

APRENDIZAGEM BASEADA EM PROBLEMAS: UM ESTUDO DE CASO NA DISCIPLINA DE TRATAMENTO DE ÁGUA, EFLUENTE E LODOS

APRENDIZAJE BASADO EN PROBLEMAS: UN ESTUDIO DE CASO EN LA DISCIPLINA DE TRATAMIENTO DE AGUA, EFLUENTE Y LODOS

PROBLEM-BASED LEARNING: CASE STUDY IN THE DISCIPLINE WATER TREATMENT, EFFLUENT AND SEWAGE.

Regina de C. O. MACHADO¹
Giani M. B. BOHM²
Emerson de MORAES³

RESUMO: Toda Instituição de Ensino que ofereça cursos profissionais carrega consigo um grande comprometimento, pois são responsáveis pela formação de um profissional plenamente apto e consciente de suas competências e habilidades, que devem ser usados em sua atuação no mercado de trabalho competitivo e seletivo. Partindo-se desta premissa e apoiando na literatura existente, a Aprendizagem Baseada em Problemas (ABP) pode ser um caminho, como sendo uma ferramenta facilitadora para que os discentes possam assimilar mais facilmente as competências (atitudes, conhecimento e habilidades), as quais podem ser aplicadas em sua futura carreira profissional de forma contundente. Portanto, a presente pesquisa teve por objetivo avaliar a ABP aplicada a disciplina de Tratamento de Água, Efluentes e Esgotos do curso Técnico em Química do IFG, realizada no ano de 2013. Para tanto, esta pesquisa baseou-se no procedimento técnico atrelado estudo de caso. A coleta de dados foi proveniente da observação participante, de questionários e do protótipo gerado. De forma geral, os resultados evidenciaram que a ABP promoveu uma maior integração e envolvimento dos alunos, motivada pela comunicação e participação bilateral docente/discente bem como o uso de tecnologias dispostas como ferramentas para crescimento pessoal, intelectual e profissional, pois os alunos ao utilizarem problemas práticos e reais ganharam destreza na resolução de problemas de ordem prática e profissional.

PALAVRAS-CHAVE: Ensino-aprendizagem. Metodologia alternativa. Modelo tradicional. Material didático.

RESUMEN: *Cualquier institución educativa que ofrezca cursos profesionales lleva consigo una gran responsabilidad traducida en la formación de un profesional plenamente apto de sus competencias y habilidades en la eminente actuación en nuestro competitivo y selectivo mercado de trabajo. A partir de esta premisa, apoyándose en la*

¹Instituto Federal de Goiás (IFG), Luziânia - GO - Brazil. Professora do departamento de Química. E-mail: regcarvoliveira@gmail.com

²Instituto Federal Sul-Riogrândense (IFSUL), Pelotas - RS - Brazil. Professora Titular do departamento de Engenharia e Gestão Ambiental. E-mail: bohmgiani@gmail.com

³Instituto Federal Sul-Riogrândense (IFSUL), Pelotas – RS - Brazil. Mestrando no programa de Engenharias e Ciências Ambientais. E-mail: ebohm2@gmail.com

literatura vasta existente, se ve el norte apuntado al Aprendizaje Basado en Problemas (PBL), como una herramienta facilitadora para que los alumnos puedan fácilmente asimilar las competencias (actitudes y conocimiento), los cuales, pueden ser aplicados en su futura carrera profesional de forma contundente. Por lo tanto, esta investigación tiene como objetivo evaluar el PBL aplicado a la disciplina de Agua, Efluentes y Tratamiento de Alcantarillado del Curso Técnico en Química del IFG, que se realizó en el año 2013. Para ello, esta investigación se basó en el procedimiento técnico vinculado al procedimiento estudio de caso. Los datos fueron recolectados a través de la observación participante, cuestionarios y el prototipo generado. En general, los resultados mostraron que el PBL fue útil para incluir mayor integración e implicación de los alumnos, motivados por la comunicación y participación bilaterales de profesores y alumnos, así como el uso de tecnologías como herramientas para crecimiento personal, intelectual y profesional, pues los alumnos al utilizar problemas prácticos y reales ganaron destreza en la resolución de problemas de orden práctico y profesional.

PALABRAS CLAVE: *Enseñanza-aprendizaje. Metodología alternativa. Modelo tradicional. Material didáctico.*

ABSTRACT: *Any Educational Institution that offers professional courses carries with it a great responsibility, that should lead to the formation of a fully qualified professional who has proper competences and abilities that are required to a competitive and selective labor market. Therefore, based on this premise and on the existing literature, we believe that Problem-based Learning (PBL) could be a guide, once it is a facilitating tool for students to assimilate skills more easily (attitudes and knowledge), which can be applied in their future professional career in a forceful way. Therefore, the present research lies with the objective of evaluating the PBL applied to the discipline of Water, Effluents and Sewage Treatment of the Technical Course in Chemistry of the IFG, that was held in the year 2013. In order to do it, this research was based on the technical procedure and a case study. Data were collected through participant observation, questionnaires and the generated prototype. In general, the results have showed that the PBL was helpful to include greater integration and involvement of the students, motivated by bilateral teacher/student communication and participation, as well as the use of technologies as tools for personal, intellectual and professional growth, as students using and real problems led them to learn skills in solving problems of both practical and professional nature.*

KEYWORDS: *Teaching-learning. Alternative methodology. Traditional model. Didactic material.*

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Introduction

There are great challenges imputed to technical vocational training teachers, among them it is imperative to highlight the absorption of knowledge in a broad way and covering the intellect of students, attempting to get the maximum extraction of their potentialities so that when they break the physical barriers of the classroom, these students

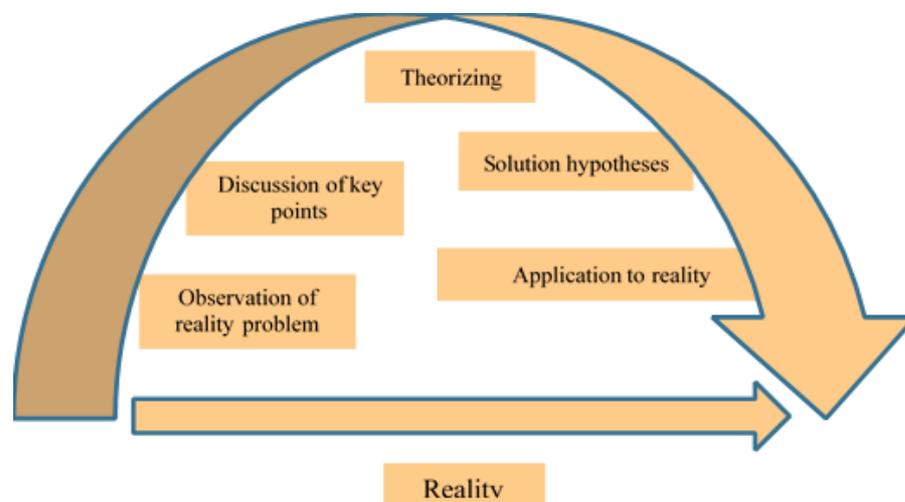
should be able to use their knowledge wisely in the labor market in order to meet its needs. In this context, it is necessary for the students to stop in theory, but actually in practice it is important to motivate actions of students to the new, to instigate their curiosities and desire to discover something, what also makes them also responsible for their learning.

However, the reality of the great majority of the Institutions brings with it the methodology of conventional teaching-learning format, in which teaching is restricted to the classroom, what makes it practical to deal with, with a simple reinforcement for academic absorption of the student. Occasionally, there is a theoretical / practical interaction, however, with the curricular grid full of subjects, the idea of multidisciplinary classes is an utopia.

In this way, teaching based on the PBL may be a good strategy for students to develop their skills and get a broader education. This learning is a teaching approach that has been successfully used for more than 30 years and it continues to be accepted in various subject areas and disciplines. In this process, the teaching of certain subjects of a discipline - the problems - are extracted through the observation of the reality experienced by the students.

The Arch of Magueres (Picture 1) is a helpful tool to discuss a problem detected in reality, which is executed through pedagogical progression through five stages: observation of reality problem, discussion of key points, theorizing, formulation of a solution hypotheses and the application to reality (BERBEL, 2016).

Picture 1 - Magueres Arch



Source: Berbel (2016)

An important part of this cycle is the identification of a group of knowledge deficiencies that complicates or hinders the proposition of solutions to the problem (key points). According to Hollenbeck (2008), the deficiencies found by the group and the search of solutions to the central problem should lead to a stage of self-directed studies. These processes are designed so that students are guided in the search for new scientific knowledge, that is required to solve the assigned problem. In addition, these approaches are focused on students who are trained to conduct research, integrate theory and practice, and apply this knowledge and skills to solve a previously chosen problem (WALKER, 2015). Therefore, problem-solving methods by reality observation encourage individual learning by collectively building deeper knowledge, making students responsible for their own learning (MUNIZ JUNIOR et al, 2017).

Studies carried out by Larmer and Mergendoller (2015), point out that eight elements are necessary for the development of this methodology: content that has meaning, the need to know, a guiding question, voice and student choice, 21st century skills, review work exposure to the public.

Therefore, this research work has been developed applying the PBL approach to a discipline (Water Treatment, Effluents and Waste) of the Technical Course in Chemistry of the Federal Institute of Goiás (IFG), Campus Luziânia, with the purpose of describing and partially experience of this methodology, as well as the results, showing its intrinsic and contextual limits and indicating the gains concerning the development of both student and teacher.

Methodological design

The Problem-based Learning (PBL) was used during the classes of the Water Treatment, Effluents and Waste course of the 4th year of the Integrated Technical Course in Chemistry of the Federal Institute of Goiás (IFG), during the year 2013.

The didactic sequence of the PBL was structured in order to contemplate conceptual, procedural and attitudinal objectives. Thus, to reach these objectives, the strategies and resources of the classes were divided into moments of interconnected learning, which enabled the teacher to adapt it according to the particularities of their students and school conditions.

At the first moment, the teacher mapped previous conceptions of the students on the subject with a guiding question: "What is the perception of the community about the

treatment of water, effluents and waste?" After the initial problematization, that regarded the reality experienced by the students, it was proposed the development of interviews with the community on the subject to be studied. The questions addressed during the interviews were proposed by the students under the teacher guidance. Seven members of the IFG community – Campus Luziânia (identified as P01-P07) were interviewed. The model of semi-structured interviews was adopted and the speeches were submitted to the Discursive Textual Analysis procedures according to the method described by Moraes and Galiuzzi (2007), that consists of three stages: unitarization - in which the text fragmentation occurred in units of meaning; the categorization – in what point the fragments were grouped according to their semantic similarities; the stage of communication - where the descriptive and interpretative texts of this categorization process were elaborated. The emergent categories were presented and discussed from the most significant fragments extracted from the statements. In some cases, to better describe and analyze the interviewees' understanding, subcategories were constructed within the respective category of analysis, what lasted for five classes. From these conceptions it was possible to structure the following steps related to the referral of the teaching plan of the discipline: the didactic and theoretical issues.

In order to address the issues discussed above, specially regarding the importance of water, and to introduce new elements to the discussions, the teacher explored with the students the contents presented in the video "Deconstructing Paris", documentary produced by the Discovery Channel and available on the website <https://www.youtube.com/watch?v=rOzw3bBLT4o>.

Later, after the first steps in understanding the scientific theory and the development of the conception, technical visits were carried out in dumps, water treatment plants, effluents and wastes, in the cities of Luziânia, Brasília and Goiânia (Picture 02 A and 2B).

Picture 2 - Technical visits



Source: IFG (2017)

After the technical visit, the students had to identify the steps of water, effluents and sewage treatment and propose solutions to the waste generated at the treatment plants. This activity was developed in groups of four students using the research as a didactic modality. Subsequently, the students carried out the exposition of the studies in groups in the classroom, through seminars, which discussed their research findings. During this process, the teacher was the mediator during the presentations and, at the end of the process, the teacher led the students to identify the proximity and distance from the research topics. In order to offer theoretical support to the students, during the term, they studied several papers regarding the theme, such as: Baran (2005); Campos and Jardim (2003); Fadine and Fadine (2001) and Lira et al (2012).

Thus, during the practical classes a water treatment plant prototype was built. For this purpose, the conventional water treatment system was divided in 5 units: quick mixing, flocculation, decanting, filtration, disinfection (cf. Picture 3). The prototype built was based on the prototype model of Lira et al (2012), Kondo and Rosa (2007), however it had some differences such as the material used that was totally originated from reuse of materials that would be discarded in the trash.

After the construction of the prototype, the students presented the topic studied and the prototype itself built for the academic community of the IFG - Luziânia Campus. It is important to highlight that during the application of this methodology, it was used formative and summative evaluation. In addition, after the presentations of the projects by the students, in order to evaluate the methodology adopted and skills developed by the students, from their point of view, as well as to give feedback on the project and the action of all during the process, the performance of the group was discussed and evaluated. This

evaluation was done through a questionnaire where the students evaluated the teaching process with questions related to methodology, content and individual and group participation. This evaluation was applied in the classroom to a group of 30 students in face-to-face meetings and it was anonymous. For the elaboration of this questionnaire the Likert scale was used, with scores varying from 1 to 5 for each item addressed, the higher the value attributed the more positive the result. For classification purposes the means were considered low from 1 to 3; satisfactory from 3.1 to 3.8; high from 3.9 to 4.4 and excellent from 4.5 to 5.

Results and discussions

After this evaluation, it was discussed the applicability of the Problem-based Learning (PBL) and the students have argued that there were several gaps and doubts about the problem in question. However, it was observed that the teaching methodology adopted to approach the students brought them closer together and aroused their interest in acquiring knowledge about the subject, due to the contextualization that was realized between the content to be taught and the immediate reality experienced by the students.

Moreover, in the interview reports on sewage and water treatment issues, the concept of the importance of basic sanitation came to light, which is perceived as a synonym of health and is identifiable through the speech of the interviewees: [...] the treatment of sewage is very important (P01, P02, P03, P04, P05, P06 and P07). Despite the fact that the interviewees mentioned local issues and recognized that improvements are necessary, most of the them delimited their approach on the importance of national public policies on basic sanitation.

In other lines, concepts have also emerged on "what is sewage treatment":

[...] sewage treatment is a state obligation (P01, P03)

[...] sewage treatment is a waste treatment (P02, P04, P05, P06, P07)

These representations have brought pedagogical implications in the scientific approach to sanitation problems and the importance on the role of the school in finding ways to overcome local policies involved in basic sanitation, which path must involve sanitation processes.

In addition, the scenario created (or situation-problem) led students to question the subject and the search for solutions through the promotion of research activities, inquiries. This methodology is known as a research-oriented approach, based on

questions (raised by students after presentation of the scenario) and involving the search for solutions (BARROWS, 1996; BORDENAVE; PEREIRA, 1998).

Another tool to motivate discussion and learning was the documentary, as it allowed the understanding of historical, scientific and cultural aspects. Architectural and urban innovations of the city of Paris were shown, as well as the historical and social character of the water treatment (health problems experienced at the time due to an epidemic in the city). The video also brought initial elements for the understanding of theoretical aspects related to the content of the discipline. In fact, this documentary made easier for students to understand theoretical concepts, which brought it closer to the reality of the students, therefore classes were more dynamic and brought theory to practice in a more creative way. Ribeiro et al (2015) has already showed how video screening is a valid tool in the classroom, their work demonstrated significant improvements in the understanding of the contents studied.

There were other advantages on building the prototype: it motivated the students and helped them to understand the concepts related to water and sewage treatment; it allowed the students to get involved with the scientific method (Picture 3). The practical classes provided students with the ability to think, to absorb basic concepts, contents and procedural and attitudinal, necessary for the resolution of practical problems (Kondo and ROSA, 2007). In addition, the prototype contributed to the cognitive development, favoring constructive learning. The use of classroom prototypes was also successfully performed by Lira et al (2012).

Picture 3 - Overview of the prototype experimental water treatment station



Source: authors

1. The quick mixing unit, where the coagulation process occurs, had a mixer, which allowed the students to use different types of coagulants, under various dosage conditions and pH;
2. The flocculation consisted of 3 chambers operated in series, with mechanized mixers that allowed the variation of the speed and flocculation time;
3. The decantation consisted of only a chamber, where the flocculated water entered through a distribution curtain and exited through the channel of collection of the decanted water. The prototype also had bottom discharge for sludge disposal, such as a conventional plant;
4. The filtration consisted in a single descending sand filter;
5. Disinfection was carried out in a mixing unit with baffle plates, where chlorine, fluorine and pH correction agents could be added.

As for the evaluation made by the students about the methodology used in the classes, the item learning tools was the one that received the highest score, classified as high (4.4). The students highlighted through informal classroom conversations that the technical visits and the construction of the prototype were very important for the learning of the topic. As for the participation in the teaching-learning process, it resulted in a high average (4.2). This result evidences a positive change in the methodology, as it was quoted by Freitas et al. (2009, p. 163-167) "*the former pedagogical model was centered on the figure of the teacher; consequently, the creative and critical interference of students, and even of teachers, was limited*". As for the interaction between the group members, the average was high (4.0), showing that the students recognized in this model the role of interaction and the exchange of experiences among the peers as a relevant pedagogical aspect. The comprehension of the subjects was scored as satisfactory (3,8). This mark can be explained because many students believe it is difficult to build their own knowledge, since the search for information is still related to the model in which the teacher present the content for the students, whereas in the new model the students are challenged to seek the information required to solve problems (MÉSZÁROS, 2005; BERBEL, 1998).

As for content evaluation, the highest mark was obtained by the relation between the topics addressed with the real world, classified as excellent (4,5), thus evidencing that the student recognizes in this model a greater applicability to the knowledge obtained. As for the ability to deepen the subjects covered and the interaction on the subject with other

topics, the average was classified as high (4.0), which shows that the students were able to perceive in this methodology the ability to develop their abilities in different areas with the use of a project, in a much more interactive and interesting way than when they study each discipline separately. *“In problem-based learning there is an integrated teaching between content and the different areas involved, whereby students learn to prepare and to solve problems related to their future profession”* (BERBEL, 1998, s/p).

Regarding the evaluation of individual and group performance, the highest score (4,6) was for the presentation of the prototype, which shows that the students had the greatest satisfaction in the final result. The lowest score was for the performance item of the other group members in the project stages, classified as satisfactory (3,7). As in this method each student participates with their own ability and creativity, it is often difficult for them to recognize the work of a colleague or even the limitations and differences in the learning of each peer. The educational system varies according to the individual or the target population (Pereira, 2003). *“Learning is as personal as a fingerprint, since different people learn in different ways. Thus, it is perceived that each person has a different degree of attention”* (CHAVES, 2000, s/p). Student motivation was classified as high (4.0). This factor is very important in this methodology, because as students have greater freedom to build their knowledge, more responsibilities, whereas the teacher should keep them motivated. Thus, according to Haguenaer (2005) the educator is required to change from the role of informant to that of knowledge builder and stimulator of the students' own production; it is not enough to have a broad and up-to-date knowledge; is taught . Participation in the construction of the prototype also received a high average (4.4), showing that students are active and participative when they are focused. Education depends on the exchange between educators and learners, the experiences of each one, based on their knowledge. According to Mészáros (2005) It is necessary a new configuration of knowledge, which is marked by interdisciplinarity, by the extension of students' freedom of trajectories, by curricula and more open content.

Table 1. Average concept assigned by 30 students of the Technical Integrated Course in Chemistry related to process evaluation and student self-evaluation in the teaching-learning process using the problem-solving methodology (assessment from 1 to 5)

Methodology	
Participation in the teaching-learning process	4,2
Group members integration	4,0
Understanding the topics covered	3,8
Learning tools used (interview, video, visits, seminars, prototype construction)	4,4
Content	
Ability to deepen the topics covered	4,0
How the topics studied related to the students real life	4,5
Interaction of the topic addressed with the different courses of the course	4,0
Assessment of individual or group performance	
Performance in carrying out all project steps	3,8
Performance of the other components of the group in the project stages	3,7
Motivation for carrying out the activities	4,0
Participation in the construction of the prototype	4,4
Presentation of the prototype	4,6

Source: autors

The use of this evaluation as a learning tool enabled the students to develop other skills such as communication and discussion. During this activity students reported positive and negative points observed during the construction of knowledge. This tool also allowed students to experience the collective character of science production.

In short, through the study, it was possible to notice a greater involvement of the students with the teaching-learning process, once students are themselves are in charge of the training process, which enabled the development of new skills, finally it leads to a more complete and human professional formation. In this trajectory some difficulties arose that were overcome during the process, the acceptance of a new model depends on the group as a whole that are often accustomed to ready models that do not require discussion or interpretation of the facts and end up participating in a path of passive formation.

Therefore, the challenge of the new methodology goes beyond building new knowledge, it is necessary to deconstruct those concepts and habits that were already rooted in the formation of these students, such as creativity and self-confidence. It is worth mentioning that as described by Freitas et al. (2009), all these changes must be accepted and experienced by students and faculty, since the proposal involves a change in the core conception of teaching, learning and professional life.

Final considerations

The PBL application in the discipline of Water, Effluent and Sewage Treatment has demonstrated the potential to improve the understanding of the contents, deepening the questions worked, as well as to awaken scientific curiosity, encourage creativity, improve social relations among working groups. Finally, it provided the students with a challenge that led to an interdisciplinary work of conventional treatment of water with recyclable materials. In addition, this methodology allowed students to assimilate the skills (knowledge, skills and attitudes) necessary for professional conduct in a meaningful way in the job market.

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