The innovative teachers training for chemistry teaching through digital technologies

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Abstract
Faced with a complex and constantly changing world, it is essential to form citizens capable of adapting to their environment and being able to position themselves consciously and critically in front of it. A Reflection-Oriented Process was developed which allows students to question simplistic views of the teaching and learning process of sciences. It is based on four interrelated contexts: (i) reflecting as a student in science classes; (ii) reflecting on other teaching practices from didactic resources; (iii) reflecting on the opinions of researchers; (iv) reflecting on their own teaching practice. A qualitative research was developed during the online classes, with 24 students, in view of the question: How to develop innovative teachers through digital technologies? The classes were developed using digital technologies and recorded through Google Meet, making it possible to obtain data. They re-thought about: the development of scientific language, the introduction of mathematical languages, the pedagogical relationships, and the development of higher-order cognitive skills.

Keywords
Innovative teachers, Reflection-Oriented Process, digital technologies

Introduction
In the face of such a complex and constantly changing world, it is essential to form citizens capable of adapting to their environment and of knowing how to position themselves consciously, responsibly and critically in front of it. In addition, in the current context, we are experiencing a cultural revolution that influences the culture of learning: the new information technologies, together with other socio-cultural changes, are opening space for a new culture of learning. At the beginning of the 21st century, Pozo and Crespo (2009) pointed out that this

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new culture of learning was already being established and is characterized by three aspects: (i) information society; (ii) multiple and decentralized knowledge society and (iii) lifelong learning society. The school no longer plays the role of primary source of information for students in the information society in different areas of knowledge. Information comes from different sources, in different formats, generally more attractive than those used in schools. The school in the current context needs to train students so that they have access to information, know how to search for it responsibly, and organize and critically interpret it. In addition, in the multiple and decentralized knowledge society, there are no longer any absolute points of view that students should assume. It must also be borne in mind that we are living in a society of continuous learning. It is increasingly necessary, in addition to mandatory training, to also have permanent professional training, given the great demand for new and different profiles for work in today's globalized world. Thus, the educational system must satisfy an important demand in this 21st century: 'learn to learn'.

Science Education in the 21st century is a means to promote the formation of citizens who can learn to learn, acquiring scientific knowledge and developing skills and abilities to reconstruct knowledge and make a critical reading of the world (Pozo et al., 2009; Praia et al., 2007) In this sense, it is necessary to offer all students a scientific education that makes science a true partner for other ways of seeing and interpreting the world, that is, different looks according to different cultures (Lemke, 2006). From the development of scientific and technological literacy, important skills can be developed, such as: critical thinking, problem-solving, creativity, innovation, communication, collaboration, making decisions, information technology application, lifelong learning. And these skills can be developed through technological tools, as long as teachers develop dialogic and reflective classes with a view to favouring meaningful learning by students.

However, since 2020, the cultural revolution has intensified. The COVID-19 pandemic that developed around the world caused multiple changes in the way of life for all of us, a situation that required us to use digital information and communication technologies much more, which enabled communication between people in all areas and regions of the planet. From the need for social isolation, we learned a lot about using digital technologies, which were particularly important in the area of education at all levels precisely to continue the activities started in all schools around the world in the beginning of 2020. Thus, we teacher trainers started to use different communication platforms

(Google Meet, Zoom) to conduct classes, meetings and virtual meetings, which made it possible to carry out our work and develop the subjects via the remote system.

Furthermore, the European Commission (2020), in its Digital Education Action Plan (2021–2027), describes the urgent need to promote high-quality, inclusive and accessible digital education. It also points to stronger cooperation for: (i) learning from the COVID-19 crisis, during which technology is being used on an unprecedented scale in education and training; and (ii) making education and training systems suitable for the digital age.

In such a complex context, the role of the teacher is extremely important for the formation of well-qualified citizens who know how to position themselves in the face of socio-scientific situations, since it is they, as teachers, who will make the necessary decisions to carry out appropriate activities in an effective way, and set out objectives with a view to providing the students' learning. Consequently, the main agents of the desired changes and innovations in school communities are teachers who, as professionals, must be aware of this role of theirs, so that they can perform it properly (Carvalho, 2011; Krasilchik, 2004). Thus, it is necessary to develop a teaching identity, in which the teachers recognize themselves as people and as professionals who work with the challenge of training and developing people. This seeks to develop an education that favours the reflective teaching practice necessary for raising awareness and developing meaningful, innovative and coherent didactic-pedagogical actions, as well as for their reorganization and improvement (García & Porlán, 2000; Macedo, 2005; Russell, 2018).

During the development of the discipline *Instrumentation for the Chemistry Teaching I* course (part of the Degree in Chemistry at the Federal University of Viçosa, which aims at training teachers for basic education), reflective practice was developed through a Reflection-Oriented Process (Abell & Bryan, 1997) – described in the methodology section below – which allows the student to question and critically reflect on simplistic views of the science teaching and learning process. In previous semesters, it was observed that students had restricted conceptions about practical activities, as well as the teaching and learning process. In this context, we sought to understand the students' conceptions/perceptions regarding the planning and carrying out of practical work and the teaching and learning process, based on activities planned and carried out through digital technologies by the students themselves. Thus, this research sought to answer the following question: How to develop innovative teachers through digital technologies.

Theoretical framework

It is essential that teachers in training experience situations that provide opportunities for meaningful reflections on teaching work with a view to the reconstruction of didactic, pedagogical and scientific knowledge, as well as situations that allow support for the realization of teaching innovations. In this way, teacher-training courses and programmes cannot be limited to processes carried out by specialists that simply aim at transmitting information, because the desired innovations will only occur if the teacher understands the importance and the meanings of the changes necessary for the promotion of meaningful learning by students, in addition to understanding their new role as a professional responsible for the construction and development of new cultures together with the school community (Harlen, 2013; Macedo, 2005; OECD, 2014; Osborne & Dillon, 2008; Silva, 2015).

In addition, the understanding about the conceptions about science teaching and learning of teachers is paramount, because, according to the constructivist perspective, teachers build conceptions both about science, as well as about methodologies for the teaching and learning of sciences, by way of environmental formation throughout their school lives (as students). These conceptions are very ingrained, acquired in a non-reflective way, as something natural, of common sense, and that will significantly influence their didactic-pedagogical actions (Abell & Bryan, 1997; Harres et al., 2005; Mansour, 2013; Morrison, 2013; Peme-Aranega et al., 2009). Still, according to Vilches Peña and Gil Pérez (2001), curriculum creation teams should consider the teachers' conceptions and their influence on the development of curricula in the classroom, pointing out that the teaching conceptions are as relevant as the alternative conceptions of students in science learning.

The importance attributed to scientific literacy for all people has been strengthened since the 1990s, when numerous investigations evidenced this need (Bybee, 1995; Cachapuz et al., 2005; DeBoer, 2000; Vilches Peña & Gil Pérez, 2001). These authors, for example, pointed out that in the National Science Education Standards, of the National Research Council (1996, p. 1), an important argument for the development of scientific literacy was published on the first page:

> In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone: we all need to use scientific information to make choices that we are faced with every day; we all need to be able to participate in public discussions on important issues related to Science and Technology; and we all deserve to share the emotion and personal fulfilment that can produce an understanding of the natural world.

As Lemke (2006) points out, Science Education must value curiosity, enchantment, interest and provide children and young people with opportunities to appreciate and value the natural world, understanding and observing natural phenomena. It is also necessary to rescue curiosity and promote young people's understanding of the natural world, as well as the functioning of technologies, favouring the development of logical reasoning and the use of multiple representations (Lemke, 2006).

However, even today, studies in the Didactics of Science have shown that traditional teaching, which provides students with limited opportunities to make contact with scientific activities given its characteristics based on the transmission-reception relationship, prevails in most classrooms, favouring the transmission of inadequate views of the way scientific knowledge is constructed and evolved (Cachapuz et al., 2005; Galvão et al., 2011; Pozo et al., 2009), and presenting restricted and distorted views that provoke students' disinterest in the sciences and can become obstacles to learning. Cachapuz et al. (2005) point out the most common distorted views: (i) Empirical-inductive conception: one that values the role of observation and 'neutral' experimentation, disregarding the essential role of hypotheses as guiding investigations; (ii) Decontextualized and neutral view: disregards the interests and influences of society; (iii) Individualist and elitist conception: scientific knowledge is the work of isolated geniuses, disregarding the role of collective work, of exchanges between teams; (iv) Rigid, algorithmic and infallible view: the scientific method is presented as a sequence of defined steps, in which "observations" and "rigorous experiences" assume a prominent position; (v) Aproblematic and ahistorical view: prevalence of the transmission of knowledge already elaborated, disregarding the problems that were intended to be solved, the evolution of knowledge and the difficulties encountered.

Lemke (2006), considering the influences of new information and communication technologies in our lives, affirms that these enable students to learn about science and the phenomena of the natural world from multiple forms of learning. And these poses an important question: "What are the most important contributions that science education can make to students and society?" In response to this question, Lemke himself (2006, p. 6) states that "we should offer all students a scientific education that makes science an authentic companion to other ways of seeing the world and an essential contribution to their multimodal literacy and [their] critical thinking skills.

When proposing practical activities to students, teachers need to involve them in a scientific investigation, aiming at the development of scientific literacy based on different actions to solve a problem, such as exchanging ideas with peers, researching, discussing and testing hypotheses, making decisions, seeking the solution to problems, all of which will promote cognitive, conceptual, and attitudinal development; these actions are always mediated by the teacher who, when questioning, dialoguing and proposing questions, helps students in understanding the concepts studied and in the elaboration of their own ideas.

In this sense, according to Zoller (1993), there are different levels of cognitive demand to be developed in the classroom, and they can be defined in two categories: lower-order cognitive skills (LOCS: Lower-Order Cognitive Skills) and those of a higher order (HOCS: Higher-Order Cognitive Skills). Lower-order cognitive skills are characterized by skills such as knowing, remembering information, or applying knowledge or algorithms memorized in familiar situations and solving exercises; while the higher-order ones are referred to as those abilities oriented towards investigation, problem-solving (not exercises), decision-making, and development of critical and evaluative thinking.

Still, for Lemke (2006), it is necessary to have a scientific education with greater honesty, greater humility, greater value for students and considering the different specificities related to students' ages. It is also necessary to have a strong concern for the quality of life of people in this globalized world, and to point out as an important goal for education the promotion of opportunities for the improvement of social welfare for all. In this sense, some specific objectives for science education throughout schooling and learning would be:

> (...) For high school: providing everyone with a potential path to scientific and technological careers, providing information about the scientific view of the world, which is of proven utility to many citizens, communicating some aspects of the role of science and technology in social life, help to develop complex logical reasoning skills and the use of multiple representations. (Lemke, 2006, p. 6)

According to Lemke (2006), young people complete their basic education without actually being scientifically literate, and he points out that it is necessary to develop a curriculum that privileges the objectives described above, and thus allows classes in which students participate actively, solving and/or discussing problems related to science and its technologies. For him,

> We have to come to understand how science and science education can help us help each other. Scientific education still has great potential for good, but only if we take the true path of science, rejecting how it has been done, and exploring together new ways of thinking, teaching and learning. (Lemke, 2006, p. 11)

In order to direct and guide the performance of the teacher and the development of dialogical interactions in the school environment, Carvalho (2011), in her proposal for science teaching and learning, points out eight important aspects for the planning and organization of the Investigative Sequences of Teaching (Appendix 1):

(i) Active student participation;

(ii) The importance of student–student interaction;

(iii) The role of the teacher as a question maker;

(iv) The creation of an encouraging environment;

(v) Teaching from the knowledge that the student brings to the classroom;

(vi) The meaningfulness of the content (the problem) for the student;

(vii) The relationship between science, technology and society;

(viii) The transition from everyday language to scientific language.

In addition, Chemistry teaching can be mediated by free software and provide the learning of chemical concepts by students from an investigative, interactive, contextualized and interdisciplinary approach, thus enabling both scientific literacy and digital literacy as well (European Commission, 2020; Leite, 2019; Mateus, 2015; Santos et al., 2010).

The development of Science Education, as already mentioned, implies profound changes in the teaching performance. It is necessary that during the initial training of teachers there are experiences to favour the formation of a new teaching profile, which will enable the teacher to have an innovative posture in his didactic-pedagogical practices, based on the development of a new vision of science and of the teaching process, teaching and learning.

Research methodology

During the discipline *Instrumentation for Chemistry Teaching I*, twenty-four (24) students participated in various activities that were developed aiming at the formation of innovative teachers who should know how to plan and conduct their classes with autonomy, and how to plan and manage innovative projects with creativity and self-confidence. In order to develop these and other teaching skills, a Reflection-Oriented Process was carried out to develop different reflective exercises from four interrelated contexts: (i) reflecting as a student in science classes; (ii) reflecting on other teaching practices from didactic resources; (iii) reflecting on the researchers' opinions; and (iv) reflecting on the teaching practice itself (Abell & Bryan, 1997). All classes in the year 2020 were developed using digital technologies due to the COVID-19 pandemic and were recorded on Google Meet, enabling data to be obtained (Amado, 2014; Coutinho, 2014). Several topics were discussed based on articles by important researchers in the area of Education in Sciences, during the PRO, such as: “Deformed visions of science and technology” by Cachapuz et al. (2005); "Why don't students learn the science that is taught to them?" by De Pozo and Crespo (2009); “The teaching and learning of sciences” by Anna M. P. Carvalho (2011); “The manifestation of cognitive skills in experimental investigative activities in high school chemistry” by Suart and Marcondes (2009); “The place of affectivity in the pedagogical relationship: Contributions to teacher education” by Amado et al. (2009); “Science education with CTS orientation” by Vieira, Tenreiro-Vieira and Martins (2011); and “The syndrome of accelerated thinking” by Cury (2007). In addition, we reflect on other teaching practices through videos produced by research professors in the area of Education in Sciences, thus enabling several reflections on important aspects for didactic-pedagogical practice, such as: the importance of active participation of students in carrying out activities which enable the development of interactions between students, since it is important and necessary to favour the understanding of the scientific concepts under study; the importance of the teacher's mediating role during the performance of activities by asking questions about the subjects studied; and the development of the transition from everyday to scientific language, among others.

The Reflection-Oriented Process provided students in the Chemistry degree course with several reflective moments when they were able to reflect on their different views on the nature of science, as well as on the teaching and learning process. Initially, an exercise was carried out so that students could reflect on their views about the nature of science from the representation of the work of scientists, through drawings.

After the various reflections provided by the researchers' opinions, including on other teaching practices based on didactic resources, a new activity was requested by the coordinating professor of the discipline: the planning and realization of a practical work, a contextualized, interdisciplinary and investigative class, to develop an experiment using digital technologies. The teacher then organized a sequence of six practical classes of 90 minutes each for six different groups, with four students in each group, addressing the chemical concept of chemical equilibrium as a guide for the six classes. To guide the preparation of the lesson plan, the teacher provided a lesson plan which included the following aspects: the topic of the lesson; the problem situation; the justification for the class; the goals; the conceptual contents; the competencies and skills; the didactic resources; the methodology; the evaluation; bibliographic references; and attachments.

The Didactic Sequence with the six classes was organized with the following themes:

1st Class: Acidity of substances.
Problem situation: How to measure the degree of acidity?
Chemical concepts: dissolution, solution, solute, solvent, water auto-ionization, degree of acidity, chemical balance in solution, pH and pOH.

2nd Class: Heartburn and poor digestion.
Problem situation: How can sodium bicarbonate act to resolve heartburn and poor digestion?
Chemical concepts: dissolution, solvation, dissociation, water auto-ionization, chemical balance and saline hydrolysis.

3rd Class: Physiological tampons.
Problem situation: How to identify a buffer solution?
Chemical concepts: dissolution, chemical equilibrium, buffer solution, physiological buffer.

4th Class: Healthy Eating.
Problem situation: How should healthy eating be? Acid or alkaline?
Chemical concepts: dissolution, chemical equilibrium, acidic and alkaline substances.

5th Class: Alkalosis and Acidosis.
Problem situation: What does alkalosis and acidosis mean in the human body? Can the chemical balance be disturbed?
Chemical concepts: dissolution, chemical equilibrium, disturbances of chemical equilibrium, Le Chatellier principle, acidic and alkaline substances.

6th Class: Dental demineralization.
Problem situation: How can dental demineralization be explained?
Chemical concepts: dissolution, chemical equilibrium, disturbances of chemical equilibrium, Le Chatellier principle, acidic and alkaline substances.

In the period of thirty days, the students prepared the class plans and developed the class prepared only for the coordinating teacher as a test class, with a view to discussing all the necessary pedagogical aspects, such as the concepts covered and the teaching strategies used, in order to reflect if what was planned and accomplished was coherent, if the class had an investigative approach, if it was contextualized and interdisciplinary, if it used appropriate digital technologies, and if it favoured the active participation of students, so that they could be protagonists of the process of knowledge construction.

After the test classes, the six classes were held with the presence of all students, those four who would teach the class acting as teachers, and the others acting as students.

Findings and discussion

As was said initially, the first exercise was the elaboration of a drawing about the work of scientists. In this exercise, students were surprised by their views on the nature of science and the work of scientists. The students compared their drawings with the categories developed by Cachapuz et al. (2005) and found distorted views, such as empirical-inductivist conception; decontextualized and neutral; aproblematic and ahistorical; individualistic and elitist. It was a very enriching moment for everyone when they manifested in their drawings conceptions that they were not even aware of. Thus, when they became aware of their distorted conceptions, they realized how necessary and important it is to have an adequate view of the nature of science to be a teacher.

The realization of the test classes was a much more enriching reflexive exercise, as the development of the test classes was extremely important to become aware of their restricted views of the teaching and learning process when giving an expository class, privileging the transmission of information and neglecting the active student participation. It was really very complex, therefore, as the lesson plan presented more current ideas for the teaching of Chemistry, with a proposal for an investigative, contextualized and interdisciplinary class. However, in all groups when taking the class, these characteristics were neglected. Thus, the discussion promoted by the teacher after the test class allowed different reflections on the part of the students and the awareness of the inconsistency between what was planned and what was accomplished. It was necessary for the teacher to reorganize the sequence of activities prepared for the class, in order to ensure that the class is really contextualized, interdisciplinary and investigative, developing three pedagogical moments: the initial problematization, the organization of knowledge and the application of knowledge. It was also necessary to highlight the importance of managing class time and the teaching strategies used. After the discussions held, the students accepted the suggestions given by the teacher, showing that the reflective practice developed was quite significant and the teacher's argument was effective. They re-thought: the development of the initial problematization; the development of scientific language; the introduction to mathematical languages (tables, graphs and equations); pedagogical relationships and affectivity; the development of higher-order cognitive skills; and how to promote dialogical interactions during the class to favour the understanding of the concepts covered and the arguments to be developed by the students. Another aspect discussed was the adequacy of digital technology to be used to promote practical work.

They also became aware that they were developing the class from a traditional approach, in which the teacher privileges the exposure of information, not valuing the initial problematization, and neither the prepared contextualization nor the effective participation of the students. The exercise of the test class was effectively a very enriching and productive reflective practice, promoting particularly important reflections on the teaching and learning process, as well as on the teacher's position in the classroom.

For the analysis of the practical classes, the videos recorded by Google Meet were watched again by the teacher to analyze the consistency between what was planned and discussed during the test class and what was accomplished. Another aspect analyzed was the application of teaching strategies with socio-constructivist principles as this had been in the articles studied before planning the class.

When developing the class, the students revealed that they reorganized the sequence of activities of the class according to the instructions given by the teacher during the test class, and valued Carvalho's proposal for science teaching and learning for the planning and organization of the Investigative Sequences of Teaching (Carvalho, 2011). All groups sought to develop active student participation; the role of the teacher as a question maker; the creation of an encouraging environment; the teaching from the knowledge that the student brings to the classroom; the meaningfulness of the problem for the student; the relationship between science, technology and society; and the transition from everyday language to scientific language. Only the student-student interactions were not well developed due to the limitation of the digital environment, as the class was held via the remote system Google Meet, making interactions between students impossible.

The classes developed by all groups were effectively contextualized, interdisciplinary and investigative, developing the three pedagogical moments. The students sought to develop dialogical interactions with the students based on several questions asked during the class, privileging the effective participation of the students, as well as the development of higher-order skills by the students. Classes that had been only expository became interactive and dialogic classes, with plausible questions and explanations with adequate scientific language.

The digital technologies that emerged from the planning and realization of classes were, as requested by the teacher:

- virtual laboratories, which enabled the development of investigative experimental activities: https://phet.colorado.edu/pt_BR/; https://interactives.ck12.org/simulations/chemistry.html, and made possible the effective participation of students; as well as enabled the understanding of chemical concepts by the students.

- videos to promote contextualization and interdisciplinarity of contents (YouTube), enabling the understanding of relationships established between science, technology and society; videos produced by the students themselves addressing experiments related to the chemical concepts covered;

- Kahoot games (like quizzes), enabling the participation of students.

A digital technology that was essential for the realization of all classes, as without it, it would not have been possible to do them, was Google Meet.

After all sessions were conducted, the teacher promoted a general discussion about the six classes, developing a new reflexive practice so that students could become aware of all the work developed, and of the reconstructions made about the teaching and learning process. She pointed out the important accomplishment made by them when developing classes with socio-constructivist principles, aiming at the development of scientific literacy and privileging the students' learning. In addition, the teacher pointed out the important teaching skills developed by them, necessary for the development of scientific literacy, such as: ability to provoke argument in the classroom; ability to transform everyday language into scientific language; ability to introduce students to the language of mathematics (tables, graphs, equations).

At the end of this reflective practice, many students wanted to express how they felt after experiencing this reflexive process during the course. Most of them expressed great satisfaction, saying that they had enjoyed all the activities performed very much. They also said that they perceived the reflexive process in an evolutionary way, in which one subject was linked to the next. They even used an analogy: they felt as if they were climbing a ladder, with each new study a new conquered step. Likewise, they enjoyed the exercise of planning and conducting practical classes using digital technologies, commenting that it was a great challenge to prepare classes with the new digital tools for a remote education system, as well as to face the various difficulties experienced for the preparation of these classes with socio-constructivist principles. Finally, they realized how much they had evolved in their views about the teaching and learning process, when they commented that exposing content is not enough to promote teaching.

Conclusion and implications for science education

The vision of science teaching as scientific literacy with a view to introducing students to the field of science, providing new views and interpretations of the world, as well as new languages, will require teachers to develop multiple strategies to promote meaningful learning by students. In this sense, the development of the discipline of *Instrumentation for Chemistry Teaching I* enabled the construction of new views about the nature of science and the teaching and learning process by developing a Reflection-Oriented Process aiming at this change of approach in science teaching, as well as the development of a new profile for the teacher, based on important reflections on the role of the teacher for the development of scientific literacy.

Both the teacher-training process performed in *Instrumentation for Chemistry Teaching I* and the didactic sequence planned and developed by the students were developed through digital technologies, revealing the great importance of the proper use of technological tools to facilitate the teaching process and to learn at different levels of education.

The students experienced several activities during the Reflection-Oriented Process, in which they were able to reflect on four interrelated contexts: (i) reflecting as a student in science classes; (ii) reflecting on other teaching practices from didactic resources; (iii) reflecting on the researchers' opinions; and (iv) reflecting on the teaching practice itself (Abell & Bryan, 1997). The

Reflection-Oriented Process enabled the construction of new visions, the awareness of the evolutionary process experienced, and new didactic postures by future teachers, as evidenced in the planning and realization of practical classes.

This has important short-term implications, as future teachers should be able to develop practical classes for their future students. The role of training future professionals in the field of Science Education in teacher training courses is, without a doubt, a fundamental educational stage. During this period, one of the main objectives should be to develop important teaching skills aimed at developing scientific and technological literacy. Teachers for 21st century schools need to be innovative. They need to know how to plan, manage and develop innovative projects with creativity, autonomy and self-confidence, as well as knowing how to use technological tools. They need to be aware of their didactic models and seek continuous learning. They need to be critical and reflexive teachers in order to articulate science, technology and social practices. They need to be entrepreneurs, transforming new ideas into appropriate actions for the development of a new learning culture effectively in schools, with a view to forming aware, responsible and more critical citizens!

A new teacher profile was developed during this discipline – an innovative teacher – which was strongly favoured by digital technologies.

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Note: In the Brazilian Educational System we have a complete four-year Major program leading to a degree in the teaching of Chemistry (as well as in other subject matters) called "Licenciatura." We have not identified a similar system in the USA or the United Kingdom.

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Appendix

1. Carvalho (2011) in her proposal for science teaching and learning points out eight important aspects for the planning and organization of the Investigative Sequences of Teaching:

(i) Active student participation: it is the basis of all constructivist theories that underlie the SEIs. The person, that is, the student, is the builder of his own knowledge.

(ii) The importance of student-student interaction: in a socio-interactionist teaching proposal, student-student interactions are significant in small groups. Communication is facilitated by interaction with peers of similar real and linguistic development, and students reflect, raise and test their hypotheses.

(iii) The role of the teacher as a question maker: one of the main roles of the teacher is to build scientific concepts together with the class, making students participate effectively in the construction of knowledge. It is necessary to make sense of the various explanations of the students on the resolution of the problem studied. For this, the teacher needs to elaborate questions that guide the students' reasoning; questions about what they did and how they did it so they can become aware of the actions taken to solve the problem, as well as to establish relationships between the variables; as well as questions about the scientific why to guide students to seek explanations. Thus, through the questions, the teacher will promote opportunities for greater student participation and encourage argumentation, thus increasing the reasoning and understanding of the phenomena under study.

(iv) The creation of an encouraging environment: the teacher needs to keep in mind the provision of a stimulating, safe, pleasant environment, which favours the active participation of the student, dialogical interactions with his peers and with the teacher in the different opportunities of discussion and expression of ideas and feelings. This environment can be easily built or destroyed by small actions, such as when the teacher, for example, accepts the students' ideas, regardless of whether they are right or wrong, trying to understand the reasoning used in that conclusion. When the teacher ignores the student's opinion, or even says "no, you're wrong", s/he may cause difficulties for the student to participate again.

(v) Teaching from the knowledge that the student brings to the classroom: this is a fundamental point in a proposal for teaching science with constructivist principles. The teacher needs to know the spontaneous conceptions that students have acquired throughout their lives and make them aware of these conceptions. In the context of the study to be carried out, these conceptions may be treated as hypotheses.

(vi) The meaningfulness of the content (the problem) for the student: the question needs to be motivating. The teacher needs to know how to problematize in order to offer students problems different from those that students are used to elaborating, thus providing opportunities for new knowledge to be elaborated, and the construction of a new look by the students through the learning of new contents (Capecchi, 2013).

(vii) The relationship between science, technology and society: one of the objectives of scientific literacy is the introduction of students into scientific culture, which implies establishing CTS relationships in the sequences of teaching by investigation (SEI).

(viii) The transition from everyday language to scientific language: from an interdisciplinary teaching, the teacher needs to know how to guide students so that they know how to use scientific language. To do science, to speak, read and write science it is necessary for the teacher to know how to articulate the different scientific languages with verbal discourse, making use of graphical representations and mathematical expressions, for example, as well as to encourage the argumentation and increase the reasoning during the activities of systematization of knowledge.