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CONCEPT MAPS AS A STRATEGY TO ASSESS CHEMISTRY LEARNING IN SHORT FILM PRODUCTIONS BY HIGH SCOOL STUDENTS

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Abstract. Chemistry is a course that develops student explanations of everyday life phenomena. Several researchers discuss about tools that help chemistry teachers to facilitate students understanding of chemical knowledge. Among these tools, the commercial cinema is a promising one. However, there are a few reports on the production of short films by high school students as a strategy for promoting meaningful learning in chemistry. This paper presents findings about how making short film production in high school helped to learn chemistry. Concept maps were used to evaluate connections between chemical concepts and scripts developed for the short film productions. Each high school student made two maps, one before and another after the production. The chemistry teacher monitored student's productions through a social network, the Facebook, as well as during the regular classes. The comparison between initials and finals students` concepts maps showed improvement on the students understanding about chemistry. More than that, our results indicated that 79% of high school students made conceptual maps with elements from their own short film production scripts. Therefore, the activity of producing short films helped to promote meaningful chemistry learning.
Key words: concept maps, chemistry learning, short film production

1 Introduction

According to Gabel (1999) Chemistry is a complex science due to some abstract concepts, which may lead to extensive misconceptions among students. There are many tools used in the Chemistry teaching to facilitate chemical knowledge construction, for example, experimentation, simulation, video, etc. There are studies about how to use cinema for learning. However, we found a few data concerning cinema as a didactic strategy in this discipline.

Cinema is the audiovisual version of storytelling. Life stories and narratives enhance emotions and therefore set up the foundation for conveying concepts. Movies provide a narrative model framed in emotions and images that are grounded in the students' familiar everyday universe. Thus, the cinema is an excellent educational tool because it presents situations as if they are lived by the protagonists, mimicking social reality, but with the great advantage of re-observe the scenes when necessary. It is possible, afterwards, to have discussions of social issues at the same time as learning chemistry. Another method utilizes certain scenes of commercial movies, adequately selected, to introduce determined social behaviors in the Chemistry teaching (Santos & Aquino, 2011). In addition, students have the opportunity to "translate" movie life histories into their own lives, and into a chemistry context, even when the movie does not belong to the chemical field. They shed light on socio-cultural elements and discuss big ideas like citizenship and social responsibility, while using the universal kind of language, images. All of this transform concepts into emotions, which can inspire student's actions.

Flipping these strategies above, we can have students building short films about chemistry themes as a way of learning. Since film has the potential to fascinate, inspire and educate students, opening their minds to the world around them, the idea was to introduce short film productions not just as a passive form of entertainment, but also as a powerful active learning tool for chemistry learning process. The questions are, "Is it possible to learn Chemistry by building short films? How to do this? What may be learned from this experience?" These questions are the basis of this study.

Knowledge building is a system with elements that necessarily supported on one another while, at the same time, these are opened to multiple exchanges with the outside (Piaget, 1995). The development of the human cognitive process is based on that. Thus, learning process assumes it is impossible to build a single knowledge as a starting point in a classification without using other domain-related knowledge, which characterizes a non-hierarchical, dynamic process of interconnected variables. In this way, meaningful learning, as defined by Ausubel (1968), happens when new knowledge connects with previous knowledge ultimately creating life-long learning.

The Ausubel`s theory of meaningful learning constitutes a basis for Chemistry teaching by short film productions. The production of short film was a learning tool and fit the characteristics of meaningful learning described by Jonassen et al (1999) shown in Table 1.

Thus, meaningful learning requires conversations and group experiences and aiming to create a learning environment able to stimulate critical thinking. In order to foster students engaging in meaningful learning we used a combination of technological elements. This environment enabled cooperation to produce short films. Vygotsky's theory of social cognitive development states, "social interaction plays a fundamental role in the development of cognition" (Vygotsky, 1998). Vygotsky's Theory of Social Cognitive Development argues that social interaction plays a fundamental role in the development of cognition. Another notable aspect of Vygotsky's theory is it claims, "Instruction is most efficient when students engage in activities within a supportive learning environment and when they receive appropriate guidance that is mediated by tools" (Vygotsky, 1998). In the short film productions to promote meaningful learning teacher guidance is fundamental to achieve students learning and activity success.

Table 1: Characteristics of meaningful learning (Jonassen et al, 1999)

Characteristic	Description
Active	Students interact with the environment, manipulate objects and observe the effects of manipulation
Constructive	Students must reflect on the activity and their observations, and interpret them in order to have a meaningful learning experience.
Intentional	When students actively try to achieve a learning goal they articulate, think and learn more.
Authentic-	Learning is meaningful, better understood and more likely to transfer to new situations when it occurs engaged with real-life, complex problems
Cooperative	Each person lives, works and learn in communities, naturally seeking ideas and assistance from each other, and negotiating and solving problems. Meaningful learning, therefore, requires conversations and group experiences.

According to AusubeI (2000) the new learning was meaningful when it could be related in a non-arbitrary way to that which a student already knew. When student's existing cognitive structure takes new information and this relates to the previously learned content forming new connections between this new information and the existing information, meaning happens.

This learning may be is promoted through concept mapping by the student's ability to not only create meaningful learning, but to transfer knowledge gained before to future problems as well. Concept mapping facilitates the student's ability to organize information, assess existing knowledge gains, develop insights into new and existing knowledge and transfer knowledge to new experiences. Regardless, concept maps can facilitate students' understanding of the organization and integration of important concepts (Pinto & Zeitz, 1997). By connecting old and new knowledge, this type of learning clarifies knowledge, improves critical thinking and assists in completing missing knowledge (Beitz, 1998).

Novak and colleagues developed concept mapping in 1972. At that time, concept maps were used to represent the conceptual network established by students throughout elementary and high school, which resulted in a longitudinal study of conceptual change in science education (Novak & Musonda, 1991). The initial milestone occurred before the birth of concept maps (1972) when David Ausubel published Assimilation Theory of Meaningful Learning and Retention (Ausubel, 2000). Although it is important to use concept maps appropriately for educational purposes. Previous studies indicate that there are two dominant processes for creating concept maps in classrooms. One process occurs when students are fully responsible for creating the concept maps by themselves without the aid of subordinate concepts, and linking words/phrases (Yin et al., 2005). The other process happens when teachers provide students with the structure of the concept map, the superordinate concept, the subordinate concepts, and linking words/phrases and are required to fill and complete the concept map to show the appropriate relational propositions (Yin & Shavelson, 2008). In chemistry, the use of concept maps has been widely investigated. According to previous studies (Markow & Lonning, 1998; Pendley et al., 1994), concept maps help chemistry learning both in classrooms and in laboratories. In this way, concept maps can improve understanding of chemical concepts and help build connections among abstract

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concepts and bind concepts with linking words that help students see connections among them and organizes the knowledge hierarchically, based on scientific knowledge (Francisco et al., 2002; Nicoll et al., 2001).

A concept map is not just a learning tool, but also an ideal evaluation tool for educators measuring the growth of and assessing student learning. When students create concept maps, they explain ideas using their own words. The map helps to identify incorrect ideas and concepts. Educators are able to see what students did not understand, providing an accurate, objective way to evaluate areas in which students do not yet grasp concepts fully. In this way, concept maps are an important tool to analyze how the short film production can promote the meaningful learning in the chemistry teaching.

In the present work, we used concept maps as tools to represent knowledge to support students' expression before and after producing their short film. This means that students concept maps represent students concept systems of preexisting knowledge, as well as activate later constructions, and possible subsystems of signification associated with the content at chemistry. Analyzing student's concept maps, we aimed to understand the student's knowledge of the determined chemistry topic and the influence of the use of short film production as a strategy for learning this determined chemistry topic.

2 Methodology

The experience developed during seven months in the Colégio de Aplicação da Universidade Federal de Pernambuco (CAp-UFPE), a public Brazilian high school, with 53 students in their final year, in the chemistry course (three weekly classes). The project was named QUIMICURTA.

Students gathered themselves into five groups by affinity. Each group produced a short film using chemistry concepts. The short film productions was an extra-class activity and the guidance of the teacher happened weekly by social network, Facebook, and, sometimes, during regular classes.

The project evaluation focused on two aspects, quality of short film and chemistry concepts applied in that production. In addition, all students made individual concept maps. The data analysis used two conceptual maps made by each student: (a) one map before initiating the short film production and (b) the second just after the short film production. This analysis used the following criteria: correct chemical concepts and relationships with related ideas, number of relationships (levels) and concepts from student's film scripts.

The number of relationships or levels of concept maps used were (authors' classification): i) N1=one level; ii) N2=two levels; iii) N3=tree levels and iv) N4=four or more levels. In this study, the number of relationships was the first visual comparison between initial and final maps.

3 Findings

3.1 Short film analyzes

The Table 2 shows the chemical themes and the script abstract produced by students for short film productions. Each group developed one theme and chose the film characteristics.

To develop contextualized stories students used all chemistry themes. Teacher`s monitoring of students development of short film productions through social network showed all students made meaningful decisions about how to apply chemical concepts in their stories. Sharing knowledge between colleagues and teacher gave students an opportunity to engage in discussions, take responsibility for their own learning and, thus, become critical thinkers. Critical thinking is valued at all levels of meaningful learning. The process of promoting critical thinking in on line space involves comprehension that students must be meaningfully motivated and encouraged to improve their thinking skills. Therefore, critical thinking and meaningful learning are interrelated. The social themes that all films showed reinforce this interconnection.

Table 2: Chemistry themes and abstract of short film production

Chemical concept	Script abstract
Isomerism	Use of Thalidomide by a high school student who became pregnant.
Polymer	Use of a polymer bulletproof vest to prevent a homicide.
Organic Function	Use of chemicals to promote coffee traffic.
Addition reaction	The history of a margarine manufacturer from vegetable oils.
Oxidation-reduction reaction	The wine oxidation and the use of Breathalyzer in the road traffic.
Ester reaction	The development of an advertising campaign for a liquid soap.

3.2 Analysis of Concept Maps

The student's initial maps indicated that all students had some previous knowledge about the proposed concept of chemistry used to short film production. All students' final concept maps expanded initial concepts as compared to the initial maps, something easily noticed by a mere glance at the size of the maps.

Table 3 showed the number of levels found in the preliminary concept maps analysis. Some initial maps presented a few concepts and relations. A purely visual comparison between the maps indicated that students added new elements, reinforcing the opportunity of using concept maps in the learning process of the chemistry. In addition, most maps (79%) presented elements of the scripts developed for the production of short films. It reveals that the process of producing the short films led to new connections between prior knowledge and new knowledge and that this strategy can support the promotion of meaningful learning.

There were maps that do not had scripts elements showing interrelation between concepts, so they did not characterize as fragments but as parts of a whole. Students with fewer representations in the initial map presented more expansion on the final map, probably influenced by group activity and class discussions.

The analysis of Table 3 showed more occurrence of N2 to N3 transitions followed by N2 to N4 transitions. If a student has relevant information in their cognitive structure to relate a new knowledge, the level number in the maps may represent this connection, and then, meaningful learning can happen. However, meaning happens when, and only when, a learner incorporates new information into their cognitive structure and relates that to which he or she already knows to form new meaning. The data showed the final maps that have remained with the same number of levels had greater organization of concepts and preserved the uniqueness of the new content. Figures 3 and 4 show example of N4 to N4 transition.

Table 3: Comparison of the number of levels in the concepts maps produced before and after short film productions.

Level number before short film production	Level number after short film production	Occurrence percentage (%)
N1	N1	1.89
N1	N2	7.55
N1	N3	1.89
N2	N3	39.62
N2	N4	32.07
N4	N4	16.98

Concept maps from two students were randomly selected to illustrate data analysis. Figures 1 e 2 show examples of the initial and final concept maps, respectively, drawn by the same student 1. Figures 3 and 4 are the initial and final concept maps of student 2. The result of maps analysis of other students was similar to one described in this paper.

In the initial map of student 1 (Figure 1) demonstrated only rudimentary knowledge of organic functions, which was the topic used in the short film production of his group. Student 1 only connected a simple classification of the organic functions and the correspondent structural molecular form. In addition, student 1 showed difficulties in the relationship between amide function and its structure. No relation was found in amide concept.

The comparison of Figure 1 and the final map represented in Figure 2 showed N2 to N4 transition. It indicates there was not only a highly significant increase in organic function knowledge, but also this knowledge was consolidated.

Accurate relationships between concepts related to organic function and the script used in the short film production was evident in Figure 2. The induction of "everyday applications" reinforce this conclusion. The scrip of short film produced by group of student 1 based in the everyday applications of chemical substances. In a short film script, traffickers sold coffee as a drug and killed people who did not want to attend traffic with chemicals. In order to contain the traffic of coffee the police opened an investigation. Terms like "medicines" and "solvents" have a direct connection with the script built by the group.

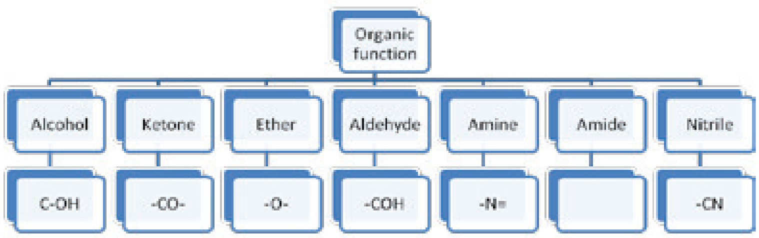

Figure 1. Initial concept map of student 1presents some previous knowledge about organic function

Thus, student 1 added significant interrelations to organic function concepts and the process of progressive differentiation was evident. The activity of researching, prior to make a short film production, seemed to facilitate this process. The progressive differentiation is the meaningful learning process of introducing new content at its highest level of generality or abstraction and then progressively getting more specific about that content as you compare it with other content that exists within a person's cognitive structure (Ausubel, 2000). In this way, Figure 2 shows a more contextualized relationship of organ function classification, but with a much lower degree of importance. Thereby, student 1 showed a significant broadening of chemistry knowledge. He also showed us the production of the short film played an important role in this new knowledge construction.

Student 2 reached similar results in his production about ester reaction. Figure 3 showed a simple connection between the ester reaction and only two types of reactions, esterification and hydrolysis. Student 2 produced only tree levels of connections. It is a basic knowledge about ester reaction.

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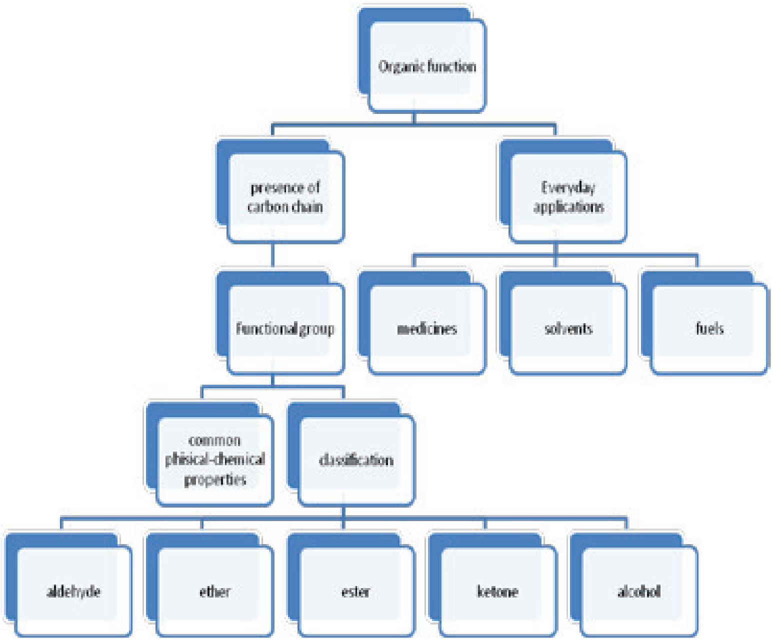

Figure 2. Concept map of student 1 after short film production

The short film produced by student 2' group focused on the development of an advertising campaign for a liquid soap. Besides the characters work in an advertising agency, they filled up their cars with gasoline. However when arriving at the gas station, they were approached by the employee who tried to speak about biodiesel advantages. Thus, student 2 showed the interrelations between the previous knowledge and the knowledge construction from short film production in the sequence of connections: "ester reaction"→"everyday"→"biodiesel" and "soap and cleaning products". The quantitative analysis of maps showed N4 to N4 transition, but the qualitative analysis showed a final concept map (Figure 4) more hierarchically organized and differentiated. It seemed to occur the progressive differentiation process.

Student 2 also represents the classification of ester reactions in the final concept map. However, the term "hydrolysis" disappears and becomes implicit in the reaction of soap production when the term "ester + sodium hydroxide" appears on the map in Figure 4. The integrative reconciliation process seemed to happen in this case. The integrative reconciliation process occurs when the new knowledge is compared with the existing knowledge to show similarities (Ausubel, 2000).

In essence, progressive differentiation points out differences, or contrast, while integrative reconciliation points out similarities, or comparisons. By using these opposite processes in the knowledge construction, student 2 could maintain at the same time the distinctness of a new idea through progressive differentiation and showed the similarities of this idea with other known ideas through integrative reconciliation.

Student 2 also represents the classification of ester reactions in the final concept map. However, the term "hydrolysis" disappears and becomes implicit in the reaction of soap production when the term "ester + sodium hydroxide" appears on the map in Figure 4. In this specific observation, it seemed to happen the integrative reconciliation process. The integrative reconciliation process occurs when we compare the new knowledge with the existing knowledge to show similarities (Ausubel, 2000).

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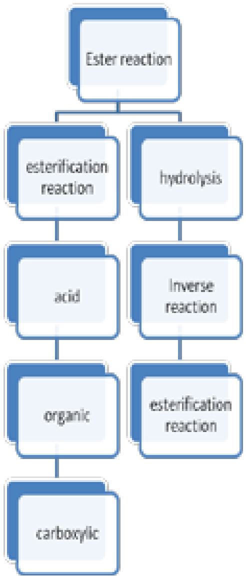

Figure 3. Initial concept map of student 2 presents some previous knowledge about ester reaction

It is reasonable to think that changes in the final map made for students correspond to changes in the conceptual structure of the student. That happened due to their participation in the short film production about the chemistry elements. Cognitive structure represents both the content of that which we already know and its organization. Our cognitive structures are organized with the larger, more inclusive, abstract ideas and concepts at the top. Information that is more specific resides at lower levels within our cognitive structures. For example, the concept of chemistry reactions would reside at a higher level in a cognitive structure than the concept of addition reaction, and the concept of addition reaction would reside at a higher level in the cognitive structure than the concept of hydrogenation. The cognitive structure is a key concept influencing learning according to Ausubel (2000). A learner has to have a relevant prior knowledge in his or her cognitive structure to which related the new information.

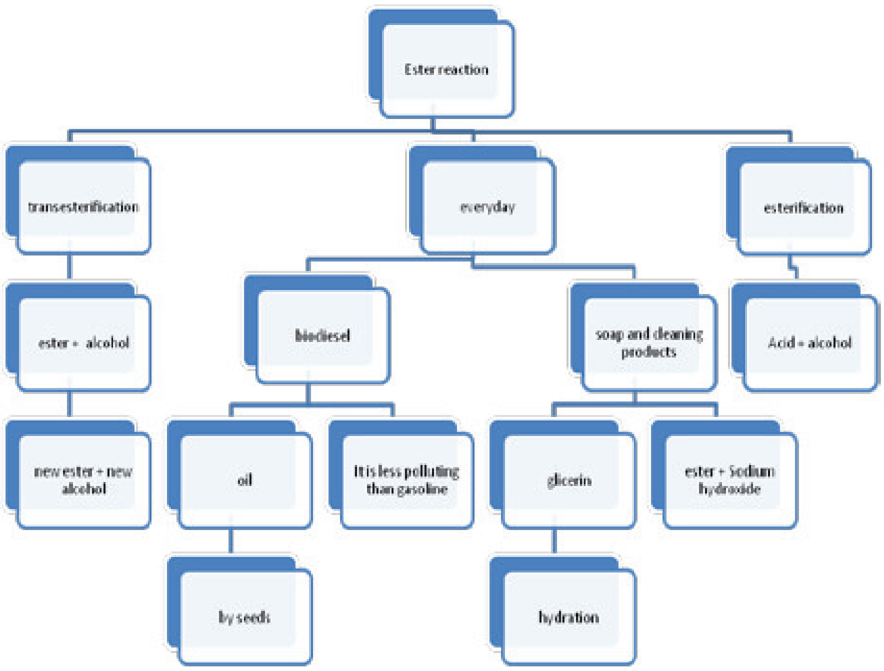

Figure 4. Concept map of student 2 after short film production

3 Summary

Cinema is the audiovisual version of storytelling. Life stories and narratives enhance emotions and therefore set up the foundation for conveying concepts. Movies provide a narrative model framed in emotions and images that grounded in the students' everyday universe. Students have new learning opportunities when the teacher

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leaves the walls of traditionalism and realize new ways of teaching, for example, using cinema as an educational tool. Our findings showed that short films productions not only mobilized students for an extra class activity, but also promoted a more dynamic learning in the discipline of chemistry. The construction of a concept map permitted the representation of knowledge before and after short film production. It worked as processes of assimilation and adaptation of new mental schemes, in terms of reflective abstraction.

What about our initial question: Was it possible to learn Chemistry developing short films? Yes, it was. Our results supported this answer. In Ausubel's cognitive theory the importance of practice is to provide opportunity for the internal processing by which new information is brought into a cognitive structure, sorted out, and connected with other information so that it becomes anchored in a meaningful manner and, thus, learned. However, every new educational practice requires creativity. Creativity is the field of imagination, inventiveness, divergence. Creativity relates to intelligence, being an association and a transformation of known elements to get a good new original result. Creativity makes it possible a great variety of ways to solve the same problem. To use the teacher's imagination and inventiveness makes students get new and divergent results. The QUIMICURTA project described in this paper is an example about creativity in the chemistry teaching and learning.

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