

CREATIVE LAB_SCI&MATH: INOVAÇÃO NO ENSINO DA MATEMÁTICA E DAS CIÊNCIAS FÍSICO-NATURAIS

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ABSTRACT

CreativeLab_Sci&Math is a didactic initiative within the department of Mathematical and Natural Sciences of the School of Education of the Polytechnic Institute of Santarém, that aims the innovation of the pedagogical practices in Higher Education, particularly in teacher education. Our didactic approach is based on following principles: use of 7E instructional model and Inquiry-Based Learning, use of innovative educational environments and curricular integration of digital technologies. Other goals of CreativeLab_Sci&Math are the dissemination of these innovative teaching practices in scientific events, development of initiation activities in programming and robotics, development of educational resources for mathematics and science and the provision of these resources to teachers on online platforms with peer review, such as Casa das Ciências®. Some activities are implemented in CreativeLab_Sci&Math with two teachers, one of each subjects, science and mathematics. This collaboration has the advantage of diverse skills in students, such as scientific, technical and technological knowledge, critical and creative thinking, reasoning and problem-solving skills, through their involvement in interdisciplinary tasks that relate content and processes of learning of the two areas.

Introduction

CreativeLab_Sci&Math is a didactic approach within the Department of Mathematic and Natural Sciences of the School of Education - Polytechnic Institute of Santarém (IPS/ESES). One aim of the CreativeLab_Sci&Math is the training future educators in teaching practices associated with new learning environments. For that purpose, we transformed traditional science labs into innovative educational environments and named it CreativeLab_Sci&Math (figure 1). This initiative focuses in promoting innovative teaching in mathematics and science. In this paper, we describe the didactic approach of CreativeLab_Sci&Math, namely the use of 7E instructional model and Inquiry-Based Learning, innovative educational environments, curricular integration of digital technologies, programming and robotics, and also the exchange of innovative didactic practices and activities in networks of science and math teachers.

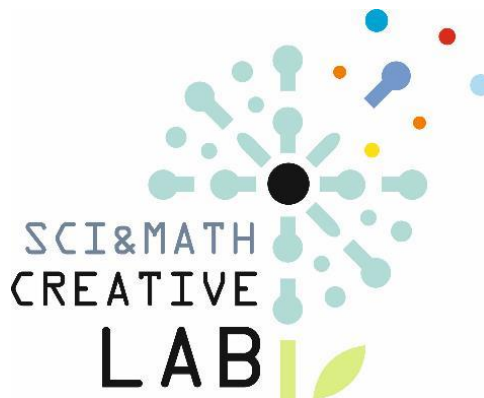


Figure 1. Logo of the CreativeLab_Sci&Math.

CreativeLab_Sci&Math didactic approach is based on following principles:

Use of 7E instructional model and Inquiry-Based Learning

CreativeLab_Sci&Math learning activities are structured according to 7E instructional model. This model includes the

following moments (BSCS, 2006; Kähkönen, 2016; Reis & Marques, 2016; Linhares & Reis, 2017): Engage, Explore, Explain, Exchange, Elaborate, Evaluate & Empowerment.

Students' involvement in a subject or problem is the main goal in the Engage moment. In this moment, it is important to understand students' prior knowledge regarding the subject or problem being studied and promote connections between previous and new learning experiences. Motivate students and organize their thinking towards the learning objectives of current tasks is another aim of this moment. Our role, as teachers, is to introduce and briefly explore the problem or the engage-task and cause a cognitive discomfort in students in order to drive them to know more, explore and understand better the subject or problem.

In the Explore moment, students are involved in hands-on and minds-on activities that help them generate new ideas, explore questions and hypothesis, design methodology for an investigation and conduct a research. In this moment, laboratorial, digital and other resources are provided to help students in their enquiry. Our role, as teachers, is to introduce activities and give students the time and space to address the problem, considering their initial ideas. When requested, we guide students in research design, clarify their doubts or help them find a path to a possible answer. In this moment, it is very important to promote group discussions and cooperative learning, giving opportunities for students to present their ideas and receive feedback from peers. In some tasks, students must work together in order to collect and share data that it will be used to achieve collective answers to a problem.

The Explain moment is used to focus the students' attention in scientific details of a concept or process. One of our goals in the Explain moment is to provide opportunities for students to demonstrate understanding of concepts, skills, values and attitudes. When necessary, we help students to understand concepts or processes, giving direct explanations or conducting

them to further enquiry. Our intention is to create, in class, an accurately scientific common language.

The Elaborate moment is used to engage students in new learning experiences by developing a more profound comprehension of scientific subjects addressed in previous tasks. One of the aims is to transfer students' knowledge to new situations, though related with previous ones. In this moment, group discussions and cooperative learning also have a main role in the learning process. The Exchange moment includes the presentation, by groups or individual students, of what they have learned. In this moment, students have to expose orally or elaborate synthesis of information using different digital resources, use proper scientific language, and be ready to answer questions placed by peers and/or by the teacher.

The Evaluate moment provides opportunities for students to assess their learning and skills. In this moment, it is very important to give feedback to students, to change possible misconceptions. There can also be a more formal moment of assessment during or at the end of the learning sequence. The main purpose of the evaluate moment is to identify if students have achieved the learning objectives.

Finally, some activities include an Empowerment moment, to raise students' awareness about socio-scientific issues in discussions and promote transfer of that knowledge to the community to help solving the problem.

Some activities were also structured using the Inquiry-Based-Learning strategy (NRC, 2000; Hutchings, 2007; Pedaste et al., 2015). Our inquiry-based learning activities are well appreciated by the prospective teachers because allow them to describe objects, raise questions, construct and evaluate explanations, considering current scientific knowledge, and communicate their ideas to others, using mathematics and science. We think that,

through immersion of future teachers in this type of teaching-learning scenarios, they will be better prepared to teach using the inquiry-based learning approach, and actively participate in solving social issues related to science, technology and the environment (Linhares & Reis, 2017).

Use of innovative educational environments

CreativeLab_Sci&Math is organized into different zones related to the 7E teaching moments and students' different needs concerning the realization of tasks. These spaces, inspired by the initiative Future Classroom Lab (European Schoolnet, 2017), match different learning areas whose aim is the development of different skills. An innovative educational environment (IEE) implies, thus, to rethink spatial organization of the 21st century classroom, its resources, teaching strategies, and teacher's and students' role. In the next figures, we present the space organization.

The area with chairs, in figure 2, is related to the Engage, Explain, Exchange and Empowerment moments. There are three areas behind chairs where students can work in large groups and, in group or individually, participate in laboratorial activities or explore digital resources (Explore, Exchange and Evaluate moments). In the left side, there is an area where students can work alone or within small groups (Explore, Exchange and Evaluate moments).



Figure 2. Main organization of the CreativeLab_Sci&Math space.

At the rear, there is a working space with lounge characteristics that can be used by students in the Exchange, Explore or Empowerment moments (Figure 3).



Figure 3. Lounge area of CreativeLab_Sci&Math used in the Exchange, Explore or Empowerment moments.

The CreativeLab_Sci&Math is equipped with wireless connection that allows students to explore digital resources and with different types of materials related to laboratorial activities of biology, geology, physics, chemistry and mathematics.

Curricular integration of digital technologies

In the CreativeLab_Sci&Math, there are learning experiences for students to explore and manipulate digital tools in a contextualized way (Llabaca, 2003), with the aim of building knowledge (Costa, 2012). Digital educational resources aim, for example, to combine real experimentation with virtual experimentation, through interactive simulations (Zacharia, 2005). Activities of initiation to programming, promotion of digital literacy, computational knowledge and integration of knowledge of different curricular areas (DGE, 2016; Partnership for 21st Century Learning, 2007) have also been promoted in this IEE.

Some of the ICT resources used in CreativeLab_Sci&Math activities include the use of TinkerPlots®, a software for dynamic data exploration. This software was developed for data visualization and modelling by middle school through university students, and it was one of our choices to explore data because can be use by our students in their future classrooms of basic education. We also integrate the Khan Academy platform as a method for students develop their knowledge about a concept or process (Explain moment) or assess their learning at the end of activities (Evaluate moment). Dynamic Geometry Environments (DGE), namely the software GeoGebra, are used in learning, not only geometry or algebra, but also in problem solving through mathematical modelling, in contexts involving applications of mathematics (Explore moments).

PhET Interactive Simulations (University of Colorado Boulder, 2018) are widely used in science classes to explore simulations of phenomena of biology, geology, chemistry and physics. Usually, those simulations are explored in group work whose elements have different tasks. Virtual experimentation through interactive simulations, involving the exploration of interactions between variables, constitutes an environment conducive to conceptual change, developing students' ability to make predictions and acceptable explanations of phenomena (Rutten, van Joolingen & van der Veen, 2012; Smetana & Bell, 2012). The simulations create an environment conducive to the active discovery of scientific content in a real context (de Jong, 2006), can be used in the context of the classroom or out of school (Bulegon, Cristofio & Pretto, 2013) and promote student interest (Araújo, Nobre, Junior & Dantas, 2015). According to Smetana and Bell (2012), computer simulations can be more effective than traditional teaching practices (expository or experimental) in promoting scientific knowledge, developing procedural skills and promoting conceptual change.

Programming and robotics

Our approach also intends to promote the development of students' programming and robotics skills. Implementation of programming and robotics activities can contribute to the development of science, mathematics, engineering and technologies competencies, also known as STEM, and can also foster students' motivation and creativity (Direção-Geral de Educação, 2016). These ideas come from the important challenges and opportunities offered by today's demanding, competitive and extremely volatile society, that contribute to the necessity of new skills and competences (Coutinho & Lisboa, 2011). One available software is the programming tool Scratch®. This tool allows students, even from early years of schooling, to program and share interactive stories, animations and games.

According to Scratch®'s creators, Resnick et al. (2009), this software is practical, interactive, encourages experimentation, incites diversity and personalization, and incorporates a social dimension, due to the association with Scratch website that incorporates a community. We use this tool to create integrate sciences and mathematics activities, through contextualized projects.

Exchange didactical approaches and share educational resources

The exchange with other teachers and researchers of our didactic approaches, activities and other materials produced in CreativeLab_Sci&Math is very important. Therefore, we routinely present our work in international and national scientific events. Our educational resources are also shared in online platforms for science and mathematics teachers, such as Casa das Ciências®, after a peer review process (Table 1). Those resources were designed for students from kindergarten to high school. Some open educational resources were awarded by the Casa das Ciências®, an annual prize that distinguishes the best digital activities for science and mathematics teaching published by teachers in Portugal.

Table 1.
CreativeLab_Sci&Math digital resources published in Casa das Ciências®.

Author	Title
<u>Correia</u>	<u>Refraction of light (Distinction Prize)</u> <u>https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40733243</u>
<u>Correia</u>	<u>Science in Christmas (Distinction Prize)</u> <u>https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40493566</u>
<u>Correia</u>	<u>Playing with Astronomy (Distinction Prize)</u> <u>https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40740087</u>

<u>Correia</u>	<u>CSI in classes of Physics and Chemistry (Merit Prize)</u> https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=39723769
<u>Correia</u>	<u>What is greenhouse effect?</u> https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40153392
<u>Correia</u>	<u>Where does rainwater come from?</u> https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40493567
<u>Correia</u>	<u>Research a dense problem</u> https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40188042
<u>Correia & Santos</u>	<u>How does balance work?</u> https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40740091
<u>Cavadas</u>	<u>Plate tectonics 12th Grade</u> https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40746912
<u>Linhares & Cavadas</u>	<u>Bad plastics</u> https://www.casadasciencias.org/cc/redindex.php?idart=303&gid=40842549

Some activities were elaborated by students or with students' collaboration. We work in a School of Education, whose main aim is the teacher training, so, involving our students in the process of designing and implementing science and mathematics activities for different school levels is very relevant.

We also developed an online page to share the CreativeLab_Sci&Math initiative: http://w3.ese.ipsantarem.pt/eseinv/creative_lab/, and promote our activities in social networks, such as Facebook@: <https://pt-br.facebook.com/SciMathCreativeLab/>. Many of our students and colleagues use our Facebook page to know what we are doing and receive notices of our next activities.

Conclusion

The 21st century is facing faster and continuous social and technological changes that are leading educators to amazing challenges. New approaches and learning experiences are daily emerging to teach the next generations, concerning didactics, technologies or curriculum. In this paper, we have presented the innovative and integrative approach of CreativeLab_Sci&Math, focusing on the use of 7E instructional model and Inquiry-Based Learning, innovative educational environments, curricular integration of digital technologies, programming and robotics and the exchange of innovative practices and activities in networks of science and mathematics teachers.

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