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I Just Want to Raise Fish! The Construction of Meanings for Chemical Concepts in an Aquaculture Course[1]

Ana Luiza de Quadros[1] https://orcid.org/0000-0001-9175-7604
Dalva Ester da Costa Ferreira[2] https://orcid.org/0000-0001-8648-2394
Roberta Guimarães Corrêa[3] https://orcid.org/0000-0003-4720-5401

[1,2,3] Universidade Federal de Minas Gerais

ABSTRACT
Learning Chemistry has been associated with the construction of meanings for the information presented in classes. Such process is no different in higher education, especially when the concepts are not associated with the future field of work. To build meanings in the General Chemistry class offered to students in an Aquaculture course, we developed the activities that led to this article. For this, we used problem-based learning strategies in a class of students in this course and analyzed their involvement with the activities developed. We observed an appreciation of the content and an active participation of students at all stages. The greater appreciation of the discipline observed in this class can have implications for General Chemistry professors, in addition to challenging us to plan new experiences.

KEYWORDS
Higher education. Aquaculture. General chemistry. Problem-based learning.

Corresponding to Author
[1] Ana Luiza de Quadros
E-mail: ana.quadros@uol.com.br
Universidade Federal de Minas Gerais
Belo Horizonte, MG, Brasil
CV Lattes
http://lattes.cnpq.br/7595956670871407

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[1] Traduzido por Gabriel Coimbra Rocha (Tikinet Edição Ltda.), bacharel em Ciências Biológicas pela Universidade do Estado do Rio de Janeiro (UNIRIO). E-mail: traducao@tikinet.com.br

Eu só Quero Criar Peixes! A Construção de Significados para Conceitos Químicos em um Curso de Aquacultura

RESUMO

A partir de perspectivas construtivistas, a aprendizagem implica na busca pelo significado das “coisas”. Aprender Química na sala de aula, portanto, remete à construção de significados para os conceitos que ali circulam e, no Ensino Superior, é indicado que esses conceitos sejam associados ao campo de trabalho futuro do aprendiz. Com o objetivo de construir significados na disciplina de Química Geral ofertada aos estudantes de um curso de Aquacultura, desenvolvemos as atividades que culminaram neste trabalho. Para isso, usamos estratégias oriundas da aprendizagem baseada em problemas em uma turma de estudantes desse curso e analisamos o envolvimento deles com as atividades. Observamos uma valorização do conteúdo desenvolvido e uma participação ativa dos estudantes em todas as etapas. A maior valorização da disciplina observada nessa turma pode trazer implicações para os professores de Química Geral, além de nos desafiar a planejar novas experiências.

PALAVRAS-CHAVE

Ensino superior. Ensino de graduação. Química. Aprendizagem baseada em problemas.

¡Solo Quiero Criar Peces! La Construcción de Significados para Conceptos Químicos en un Curso de Acuicultura

RESUMEN

El aprendizaje de la química se ha asociado con la construcción de significados para la información que se transmite en las clases. En Educación Superior esto no es diferente, especialmente cuando los conceptos no están asociados con el campo laboral futuro. Con el fin de construir significados en el curso de Química General que se ofrece a los alumnos de un curso de Acuicultura, desarrollamos las actividades que culminaron en este trabajo. Para ello, utilizamos estrategias de aprendizaje basado en problemas en una clase de alumnos de este curso y analizamos su implicación con las actividades. Observamos una apreciación del contenido desarrollado y una participación activa de los estudiantes en todas las etapas. La mayor apreciación de la disciplina observada en esta clase puede tener implicaciones para los profesores de Química General, además de desafiarnos a planificar nuevas experiencias.

PALABRAS CLAVE

Educación superior. Acuicultura. Química. Aprendizaje activo.

Introduction

Learning in Nature Sciences classes has been associated with the construction of meanings, by students, for the information conveyed in these classes. For this to happen, numerous strategies have been used, among them, linking scientific concepts to the world of students' lives, addressed in the literature as "teaching from contextual themes" (SANTOS, 2011; RODRIGUES; QUADROS, 2020), "contextualization or daily life" (e.g., WARTHA, SILVA; BEJARANO, 2013; SILVA; MARCONDES, 2010), thematic classes (LEITE; SANTOS, 2014; QUADROS, RODRIGUES; BOTELHO, 2018). There seems to be a consensus among these authors that the appropriation of new knowledge happens more easily when the student is able to perceive the relationship between the "new" and what they already know.

In Higher Education this reality is also present. Some undergraduate courses have, in their curriculum, subjects whose relevance students fail to perceive (DEL PINO, 2012; HOLME; CARUTHERS, 2013) and whose removal from the curriculum is sometimes even suggested by them (QUADROS *et al*., 2006; SILVA; EICHLER; DEL PINO, 2003). This is evidence that these students do not manage to give meaning to the content presented in the subject, perhaps because they do not associate the knowledge developed in them with their future field of work or with their life world.

In this work, we start from a situation in which the course curriculum has a single subject – General Chemistry, which explores chemical knowledge. It is the Aquaculture course, offered at the Federal University of Minas Gerais since 2009 and which, despite having a wide field of action, is primarily sought after by subjects interested in fish farming. Our experience has shown that, for undergraduates in a course like this, subjects such as General Chemistry have a large list of syllabus contents that are difficult to assimilate. In addition, undergraduates claim that the contents developed in the subject contribute little to their professional development and profession. Although, in some cases, they recognize that they had a deficient previous education, which impairs their performance in General Chemistry, students are not always able to understand the relationship of the knowledge offered with the profession and, therefore, they end up considering the subject unnecessary.

The objective of developing this work was analyzing possible contributions of problem-based teaching for the valorization of chemical knowledge by students of an Aquaculture course.

Theoretical Reference

Chemistry is a field of the Natural Sciences that studies materials in their constitution, properties and transformations. It is a basic science that has a strong connection with the most technological areas, linked to the creation and development of instruments, techniques and new materials. Therefore, many undergraduate courses offer subjects that address chemical knowledge. In courses such as Chemical Engineering and Pharmacy, among others, it is not common to question the need for this knowledge, since the relationship between the course and Chemistry is more direct and, therefore, easily perceptible. In others, however, Chemistry is not always well received by students, especially in cases where it is limited to just one or two subjects.

César, Andrade and Alvim (2005), when analyzing the subject of General Chemistry in several undergraduate courses in Chemistry and Engineering, realized that it does not differ much from one institution to another. At the Federal University of Minas Gerais, as happens in most Higher Education institutions, the subject of General Chemistry is offered for several courses and, in many of them, it represents the only subject directly linked to chemical knowledge. In a way, there is, in the curriculum of these courses, a much greater appreciation for subjects in the professional area to the detriment of those of a more basic nature. Holme (2001), referring to Engineering undergraduates, states that the experience with engineering professionals constitutes their cultural environment and the attention of these students tends to be directed towards subjects directly related to the specific field of training and that, therefore, learning is affected by the environment in which they are inserted. This has implications for professors of subjects such as General Chemistry.

Quadros *et al*. (2006) investigated the perception by Production Engineering students of the subject of General Chemistry. According to these researchers, students are unable to perceive the link between chemical knowledge present in the subject and their field of work and, therefore, consider it unnecessary. Based on the results found, the authors propose that General Chemistry consider the context of students' professional performance as a strategy to reduce the resistance of these students in relation to this subject. If they acknowledged the importance of Chemistry for other subjects and for their future professional activity, attention to scientific concepts would certainly be greater. However, such a proposal depends as much on the actions of the professors who teach General Chemistry as the other professors of the course. These actions involve, in addition to adopting more adequate teaching strategies and approaches, a holistic view of the course in which General Chemistry is offered, that is, the professor must have a notion of the undergraduate profile to be trained in the course and how Chemistry can contribute to the construction of this profile.

Neves, Gomes and Vicente (2016) developed a computer program they called an "intelligent system" to assess the role of General Chemistry in the training of students in a Portuguese higher education institution. This program was tested with 122 Agronomy, Biology and Human Biology students, as the researchers consider that the assessment of the real contribution of this subject in their training must be done with the students themselves. According to these researchers, the inclusion of GC in the curricula of different undergraduate courses is intended to help in the development of some skills necessary for the continuation of studies and, mainly, to respond to the need to provide these future professionals with knowledge to analyze and resolve multidisciplinary problems they will face in the profession. However, for the students they investigated, chemistry is not always seen in this way.

Crippen *et al*. (2016) carried out a study involving Chemistry taught in undergraduate engineering courses in the United States. They claim that the dropout rate is high and that the subjects are generally considered “cold” and strict, requiring students to have special tools for survival and protection. In the analyzed courses, there are two General Chemistry subjects (I and II) in which classes are organized around problem situations, called mini-projects. At the end of the course, two groups of students answered an extensive questionnaire involving the subjects of General Chemistry. Among the numerous questions was, for example, the question “Has having completed mini-projects helped me understand how an engineer uses chemistry to work?”. Crippen *et al*. (2016) argue that learning is more than the accumulation of knowledge. It represents a transformation of students from beginners to full members in the community of practicing engineers. When analyzing the questionnaire data, these researchers also found problems with learning and, therefore, state that it is necessary to investigate whether these are specific to engineering or if they are present in a larger population of students from other technological courses taking General Chemistry. For them, a new curriculum perspective is needed, in order to emphasize collaborative problem-solving and authentic professional practice.

General Chemistry taught for Health Sciences courses received attention from González *et al*. (2017). Considering that this subject is offered to all courses in Basic Biomedical Sciences at the University of Havana, Cuba, usually in the second period of the first year of these courses, they argue that it provides knowledge that constitutes the basis for understanding biological phenomena. In an attempt to improve the quality of learning, they analyzed the results of problem-based teaching used in General Chemistry subjects. According to these researchers, the problematic focus on chemical contents facilitated the construction of new meanings based on what students already knew, and they proved to be more familiar with the knowledge and methods of Science, and also developed the skills necessary for the future profession.

In Brazilian higher education institutions, greater attention has been paid to the role of General Chemistry in the education of students, mainly due to a perception of the high dropout and failure rate (YAMAGUCHIA; SILVA and SILVA, 2019; RIOS, SANTOS; NASCIMENTO, 2001; SANTOS FILHO, 2000; PAULA *et al*., 2016). This attention is also directed towards the understanding of professors regarding this subject and how they organize it (DEL PINO, 2012) and also towards the investigation of their teaching and learning processes in this context (LEMES, 2016).

For a long time, institutions offered General Chemistry for several courses without considering the context, as it was about basic concepts. However, the fact that students did not realize the “usefulness” of those concepts and were not able to form chemical thinking that would help them in the future profession is evidence that this subject was not reaching its goals. These concepts are the basis for structuring chemical thinking and need to be organized for that to happen.

In a way, students in more technical courses or in applied sciences seem to pay less attention to subjects linked to basic sciences and are not always able to construct meanings for what is presented in these subjects and does not belong to their cultural environments. In these cases, developing classes in which chemical knowledge is more directly related to the future field of work of undergraduates may be an activity that demands from the professor a much greater attention to the process of meaning of scientific content or concepts. Therefore, we direct our attention to this process of signification.

According to Bruner (1986), one of the great challenges of psychology has been to understand how a text (oral or written) acquires meaning in a reader's head. The discourse of professors in the classroom faces a similar challenge: how is it signified by students? In this regard Bruner claims that

> […] referring to something aiming to draw one's attention to it requires, even in its simplest form, some form of negotiation, some hermeneutic process. And this is accentuated when the reference is not present or accessible for demonstration or other overt maneuver (BRUNER, 1986, p. 67).

In a Chemistry class, in which we deal with atoms, molecules, ions and other "entities" that are not accessible to human eyes, but explain the physical world, it is certainly necessary to do more than convey words and information. Based on Bruner (1986) and on Vigotski (2009), we defend the establishment of a "negotiation" process, in which meanings for scientific concepts will be negotiated and renegotiated. Vigotski (2009) highlights the role of language in the construction of meanings. Based on the studies of this researcher, we affirm that language does not have transmission as its only function. It creates realities and develops awareness, providing the means for the subject to explain the world.

When studying the formation of concepts in children, Vigotski (2009) shows that the meaning of a word changes over time and that the same word can have several meanings, depending on the context. In relation to this, he states:

> At any age, a concept expressed by a word represents a generalization. But word meanings evolve. When a new word, linked to a certain meaning, is learned by the child, its development is just starting; in the beginning, it is a generalization of the most elementary type that, as the child develops, is replaced by generalizations of an increasingly higher type, culminating in the formation of true concepts (VIGOTSKI, 2009, p. 246).

In this sense, teaching concepts in the classroom, without paying attention to how this concept is signified, may, according to Vigotski (2009), incur an empty verbalism. Perhaps this explains the fact that students from an Aquaculture course, when faced with a chemical, complex and abstract knowledge, whose relationship with their future field of work they cannot perceive, results in difficulties in appropriating this knowledge, and as a consequence a high failure rate.

Thus, we defend that the construction of meanings for the concepts addressed by General Chemistry needs to be the object of attention, so that these students realize the importance of these studies and can engage in this process.

Aquaculture and the Training Course

According to the Food and Agriculture Organization of the United Nations (FAO), Aquaculture constitutes a productive process of animal protein, of high importance for improving food security, increasing nutritional standards and reducing poverty in less developed countries. We know that the natural resources that support life on our planet are being drastically affected by the way people use their knowledge in animal production and the way they relate to the environment. Thus, it is expected that the training of the aquaculturist is sufficiently wide to handle production that minimally affects the environment and produces healthy food at fair prices.

The Aquaculture course at UFMG, conceived in 2008, has been offered by the Veterinary School since 2009, being the first in the Southeast region of Brazil. It is aimed at training professionals with knowledge about the entire production chain of aquatic organisms, covering the Biology and Physiology of species of economic value, production methods, sanitary control and food processing for both human consumption and that of aquatic organisms. The course also offers notions of economics, marketing and planning, which allows the aquaculturist to promote the economic and sustainable development of aquatic species.

The curriculum totals 3135 hours, divided into 10 academic periods (5 years) in the Bachelor's degree modality. The course receives annually, through the National Secondary Education Examination (Enem) and the Unified Selection System (Sisu), 50 students; 25 per semester. Classes take place during the day, morning and afternoon, at the Veterinary School and at several other units at UFMG, such as the Geosciences Institute (IGC), the Engineering School, the Biological Sciences Institute (ICB) and the Institute of Exact Sciences (ICEx), in which the Chemistry Department is located, which offers the General Chemistry subject. A few courses are offered in a virtual environment.

In the case of General Chemistry offered in the Aquaculture course, the course syllabus includes basic contents, such as: atomic structure and periodic table; ionic bonds, covalent and molecular structure; intermolecular forces; inorganic functions; stoichiometric calculations; solutions and reactions; acids, bases and pH scale; introduction to organic chemistry. The physicochemical parameters of water – dissolved oxygen, temperature, turbidity, total dissolved solids, electrical conductivity, acidity and alkalinity/pH – explored in the experience reported here, are distributed throughout the syllabus of the subject.

Methodology

Students Participating in Activities

In the second semester of 2019, the General Chemistry subject received 62 enrollments, 14 students dropped out or were automatically dismissed and, therefore, did not even attend classes. Another three dropped out of the subject during the semester. Thus, the group that attended the course consisted of 45 students. This group, which was quite heterogeneous in terms of age and interest, was made up of students who had completed high school less than two years ago and others who had already completed higher education and had vast experience in the job market.

Although 25 new students joined the semester in question, half of the class was made up of freshmen from previous semesters (one joined in 2014, one in 2016, seven in 2017, five in 2018 and six in the first semester of 2019), probably studying the subject of General Chemistry for at least the second time. At the end of the semester, we received information from the regent professor that 29 students passed, 12 failed due to grade and another four failed due to attendance.

Although Aquaculture is a science focused on the study and development of techniques for the cultivation and reproduction of aquatic organisms, such as fish, mollusks, algae, crustaceans and even turtles or alligators, it is common for students who attend the course to refer to fish farming as a professional goal. Some of these older students already have a profession – Lawyer, Biologist, Engineer – and seem to be investing in training that can bring them personal, rather than professional, satisfaction. One of the students in the class, aged over 50, often stated that she was looking for personal satisfaction in the course and just wanted to learn how to raise fish for family consumption.

Problem-Based Teaching: Some Possibilities and Limitations

The proposition of alternatives to make the classroom a space for active participation for students is not something recent. John Dewey, at the end of the 19th century, already defended that the student should have an active role in the educational process, proposing teaching through projects based on a problem to be solved. The use of problems in the classroom can contribute to the subjects' involvement in the search for alternatives for their resolution. However, it is important to highlight the nature of the problem, which must be elaborated or presented based on the knowledge of your target audience. Good problems can contribute to the mobilization of skills and the acquisition of knowledge (DALBEN, 2013).

The use of a problem in the classroom can vary considerably, starting or ending the discussion of a content, serving as an individual or group evaluation method. It can also serve as a trigger and guide for learning processes carried out by students, usually in groups, who select, study and apply what they have learned in a self-directed way, with the resolution being socialized with the whole class. This approach, called Problem-Based Learning (PBL), was initially conceived to help medical students and has its origins in the 1960s, in Canada, in the Medicine course at McMaster University (BRANDA, 2016).

Since then, PBL has been used in different spaces and numerous investigations have been carried out. These investigations involve theoretical studies (CONRADO; NUNES-NETO; EL-HANI, 2014), studies in mid-level professional training (LOPES *et al*., 2011), discussions on Green Chemistry[2] in an undergraduate course in Chemistry (OVERTON; RANDLES, 2015), in the teaching of Chemical Bonds in Higher Education (LIMA, ARENAS; PASSOS, 2018) and even the use of PBL in the subject of General Chemistry (GONZÁLEZ et al., 2017). The conceptual, procedural and attitudinal development of students when involved with PBL is present in some of these works.

Still considering Higher Education and the contents of Chemistry, Lima, Arenas and Passos (2018) report the use of problem-solving, considered a variant of PBL, in the study of chemical bonds, more specifically ionic bonds. For the authors, problem solving begins with the presentation of a problem-situation that, in order to be solved, requires the application of scientific knowledge. In addition to learning conceptual content, the investigation carried out also evidenced the development of procedural and attitudinal content.

The experience reported in this work involves the planning and development of a sequence of activities aimed at discussing physicochemical parameters and water quality. The activities involved reading and discussing real situations (news), a problem-situation presented to students and an expository-dialogue class. The use of a problem-situation in the classroom, according to Perrenoud (2000), corresponds to a problem that, at first, students do not present an answer to, and the solution process involves thinking about it based on scientific knowledge. In this case, theoretical knowledge is directly related to context.

The Organization of Activities

The professor had distributed two texts in a previous class, both dealing with an unusual phenomenon, which had been identified as "Red Tide[3]". The first text deals with an event that took place on Hermenegildo beach, in Rio Grande do Sul, in 1978, and the second in Bahia, in 2007. Students should read these two texts so that they could be discussed in the class that was the object of this study.

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[2] Green Chemistry is defined by the International Union of Pure and Applied Chemistry (IUPAC) as the branch of invention, development and application of chemical products and processes to reduce or eliminate the use and generation of harmful or toxic substances to human health and the environment.

[3] The term Red Tide refers to a phenomenon caused by the excessive proliferation of microalgae due to environmental changes. This proliferation ends up triggering several other environmental complications.

At the beginning of the class, the professor asked students to comment on the phenomena present in the texts read and then presented a video of a report aired on RBSTV, a branch of Rede Globo, involving the 40th anniversary of the "Disaster of Hermenegildo[4]". In this article, it was clear that doubts persist in relation to the phenomenon that occurred. Technicians who participated in the analysis at the time of the disaster were interviewed, and many of them stated that they are still not sure if the phenomenon was really a red tide. Then the students commented on the video and gave their opinion on the phenomena that took place in Hermenegildo and Bahia.

The professor provided the students with a problem-situation in which fish died in a breeding tank, and the students should analyze the problem and present suggestions for its resolution. To avoid simplistic solutions, the professor excluded some possibilities, stating that the fish farmer had already analyzed them. The following is the text given to students:

> A novice fish farmer who raised fish in ponds noted that in recent days some fish were dying and consumers commented on the unpleasant taste perceived in the flesh of their fish. He also noticed that fish sales had dropped dramatically. Intrigued, the fish farmer decided to investigate the possible causes behind these facts. He found that the death of the fish was not caused by neither by infectious etiology, nor management errors or intoxication.
> The apparent unsolvability of the case forced the fish farmer to seek consulting at the company for which you and some of your colleagues work. The company called its team, which was responsible for advising the fish farmer.
> Remember that during an investigation like this, one must use prudence and not disregard any feature, sign or symptom, no matter how common or usual it may seem.

Students were asked to make an initial analysis of the situation, as a way to assess if the problem had been properly understood. The rest of the class (1 h and 40 min) was used by the professor to deal with the physicochemical parameters of water.

Students were given two weeks to submit a written report describing the analysis they had done, possible solutions to the problem and the implications of solving a problem during the course of General Chemistry. Two weeks later, the professor summarized the texts delivered by the students, socializing them through a *PowerPoint presentation*.

Data Collection and Analysis

For this study, we considered the data from the two classes and the reports delivered by the students. The two classes were videotaped to facilitate the analysis. We transcribed the entire first class and from the second just the interval in which the professor shared the synthesis she made of the texts delivered by the students. When performing the transcription, we identify students with fictitious names, with the intention of preserving their identities. From these classes, we analyzed the understandings in relation to the news involving the "red tide" phenomenon, the strategy used to understand the problem situation, the reports produced by the students, and also the fragment of the class in which the data contained in the reports were shared.

[4] Phenomenon that occurred in April 1978 that caused the death of fish and shellfish on Hermenegildo beach, in Rio Grande do Sul.

We analyzed together the reports delivered by the students two weeks after the first class, in order to understand what knowledge they mobilized to solve the problem-situation. This analysis was shared with the students two weeks after delivery, at which time the students justified some of the choices they made and explained their own opinions regarding the proposed activity.

Results and Discussion

We organized the results according to the activities planned by the professor, to maintain a temporal sequence. Therefore, we present the initial understanding of the cases in which the red tide was used as an explanation (a), the problem situation and the strategies for understanding (b), the class involving the physicochemical parameters of water (c), the reports produced by the students (d) and, finally, the sharing of the analysis of these reports (e).

The Red Tide and the Two Cases Shared with Students

In the class in question, the professor took the two texts given to the students and asked them to comment on the stories present in the texts. As we have already said, these texts involve fish mortality phenomena, which were related to the red tide.

Students actively participated, giving their opinion about the case and emphasizing the lack of certainty about what happened: chemical contamination or natural disaster? We highlight a moment when several students gave their opinion:

> **Maria**: There was an excess of algae, a lot of organic matter, as a result of an accident. Then it caused this number of algae.
> **Pedro**: I understood that this increase in the number of algae was due to weather conditions. It had been 90 days without rain and this favored the growth of these algae.
> **João**: I also think that the environmental conditions favored algae growth. That type of alga, in the case of Bahia, there was an excess of algae production and a consumption of oxygen in the water, without contaminating the animal.
> **Patrícia**: But they said not to consume the fish!
> **Sandro**: In this other contamination, there was an orientation not to consume anything fished in the region. There was an excess of algae production and the fish died precisely because of the oxygen, which was insufficient for them.

We can see that reading the two reports narrating the cases left them full of doubts regarding the factors that led to the death of the fish. After watching the video “40 years of the Disaster of Hermenegildo,” they apparently felt more comfortable, as the doubts they had regarding the two cases discussed were similar to the doubts of the experts, who were interviewed in the report. However, the fact that there is no certainty seems to have bothered some of them.

The Problem Situation: Strategies for Understanding it

The professor presented the problem situation to the students, which was read together, and to make sure that the problem had been understood, she asked the students some questions. She then asked the students to try to imagine what had happened to the farmer's fish. This initial moment, of understanding and questioning the problem-situation presented, is essential for students to appropriate the context and establish links with the problem (DALBEN, 2013).

During the initial problematization, it was mentioned that the cause would be ammonia resulting from the excess of feed that the fish farmer was supplying. The professor then recalled that the management was adequate. The performance of blood tests on the animals was also mentioned, and she pointed out that there was no type of infection in the animals. The proliferation of algae, the quality of the water that entered the tanks and knowledge of the surroundings, to recognize the source of this water and whether it was affecting other fish farmers in the region were also mentioned. In addition, the stress of the animals due to a high population density and inadequate transport of the animals was also considered, but were immediately ruled out by a colleague, as the management would be adequate and death was already taking place inside the tanks.

After about 10 minutes of discussion, the professor warned that many cited water as responsible for the problem discussed and then resumed her speech bringing some data involving water quality: temperature, pH, turbidity, and dissolved oxygen were addressed along with the formation of ammonia. To deal with the relationship between ammonia and other physicochemical parameters of water, the professor based her work mainly on Kubitza (2003). In addition, some water samples were made available to the students, collected in different fish breeding tanks of the Aquaculture Laboratory (Laqua) of the UFMG Veterinary School, so that they could measure pH using universal indicator paper strips[5] and comparing the result with the accompanying table. Dalben (2013) calls this stage of pedagogical induction the resolution process, through which the provision of additional information or complementary data, which can be made available in different ways (videos, news, reports, images), contributes to deepen students' knowledge of the subject and also to guide the resolution process.

We noticed that, throughout the professor's explanation, the students were very participative, taking cases they already knew or had heard about at some point before the class. Apparently, the problem-situation given to them made all the content related to the physicochemical parameters of water more valued, since the relationship of that content with the future professional world had been well explained. As identified in the studies by González *et al*. (2007), we argue that the construction of new meanings takes place from what students already know. In this case, they related the physicochemical parameters of the water to what they were familiar with on the course: fish farming.

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[5] Absorbent paper tapes that have a mixture of pH indicators. When immersed in solution, the color shown by the tape indicates the pH of that solution, in a 1 to 14 range.

Analyzing the Report Produced by the Students

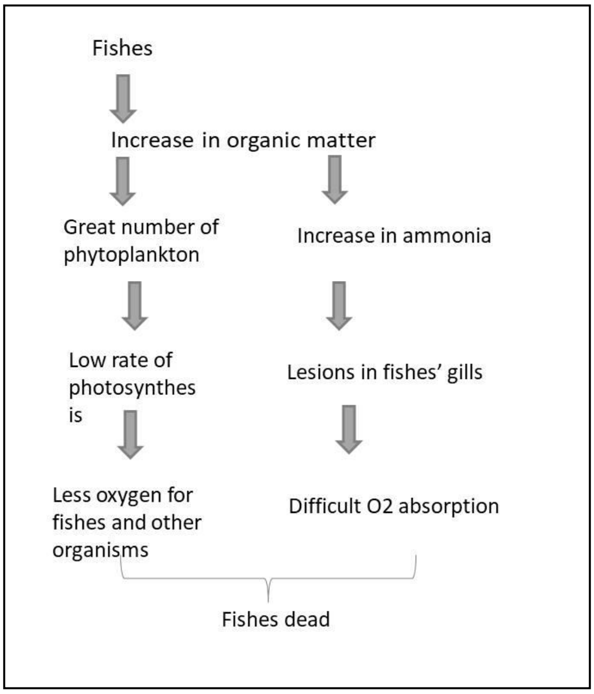
To analyze and point out solutions to the problem they were challenged with, the 45 students formed 12 groups (one group with two students, four with four, six with three and one with five students), given that four students chose to report individually. At first, we tried to identify how these students analyzed the problem-situation provided, that is, the cause of the problem they pointed out.

In the problem-situation they were informed that "the death of the fish was not caused by an infectious etiology[6], due to handling errors or cases of intoxication" and this information had been highlighted in the class in which the problem was delivered. Despite this, four reports failed to consider this information. Two groups cited the amount of feed provided to the fish, although both groups also highlighted the quality of the water. Two other groups cited the high density of fish as one of the factors that led to their death. Specialized literature deals with a specific stocking density for each type of crop for fish farming in ponds. Faria *et al*. (2013, p. 33) state that in the extensive system, stocking density of one fish is used for 5 m^2 of water, in the semi-intensive system the ponds are populated with one to two fish/m^2, in the intensive system more than three fish/m^2 of water can be placed and, finally, in the super intensive system, more than 70 fish/m^3 of water are usually used. This amount may vary slightly depending on the type of fish to be raised. We understand, however, that population density is directly related to adequate management and that, therefore, when referring to this density, students did not consider the information provided. Of these last two groups, one of them also used water quality as a possible cause of the mortality.

The other groups used one or more physicochemical parameters as possible causes of the phenomenon in question, explaining the consequences for the fish-farming pond. We highlight, as an example, one of the groups that, after arguing that the fish were dying from asphyxia, explained how the increase in organic matter could lead to a decrease in dissolved oxygen. Then, a scheme was presented synthesizing the information present in the explanation, which we reproduce in Figure 1.

[6] Infection caused by viruses, bacteria, fungi, protozoa and a host of other pathogenic microorganisms causing infections.

Figure 1. Scheme built by group 13



Source: schema present in a report

For them, phytoplankton[7] grew as a function of factors such as light availability and temperature. With this growth, came a decrease in the luminosity in the tank, impairing photosynthesis. Also, as a consequence of excess organic matter, they highlighted phosphorus and nitrogen, describing their effect on fish.

We also analyze the solutions presented to stop fish mortality. These solutions were directly related to the analysis made by each group. The taste of fish, for example, was indicated by three groups as coming from contamination of the water that entered the tanks. For them, this water was, at some point, receiving untreated sewage, which facilitated the production/proliferation of geosmin or MIB and, in these cases, the solution presented was cleaning the tanks, using aerators and improving of the water flow. According to Boyd (2005), some types of blue-green algae produce compounds that can cause an unpleasant taste and smell to drinking water. According to this author, the two most harmful compounds are geosmin and MIB[8], which can be absorbed by fish, shrimp and other aquatic animals, imparting unpleasant smell and taste to the meat and, therefore, low market acceptance.

In cases where some physicochemical parameter was mentioned by the students, the solution presented was linked to that parameter (monitoring, pH adjustment/correction, aeration).

[7] set of microscopic algae.

[8] Geosmin and 2-methylisoborneol (MIB) are organic compounds produced in water, mainly by cyanobacteria, which are generally associated with changes in the taste and smell of water.

Group 1, which had highlighted the high water temperature (explaining all the consequences) and excess organic matter, cited two sets of actions, one in the short term and one in the medium term. In addition to relocating the fish in a hospital tank, to disinfect the tank in which the problem occurred, they proposed, in the short term, daily monitoring of physicochemical parameters, the search for a new water collection point and communication to the competent bodies for the assessment of water in the stream. In the medium term, the construction of an artesian well, the improvement of the water aeration system and the introduction of a water quality monitoring protocol (pH, dissolved oxygen, temperature and ammonia) were mentioned.

Regarding the implications of the problem-situation dealt with in a Chemistry course, many students highlighted the "inaccuracies" present in a real situation and the importance of constant monitoring in fish farming ponds. Some groups, however, dealt with the direct relationship of Aquaculture practices with other fields of knowledge. We highlight an excerpt from the report of group 14 as representative of this increase in awareness in relation to chemical knowledge.

> This situation dealt with during the course used knowledge from several areas: Chemistry, by changing the physicochemical parameters of water; geological and pedological, if the alteration involves some mineral brought by the water; social, when the change takes place through anthropic intervention such as inadequate agricultural or livestock practices; legal, as we need to know the legislation when the resolution does not occur through dialogue. (Group 14)

We can infer, based on this comment made by group 14 and others like it, that the students realized that chemical knowledge can be important for solving problems in their professional field. According to Holme (2001), students' attention tends to be directed more towards content related to their cultural environment, which, in this case, is Aquaculture. Upon realizing the relationship between Chemistry and the future profession, it is possible that they will start looking at this subject more closely. We agree with Crippen *et al*. (2016), by alerting to the need to include collaborative problem solving in course curricula.

We are aware that a single activity is not enough for students to signify chemical concepts, relating them to their future profession. It is a challenge that we are going to engage with in future classes.

Experience Feedback

Two weeks after the reports were delivered, the professor took 24 minutes of class to comment on the experience with the problem-situation, using, for that, a *PowerPoint presentation* in which she summarized the results. Early on, she highlighted the good participation of students in all stages of the work and then commented on each one of them.

Regarding the reports, the professor made comments that involved the options of different groups, highlighting some perceptions she had. Among them was the fact that some groups, when analyzing the problem situation, brought up practically all the possibilities involving water quality (testing of pH, dissolved oxygen, temperature and nitrogen indices in the tank). She warned that presenting a range of possibilities (a diagnosis) instead of a solution could diminish the credibility of the "aquaculturist" with the fish farmer who sought help. There were no comments from students regarding this feature perceived by the professor.

Then it was highlighted that only 13 participants considered the unpleasant taste present in fish meat. The professor warned that this was an important tip for solving the problem, as the proliferation of algae would lead to the formation of geosmin and MIB. With that, she explained how these substances are formed and how they affect fish. One of the students justified this option by saying that she had not considered this factor because the meat would not be consumed as the fish were dying, which was discussed briefly. Another student claimed to have taken this problem to other professors in the course, with the intention of finding a solution. With that, the professor explained how the unpleasant taste of the meat must be a factor considered in solving the problem that is causing the death of fish.

In another moment, the professor highlighted her perception that students had a great involvement with reading. According to her, the reports delivered were referenced and with information visibly sought in scientific articles. Some of them expressed themselves saying that, despite being common, it was not an easy problem to solve. Tourinho (2011), when stating that higher education students have little involvement with reading, due to the non-prioritization of reader training in our country, argues that it is necessary to insert academic reading as a cultural habit that generates information, knowledge and pleasure. In this case, reading may have meant a "survival" strategy, as it was necessary for the work they were supposed to deliver. By emphasizing this involvement, however, the professor may have helped them to perceive reading as essential to any area of knowledge.

Continuing the comments, the professor returned to a problem that had already been alerted by the delivery of the problem situation: the fact that they had considered feed control and population density. In the description of the problem-situation, management had already been ruled out as a problem, as well as any type of infectious disease. Four groups, however, had used these possibilities as the cause of death of the fish. Again, there was no comment from the students.

The professor then highlighted water quality control and its importance for the Aquaculture professional. With that, the students made some comments involving this activity in the General Chemistry subject. We selected one of them, as a way to exemplify the thoughts of others.

> Chemistry is complicated. I can say that (laughs), as I'm taking it for the fourth time. When the professor brings something from Aquaculture into Chemistry class, it's way better. I heard several colleagues talking about this class, who liked it and all. There was a link with the field and this motivates, helps us to look for more, as you said, reading and such. (Martha)

Through this comment by Marta, we can see that the activity was well received by the group and even discussed outside the classroom. These students, when the professor explored water quality, were very participative. They probably had the opportunity to associate the concepts brought by the professor (the new) with knowledge that was familiar to them. This is a condition, according to Vigotski (2009), for the construction of meanings.

Finally, the professor resumed her perception regarding the participation of students in these activities, the quality of the written texts and the apparent search for readings, and mentioned the book used in the preparation of classes. She emphasized that, according to the author (KUBITZA, 2003), when management is correct and there are no infectious diseases, water quality is certainly the answer. One of the students made comments that showed they already knew the book and had read some of its content.

According to the professor, after this activity, students were much more receptive to the subject and apparently studied more when compared to other classes in which she taught the same subject. She also commented that the students did not fail to say that the content was difficult, but that they tried harder to learn.

Final Considerations

By planning the activity using a problem-situation, our intention was to contribute so that the Aquaculture course students began to value more the chemical knowledge present in the General Chemistry subject and, thus, could have the opportunity to appropriate this knowledge. When developing these activities, we realized that the involvement with them was superior to what had been happening in the subject. They answered the professor's questions, gave their opinions regarding the news brought to the classroom, explored readings that helped them find a solution to the problem-question and, during the more theoretical class, offered broad contributions, bringing examples of situations already known to them.

These data lead us to argue, along with other researchers (e.g., SANTOS, 2011; RODRIGUES; TABLES, 2020; WARTHA, SILVA; BEJARANO, 2013), about the importance of the knowledge to be "taught" having an explicit relationship with what the student already knows and that this knowledge is linked to their cultural environment (HOLME, 2001).

By using a problem-situation and, from there, developing chemical knowledge about water quality, we help students create realities and awareness (BRUNER, 1986; VIGOTSKI, 2009) that enabled them to better explain the situation they analyzed. By participating more actively, they used language in the process of negotiating meanings. At times, they advanced in understanding the situation, by inserting the physicochemical parameters to solve the problem, and at others, they returned to their previous understanding, by bringing back the management of fish as a justification for the problem. This going "forward" and "backward" is part of the process of negotiating meanings, and it is up to the professor, when realizing that there has been a setback, to make use of other strategies.

Although we have not used, in this work, specific instruments for learning analysis, we argue that if students are not able to perceive the direct relationship of the knowledge developed in General Chemistry with their future field of work, they will hardly appropriate this knowledge when faced with a problem to be solved. This has direct implications for our department, which offers this subject to several courses. We also warn that this is an initial activity, which poses the challenge of expanding it so that we can consolidate and expand the results.

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