exchange of chemical substance of neurons that when feeling something, emotion, touch or smell, etc., one neuron transmits these substances to the other neuron without touching itself.*"
>
> **Participant 26 –** "*The synapse is a small region between a neuron and another cell through which nerve impulses are transmitted.*"
>
> **Participant 18 –** "*Synapse is the cell that receives the most information about movement that passes from one to another with the electrical impulse that is very important i can cause a lot of harm if it is affected.*"

It is noticeable that the students demonstrate, in their answers, concepts present in the material sent for research. Some students showed a different understanding of the more technical information, as noted.

In the second question about potential for action, the participants wrote the information below, *ipsis litteris,* as follows:

> **Participant 1 -** "*The nerve impulse (or action potential) is a rapid change in the electrical potential of neuron membranes. ... Generally, the potential for homes is negative, i.e., the outside is more positive than the inside. It is mainly due to the difference in the concentration of sodium (Na+) and potassium (K+) ions inside and outside the cell.*"

Participant 9 - "*In summary, it is when the neuron at rest, which until that moment has a negative charge, receives a stimulus where it reverses its polarity, providing the propagation of the nerve impulse*"

Participant 12 - "*It is an inversion of the membrane potential that runs through the membrane of a cell*"

In this questioning, the vast majority of the students relied on the material and described in a structured, albeit summarized, way, that the action potential is aimed at an alteration of the neuron membrane.

In order to follow the students' study, a second Google Forms link was sent addressing information about nerve stimulus, act and reflex arc.

Questions from the second *Google Forms link*

1. Can you explain what stimulus is and give examples?
2. Explain in your own words what is reflex act and reflex arc?
3. What can cause people to faint when they are hit on the head? Read the material and watch the video. Write in your own words what you understood.

Listed below are some answers, *ipsis litteris,* of the students of the first question listed above about the understanding of what the nerve stimulus is.

Participant 7 – *"I didn't understand it very well, but I think it's the change that can be seen in the environments inside and outside."*

Participant 8 – *"Stimuli by talking roughly are felt, a person approaches the high temperature of a candle generating a kind of "electrical discharge" in the brain alerting the body how dangerous it can be to approach"*

Participant 10 – *"These are physical or chemical signals that give rise to a reaction in the body. E.g. temperature and pressure variation; Ex: When people change it into something and end up getting burned;"*

Some students have found it difficult to understand the meaning of nerve stimulus, understanding it as changes in the organism or trying to explain it through examples.

In the second question, the students were approached with information about the act and reflex arc, let's see the answers, *ipsis litteris,* below:

Participant 2 – *"The movement performed is called a reflex act, or just a reflex. The path taken by the nerve impulse, which led to the execution of the movement, is the reflex arc."*

Participant 4 – *"Reflex act is a response that your body gives immediately to protect itself, such as when we pick up something hot. Reflex arc is related to the unconscious immediate response of the individual through the excitation of a nerve."*

Participant 9 – *"Act is what you do and the bow is the path that the stimulus will take"*

Participant 12 – *"Reflex act: it is when our action is spontaneous, they are actions that our whole body for our own protection. reflex arc: it is an involuntary action, that is, it happens without us even noticing"*

Participant 15 – *"Reflex Act Is When You Have A Certain Response Your Body To Touch A Hot Plate, Step On A Nail And Take Our Hand Or Our Foot Off Quickly. Reflex Arc Is The Action A Person Takes When Touching Something Hot Or Pointy"*

Some students brought the summary ideas of the act and reflex arc correctly. Other participants demonstrated that act and reflex arc would be the same thing, not differentiating the process and structure. The third question seeks the student's knowledge about the causes of a brain concussion. Let's look at some of the explanations below, *ipsis litteris,* given by them.

Participant 3 – "*I think that at the time the person loses consciousness of everything because he touches the core of his head like blood*."

Participant 4 – "*Celebro is responsible for commands sent to the rest of our organs, responsible for memory and etc., when a blow occurs to the head, it generates damage to cells and nerves, thus causing fainting*."

Participant 6 – "*When you get hit on the head, you can develop sequelae such as epilepsy or even lose your memory. Or it can cause by traumas such as falls, or blow to the head, accident ... It should be guided by a neurologist, when the pain is mild, it can be recommended only absolute rest type can not work or heavy activities*."

Participant 10 – "*It occurs when blood pressure drops and there is not enough oxygen in the brain*"

When the students answered the questionnaire, they showed a certain knowledge about the causes of a brain concussion, and recognized the importance of the brain for the activities of the human being. However, some participants pointed the fainting spells to problems in blood pressure.

In the analysis of the guiding questions, it is possible to observe the students' involvement with the study material provided, since *Google Forms* allows the analysis of information and the recording of answers for a qualitative evaluation of the process (MONTEIRO and SANTOS, 2019), in addition to verifying the limitations of students to access materials in the remote teaching modality, especially in the countryside and with low-income students in times of pandemic (NASCIMENTO, *et al*., 2020).

ANALYSIS OF THE DIAGNOSTIC QUESTIONNAIRE AND DIDACTIC MODELS

We resumed the meeting with a remote class highlighting the nerve cell, its functioning and interaction with other nerve cells and the structures that form the nervous system. The remote

moment was important so that doubts could be removed and encourage the participation of students in synchronous and asynchronous moments. The students were instructed to access and answer a semi-structured diagnostic questionnaire (DDQ), which was sent through a link to the *forms* in the *WhatsApp group*.

The QD has information about AFSNH, consisting of five discursive and five objective questions. In this QD, concepts related to the structure of nerve cells and their functionalities, about the functioning of the reflex act and the structure that compose it, as well as some structures of the nervous system, such as the brain, for example, were addressed. The QD aims to accompany a more meaningful learning by addressing important concepts about the Human Nervous System.

DIAGNOSTIC QUESTIONNAIRE (DQ) ANALYSIS

Conducting a questionnaire during the teaching process is important as an evaluation method in order to verify student learning (OLIVEIRA, et al., 2019). The QD has five objective and five subjective questions, as it seeks to address basic concepts about AFSNH. The students' answers were analyzed conceptually. The objective questions are identified as Q1, Q4, Q6, Q8 and Q10, according to the sequence in the QD. Table 4 lists the students' concepts and correct answers.

Table 4. Quantitative analysis of the objective questions of the QD

Issues	Concepts covered	Correct answers (%)
Q1	*Know the name of the nerve cell.*	100%
Q4	*Characterize the structural parts of the nerve cell.*	93,9%
Q6	*Identify the potential for rest.*	57,5%
Q8	*Recognize other parts of the brain.*	100%
Q10	*Distinguishing the parts of the reflex arc*	60,6%

Source: Author

In the first moment of QD analysis, it was noticed that the participants encountered difficulties in the concepts of Q6 and Q10, which address the potential for rest and distinction of the parts of the reflex arc. They were more successful in Q1, Q4 and Q8. Thus, we observed the high rate of assertive questions asked by the students, which shows the use of QD as a favorable method at this moment of learning.

Objective questions have a quantitative bias, and the use of questionnaires is important to assist the teacher in the analysis of different capacities of the students. More structured questions help to develop students' logical reasoning, however, subjective questions, in addition, stimulate the exercise of writing (OLIVEIRA, *et al*., 2019).

As previously described, the QD also has five subjective questions, which aim to analyze the students' writing regarding the concepts about the AFSNH, for which these questions are in table 5,

just below, identified as Q2, Q3, Q5, Q7 and Q9 and their relevant concepts on the side in order to facilitate their understanding of the students' understanding of each one of them.

Table 5. Quantitative analysis of the subjective questions of the QD

Issues	Concepts covered	Correct answers (%)
Q2	*Know the name given to the electrical impulse.*	46,5%
Q3	*Describe the name of the space between neurons.*	75,8%
Q5	*Report the importance of the myelin sheath.*	54,5%
Q7	*Recognize the most important organ of the SNH*.*	100%
Q9	*Discuss the notability of ME**.*	63,5%

*Human Nervous System, **Spinal Cord. Source: Author

The table quantitatively reports the participants' responses. However, when observing some answers to direct questions such as Q2, it was found that some still had difficulties in understanding the subject, as some students answered that the transmission of the electrical impulse between neurons was called synapse, and others were unable to report the importance of the myelin sheath and spinal cord.

Even though the use of questionnaires proves to be more efficient and has some advantages, among them, ease in obtaining samples, no influence from the researcher and less inhibition of the participant, it also has disadvantages such as less detail of the answers, interpretation and comprehension dependent on the informant, which can influence the quality of the answer, as it also depends on the quality of the answer. the quality of the questions elaborated, which requires good preparation and experience from the researcher regarding the preparation of the questionnaires (MAIA, 2020).

ANALYSIS OF DIDACTIC MODELS (DMS)

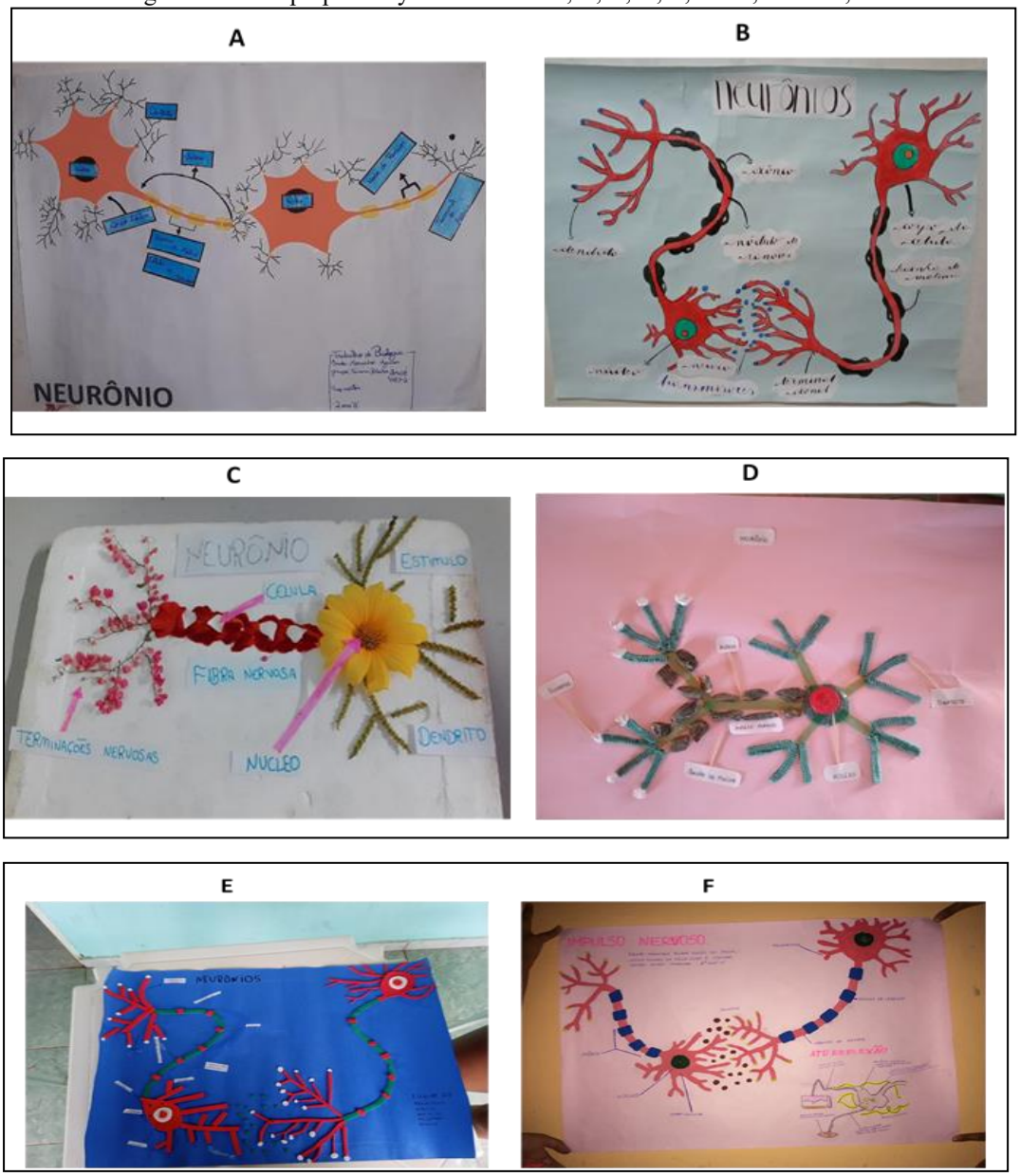
At this time, the students were instructed to organize themselves into groups, preferably by location, to be able to meet and carry out the work respecting the health guidelines against the pandemic required in the period. The elaboration of the DMs (figures 1 and 2) refers to the nerve cell, the nerve impulse (NI) and the reflex act and arc. These models become an important tool to favor the teaching-learning process, as they stimulate the interest of students, facilitating a better understanding of important concepts and the structures studied.

The students had total freedom to carry out the activity, being encouraged to use creativity to create the DMs.

The preparation of the MDs by the students was important for the understanding of the structures and processes of the human nervous system. The participants felt motivated and very comfortable to produce the models using resources they had at home.

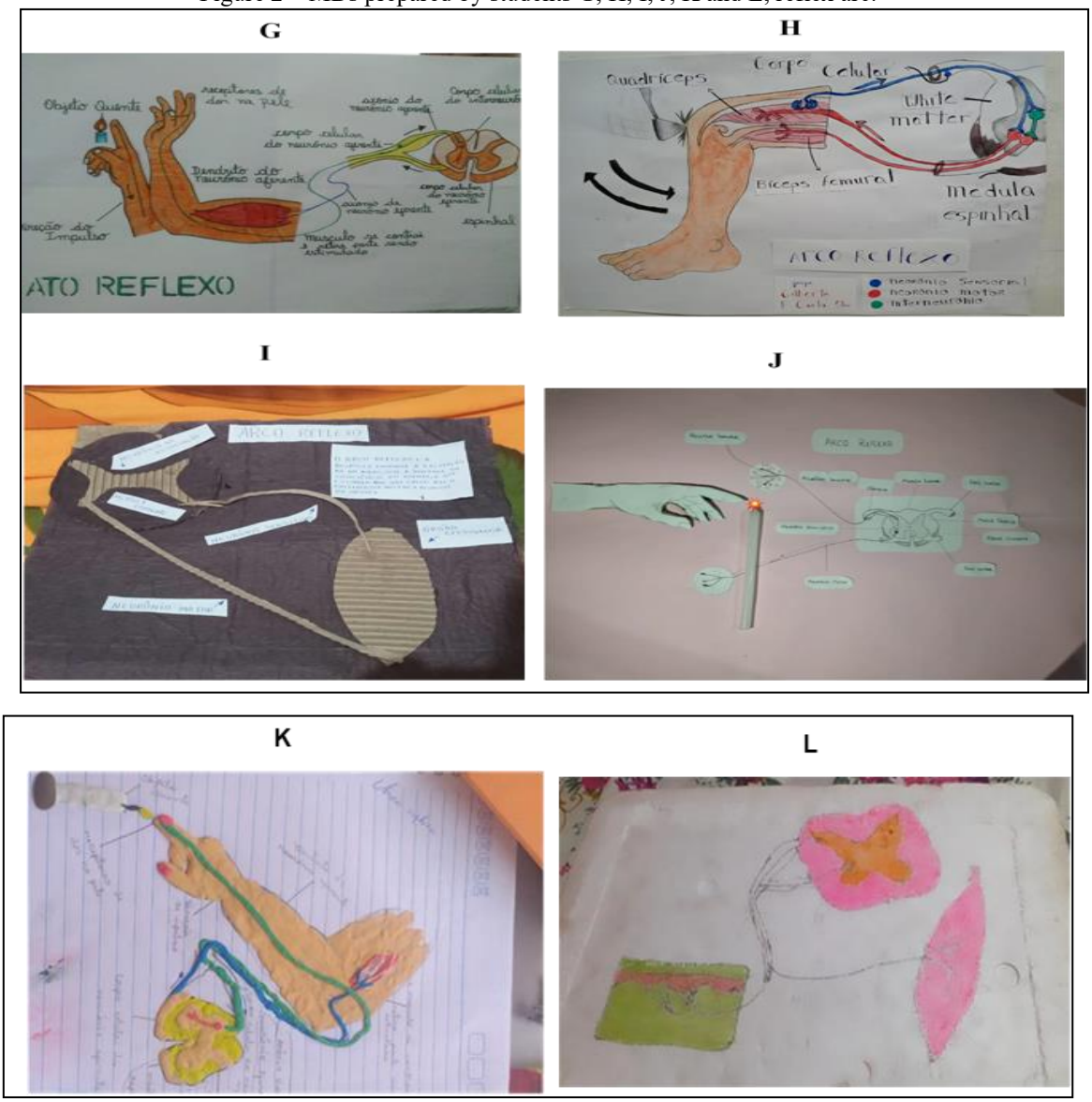
MDs are excellent resources that enable students to visualize biological structures in an expanded size beyond the didactic material, providing the use of materials that can be more easily acquired, making teaching more motivating and attractive (GERPE, 2020). In this pandemic moment, the use of different resources becomes essential with regard to materials that can be produced and shared in an adapted remote teaching, adjusting the application of existing materials (GUGLIANO; FERREIRA, 2021). The use of didactic models is an efficient strategy for learning, even in the remote teaching modality (RODRIGUES, 2021).

Figure 1 – DMs prepared by the students. A, B, C, D, E, and F, neurons, and IN.



Source: Author

Figure 2 – MDs prepared by students G, H, I, J, K and L, reflex arc.



Source: Author

ANALYSIS OF THE RESUMPTION OF HYPOTHESES (RH)

At this time, a class was taught remotely through *Google Meet* and discussions were held in addition to the traditional class. Important concepts were resumed to remove doubts, focused on AFSNH and its functioning.

Faced with the situation of social isolation, it was necessary to experiment, innovate, systematize and evaluate students' learning processes, in order to make the best possible use of technological tools, and it was necessary to reflect on the teaching practice regarding the approach to relevant issues that would be worked on in the classroom, as well as the need for didactic and methodological adjustments (VIEIRA; RICCI, 2020).

In view of this, the hypotheses of the problematizations were made available to each of the participants to be analyzed and they were asked to rewrite their ideas after carrying out the previous

activities, with the aim of stimulating student protagonism for meaningful learning, valuing reflection, critical thinking, and knowledge (OLIVEIRA, 2020).

With the resumption of the hypotheses, during the remote activity, the students were involved in digital technologies and strategies aimed at scientific literacy, maintaining the autonomy of the participants (MARQUES, *et al.,* 2021), which provided more technical writing and a learning gain.

After sending the resumptions of the hypotheses, categories were created for a better understanding of the arguments made in the face of the analysis and rewriting of the hypotheses. The first problematization, at this moment, is focused on the concept of the ***existence of electric current in the human body.***

In the arguments presented by the students, more scientific expressions were found in the writing, such as chemical signs mentioned by one of the participants, *ipsis litteris*: *"Yes. It is present in the human body nerve impulses, chemical signals emitted by nerve cells until muscle contractions are controlled by small electrical currents*", Another mentions about nerve impulse and electrical charges: *"It happens that the transmission of the nerve impulse goes as a wave up the axon membrane causing the highest concentration of ions, presenting positive and negative charge, and so the electric current happens"* or quoting, more simply, about the nerve impulse: "*Yes, we have a current that is called a nerve impulse*." We find more arguments described by the students in Appendix I.

Some participants presented ***small distortions in the understanding of the existence of electric current in the human body,*** *despite transmitting the idea of electric current in the body, such as: "They are electrical discharges that generate pain information",* and it was found, in a smaller quantity, a writing with ***apparent research of the participant***, as observed below: "*Yes, we call a nerve impulse the electrical current that passes through the membrane of neurons and increases along these cells. This occurs as a wave of polarization change of the axon membrane, and in the extracellular medium there is a large amount of sodium ions (Na+) that causes the membrane on the outer face to have a positive charge and a negative charge on the inner side*." Table 6 is below, which presents a quantitative analysis of the criteria established in this HR of the first problem.

Table 6. Quantitative analysis of RH regarding the presence of electric current in the human body

HR criteria of the first problematization	**% criteria**
More scientific arguments for the existence of electric current in the human body.	*87,5%*
Written with apparent research by the participant.	*3,1%*
Analysis with small distortions in the understanding of the existence of electric current in the human body.	*9,4%*

Source: Author

When we compare the initial hypotheses with the resumption of concepts, an increase in the quality of writing is observed, demonstrating the knowledge learned during this SEI, even if there are

comments that show a quick research carried out by one or another student, which demonstrates interest in participating in the work.

The second problem focuses on the students' understanding of the defense reaction of the human body in the face of a dangerous situation known as the reflex act. For this second analysis, two concepts were elaborated. The first concept refers to the ***description of the presence of the reflex act as a defense system***, where most of the students presented a good understanding, in view of what was written, about the importance of the reflex act, as stated by one of the participants: *"This is usually a sense of defense of our body that is highly defensive because of the sensitivity of our body and this defense movement is transmitted by our body through our spinal column or perhaps by our senses and reflexes",* the opinion formed of the defense of the organism and even of its functioning is observed, as is confirmed when another student writes the following: *"It is the reflex act, the message does not go to our brain but to our bone marrow so it makes the stimulus respond faster and more involuntary before we think of taking it out.",* the elaboration of more detailed answers and with more elaborate arguments shows a greater involvement of the students with the content, which can be seen in appendix J.

The way in which the teaching of biology is approached can be more interesting and attractive to students, having a constructivist effect when referring to scientific literacy in a teaching by inquiry. This form of teaching makes the contents more meaningful for the students, as the didactic sequences allow a greater protagonism of the students, in addition to a better understanding of the concepts and production of scientific knowledge (SCARPA; CAMPOS, 2018).

Although some participants were embraced by the concept containing ***explanations with slight distortions about the reflex act***, they still presented ideas related to the theme, as we found in the speech of one of the students described, *ipsis litteris*, below: "*When touching something hot or sharp our system reacts to remove the finger from the place and it happens without us noticing, because the brain sends the message to the nervous system, a reflex act that conducts information to the brain*." Even though he describes that the response comes from the brain, he also recognizes the reflex act as a defense system, having as a reaction after the finger touches sharp objects.

In view of the significant difference in the results of before and after, it is concluded that the contextualization of the content to create hypotheses was more effective for assimilating the contents referring to the presence of the reflex act as a defense system. Thus, the teaching process carried out through the use of strategies from an investigative teaching sequence produced a substantial change in the results, as well as progress in the use of all students and a greater homogenization of the results obtained.

Table 7 below shows a quantitative analysis of the previously mentioned concepts of HR in the second problematization.

Table 7. Quantitative analysis of RH regarding the presence of the reflex act as a defense system of the human body

HR criteria of the second problematization	% criteria
Description of the presence of the reflex act as a defense system	*87,5%*
Explanations with slight distortions about the reflex act	*12,5%*

Source: Author

By comparing the hypotheses described by the students at the beginning of the SEI with those made in the resumption of the concepts, a learning gain observed in the students' better writing ability is identified, even though there are small distortions regarding the functioning of the reflex act.

In the third problematization, the object of analysis is the understanding that a cerebral concussion can cause alterations in the human nervous system and lead the individual to fainting. Initially, the criterion established in the rewriting in the face of the reports presented was ***alterations in the nervous system due to a brain concussion***, in the analysis of the students' writing, they expressed the relationship between brain concussion and fainting, some participants wrote: "*What occurs is a concussion caused by a strong blow to the head, in some cases it can even generate memory loss or certain irregularities in the nervous system.*", others described this problematization as follows: "*When the fighter receives a blow to the head, the loss of consciousness, interrupting the sudden movement of the brain. The impact causes damage to the brain.*", it is observed, in the participants' answers, a better understanding of the causes of fainting in the face of a strong blow to the head, they even report consequences of a situation like this.

Some students presented ***descriptions with slight distortions about brain concussion***, or even that they could not express their ideas better, one of the students wrote: "*When they are hit hard it immediately causes dizziness and fainting causing the body to stop working for a few minutes*.", or some more incomplete lines like: "*Concussion the fighter may have injured something.*", here the participants sought to explain the problem of what is important in remote teaching.

It was found that some students remained with some of the initial ideas with ***explanations about fainting not linked to brain concussion***, one of the participants reports: "*It must have reached the brain causing fainting, it occurs when the pressure goes and there is no oxygen to* the brain.", the student tries to explain the causes of brain concussion in a wrong way, but recognizes that a blow to the head leads to fainting.

The last criterion elaborated was about writing ***with apparent research on the part of the participant about brain concussion***, where it is identified in some of the answers given by the students the presence of much more technical information, not perceiving the student's opinion. One

of the participants wrote: "*The MMA fighter had a CONCLUSION caused by a slight blow to the head. Today the tendency is to consider concussion as resulting from a mild degree of diffuse axonal injury. Sudden rotational forces would cause stretching of axons and synapses, sufficient to cause a physiological blackout, but not permanent anatomical damage."*, some terms demonstrate a response with information directly from the internet, revealing the interest in participating in the resumption using the research.

Research is the action of the researcher with his/her object of knowledge acting on the phenomena investigated and provoking reactions and comparisons with situations studied, making it possible to draw conclusions to understand phenomena as it happens in the learning process (SCARPA; CAMPOS, 2018).

Keeping the same line of a quantitative analysis, in Table 8, below, we find the criteria previously described in the RH analysis of the third problematization that addresses alterations in the human nervous system in situations of cerebral concussion.

Table 8. Quantitative RH analysis of fainting caused by brain concussions

HR criteria of the third problematization	**% criteria**
Report of changes in the nervous system due to a brain concussion	*75%*
Descriptions with slight distortions about brain concussion	*9,4%*
Explanations for fainting spells not linked to brain concussion	*9,4%*
Written with apparent research on the part of the participant on brain concussion.	*6,2%*

Source: Author

The participants, in this problematization, had a better understanding of fainting in cases of cerebral concussion, although we have 9.4% of the participants with explanations not linked to this process, we have an improvement in the writing of the students who, in a simple or more elaborate way, with small distortions or not, presented a more worked language when they participated in this moment.

The process of contextualization of the knowledge to be learned was carried out at the moment of presentation of the questions to be solved, aiming to make the student understand the content to be applied, arousing their interest in the subject addressed. At the end of the SEI activities, it was necessary, according to Carvalho's (2013) perspective, to carry out an evaluation to monitor learning.

ANALYSIS OF THE CES QUESTIONNAIRE

The structured questionnaire for the evaluation of the SEI addressed the students' opinion regarding the ***accomplishment of the activities of this SEI,*** whether they would find it interesting to ***apply this methodology in other moments of the discipline***, whether this work ***contributed to learning*** and, within what was worked on, ***what could be improved***.

To facilitate the understanding of the students' opinion about some of their statements, table 9 was prepared below, containing some of the participants' comments.

Table 9. Opinion reports on the realization of the SEI

1. Implementation of the activities of this SEI
Participant 14 – "Yes, I liked it a lot, it's a different proposal for the classes"
Participant 23 – "Yes, I liked it a lot, it was very cool, in addition to understanding the content more"
2. Application of this methodology in other moments of the discipline
Participant 14 – "Yes, it draws a lot of attention because it's really cool and much better to learn, because it gets more attention because it's interesting"
Participant 22 – "Yes, I think it would be nice to create a more interesting way to learn about the subject"
3. Contributed to learning
Participant 1 – "Yes, because with the game and the models it helped me a lot in fixing the contents"
Participant 21 – "Yes, because we can develop more and we can also understand more about the subject, ask questions"
4. What could be improved
Participant 14 – "I think it's a more theoretical work"
Participant 23 – "I can't say, for me they were all good."

Source: Author

The reports in table 9 describe not only the acceptance of activities for a better understanding of certain contents, but also the need for a more practical, motivating, participatory and innovative teaching.

In inquiry-based teaching, the teacher must understand that an innovation is not an opposition to the traditional method and that investigative teaching is not a single teaching method, but a possibility for the student to become the main responsible for their learning, even if it is remotely (DOS SANTOS, 2018).

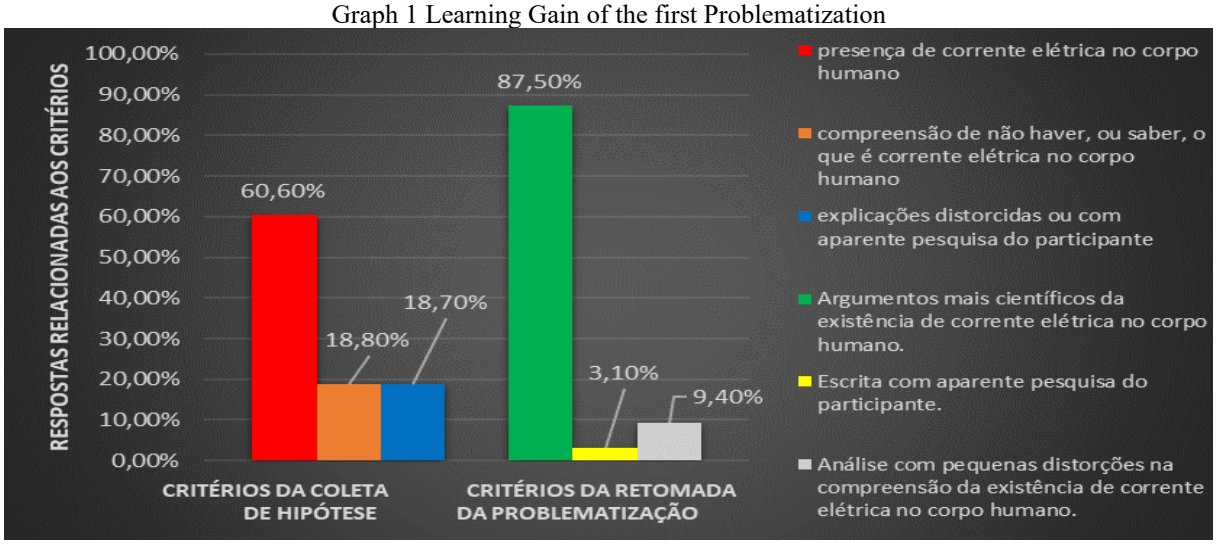
According to the students, the activities took place in an attractive, dynamic and fun way throughout the SEI without compromising the educational part.

QUALITATIVE ANALYSIS OF THE RESUMPTION OF THE PROBLEMATIZATIONS OF THIS SEI

For the purpose of quantitative analysis of the process carried out, an accessible and comprehensible observation is made available, through graphs, of the learning gain demonstrated by the students when we compare the collection of hypotheses applied at the beginning of the SEI.

In the first problematization, where the student was questioned about the presence of an electrical correction in the human body, an assertive growth of the answers was identified in the observation of the students' comments, as seen in graph 1 below.

Graph 1 Learning Gain of the first Problematization

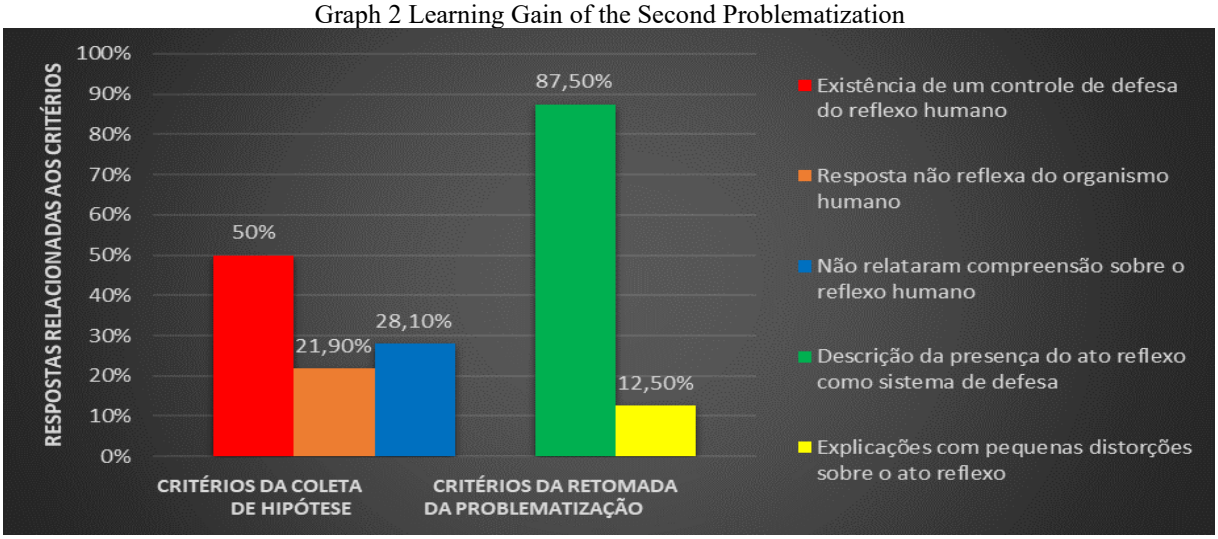


Source: Author

The value of 87.5% in the graph above regarding the problematization demonstrates more than the student's understanding of the existence of electric current in the human body, revealing the understanding of the existence of elements and processes that generate it in the organism. The presence of answers with a more scientific language can be interpreted as an improvement in the student's learning.

In the second problematization, where the students were questioned about the human reflex as a response and defense system, it is observed in their comments an improvement in the understanding of the process with more accurate comments when compared to the answers given by them at the beginning of the research. This can be seen in graph 2 below.

Graph 2 Learning Gain of the Second Problematization



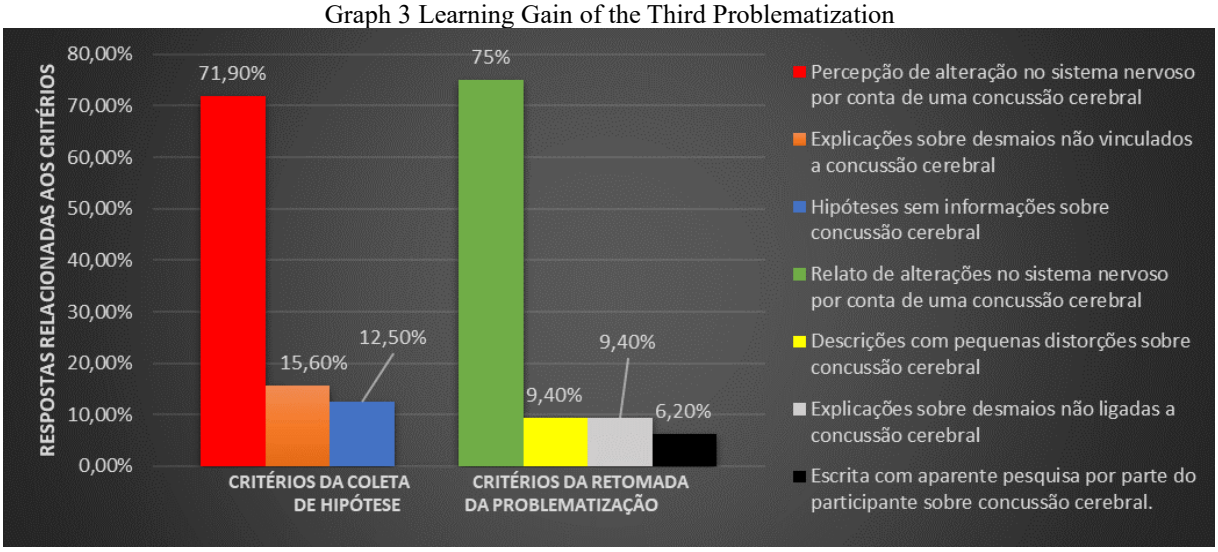
Source: Author

It can be seen in the graph above that initially 21.9% of the participants indicated in their answers a *non-reflex response of the human organism*, and 28.1% of these *did not report*

understanding of the human reflex situation. However, when we verified the answers in HR, it was verified that 87.5% of the participants were able *to describe the presence of the reflex act as a defense system* for the human body, demonstrating a solid scientific literacy in the learning gain.

In the third and last question, the participants were asked about what brain concussion would be, and a certain understanding of this phenomenon is verified in the initial answers of the students, although the answers do not present more scientific arguments. However, after HR, the students presented a better argumentation and a more specific understanding of the subject, which can be seen in graph 3, below.

Graph 3 Learning Gain of the Third Problematization



Source: Author

The graph shows a certain learning gain when we observe an increase in arguments, on the part of the students, with the recognition of 75% of the responses recognizing *changes in the nervous system caused by a brain concussion*. This is due to their involvement with the studies of this SEI carried out remotely, reflecting the scientific literacy presented by the students.

FINAL THOUGHTS

The pandemic moment required this SEI to be developed remotely, with creativity and with a very clear and motivating language suitable for students in situations of social isolation. We sought to meet the diverse educational needs of the students through educational strategies available with the use of discourses and commitment to the activities.

It was evident that the use of the internet was essential for the participation of the students in the research and that the use of platforms such as *WhatsApp and Google Forms* were satisfactory for communication, information collection and activities in synchronous and asynchronous moments.

Considering the different socioeconomic levels of the participants, the accomplishment of this work was possible even remotely.

The didactic sequence carried out allowed the development of several skills such as research, reading, discussions and arguments on the subject, virtual records of hypotheses, construction of didactic models in a creative way, which was challenging at a time of pandemic. The students resumed their hypotheses, expressed their doubts, and rewrote, in a reflexive way, their initial ideas about the problematizations, participated in the review of concepts in the card game, formed protagonists throughout the process. In the asynchronous moments, studies and research were carried out, which were accompanied by the answers to the guiding questions and the diagnostic questionnaire. The accomplishment of the work was satisfactory, despite the difficulties present in the pandemic, such as constant access to the internet or even direct access to information that may not have been so reflective.

More consistent arguments about the situations posed to the students during the investigative activity were recorded to favor a more qualitative analysis, an important activity to identify the improvement of the students' writing with more scientific claims, demonstrating scientific literacy.

In the end, it is important to apply new educational experiences with students and to develop didactic methods and strategies that awaken the formulation of hypotheses, reflection and critical thinking, in addition to the development and application of virtual tools that contribute to teaching and learning when these are carried out in times of social isolation.

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APPENDIX A

Questionnaire of guiding situations and problem-solving questions

1. Guiding questions

01. Which cell in our body is called a nerve cell?

02. Why is she called "nervous"?

03. In some movies or cartoons an idea is represented with a light bulb going on over the head, do we generate energy in the brain?

04. Walking down the street, we identify pleasant smells, such as well-made food or a pleasant perfume, how can we identify these smells? How do we perceive this from a distance?

05. Have you ever been nervous or anxious about something? What causes us to have these sensations? Does it have something to do with the nerves?

2. Problematizing questions

06. Sometimes we "pull" our arm or hand when we unknowingly touch hot or sharp places, how can this happen without us being prepared for it?

07. In some MMA fights, we see some fighters fainting at a certain point in the fight. What could have happened?

08. Have you ever hit your elbow and felt that shock? Do we have any electrical current running in our body?

APPENDIX B

Questions made available in the asynchronous moment in order to follow up on the participants' studies

1st follow-up questionnaire

(material sent by link - *https://forms.gle/jEvi2iAyfWQgy5mVA* ***)***

- ✓ Can you explain what stimulus is and give examples?
- ✓ Explain in your own words what is reflex act and reflex arc?
- ✓ What can cause people to faint when they are hit in the head? Read the material and watch the video. Write in your own words what you understood.

2nd follow-up questionnaire

(material sent by link - *https://forms.gle/wp9ABEUNvp3WiUdZ* ***)***

- ✓ After reading the material and watching the video, what did you understand about what a nerve impulse is? Speak with your words.
- ✓ What is nerve stimulation? What can it do? Can you give some examples of what these stimuli are? Explain in your own words.

APPENDIX C

Diagnostic Questionnaire

Material present at the following link:

https://docs.google.com/forms/d/e/1FAIpQLSdZWJ8UT_K6fxim2iFBTO42FxHMFW7yCogijvGJ34O8f9xpBw/viewform?usp=sf_link

01. What Is The Typical Nerve Tissue Cell?

a) Neuron

b) Myocyte

c) Red blood cells

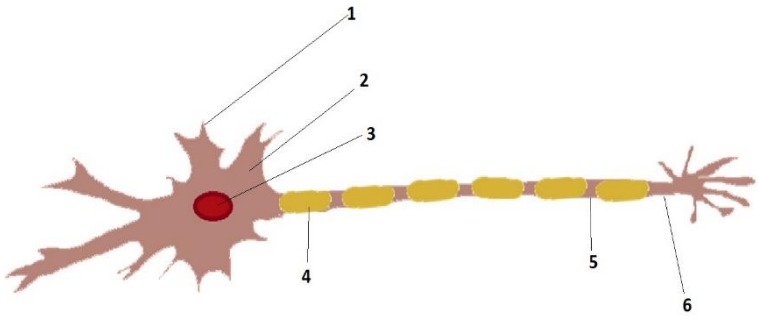
d) nephron

02. What is the name given to the transmission of the electrical impulse by the nerve fiber?

03. What is the name of the space found between neurons?

04. Check the cell below and identify its structures as indicated:

Analyze the structures indicated in the figure



a) 1- Dendrite; 2- Axon; 3- Cell body; 4- Myelin sheath; 5- Core; 6- Ranvier's nodule.

b) 1- Axon; 2- Cell body; 3- Core; 4-Ranvier's nodule; 5- Myelin sheath; 6- Dendrites.

c) 1- Cell body; 2- Dendritus; 3- Core; 4- Myelin sheath; 5-Ranvier's nodule; 6- Axon.

d) 1- Dendrite; 2- Cell body; 3- Core; 4- Melin sheath; 5- Ranvier's nodule; 6- Axon.

e) 1- Cell body; 2- Axon; 3- Core; 4- Dendritus; 5- Myelin sheath; 6- Ranvier's nodule.

05. What is the function of the myelin sheath?

06. The nerve cells specialized in the propagation of the electrical impulse receive a stimulus that ensures communication between them. In order for the impulse to start, it is necessary that the membrane of this cell is stimulated and has a resting potential. This potential is maintained when the nerve cell membrane:

a) it is pumping Na^+ to the external medium and transferring K+ ions to the internal medium.

b) it is pumping K+ into the external medium and transferring $Na^{+\ ions}$ into the internal medium.

c) is pumping K+ and Na^{+} to the external medium.

d) is pumping K^{+} and Na^{+} into the internal medium.

e) it is not pumping ions.

07. What is the most important organ of the nervous system?

08. The brain has several functions that are extremely important for the body. Each part of this structure is related to a different activity. The cerebellum, for example, is related to what functions?

a) the regulation of body temperature.

b) endocrine functions.

c) sexual behavior.

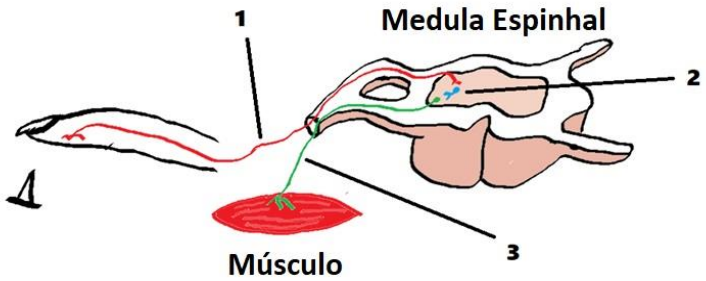
(d) coordination and balance.

e) swallowing.

09. What is the importance of the spinal cord?

10. The figure below shows the components involved in quick and simple responses to certain stimuli, take off the arm when touching a heated metal.

Observe the structures involved in the spinal cord response



Regarding the reflex responses of the spinal cord, identify the structures presented above:

a) The structure represented by the number 1 is an associative neuron.

b) The associative neuron, indicated by the number 2, is responsible for carrying the message to the brain.

c) The structure indicated by number 3 is a motor neuron, responsible for carrying the response to the effector organ.

d) The structure represented by 1 is responsible for capturing the stimulus and carrying it to the brain.