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Potentially meaningful teaching unit with the transversal theme traffic education for the teaching of kinematics in Sciences

Unidade de ensino potencialmente significativa com tema transversal educação para o trânsito no ensino de cinemática em ciências

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ABSTRACT
The work presents the results of a Potentially Significant Teaching Unit (UEPS), with the transversal theme "Traffic Education", applied in a ninth-grade class of Elementary School. This work derives from a qualitative research whose objective was to verify the potential of a LIFO in promoting meaningful learning of Kinematics contents. The materials and stages of the LIFO were grounded in the Theory of Meaningful Learning. The evaluation conducted during the UEPS had a formative character, as there was a follow-up of the students in the accomplishment of tasks in the different stages. The data from several evaluative instruments were analyzed by means of descriptive statistics and Discursive Textual Analysis. The analysis showed that the objective of this work was achieved, as there were advances in the understanding of Kinematics concepts and favored the improvement of students' attitudes to deal more adequately with the complexity of the "Traffic" phenomenon. The study showed that the use of this transversal theme produced relevant relationships for learning, contributing to new ways of teaching and learning Science. This proposal was, therefore, a material that can be qualified with potential for the development of meaningful learning.

Keywords: Traffic education, Science teaching, Cross-cutting themes, Meaningful learning, Kinematics.

INTRODUCTION

School learning problems in Science seem to be related to each other by the way the contents are selected, organized, planned and developed in the classroom (Lopes, 2007). Studies carried out by education researchers, such as Demo (2014), Carvalho et al. (2011), Moreira (2011a), Zabala and Arnau (2010), Márquez Bargalló and Roca Tort (2006), Delizoicov, Angotti and Pernambuco (2002), have contributed to the discussion of important questions about the role of education and grounded ways of conducting the processes of teaching and learning. signaling the need to transform the school into a privileged space for articulation between theory and

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practice and for the multiplicity of experiences. Thus, it is relevant to rethink the curricular organization of Science content in an attempt to create conditions for meaningful learning for students. Köche (1975) already postulated that:

> Education, in turn, must be restructured according to the gradual changes that occur in society. It is up to education to think more about what kind of activities, action plans, lead the individual to self-regulation, to the exercise of the constant search for balance within the system (KÖCHE, 1993, p. 11).

The fragmentation of curricular contents, the compartmentalization of knowledge and learning by memorization are elements of a model that "does not recognize the enormous complexity of the teaching and learning processes", as stated by Zabala and Arnau (2010, p. 45). For Morin (2003), the hyperspecialization generated by the fragmentation of knowledge impedes the global vision and the perception of the essential in problems that need to be analyzed in a multidisciplinary perspective, in order to enable different readings and interpretations.

According to Santos (2007), the teaching of science in elementary school is mostly limited to processes of memorization and resolution of exercises and problems that do not require the understanding of the concepts studied. In addition, the teaching of science reproduces a contradiction that perpetuates the disciplinary treatment of scientific knowledge (Mundim & Santos, 2012). In general, this teaching is also characterized by the presentation of knowledge as absolute and immutable truths, which contradicts the evolution of science, which, according to Kuhn (2000), is a process permeated by revolutions, relatively slow, but evolutionary.

To overcome this way of teaching, Angotti, Bastos and Mion (2001) point out the need to implement political-pedagogical proposals that enable education from a perspective that liberates those involved. These authors emphasize that it is necessary to discuss themes that problematize situations and phenomena of our daily lives. In this sense, problematizing situations are resources used to mobilize students to actively participate in the teaching and learning processes. They can be problematizing experimental activities (Silva, Moura & Del Pino, 2015), a didactic sequence in which problem situations are proposed (Ramos & Serrano, 2015), as well as didactic interventions that use problem situations (Fernandes & Campos, 2014).

Official Brazilian documents, such as Law 9394/96 (http://www.planalto.gov.br/ccivil_03/leis/L9394.htm) and the National Curriculum Guidelines for Basic Education (DCN) (Brasil, 2013), emphasize that teaching should be focused on the social context and issues present in the student's daily life. This contextualized approach can be developed in school disciplines through cross-cutting themes. These themes, according to Yus (1998), are based on proposals for education for life through the development of humanistic values and the formation of critical and supportive individuals. Cross-cutting approaches are common to most human actions in everyday life and should be pertinent to the school context, in order to favor "an integration in the curriculum that makes it possible to make the knowledge addressed more meaningful to the students and favor the active participation of the students" (Brasil, 2013, p. 118).

In this sense, the transversal theme "Traffic Education" is a proposal that meets these characteristics, that is, aligned with the social context, seeking to answer questions of this theme present in the student's daily life and integrating disciplines.

Some characteristics of this context, in relation to traffic problems, are highlighted in the survey carried out by the National Observatory of Road Safety. This study reveals that car accidents surpass cases of homicide or cancer (http://www.onsv.org.br/noticias/brasil-tem-mais-vitimas-de-acidentes-de-transito-do-que-cancer-informa-estudo/) According to records of the compulsory insurance "Personal Injuries Caused by Motor Vehicles by Land" (DPVAT), Brazil has 31.3 fatal victims per 100 thousand inhabitants. In 2012, there were 60,700 deaths and 352,000 cases of permanent disability. Accidents involving young people between 18 and 24 years of age accounted for 41% of the records. These numbers demonstrate the urgency of adopting measures that develop an "education for life, which contributes to the development of people in their socialization in the public space", according to the "National Guidelines for Traffic Education in Elementary School" (Brasil, 2009, p.14).

In this context, "Traffic Education" presents itself as a theme of social relevance to favor the change of behaviors necessary for the formation of conscious drivers, cautious pedestrians and responsible citizens, and can become "bridges between scientific and vulgar knowledge for the personal and collective reconstruction of culture" (Yus, 1998, p. 43).

Thus, in order to contribute to overcoming a disciplinary and decontextualized teaching process, in this article, we present the results of a research that sought to answer the following question: Does a teaching unit with the transversal theme "Traffic Education" have the potential for a significant learning of Kinematics contents?

To answer this question, this article describes the results obtained from the application of a Potentially Significant Teaching Unit, as suggested by Moreira (2011a), on the theme "Traffic Education", in the discipline of Science in the ninth grade of Elementary School, together with the content of Kinematics. The proposal aimed at the re-elaboration of educational knowledge of Physics, producing reflections on its meanings of concepts, laws and principles as a way to integrate scientific knowledge into a context of social relevance of students.

The following text is organized as follows: it begins with some assumptions of the Theory of Meaningful Learning (SAD), the Potentially Significant Teaching Unit (UEPS) and transversality in the teaching of Science; Then, the methodological and didactic path of this investigation is presented, the data analysis and discussion and concludes with the final considerations.

SOME THEORETICAL ASSUMPTIONS OF MEANINGFUL LEARNING, LEUPO AND TRANSVERSALITY

The existence of prior knowledge (subsumers) in the student's cognitive structure is crucial for them to establish relationships with the new concepts taught, becoming the main factor that influences meaningful learning and retention (Ausubel, 2003).

In order to learn meaningfully, the student needs to manifest a predisposition to relate in a non-arbitrary and non-literal way to his cognitive structure the meanings he captures from potentially significant educational materials, that is, when the student relates a new concept in a plausible and non-random way to any appropriate and relevant cognitive structure (Ausubel, 2003). The student does not always have the subsumers to learn, in which case it is necessary to use previous organizers, that is, activities and materials whose function is to "provide ideological support for the incorporation and stable retention of the more detailed and differentiable material that follows the passage of learning" (Ausubel, 2003, p. 151).

To facilitate the occurrence of meaningful learning, the materials should be organized by content structured in a logical way, prioritizing comprehension over memorization, relating relevant ideas to the knowledge that the student already has, and using previous organizers to anchor the new knowledge. One way to organize this material is through didactic sequences consisting of an ordered and articulated series of activities that allow the analysis of the different forms of intervention and the meaning that these activities acquire for the construction of educational objectives (Zabala & Arnau, 2010). In this context, the Potentially Significant Teaching Units (UEPS), idealized by Moreira (2011a), emerge as an alternative to promote meaningful learning.

The UEPS is a didactic sequence based on TAS and characterized by a set of eight stages in which conceptual, procedural and attitudinal contents are delimited. The use of diversified materials and strategies, articulated according to the stages, and which privilege questioning, dialogue, criticism and collaborative activities enhance the occurrence of progressive differentiation and integrative reconciliation. According to Moreira (2011b), progressive differentiation occurs when ideas, concepts, propositions that are more general and inclusive of the content are presented at the beginning of the teaching unit and progressively differentiated in terms of details and specificities. In this case, a given subsumer serves as an anchorage for new knowledge in an interactive and dialectical process. Integrative reconciliation occurs as the student establishes relationships between ideas, concepts, propositions, pointing out important similarities and differences, reconciling real or apparent discrepancies. Thus, subsumers and new knowledge can be recognized as related, reorganizing, expanding, and acquiring new meanings. Therefore, if progressive differentiation and integrative reconciliation are fundamental processes of the dynamics of cognitive structure, the facilitation of learning in teaching situations will need to use them as programmatic principles of the subject of the topic to be taught (Moreira, 2011b).

In the focus of the Theory of Meaningful Learning, the learning contents should contribute to the continuous development of the person and society, in order to form individuals capable of intervening and promoting "sustainable human development, mutual understanding among peoples, with a renewal of democracy effectively lived" (Zabala & Arnau, 2010, p. 78). This assumption refers to cross-cutting themes because, according to the DCN (Brasil, 2013, p.29), they are ways "of establishing, in educational practice, an analogy between learning theoretically systematized knowledge (learning about reality) and real-life issues (learning in reality and from reality)". Also, according to Bovo (2004), these themes

> They deal with processes that are being intensely experienced by society, communities, families, students and educators in their daily lives. They are discussed in different social spaces in search of solutions and alternatives, confronting different positions both in relation to intervention in the broader social sphere and personal action (Bovo, 2004, p.4).

Due to its social relevance, the theme "Traffic Education" began to be officially implemented by the Brazilian Traffic Code, Law No. 9.503 (http://www.planalto.gov.br/ccivil_03/leis/L9503.htm) of September 23, 1997. In 2009, the National Traffic Department produced the document "National Guidelines for Traffic Education in Elementary Education" (Brasil, 2009) to provide subsidies for addressing this issue in elementary schools as a means of modifying the current situation regarding traffic accidents. The statistical data reveal the serious situation of Brazilian traffic and reinforce the need to address this issue in a more comprehensive and early way with students, thus making it necessary to review the reductionist approaches that relate the theme "traffic" to the vehicle-driver binomial, treating only the technical contents, and seek to establish an interface with psychosocial and pedagogical aspects. broadening this spectrum.

Students will be future drivers and preparing them for the exercise of citizenship is the school's social commitment. Allied to the attribution of meaning to learning contents, the process of teaching and learning also needs to enable students to understand knowledge as a means to expand their ability to provide answers to important questions in society.

The use of the transversal theme "Traffic Education" aimed to develop skills that structure a lasting learning of Kinematics concepts and the formation of citizenship because, according to the DCN (Brasil, 2013, p. 134), "transversality is one of the ways of working the curricular components, the areas of knowledge and the social themes in an integrated perspective". The use of transversal themes in the final grades of Elementary School based on SAD has already been the subject of research by Zompero et al. (2014).

Based on the theoretical frameworks described above, the next section describes the methodological and didactic path of the UEPS, with the transversal theme "Traffic Education".

METHODOLOGICAL AND DIDACTIC APPROACH

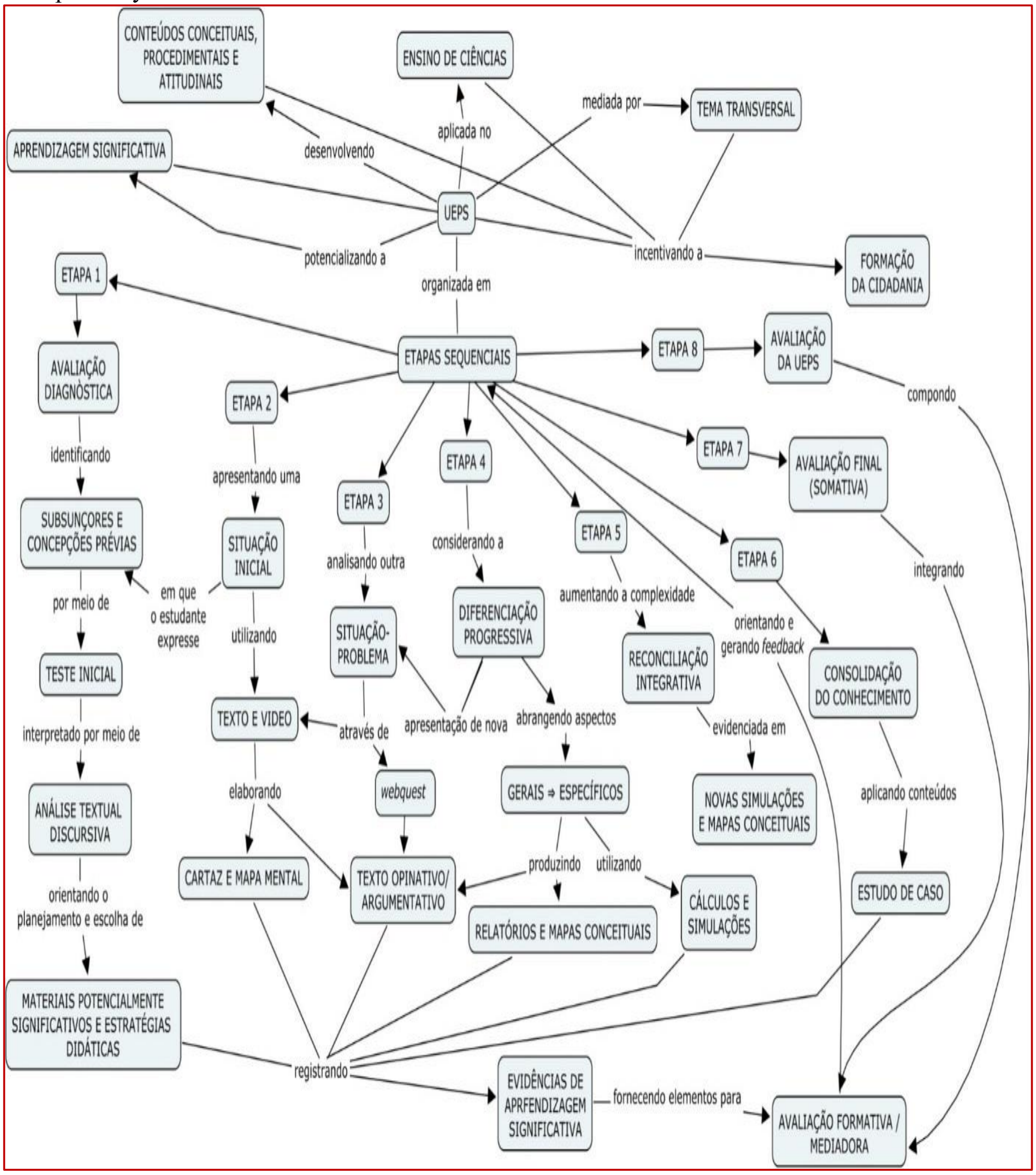
The study presented in this article is part of a professional master's research project (Author 1, 2015). The research carried out is applied in nature with a qualitative approach; in relation to the objectives, it is descriptive and explanatory, and in relation to the technical procedures, it is characterized as a participant, according to Gil (2002).

A UEPS was planned and applied in a ninth-grade class of an elementary school in a state public school in the city of Bom Princípio, state of Rio Grande do Sul (Brazil), in the discipline of Science. The transversal theme "Traffic Education" was addressed in the Kinematics part of the syllabus of the Science discipline. The syllabus of the series is defined in the school's Work Plans and Curriculum Guidelines.

The activities and materials that make up the UEPS, applied in this investigation, were planned taking into account the students' previous knowledge, starting with varied contents, activities and situations in increasing order of complexity. This procedure is in line with a study carried out by Freschi and Ramos (2009) that points out the need to know the context of teaching and learning, based on previous knowledge, to carry out varied activities, to promote the negotiation of meanings, to encourage reading and recording so that students understand the phenomena studied in the school environment and that they reconstruct their knowledge. thus favoring their learning.

The characterization and the different procedures used in each stage of the LIFO are presented in the conceptual map in Figure 1.

Figure 1. - Conceptual map of the UEPS with a transversal theme "Traffic Education" in the teaching of Science and its stages. Prepared by the authors.



The LIFO was organized in 8 stages and, according to the conceptual map in Figure 1, they are structured in a logical way of knowledge, with the performance of varied activities, at an increasing level of complexity, to favor the occurrence of progressive differentiation and integrative reconciliation represented in this map by the horizontal and crossed connectives, respectively.

Chart 1 describes the stages of the sequential development of the LIFO and the activities carried out. The number of class hours (h-a) for each of the stages varied according to the characterization of its dynamics, totaling 21 h-a.

Table 1. - Characterization of the stages and brief description of the activities developed in the UEPS.

LIFO Stage (Number of Class Hours)	Characterization of the dynamics of the stage	Didactic Strategies / Resources
Step 1 (1 h-y)		Diagnostic evaluation: test to identify previous knowledge and conceptions.
Step 2 (2 h-y)	Presentation of an initial situation that leads the student to externalize his/her previous knowledge in the context of the subject, supposedly relevant to the meaningful learning of the subject.	Video, reading and discussion of text, activities in the Student's Notebook, elaboration of concept map.
Step 3 (3 h-y)	Proposition of problem-situations at the introductory level, considering the student's previous knowledge and preparing for the introduction of the subject that is intended to be taught, in an accessible and problematic way.	Video,*webquest*, activities in the Student's Notebook.
Step 4 (4 h-y)	Presentation of the knowledge to be taught, considering progressive differentiation; starting with a more general view of the whole and then addressing more specific aspects of the teaching unit.	Videos, text, graphs, braking and stopping distance calculations, simulations, concept map.
Step 5 (4 h-y)	Resumption of general aspects of the content in a new presentation at a higher level of complexity aiming at integrative reconciliation.	Texts and newspaper news, activities in the Student's Notebook, effects of alcohol, simulation, posters.
Step 6 (3 h-y)	Continuation of progressive differentiation in an integrative perspective (integrative reconciliation) through the proposal of a problem-situation at a higher level of complexity and in a collaborative way. Consolidation of knowledge.	Collaborative activities, elaboration of a problem-situation, reorganization of the concept map.
Step 7 (2 h-y)	Summative assessment	Application of the same test as in step 1 (summative assessment).
Step 8 (2 h-y)	LIFO Assessment	Evaluation of the LIFO by the students through the elaboration of a text.

The evaluation process conducted at UEPS had a formative character, as there was a follow-up of the students in the performance of individual and group tasks and tests; they were frequent, gradual, and complementary (Hoffmann, 2014). Evaluation, in this context, is understood as a process aimed at obtaining data in relation to student learning and, based on these, predicting actions to intervene in the improvement of learning. These actions, related to evaluation, in a logical order and of increasing complexity, made it possible to monitor the cognitive evolution of the student to help him advance in his learning, overcoming any obstacles to the construction of new knowledge.

The dynamics of the UEPS considered different types of assessment, resources and strategies organized in a varied environment, conducive to the promotion of meaningful learning in science teaching. Of the various evaluative instruments used by Author 1 (2015) in his professional master's thesis, such as concept maps, posters, texts, videos, interactive simulations, elaboration of problem-situations, textual productions of students, diagnostic and summative assessment and records (logbook), in this article are presented the results and analysis of the diagnostic assessment, the concept maps and a comparative analysis of the summative assessment with the assessments Previous.

The questions and problem-situations proposed at the UEPS were selected in increasing order of complexity on the structuring contents of Kinematics and endorsed by a group of three professors who are experts in the area.

In relation to the concept maps (CM), they are considered important resources for an evaluation of the evolution of the concepts constructed by the students, that is, they are evaluative resources that can evidence the progression of the construction of knowledge and, therefore, are indicators of the occurrence of significant learning. Concepts are fundamental to human understanding and a concept map is a concept structurer. Concept maps were proposed by Novak (2000) as instruments to represent meaningful relationships in the form of propositions. According to Moreira (2012; 2010), CM are hierarchical diagrams because it is considered that some concepts are more relevant, comprehensive and structuring than others. In MC, concepts are interconnected by lines that unite them and are connected by words – connectives – that help to explain the nature of the relationship. The two concepts plus the connective form a proposition in a synthetic way and reflect the conceptual structure of the content being diagrammed. In the elaboration of the KM, the student makes his knowledge explicit and when re-elaborating it, he reorganizes his ideas, broadens conceptions and evidences facilities and difficulties in the understanding of concepts and in the relationship of meanings. Thus, the KM represents an instrument with potential to evaluate and monitor student learning. When performed in small groups, KMs can perform a useful social function and lead to lively class discussions (Novak, 2000).

The application of the LIFO began with a diagnostic assessment consisting of a set of six questions (as shown in step 1 of Chart 1). Five of these questions were open-ended, and aimed to ascertain previous knowledge about basic concepts of kinematics, necessary to understand the subject of study. And, finally, a multiple-choice question aimed to identify students' conceptions about traffic. All questions were elaborated by the author and discussed with his peers. The answers to the questions of the DA were not commented on with the students after their application, because the same instrument was used at the end of the LIFO to assess the learning of the concepts worked on in the Unit.

In stage 2, kinematics, necessary to understand the subject of study. And, finally, a multiple-choice question aimed to identify students' conceptions about traffic. All questions were elaborated by the author and discussed with his peers. The answers to the questions of the DA were not commented on with the students after their application because the same instrument was used at the end of the UEPS to evaluate the learning of the concepts worked on in the Unit http://www.youtube.com/watch?v=-wRePBit2W4. by the students, of an initial concept map.

Concept maps were also elaborated by the students in stages 4 and 6, in order to evaluate the evolution in the understanding of the concepts related to the subject of study. It should be noted that these concept maps were prepared in conjunction with other activities developed throughout the UEPS, as described in Chart 1, and that they are in accordance with the proposal for monitoring the evaluation process suggested by Hoffmann (2014). For a more complete analysis, with all the evaluation instruments, it is recommended to read the work developed by Author 1 (2015).

Discursive textual analysis was used as an instrument to analyze the answers to questions 3, 4 and 5 of the diagnostic evaluation and summative evaluation (stage 7). This procedure of qualitative data analysis, according to Moraes and Galiazzi (2011), requires an intense impregnation in the investigated phenomenon and the analysis is carried out from readings and rereadings, unitarization and categorization and especially from the production of the metatext.

DATA ANALYSIS AND DISCUSSION

Next, the results of the procedural evaluation composed of the diagnostic evaluation (DA), concept map analysis (formative evaluation) and the final evaluation called summative (SA) are presented and discussed, developed during the application of the UEPS. In the dynamics of the UEPS, several works were carried out collectively and in groups of three students. In this article, in the citations referring to the students, they are identified by the numbers from 1 to 28 and the groups of 8.1 a

Questions 1 and 2 of the AD evaluated the students' perception of the relationship between the quantities distance, time and velocity in uniform rectilinear motion. The data regarding these questions are presented in Table 1.

In question 1, half of the students (50%) correctly determined the distance; Some used the mean velocity formula and others did so by means of proportionality relations without the use of the formula. Among the possible causes of error in the resolution of question 1, the mechanical

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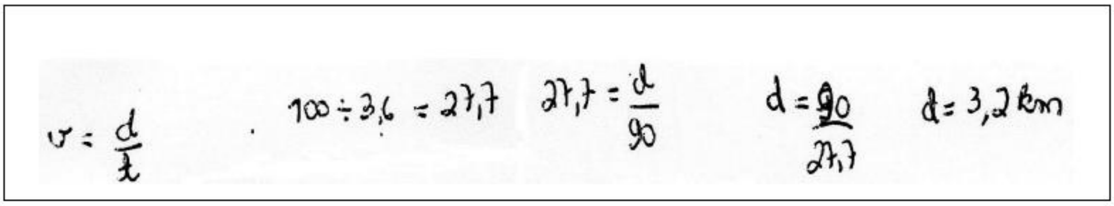
use of an algorithm is noted, as can be observed in the resolution of question 1 by student 12, presented in Figure 2.

Table 1. - Answers to questions 1, 2 and 6 of the diagnostic evaluation.

Question 1: A driver looks at the speedometer of his car and sees the indication 100km/h. He makes a mental calculation and concludes that if he maintains this speed he will reach his destination in 1 hour and a half. How far from the finish point is he at this point?	
Aspects evaluated	Responses (%)
Correct Distance Determination	50,0
Incorrect Distance Determination	50,0
Question 2: A bus trip took 3 hours at an average speed of 70 km/h. To do it in half that time, what should have been the average speed of the bus?	
Aspects evaluated	Responses (%)
Correct speed determination	53,6
Incorrect speed determination	46,4
Question 6: News published in the newspaper Vale do Sinos on 04/07/14, p. 26, reports the flagrant of two motorcycles traveling on RS 122, in São Sebastião do Caí (RS), at 212 km/h in a stretch of maximum allowed speed of . In the event of an emergency braking, how far would the rider travel before the bike actually stopped? Get an estimate80 km/h	
Aspects evaluated	Responses (%)
Correct estimation of stopping distance	0,0
Incorrect estimation of stopping distance	100,0

In the resolution of question 1, presented in Figure 2, the student maintained the division of quantities instead of applying the inverse operation and, in addition, did not perform the correct conversions of units. According to Kamii and Livingstone (1995), if students know formal algorithms, they have greater difficulty in establishing meaningful relationships in the problem because they have become accustomed to solving them mechanically.

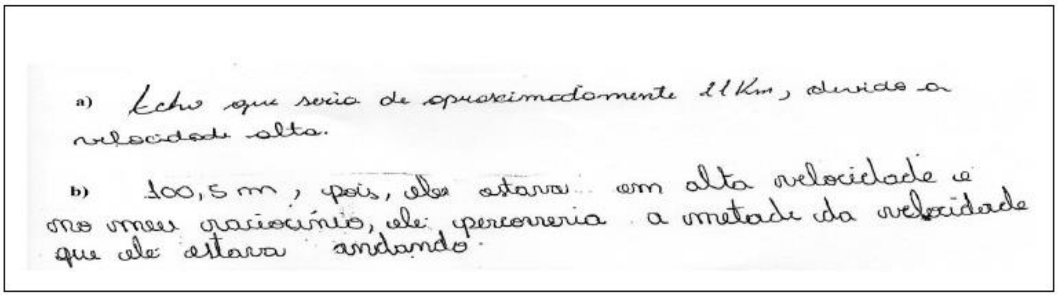
Figure 2. - Resolution of question 1 by student 12



In question 2, the increase in the percentage of correct answers, almost 4%, was due to the application of the mean speed formula, because, in this question, the values stated favored the use of an equation. The high error rates in questions 1 and 2, about 50%, were due to the lack of understanding of the quantities, the application and the algebraic operations in the formula.

Question 6 evaluated the ability to estimate the stopping distance of a vehicle as a function of its speed, since the specific formulas for performing the calculation were not yet known by the students. According to Table 1, no student was able to estimate the stopping distance by presenting their estimate with the development of procedures such as hypothesis raising and application of the mean speed formula, as evidenced by the answers given by students 7 and 18 in Figure 3.

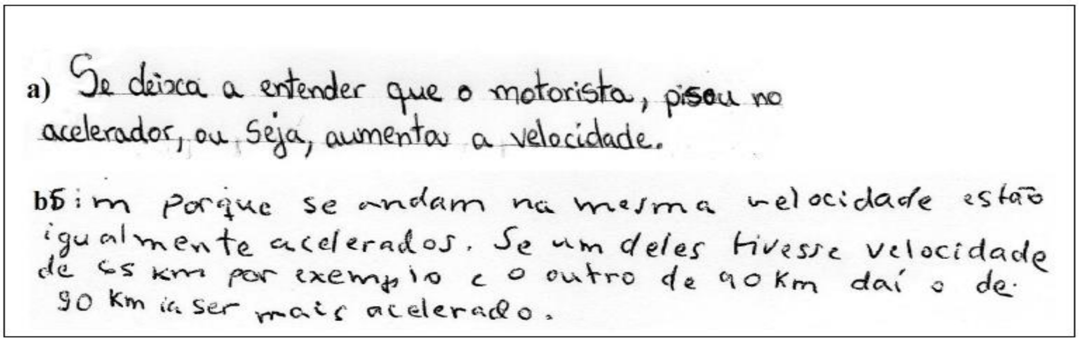
Figure 3.- Answers given to question 6: a) student 7; b) Student 18.


a) Acho que seria de aproximadamente 11Km, devido a velocidade alta.

b) 100,5 m, pois, ele estava em alta velocidade e no meu raciocínio, ele percorreria a metade da velocidade que ele estava andando.

The answers to questions 3, 4 and 5 of the DA are presented in Table 2. The answers were analyzed and categorized according to the method of discursive textual analysis (Moraes and Galiazzi, 2011). Questions 3 and 4 evaluated the students' conceptions of the concepts of velocity and acceleration. In question 3, the majority of students, 85.7%, understood that acceleration is related to the increase in speed (Figure 4a) and only 14.3% showed their understanding of the concept of acceleration. In relation to question 4, the students' answers indicate a misconception of these quantities (Figure 4b).

Figure 4 - a) Student 5's answer to question 3; b) Answer given to question 4 by student 11.


a) Se deixa a entender que o motorista, pisou no acelerador, ou seja, aumentou a velocidade.

b) Sim porque se andam na mesma velocidade estão igualmente acelerados. Se um deles tivesse velocidade de 65 km por exemplo e o outro de 90 km daí o de 90 km ia ser mais acelerado.

For Leite (1993, p. 54), this conception evidences "the importance attributed by the student to the position to the detriment of the relationship between speed variation and time variation".

In the answers to question 5, several students' conceptions about traffic situations are evident. According to the data in Table 2, approximately 46% of the students understand that drivers are not to blame for traffic accidents. This high percentage is corroborated by the fact that almost 61% of students understand that some transgressions practiced by drivers do not increase the risk of accidents. In addition, almost 72% highlight that accidents happen due to fatalities. In view of these results, we can affirm that a high percentage of students understand that traffic accidents do not result from the direct actions of drivers.

Table 2. - Answers to questions 3, 4 and 5 of the diagnostic evaluation (AD).

Question 3: What do you mean when you hear someone say that "the driver accelerated the car"?	
Categories	Responses (%)
To accelerate is to increase speed	85,7
To accelerate is to modify the speed	14,3
Question 4: When passing through an electronic speed bump, two vehicles were traveling at a speed of 65 km/h. Do you agree that they have the same acceleration?	
Categories	Responses (%)
Same speed means same acceleration	92,9
I didn't know how to answer	7,1
Question 5: Which of the following statements do you agree with? (Possibility to check more than one option)	
Categories	Responses (%)
Drivers are blamed for accidents	53,6
Respecting the laws reduces the risk of accidents	100,0
Some transgressions do not increase the risk of accidents	60,7
Accidents are fatalities	71,4
Traffic laws only apply to drivers	78,6

Another result to be highlighted in question 5 (Table 2) is that for 78.6% of the students, the laws and rules only apply to drivers. This high percentage indicates a distorted understanding of the pedestrian/driver relationship, attributing a secondary role to the pedestrian who "assumes the role of second-class citizen, in a city that is increasingly the habitat of the vehicle and the anti-habitat of man" (Vasconcelos, 1985, p.32).

In view of this initial analysis, the cross-cutting theme "Traffic Education" in Science Teaching becomes relevant to provoke changes in these misconceptions about the role of drivers and pedestrians in traffic. The characterization of the conceptions, identified in question 5, signals the need to promote a critical reflection on the collective responsibility for accidents, in order to achieve the main goal of educational actions: the reduction of risks in traffic (Faria & Braga, 2011).

Next, we analyze and discuss the students' productions in the elaboration of concept maps (CM) as a resource of formative assessment, produced in stages 2, 4 and 6 presented in Chart 1.

For the evaluation of CM, we defined some criteria based on Müller and Moreira (2013), Moreira (2012) and Trindade and Hartwig (2012), such as a root, valid concepts, links between these concepts, connectives and propositions with logical meaning, as well as the hierarchy of

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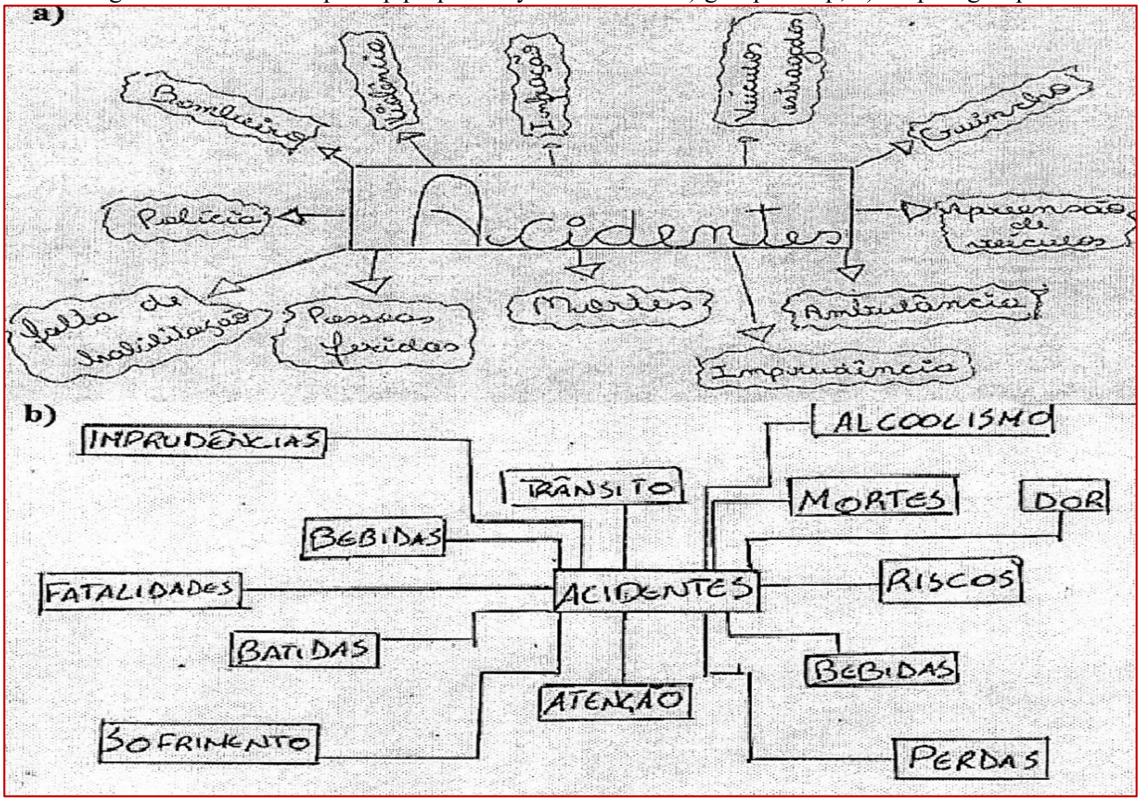
concepts that can evidence progressive differentiation and integrative reconciliation. The elaboration of the first MC took place in stage 2 of the UEPS. For this elaboration, the words "traffic" or "accidents" were suggested as roots or keywords. From then on, the students made a free association of ideas. In this first elaboration, the concepts were essentially focused on the causes and effects of traffic accidents (Figure 5).

Figure 5. - First concept map prepared by the students: a) group 2 map; b) Map of group 8.



In the elaboration of this first concept map, most students reported having found it difficult to establish a connection between the concepts. This difficulty can possibly be understood by the fact that both the type of activity proposed and the theme addressed were not familiar to the students and that

> The construction of the map requires considerable creativity in the organization of the structure, selection of important and relevant concepts to be added to the map and search for cross-links [...]. Of course, it is necessary to give students weeks of practice and constructive information through the construction of smaller concept maps (Novak, 2000, p. 192).

Evidence of these assumptions (creativity, organization of structure, selection of concepts) can be seen in the third map prepared by the same groups mentioned above, as shown in the maps in Figure 6.

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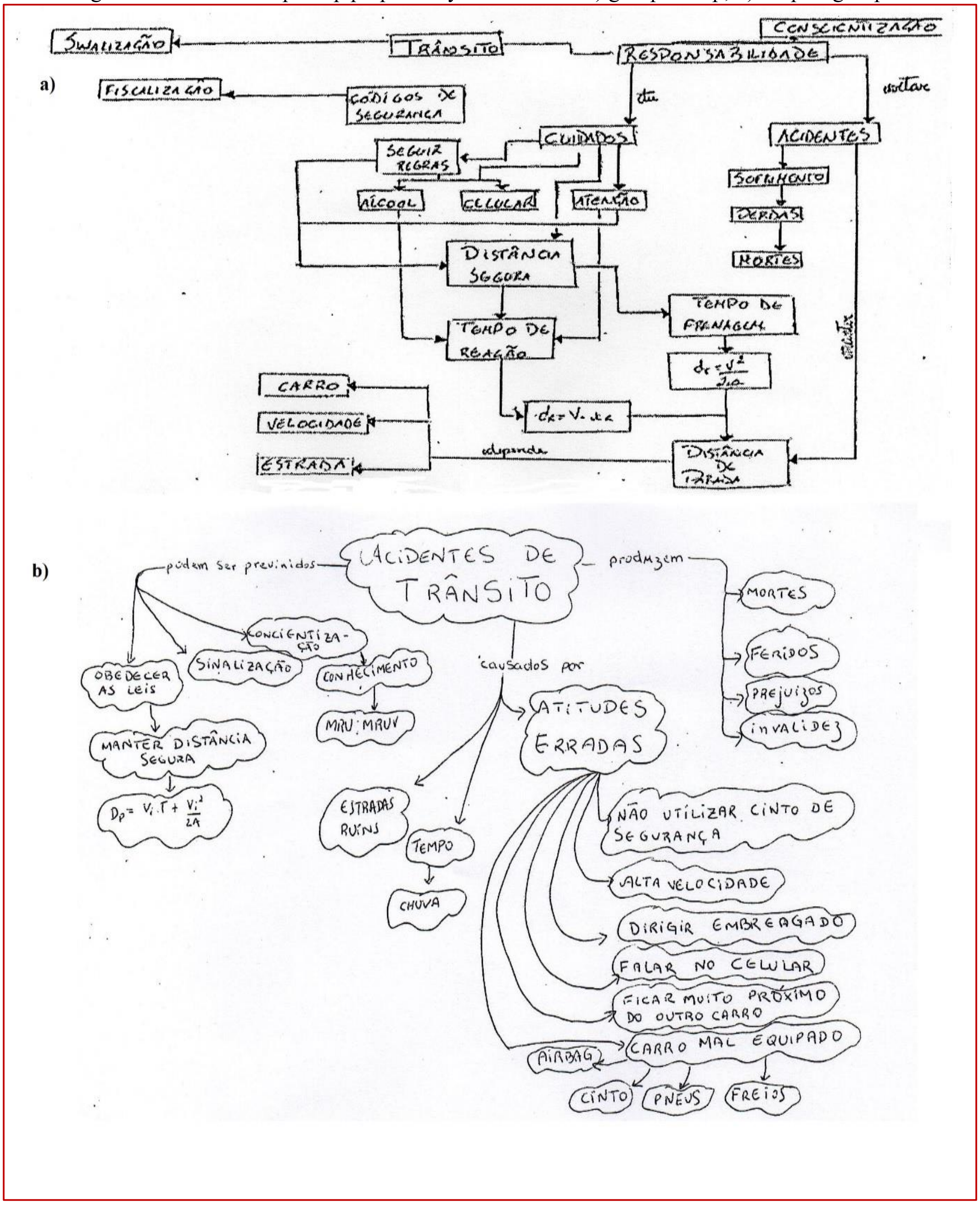
Figure 6. - Third concept map prepared by the students: a) group 2 map; b) Map of group 8.



In the MC in Figure6, there are advances in organization, expansion of the number of concepts, in the relationships between concepts, and in hierarchization. This evidence indicates the occurrence of the process of progressive differentiation. In the conceptual map of Figure 6a, the presence of cross-relationships between concepts can be observed, which may indicate the establishment of an integrative reconciliation.

In the comparative analysis of the CM in Figures 5 and 6, a transition from the radial organization to a more complex organization of the tree type is observed (Moreira, 2012), showing that in the organization of the concepts present in the final maps (Figure 6), the new concept, which was worked on during the UEPS, was related to the concepts available in the cognitive structure of the students (Ausubel, 2003).

In the initial MCs (Figure 5) only free associations appear, there are no relations between concepts, only some ideas without logical organization. On the other hand, in the final CM (Figure 6), the presence of connectives between the concepts can be observed. In addition, more general concepts appear at the top of the map and more specific ones at the bottom of the map. It is possible to perceive a greater number of relationships between the concepts worked, consequently an increase in meanings. These characteristics presented in the third MCs, according to Trindade and Hartwig (2012), are indications that the instructional material was potentially significant because it provided subsidies to students for the understanding of contents related to the theme "Traffic Education".

Table 3. – Answers to questions 1, 2 and 6 of the summative assessment (SA).

Question 1: A driver looks at the speedometer of his car and sees the indication 100km/h. He makes a mental calculation and concludes that if he maintains this speed he will reach his destination in 1 hour and a half. How far from the finish point is he at this point?	
Aspects evaluated	Responses (%)
Correct Distance Determination	85,7
Incorrect Distance Determination	14,3
Question 2: A bus trip took 3 hours at an average speed of 70 km/h. To do it in half that time, what should have been the average speed of the bus?	
Aspects evaluated	Responses (%)
Correct speed determination	82,1
Incorrect speed determination	17,9
Question 6: News published in the newspaper Vale do Sinos on 04/07/14, p. 26, reports the flagrant of two motorcycles traveling on RS 122, in São Sebastião do Caí (RS), at 212 km/h in a stretch of maximum allowed speed of . In the event of an emergency braking, how far would the rider travel before the bike actually stopped? Get an estimate80 km/h	
Aspects evaluated	Responses (%)
Correct estimation of stopping distance	77,4
Incorrect estimation of stopping distance	22,6

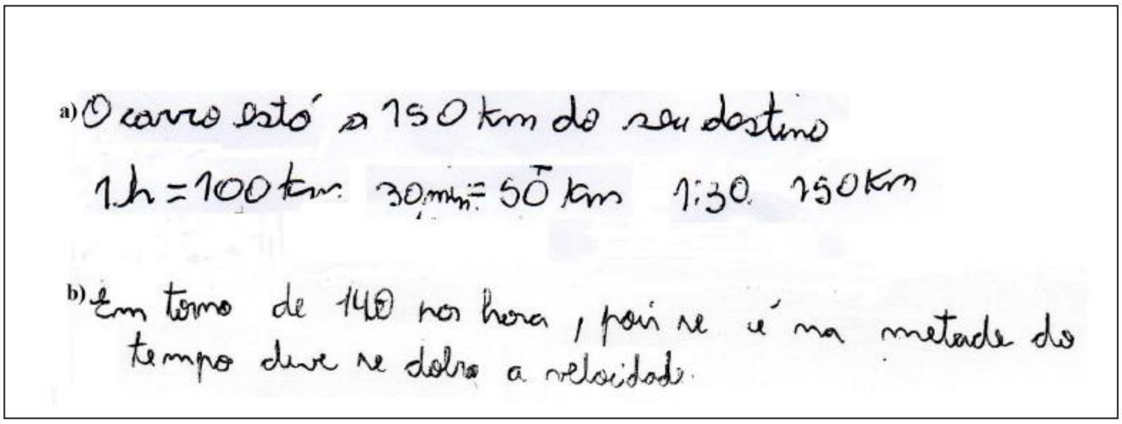
The variety of concepts both in relation to the content of Kinematics and to the theme of "Traffic Education" in the MCs in Figure 6 indicated a new elaboration of contents, procedures and attitudes in the students' productions.

In view of these new characteristics in the final CM (Figure 6), there is evidence of progressive differentiation and integrative reconciliation. Therefore, it is possible to affirm that the elaboration of concept maps has been shown to be a potential resource for the occurrence of meaningful learning.

According to Novak (2000), the expressive number of concepts used in a concept map signals the approach to meaningful learning. In addition, Moreira (2012) emphasizes that if in the explanation of the map the learner rises and falls in the conceptual hierarchies, this is an indication of integrative reconciliation.

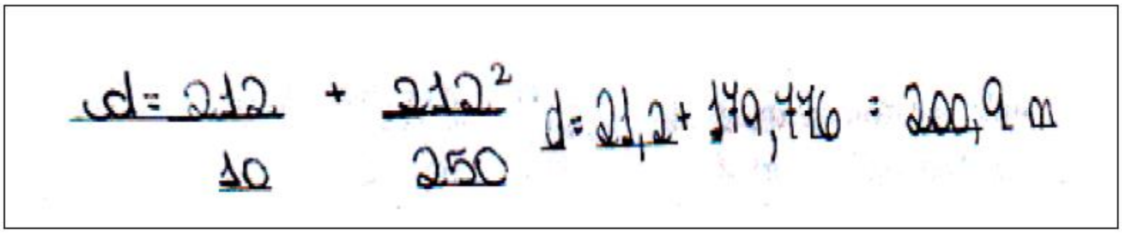
Summative assessment (SA) was applied in step 7 of the LIFO (see Chart 1). The data obtained in relation to questions 1, 2 and 6 of the SS are presented in Table 3. In the comparative analysis between the answers of the HC and the SA, in relation to question 1, there was an increase of almost 36% in the correct determination of the distance and, in question 2, there was an increase of approximately 29%. The improvement of these indexes, associated with the results presented in the conceptual maps in Figure 6, allows us to infer that the students correctly applied the physical quantities involved in the mean speed formula, as evidenced by the answers of students 12 and 15 to questions 1 and 2 of the SSA, respectively, presented in Figure 7.

Figure 7. - Answers given to questions 1 and 2, respectively: a) student's answer 12 and b) student's answer 15.



In relation to question 6, with a higher level of complexity than questions 1 and 2, in HC no student made a correct estimate of the stopping distance. However, in SA, the vast majority of students, 77.4%, correctly estimated the stopping distance of the motorcycle, and it was possible to verify that the students understood the physical meaning of these quantities and correctly applied the formulas presented in the *webquest* in step 2 (see Chart 1) in a more complex problem and close to a real situation. Figure 8 shows the calculation performed by student 4 to answer question 6.

Figure 8. - Resolution of question 6 by student 4.



Even though there are still some difficulties in performing calculations through the use of algorithms, the basic principles of this procedure are satisfactorily performed. In this context, we agree that

> The routes of construction of students' knowledge are not standardized, which means that each student follows a personal and distinct path along a didactic intervention activity. Commitments to one's own learning, alternative conceptions, learning styles and personal motivations guide a given subject while undergoing the teaching process (Carvalho Junior, 2011, p.8).

Thus, it is likely that the personal conditions of each student are factors that interfere with learning, determining different rhythms for the elaboration and assimilation of knowledge.

The answers to questions 3, 4 and 5 were categorized in the same way as in Table 2, and the results of SS are presented in Table 4. When comparing the percentage of the students' answers to question 3 of the AS (Table 4) with the DA (Table 2), it is observed that 26.4% of the students, an increase of approximately 12%, stated that to accelerate is to modify the speed, as observed in the answer of student 8: "having the same speed does not mean that the cars have the same acceleration, It's going to depend on how it changed and how long it took for them to change their speed."

However, this increase in the percentage of correct answers in question 3 of the SSA does not correspond to an understanding of the concept of acceleration because, in question 4, all students did not know how to answer this question correctly. The students' answers to the situation described in question 4 reveal knowledge gaps in the differentiation between velocity and acceleration. These results corroborate the study conducted by Trowbridge and McDermott (1980) on the learning of kinematics, which revealed that most students were unable to distinguish the concepts of position, velocity and acceleration.

The results of questions 3 and 4 of the SS confirm the persistence of the previous conceptions, as can be seen in the answer of student 3 when he states that to accelerate is "to change speed, that is, to go faster". Throughout their life experience, students construct their own concepts about phenomena that they observe and experience in their daily lives, which, in turn,

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are resistant to change and interfere, to a certain degree, in the learning of scientifically accepted concepts.

Table 4 - Answers to questions 3, 4 and 5 of the summative assessment.

Question 3: What do you mean when you hear someone say that "the driver accelerated the car"?	
Categories	Responses (%)
To accelerate is to increase speed	73,6
To accelerate is to modify the speed	26,4
Question 4: When passing through an electronic speed bump, two vehicles were traveling at a speed of 65 km/h. Do you agree that they have the same acceleration?	
Categories	Responses (%)
Same speed means same acceleration	72,3
I didn't know how to answer	27,7
Question 5: Which of the following statements do you agree with? (Possibility to check more than one option)	
Categories	Responses (%)
Drivers are blamed for accidents	48,7
Respecting the laws reduces the risk of accidents	100,0
Some transgressions do not increase the risk of accidents	31,2
Accidents are fatalities	33,0
Traffic laws only apply to drivers	27,5

The concepts of kinematics, especially acceleration, which were not apprehended from the perspective of scientific knowledge, are possibly still strongly anchored in knowledge constructed in other contexts and previous conceptions (Horton, 2007). Effects of rote learning can also hinder the acquisition of new knowledge because "students, when accustomed to the traditional education system, generally show resistance to new ways of learning" (Müller & Moreira, 2013, p. 26).

Although the correct answers to questions 3 and 4 are not a guarantee of the occurrence of significant learning, the results obtained in the set of assessment instruments (AD, MC and SA) indicate that there was an improvement in the understanding of the concepts of distance, time and speed.

However, the students' perception of the concept of acceleration did not show an improvement. Thus, Moreira (2011b) points out that the process of assessing meaningful learning involves inferring understanding and the ability to transfer to unknown situations, emphasizing that learning is progressive, and error is expected to occur.

Error, in this context, is understood as a datum to intervene in the evaluation process, reviewing the actions of the teacher and the student in a dialogical perspective and providing *feedback*, as it can be an important element for the production of knowledge when considered from the perspective of what has not yet been learned. In this sense, it is much more valued, important, fruitful and positive for the evaluation process (Hoffmann, 2014).

In the comparative analysis of the results of question 5 of SA and AD, it was observed that there was a reduction of 4.9% in the understanding that drivers are to blame for accidents. This result is contrary to what would be expected after the application of the UEPS. In other words, the material (strategy, resources) did not favor a change in the understanding of drivers' responsibility in relation to traffic accidents. This result provides clues for the teacher to review the materials used in the LIFO on that specific topic.

On the other hand, in the statements "Some transgressions do not increase the risk of accidents" and "Accidents are fatalities" in question 5, there was an improvement of almost 30% in students' understanding that transgressions increase the risk of accidents (from 60.7% to 31.2%) and an improvement of approximately 40% in the understanding that accidents are not fatalities (from 71.4% to 33%). These results indicate that the students perceived that traffic accidents result from some transgressions committed by drivers, contrary to what they perceived from these same statements in AD. And, in relation to the statement "Traffic laws only apply to drivers", there was a change in the students' perception that traffic laws do not apply only to drivers (from 78.6% to 27.5%), indicating that the diversified materials and strategies favored a change in attitudinal contents.

These results corroborate, to a high degree, the National Curriculum Guidelines for Traffic Education in Elementary School (Brasil, 2009), which emphasize the understanding that there are no pedestrians, drivers or passengers and emphasize the importance of developing activities that allow students to confront situations in which they assume different roles that enable them to understand traffic conflicts. regardless of the position he occupies.

FINAL THOUGHTS

The results of this study showed that the Potentially Significant Teaching Unit, with the transversal theme Traffic Education, applied in the discipline of Science in Elementary Education, based on the Theory of Meaningful Learning, emerges as a viable alternative to break with the predominantly expository, decontextualized and disciplinary class. The dynamics of the UEPS made it possible to integrate, in an organized way, students' previous knowledge about Kinematics contents present in everyday life with the scientific foundations of this topic in a logical way and in increasing degrees of complexity with this transversal theme and, thus, providing evidence of the occurrence of significant learning.

In the UEPS on the theme "Traffic Education" it was possible to perceive, from the analysis of the results obtained by the various evaluative instruments, such as diagnostic evaluation (AD), concept maps (MC) and summative evaluation (AS), an advance in the understanding of the concepts of Kinematics. However, in relation to acceleration, there was no conceptual evolution. In this sense, Lopes (2007) points out that school learning problems in Science, such as the concept of acceleration, can be related to the selection of contents, their organization and the way the teacher acts in the classroom. Thus, these results indicate the need to review to some degree the organization of the content, materials and strategies used by the teacher so that in the next application of this LIFO it can fill gaps in knowledge about the concept of acceleration (Moretto, 2008).

It should also be noted that the material worked favored the improvement of students' attitudes to deal more adequately with the complexity of the 'traffic' phenomenon. Thus, it is possible to affirm that a more comprehensive human formation occurred than just accumulating information. The performance of collaborative tasks in small groups and the socialization of the results in the large group also favored social interaction, a relevant aspect of meaningful learning. Therefore, the practice of this LIFO offered favorable conditions for the development of new attitudes towards traffic education.

The evaluation process developed at the UEPS, continuously, in all its stages, of a formative nature and with varied evaluation instruments, favors a reflection on the need to change a traditional posture of evaluating as a synonym of grade (quantitative result) using other elements and instruments that enabled students to express their progress in learning. characterizing a more comprehensive assessment in the service of learning (Hoffmann, 2014). For Moreira (2011a), the evaluation process is fundamental in the context of SS theory and should take place during the class, in the progress of the students' work, in moments of discussion and in the performance of individual and group tasks.

These results demonstrate that the theme Traffic Education can be used as a transversal axis for the learning of Kinematics concepts, since it contextualizes the teaching of Science, helping in the understanding of different contents, both conceptual and attitudinal, and contributing to the facilitation of meaningful learning.

Traffic education will be effectively developed at school, with the relevance it deserves, when we are able to mobilize science teachers in understanding and raising awareness of the importance of establishing relationships between various areas of knowledge, which requires a commitment to reflect on trends, conceptions, attitudes and innovative pedagogical practices in the classroom.

We are aware that the research theme has not been exhausted in this discussion, which motivates the development of new studies. Nor does it pretend to consider it a model to be faithfully followed because, being a construction, it requires adaptations and modifications necessary to the characteristics of the students in order to create adequate conditions for the context of its application.

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