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Light pollution and its damages to astronomical observations and to living beings

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Abstract. Interdisciplinarity in the area of Natural Sciences, combined with collaborative work, is fundamental to the new BNCC for High Schools. Based on this premise, we applied a didactic sequence in a teacher training course, whose theme was “Light pollution and its damage to astronomical observation and to living beings”. This didactic sequence was presented as part of a training course for 75 teachers in the STEAM approach (Science, Technology, Engineering, Art and Mathematic), offered by the State Secretariat for Education, Sport and Culture of the state of Sergipe (SEDUC). The objective of this course was to promote the learning of the Problem Based Learning (PBL) methodology, with a focus on the STEAM approach. The provocative theme, allied to the methodology, stimulated collaboration between peers in the search for a solution that provided metacognition and the development of: interpersonal relationships, critical and creative sense, time management and autonomy.

Resumo. A interdisciplinaridade na área de Ciências da Natureza, aliada ao trabalho colaborativo, é fundamental à nova BNCC para o Ensino Médio. Com base nessa premissa aplicamos uma sequência didática em um curso de formação de professores, cujo tema foi “A poluição luminosa e seus prejuízos para a observação astronômica e para os seres vivos”. Esta sequência didática foi apresentada como parte de um curso de formação de 75 professores na abordagem STEAM (Science, Technology, Engineering, Art and Mathematic), oferecido pela Secretaria de Estado da Educação, do Esporte e da Cultura do estado de Sergipe (SEDUC). O objetivo deste curso foi promover a aprendizagem da metodologia Problem Based Learning (PBL), com foco na abordagem STEAM. O tema provocador, aliado à metodologia, estimulou a colaboração entre os pares na busca de uma solução que propiciou a metacognição e o desenvolvimento de: relações interpessoais, senso crítico e criativo, gestão do tempo e autonomia.

Keywords. Teaching of Astronomy – Light pollution – Atmospheric effects

1. Introduction

Law 13.415 of February 16, 2017 provides for the use of interdisciplinarity combined with collaborative work as a key part of the new Common National Curriculum Base (BNCC) for High School and which must be implemented throughout Brazil by 2022. Therefore, we apply a didactic sequence as part of a teacher training course for the state network of Sergipe, presenting a guiding text with the theme "Light pollution and its damage to astronomical observation and to living beings", using the STEAM approach (Science, Technology, Engineering, Art and Mathematic). The course was offered by the Sergipe State Department of Education, Sport and Culture (SEDUC) and its objective was to promote the learning of the Problem Based Learning (PBL) or Project Based Learning (ABP) methodology, with a focus on STEAM approach. In this course, undulatory, circadian cycles of living beings, light spectra obtained from artificial light sources, the design of lighting fixtures in public lighting and the analysis of the percentage of light that is scattered in the night sky are some of the concepts involved in this course. in the proposed theme, involving interdisciplinarity and transdisciplinarity in the classroom.

2. Methodology

2.1. The STEAM approach

This approach, which aims to develop a citizen prepared to interact with today’s technological world, is characterized by being transdisciplinary, contextualized, collaborative, creative and project-centered. STEAM leads students to investigate, developing their values and competencies Bacich & Holanda (2020), while using the Project-Based Learning (ABP) methodology, which is a work proposal that develops the student’s metacognition, that is, the young man learns to learn. The STEAM involves the use of: Science, through the necessary concepts; Technology, through the analysis of the different types of lamps; Engineering, through the strategies used in search of a solution; Arts, through the analysis of the design of the lamps; and Mathematics, through the analysis of the spectra obtained from the light emitted by the lamps.

PBL uses current and real contexts, which motivate the learner to adopt an interested and participatory behavior, in a collaborative environment that allows respect and sharing of ideas. Currently, numerous research works in collaborative environments are performed with PBL, which finds in John Dewey’s Active Pedagogy the inspiration for meaningful learning from real problem situations. Dewey believed that the cognition of a student was stimulated from real situations of his daily life, mobilizing the practice of research, critical analysis and creative resolution of problems Souza & Dourado (2015).

According to Raine & Symons (2005), over time PBL has undergone adaptations as it is applied and has also been used in a number of approaches: Contextual Learning, Case-Based Learning and Research-Based Learning. Initial provocative situations range from problem scenarios to general investigation and case questions. But it is important to consider that, according to Raine & Symons (2005, p.4), the "[...] PBL, as well as any pedagogy, does not work by imitation. It has to be adapted, usually by trial and error, to local circumstances."

In addition to the health area, PBL was incorporated (and adapted) by other areas of knowledge: engineering, mathematics, physics, biology, chemistry, law, psychology and geography, among others. The PBL was also incorporated at different levels of education, from basic education to higher education and post-graduation Souza & Dourado (2015).

2.2. Characteristics of the PBL

In the participation of an PBL the students aim to solve the problems actively, while the teacher guides and keeps the students involved in the process, ensuring challenges that encourage the construction of meanings in the learning of concepts. In order for interaction to occur between participants of the knowledge construction process in Problem-Based Learning, it is necessary to consider some points:

- Creating a collaborative and encouraging environment;
- Stimulating active student participation;
- The importance of student-student and student-tutor relationships;
- The development of teaching strategies from the apprentice's prior knowledge;
- The role of the tutor as advisor and maintainer of the challenge x solution balance of the presented problem;
- The problem situation presented should make sense to the student;
- The presence of the relationship between Science, Technology and Society.

Among the students who are part of the group one will be the coordinator and the other will be the secretary, being able to perform a rotation at each session, so that all exercise these functions. Each session of an ABP has two tutorials: the 1° tutorial (opening) involves reading and interpretation (identification of the main problem), data analysis, brainstorming for the survey of hypotheses and research objectives; after extra class research, participants bring the research results to a debate in search of a solution to the problem identified in the text, followed by its application, analysis and record of the results (2° tutorial). Participation and exchange of ideas contribute to mutual learning Rodrigues (2019).

Considering possible adaptations and based on the 7 steps of the Maastricht University (Netherlands), the stages of the PBL are represented in the image in Figure 1:

2.3. The text - on light pollution and astronomical observation

The excess light from artificial sources can be dispersed by aerosol scattering or by pollutants in the atmosphere, in the form of small particles, generating what is called the diffuse brightness of the sky, often seen from afar. This form of light pollution hinders the astronomical observation of the night sky, imposing the need to build the observatories in higher places, distant from cities and in regions of low relative humidity of the air Lima et al. (2018).

The guiding text deals with the right to see the night sky, how the excess of luminosity affects the circadian cycle and the LED technologies, requiring participants to know about wave study, optics, modern physics and astronomy. The supporting material is available at https://bit.ly/RodriguesSantos_SAB2021 or QR Code, shown in Fig. 2.

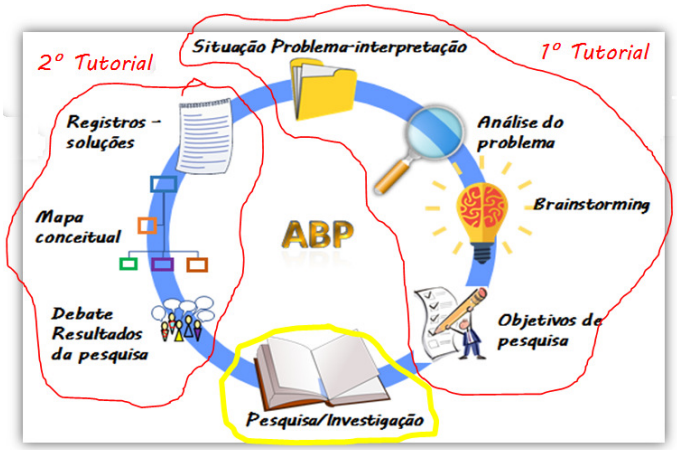

Figure 1. ABP Steps. Adapted from Raine & Symons (2005), by Rodrigues (2019)

Figure 2. QR Code - access to the folder with the material supporting the application of the didactic sequence.

2.4. Implementation stages

The application of the didactic sequence took place through two tutorials that make up the Problem Based Learning (PBL) methodology, using the STEAM approach, presented in Tab. 1 and Tab. 2.

Table 1. 1° PBL tutorial

1. Presentation of the problem situation	- Reading of the guiding text.
2. Analysis of the problem	- Interpretation of the guiding text to identify the central issue of the problem. - Identify the key concepts.
3. Brainstorming (storm of ideas)	- Debate the situation through a brainstorming (storm of ideas) between the components of each team, using their previous knowledge. Each student should present their ideas to the group and if they succeed, launch a possible solution or hypothesis.
4. Research objectives	- Identify what you need to research, to list the research objectives.

The second tutorial required experimental investigation that involved the construction of a homemade spectrograph Santos (2018) to obtain and analyze the spectra obtained with the available lamps presented in the guiding text.

Table 2. 2° PBL tutorial

1. Research	- experimental investigation; -Individual search; Experimental investigation; record of research results and sources.
2. Discussion	- Exchange of ideas for analyzing the feasibility of a solution.
3.Results record	- Registration and presentation of the solution and application strategies.
4. Self-evaluation	- Carry out a self-assessment, based on the rubric presented.

3. Results

After analyzing the spectra and costs of the lamps, the design of luminaires used in public lighting and the damage caused to the circadian cycle of living beings across the city, the participants deliberated on the best position for an astronomical observatory and the best way to avoid light pollution . The application of the sequence ended with the presentation of the solutions and the construction of a new didactic sequence, by each team, using the PBL methodology with a focus on the STEAM approach.

4. Conclusion

At the end of the course, the learning process was evaluated by the participants on the SEDUC platform considering method, support materials (texts and videos), theme (guiding text), activities and tools (technology). The results encouraged us to participate in another proposal for a teacher training process, which will be financed by Fapitec-SE (a research promotion agency). Participants expressed expressive curiosity for Astronomy, showing a strong interest in the Pollution of Light theme, and recognized its potential to favor transdisciplinarity, noting how rich it was to experience the PBL methodology in the STEAM approach through the applied didactic sequence. It is important to emphasize that there was a request regarding the possibility of increasing the duration of the course. Fig. 3, Fig. 4 and Fig. 5 below shows the results of the survey carried out with the participants:

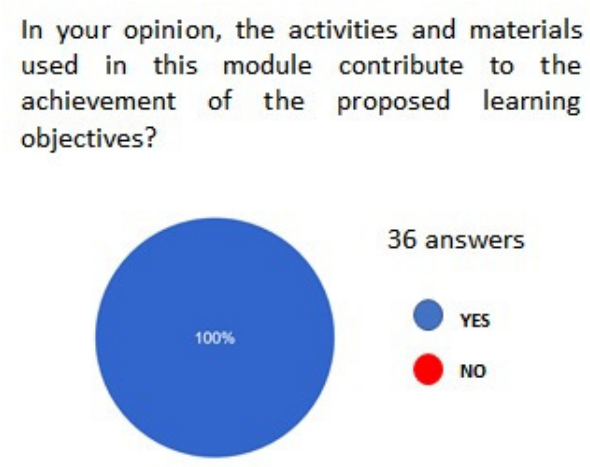

Figure 3. Results of the survey with course participants of course - question 1

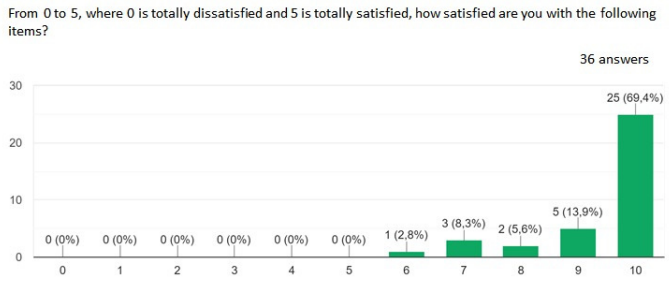

Figure 4. Results of the survey with course participants of course - question 2.

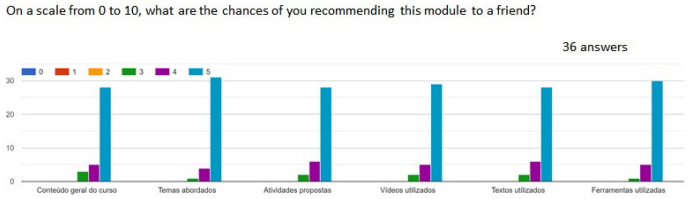

Figure 5. Results of the survey with course participants of course - question 3.

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