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Resultado de Investigación

STUDENTS' PERCEPTIONS ABOUT A METACOGNITIVE ACTIVITY INVOLVING THE CONCEPT OF THE AMOUNT OF SUBSTANCE

PERCEPÇÕES DOS ALUNOS SOBRE UMA ATIVIDADE METACOGNITIVA ENVOLVENDO O CONCEITO DE QUANTIDADE DE SUBSTÂNCIA

PERCEPCIONES DE LOS ESTUDIANTES SOBRE UNA ACTIVIDAD METACOGNITIVA QUE INVOLUCRA EL CONCEPTO DE CANTIDAD DE SUSTANCIA

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Abstract

The amount of substance, that has the mole as a unit, is a concept that has been causing learning problems for both students and for teachers. This article aims to present students' impressions of a metacognitive activity involving the concept of amount of substance. The data were collected during a case study carried out with 10 students from a popular preparatory course for the entrance exam, which at the end of the participation in the activity provided their impressions through text and verbally during a group discussion. The data were analyzed in the light of the content analysis and the results suggest that the metacognitive strategy used favors the performance of activities because the use of the table stimulates conscious self-regulation while the investigative molds proposed during the activity increase students' motivation.

Keywords: High school. Didactics. Learning strategy. Experimentation.

Resumen

La cantidad de sustancia, que tiene el mole como unidad, es un concepto que ha causado problemas de aprendizaje, tanto a alumnos como a profesores. Este artículo presenta las impresiones del estudiantado sobre una actividad metacognitiva que involucra el concepto de cantidad de sustancia. Los datos fueron recolectados durante un estudio de caso con diez estudiantes de un curso preparatorio popular para el examen de ingreso que, al finalizar la participación en la actividad, brindaron sus impresiones a través del texto y verbalmente durante una discusión grupal. Los datos fueron sometidos al análisis de contenido, y los resultados sugieren que la estrategia metacognitiva

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favorece el desempeño de las actividades porque el uso de la tabla estimula la autorregulación consciente, mientras que los moldes investigativos propuestos aumentan la motivación en el alumnado.
Palabras clave: enseñanza secundaria, didáctica, estrategia de aprendizaje, experimentación.

Resumo

A quantidade de substância, que tem como unidade o mol, é um conceito que vem causando problemas de aprendizagem, tanto para alunos compreenderem quanto para professores. Sendo assim, este artigo tem como objetivo, apresentar as impressões dos estudantes acerca de uma atividade metacognitiva envolvendo o conceito de quantidade de substância. Os dados foram coletados durante um estudo de caso realizado com 10 alunos de um curso popular preparatório para o vestibular, que ao final da participação da atividade forneceram suas impressões por meio de texto e verbalmente durante uma discussão de grupo. Os dados foram analisados sob a luz da análise do conteúdo e os resultados sugerem que a estratégia metacognitiva utilizada favorece a realização de atividades, pois o uso da tabela estimula a autorregulação consciente, enquanto os moldes investigativos propostos durante a atividade aumentam a motivação dos estudantes.
Palavras chave: Ensino médio. Didática. Estratégia de aprendizagem. Experimentação.

1. Introduction

In the educational context, the amount of substance has been among the topics, the subject on which students have shown great difficulty understanding (CASE, FRASER, 1999; FURIÓ, AZCONA, GUISASOLA, 2002; NOVICK, MENIS, 1976). Agreeing with it, recent research has concluded that some students could not translate chemical problems into a mathematical form, the same way as they demonstrated difficulty in knowing the special terms related to the concept of mole. Researchers have attributed the cause to the lack of prominence in teachers' understanding of the language related to the mole (OMWIRHIREN, 2015).

Another research (DIERKS, 1981) has shown that some barriers, encountered by high school students, are as described in the sequence. Students have related the mole with the number of particles and a certain mass; in addition, there is a belief that the mole is a property of the molecule, relating the molar mass to other quantities such as density, volume, or even with the atomic formula. All this has been constituted of obstacles to learning (DIERKS, 1981).

As the amount of substance is a fundamental physical unit, problems in its learning have impacts on future points, such as stoichiometry, a main topic involving that subject, and a common obstacle to students (DAHSAH, COLL, 2008; SANTOS, SILVA, 2014).

Considering how teachers have taught students or the definition of mole they have used, it is noticed that teachers have used the first definition of this idea. Maybe, by not understanding the term "quantity of matter" or by the fact of the term mole was introduced before the amount of matter in the scientific language, generating a delay of information in the school environment (FURIÓ et al., 2000).

This scenario has contributed to the increasing of difficulties presented by students, and then new approaches are necessary to be used, bringing a different way of teaching, with another path of comprehension (OMWIRHIREN, 2015), such as the use of metacognition.

Metacognitive studies were introduced by FLAVELL (1976) as the act of acquiring knowledge about cognitive processes and using it to regulate the own cognition itself consciously.

The simplified model, presented in Figure 1, can exemplify the relationships between cognition and metacognition:

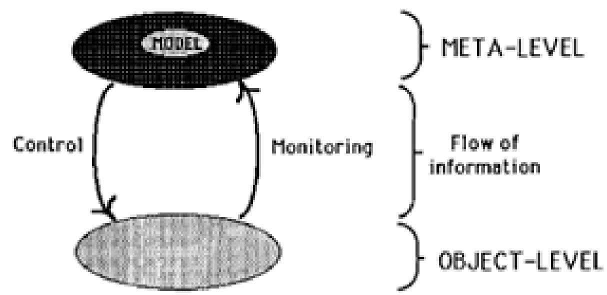

Figure 1. Theoretical mechanism of metacognition and its relationship with the cognitive.
Source: NELSON, NARENS (1990).

This scheme demonstrates the relationship between metacognition, represented by the meta-level, and the cognition that is found at the object level, the relationship between the two levels is named according to the direction of the information.

When information flows from cognition to metacognition, in this model, it is called monitoring, in order to be reconsidered and evaluated, and then the thought monitoring may happen.

In the opposite direction, by reversing the flow to metacognition-cognition, after passing through the reflection of thought, the metacognitive level returns the ideas to the cognitive, performing the control of it, thus evidencing that the metacognition can alter the cognition and activity. This process happens continuously, showing how metacognitive monitoring is used to verify and update the model of an ongoing task, then performing the modeling.

The power to model a task during its resolution, with metacognition, may help students during the learning process, the awareness of their own knowledge makes it possible to them to reformulate their way of learning (PORTILHO, DREHER, 2012).

Metacognition commonly has two aspects, "knowledge of cognition and regulation of cognition" (SCHRAW, 1998 p. 113), referring, basically, to the individual awareness about what he or she knows, and the use of knowledge for the reconstruction of thought, respectively.

LOCATELLI, DAVIDOWITZ (2021) have strengthened the importance of metacognitive strategies that may lead the student to an autonomy increase, promoting self-regulation with intentionality, and allowing them to revise chemical concepts.

Metacognitive regulation may be very useful during classes, as it helps students to check if their goals were achieved, such as self-questioning at the end or during a task. The simple fact of questioning oneself about the activity stimulates the elaboration of the hypothesis, enabling the student to perceive if he or she can answer them and, if not, think about what to do to achieve the objectives of the proposed task, thus developing an appropriate resolution strategy.

This research has as its main objective to present the perceptions and impressions of students who participated in a metacognitive activity that had as its central theme the amount of substance. Then now, briefly, both metacognitive strategies applied to the proposed activity will be discussed, think-aloud and self-questioning strategies.

2. Metacognitive strategies

Some authors have emphasized the importance of using metacognitive strategies during classes with the objective of expanding and developing students' metacognitive abilities (COOK, KENNEDY, MCGUIRE, 2013; FLAVELL, 1976).

One way to students use metacognition, is the application of metacognitive strategies, according to PINTRICH (2002) it is possible to stimulate and instruct students through very clear metacognitive strategies, the conscious use of it might induce the use of this strategy in other moments, with different knowledge, as self-questioning and think aloud strategies, being both incorporated in this activity.

a. Think-aloud strategy

In this strategy, research participants are instructed to speak aloud what they are thinking about during problem-solving, while reading, or in any other activity that requires cognitive commitment, that is, they must verbalize all thoughts related to that activity.

The goal of the think-aloud protocols is to allow the researcher to access and identify both cognitive and metacognitive processes during the task, regardless of the area or subject to which it is related (BANNERT, MENGELKAMP, 2008).

The verbalizations of the participants are recorded so that in their transcripts, the lines of reasoning that are raised throughout the procedure will be present, allowing the analysis of the participants' metacognitive and decision processes (JORDANO, TOURON, 2018).

ERICSSON, SIMON (1993) have presented in their studies some steps to be followed during the implementation of think-aloud protocols. Initially, as already stated, people must be instructed to focus more on verbalizing their task than on explaining it to other participants. As an initial training, they have recommended an easier performance, requiring students to say aloud what they are thinking about simple tasks before starting the main study, helping participants to become more comfortable and to understand better how it works.

b. Self-questioning strategy

This collection of questions is not and does not encompass everything that metacognition presents, instead of this, the issues provide a starting point for both students and teachers who want to work openly on metacognitive strategies with the students (TANNER, 2012).

This strategy was used with high school students using self-questioning in Ohm's law teaching (PATE, MILLER, 2011), showing that in classes where this method was used, students reached better results than those who did not use self-questioning.

It demonstrates that students who used this technique are more capable to learn Ohm's law, suggesting the use of self-questioning by educators during their activities to be done (PATE, MILLER, 2011).

3. Methodology

a. Research context

This research was carried out with 10 high school students (named S1, S2, etc.), who are attending a preparatory course, which seeks to facilitate the entry of needy young people into Brazilian higher education.

This course is an extension program offered by the Federal University of ABC, where the first author has worked as a chemistry teacher in that extension program.

It is important to emphasize that this activity is only a part of a master's work developed, and therefore, it was opted at first, by the analysis of the impressions of the participants, while the transcriptions and drawings will be later presented in other papers.

b. Description of activity

A pair of students should solve a problem related to the amount of matter during this investigative class, and a regulatory checklist (RC) was proposed to be used during problem-solving.

This list contains generic questions that will assist students in the problem-solving process, thus promoting self-questioning. The list of questions was taken from the work of PATE, MILLER (2011) which is an adaptation of SCHRAW (1998), which constitutes the theoretical reference adopted in this work regarding self-questioning.

In this research, it was considered that the original RC could cause some dismay in students, a repulsion effect, or even some confusion on how to use it, so in order to facilitate the use of RC, it was chosen to decrease the number of questions, retaining those that were judged as most important to assist in the metacognitive process.

The teacher used the other questions, given their importance, indirectly, when he was applying the activity.

The modified RC is presented in Table 1:

Table 1. Resumed self-questioning table.

Planning
What is my problem? What information have I received? How can this help me? Is there another way to do this?
Monitoring
What is my goal now? Am I on the right path? Am I using my strategy?
Evaluating
What worked? What did not work? What should I do differently next time?

Source: Authors.

During the activity, the teacher must accompany and conduct the activity carrying this list of questions, instructing students to work using it on the problems proposed. Directing students and assisting them to complete the task, besides its importance, must not be the limit of the teacher's work, but a part of it. A big effort should be directed to make them metacognitive, not meaning to exclude the cognitive task, but rather to use the information provided to help them carefully to plan how to approach a new idea (TANNER, 2012).

The didactic sequence is divided into three major moments, named, Pre-activity 1, Activity 1, and Activity 2, as represented by Figure 2, which will be explained in the sequence:

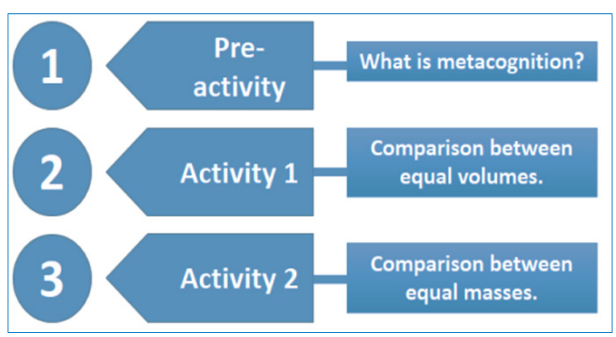

Figure 2. Schematic of the didactic sequence.
Source: Authors.

c. Pre-activity 1

Pre-activity 1 refers to the topic "What is metacognition" (figure 2). In this stage, the students were presented to metacognition. The teacher explained and introduced basic concepts of metacognition and he proposed a brief discussion with the students about this topic.

d. Activity 1

As the focus of the activity is a student's appropriation with the RC, it has been chosen a common problem to solve, involving two equal volume cylinders, which distinguish only in their material, one made of aluminum and the other made of copper. The problems that students needed to deal with are shown below:

1. Do you think we have the same number of atoms in the samples?
2. Propose an activity that confirms your hypothesis and write down the steps you used to get your answer.
3. With a drawing, represent how you believe to be the arrangement of the atoms, in the copper cylinder and in the aluminum cylinder, making a drawing for each one.

After presenting the problem, the students received a series of objects that could assist them in solving the task. The materials received were: metal cylinders, graduated test tubes, water, and beakers, such as the periodic table and the RC itself. As an activity to be investigative, after receiving the materials and problem, students were free to plan their strategies and to seek the answer to the problem in the way they wanted to propose.

e. Activity 2

At this point, students are expected to be more familiar with the question table, which may facilitate the resolution of the activity. Thinking about this, the procedure of the previous activity was maintained, modifying only the problem they had received, because now were presented equal masses of aluminum and copper, causing a certain discomfort in the students, who visually observed a volume of aluminum much larger than copper.

f. Description of data analysis

This research has followed the content analysis method (BARDIN, 2011), which can be defined as a set of techniques for analyzing communications by indicators, through systematic procedures and objectives for describing the content of the messages, indicators (quantitative or not) that makes possible the inference of knowledge, the conditions of production/ reception (inferred variables).
The material used to carry out this analysis was the participants' impressions regarding the RC provided (self-questioning) and their impressions about the task in general.
Thus, the methodology was based on three stages: pre-analysis, material exploration, and data processing (inference and interpretation). Pre-analysis may be summarized, as the moment of organization of the analysis, is nothing more than the systematization of ideas, leading to a clear and detailed plan to be followed. Afterward, the material was explored and finally, the data was processed, at which stage the categories appeared (BARDIN, 2011).

4. Results

From this analysis, six categories emerged, two related to the activity and four others related to the RC. All categories are reported in Table 2.

Table 2. Categories analyzed/ reported by students.

ABOUT THE RC	Incidents number	ABOUT THE ACTIVITY	Incidents number
1. Objective Monitoring	5	1.Freedom of choice	2
2.Organization of thoughts	4		
3.Task planning	4	2.Contact with chemistry	3
4.Support	3		

Source: Authors.

Based on the data obtained, five students were in the category of objective monitoring (Table 2) because they affirmed in their impressions that the table helped them to verify if they were approaching their objectives. Seeking to exemplify better, some statements are presented below:

S3: "[...] I used it again only at the end, to see if I had fulfilled my goal."
S9: "The table works as a step-by-step not to disperse the final goal […]"

From the above transcripts, it is possible to perceive how the presence of a physical tool was able to help them accomplish the task, providing the consciousness of self-monitoring. Constant monitoring allows the student to compare what they have achieved, to the point where they are, in order to achieve the goals. This comparison movement generates a set of cognitive assessments that together provide sufficient information about how the student can proceed in subsequent steps (DUNLOSKY, METCALFE, 2009). In other words, the more often a person makes mental updates about the task, the more regulation processes are taking place, which ultimately improves their performance on the task (JORDANO, TOURON, 2018). The organization of thoughts appears in four reports, two of them presented in the sequence:

S2: "The table helped a lot in the activity so that we have a good organization of thoughts"
S6: "The table was necessary to have a sense of organization and not lose the reasoning so fast."

This organization mentioned by students can be understood as a metacognitive activity of self-regulation, or regulation of knowledge since part of this process involves the organization of coherent information (BROWN, 1987). Moreover, metacognitive questioning encourages students to seek their own prior knowledge, analyze information, consider, and evaluate the problem, and integrate information to reconstruct the problem more coherently (CARDELLE–ELAWAR, 1995).

The task planning category emerged in four of the ten reports, and it is present for these students because the table was of great importance for them to be able to draw up previous strategies. Some excerpts are presented in the following sequence:

S3: "The table helped a lot I used it before starting to know how I had to do"
S5: "The table helped guide ideas and establish a methodology."

One of the objectives of RC is to promote and facilitate cognitive regulation during task resolution, and one of the skills to assist in this process is planning (BARDIN, 2011).
The next category is the support and it appeared when students were lost and/or destabilized during the activity. They used the RC as a form of support or guidance, which can be understood as a gain of autonomy, as they initially resort to the table, and then, if necessary, seek helping from the teacher, changing from a dependent learning state to an autonomous learner (SCHRAW, CRIPPEN, HARTLEY, 2006).
Regarding the activity, the impressions were very similar, because they were divided into only two categories, freedom of choice and contact with chemistry. Examples of the two categories are found below:

Freedom of choice
S1: "I liked it so much, for the freedom to choose the methods [...]"
S2: "I also liked the freedom to use the balance and everything else"
Contact with chemistry
S7: "In addition, it is very interesting to also deal with the material of the question, it facilitates the visualization of the proposal"
S3: "I thought it was a very dynamic activity and it was interesting because we could get in touch with the things"

In general, for subjects such as the quantity of matter, which require many calculations, the approach chosen is reduced to explanations and theoretical calculations. In this task, students were able to observe the influence of the concept of the quantity of matter on macroscopic phenomena (GILBERT, TREAGUST, 2009), besides that, this manipulation of materials may still have had a positive influence on students' motivation to carry out the activity (ZULIANI, ÂNGELO, 1999). For OLIVEIRA, CATÃO (2017), students tend to feel more motivated when inserted in learning environments in which teachers stimulate the development of autonomy.

The greater freedom perceived by the students was one of the initial objectives of this activity that is characterized as an investigative activity, having an initial issue, and a higher degree of freedom, not requiring a script. This approach allows students to pass from the passivity of following instructions to seeking to relate, decide, plan, propose, discuss, report, etc. (FERREIRA, HARTWIG, OLIVEIRA, 2010).

5. Conclusions and/or final considerations

As the present work refers to a small cut of a larger research, the purpose of this text is to disseminate a metacognitive activity involving the concepts of quantity of matter, using self-questioning as a metacognitive strategy.

From the analyzes presented previously, it is possible to affirm that in this brief analysis, the concepts related to metacognition were presented not only in the conception of the activity but were also perceptible by the students who participated in the activity. KING (1991), SCHRAW (1998), PINTRICH (2002), and PATE, MILLER (2011) suggest that clear metacognitive instructions can aid in the student's metacognitive development.

The use of RC provided greater autonomy for students, allowing them to develop strategies and raise hypotheses without the help of the teacher, which in a way made them continue in the accomplishment of the activity finding less difficulty.

As LOCATELLI (2017) has proposed, this kind of learning takes time requiring effort in a gradual process, for the development of one's own metacognitive abilities, then "it is recommended its incorporation into daily practice in the classroom" (p.21). Being high-order thoughts (BROWN, 2006), it is expected that only this activity is not enough to change the attitude of the participants, but during larger planning, or during the student's trajectory, it is possible that in a long time, they incorporate self-questioning and begin to apply it in other areas (Schraw, 1998).

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