

**Case study: active learning methodology approach in corrosion and science practices**

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Recebido: 26/01/2017 – Aceito: 01/03/2017

**Abstract**

The study evaluates a survey conducted on the last day of the course with 118 students of the last year of two undergraduate engineering courses in Brazil, it was 86 students of the 4th year (8th level or period) of the metallurgical engineering course and 32 students of the 3rd year (6th level) of course materials engineering, to teaching students how to use and interpret polarization curves for predictive and preventive action of corrosion and its chemical mechanisms. The time period was from February 2012 to December 2013 in just three semesters (no summer school). During the time which an educational institution holds classes was required all students to read content before and during class and then work in groups to complete problems and answer conceptual questions and practical pertaining to the material they read. Teachers spent class time answering students' questions. These students' post course ratings on the respondents specify their level of agreement or disagreement on a symmetric agree-disagree scale for a series of attitudes and skills competence statements using a Likert-type scale. The results indicated that the students experiencing using an active learning methodology had more confidence in their ability to perform and interpret chemical corrosion mechanisms. Additionally, these students' attitude scores were positively. In some cases, as shown by the student experience survey, assessing students' attitudes can be an effective solution to these methodological discuss the various methodological problems faced by classroom researchers and suggest that, in some problems. Conclusions are made on ways to overcome or minimize the problems based on difficulty in learning and its chemical corrosion mechanisms through an active learning methodology approach.

**Keywords:** Active learning methodology; Experimental practice; Corrosion; Chemistry

## **1. Introdução**

Active methodologies help to reinforce the relationship between theory and practice and to strengthen the autonomy of the student. According to the cognitive theory of Ausubel (COLL; MARCHESI; PALACIOS, 2016), one has a more efficient learning when the student can add and incorporate new content to existing ones. Ausubel (COLL; MARCHESI; PALACIOS, 2016) theory is that knowledge is hierarchically organized and opposed to rote learning or memorization.

Seen in this way, the objective of this study is to present the results of the impact of the implementation of a practical-theoretical activity in learning of corrosion by proper analysis of the corrosion phenomenon through active learning methodologies in this context. It is carried out, thus, a qualitative research, which aimed to determine whether the use of active learning methodologies and pedagogical practices improves the performance of learning chemistry and corrosion in the construction of knowledge.

## **2. Significant learning and active learning**

In the teaching-learning process, the teacher organizes the form, content and evaluations to create learning opportunities for students.

It is observed that insofar as it can perform an educational work that promotes the learning through discovery, it can achieve the significant learning. In other words, the learning is instigated by principle of discovery, in the authors' view, that is, the more the students investigate, more tend to learn and have interest in the content.

When working with knowledge and concepts close to those that the students already have, namely a proximal region of knowledge, learning is facilitated (IBRAHIM-DIDI et al, 2017; DUARTE, 2017) The learning that occurs with concepts close to what the student already knows facilitates the mooring or anchoring of new information and allows happen to meaningful learning.

Another aspect that is important to learning is the social interaction. The interaction and emotions that occur in the processes of learning can facilitate the occurrence of this (SCHORN, 2015). In educational processes in which we can make happen interaction among stakeholders on the proposed theme can facilitate learning.

The active methods of teaching and learning, according to Borges (BORGES, 2014),

defined as "Problem-Based Learning" or PBL, promote the "learning to learn" constructively and proactively. This process is focused on an issue presented in most cases as a case study and its solving according to Perrenoud (PERRENOUD, 2000) within clear rules based on real in the proximal area, as mentioned by Vygotsky (DUARTE, 2017) and Freire (MATIAS; 2016).

Corrosion is studied in undergraduate courses in Engineering and Industrial Chemistry. In general, the teaching of corrosion is usually part of the curriculum of chemistry and engineering courses, mainly in metallurgical, materials, chemistry, civil and mechanical (ROSO, 2015). Strictly speaking, the corrosion teaching is not always required and many courses have offered it as an elective discipline in 3rd year (6th level), which studies the phenomena associated with chemical corrosion (MERÇON; GUIMARÃES; MAINIER, 2004; GENTIL, 2011).

According to Lobo (LOBO; MORADILLO, 2003), the epistemological concepts of chemistry teachers and covering in this study those who teach corrosion, are mostly of technicalities nature, derived from the historical formation in exact sciences, decisive for the common use of pedagogical models that teacher chemical use in the classroom. In principle, the discipline of corrosion and scientific knowledge are understood objectively and truthfully in absolute terms, ie as a non-ideological knowledge par excellence, without influence of any subjectivity and only able to be recognized by discovery and proven experimentally, by observation and experimentation grants.

The technician model of engineering education in the twentieth century have hampered the learning due to establishing fixed rules of cause-effect, the use of quantitative research methods and theoretical generalizable facts (HUSSEIN, 2015). In the case of the thermodynamic and kinetic mechanisms associated with corrosion such models are not always universal in practice and can lead to a high complexity when considering conditions of the metal reacting with the external environment. This difficulty in the implementation of teaching model the students cause a low school performance and a certain antipathy to corrosion discipline, since the corrosion course students have difficulty understanding and propose thermodynamic models and kinetic without the experience of how proceeds corrosion on the spot, i.e., lack of witness practice to understand the theory.

In this regard, the practice of corrosion aims to meet the demand of students and stimulate the appropriation of knowledge on corrosion levels: phenomenological, theoretical and representational. Such knowledge, in phenomenological terms, corresponds to the unspoken observations confirmed by students. But the theoretical level refers to the

interpretations that occur by observation, while the representational level concerns the chemical language and engineering used to explain these phenomena (symbols, equations and formulas). Thus, the practical experiment has an educational role and should be treated as such. In this regard, it is emphasized the importance of the previous theoretical knowledge related to concepts involved to providing the effective association between theory and practice. It is therefore necessary to combine both of them to avoid practice without reasoning or "empty" of meaning.

The teacher, in classroom practice, promotes not only the trial, but also the dialogue with the arguments of students enriching the theory and the practice, transcending the experiment itself (FONSECA; SANTOS, 2016; MARTORANO, 2016; MÜLLER, 2015; NARDI, 2016; SANGIOGO; MARQUES, 2015)

In terms of theoretical relevance of the knowledge worked on Corrosion course, it is known that most solid materials has some interaction with a large number of different chemical and physical environments. One of the possible products of this interaction is the spontaneous deterioration by corrosion. Often, erosive or oxidative action of the material by an external aggressive environment compromises their usefulness or original function (POPOV, 2015; PARKER, 2016).

### **3. Methodology**

Research is the systematic investigation of something or phenomenon in order to obtain or build some knowledge and it can be qualitative or quantitative. In this case study, carried out a qualitative research with quantitative bias front of students consisting of seeking opinions through interviews and reviews of surveys on the reactions and products obtained in the practice of corrosion. In qualitative research, there are some features that are the natural environment as a direct source of data and the researcher as a key tool, the descriptive character, the meaning that people give to things and the inductive approach. In quantitative research, there is concern of working with numbers (ESTRELA, 2005, LUDKE; ANDRE, 2013). In this article, a survey using a qualitative research with quantitative bias through the performance scores of students so that it can complement itself (YIN, 2015). A Likert item is simply a statement to set this proposed survey which the respondent is asked to evaluate according to the level of agreement or disagreement of subjective or objective criteria. In this study five ordered response levels: 1 – I disagree completely; 2 – I disagree partly; 3 – I agree partly; 4 – I agree with the statement; 5 – I agree completely.

The survey was conducted with 118 students of the last year of two undergraduate courses, it was 86 students of the 4th year (8th level or period) of the metallurgical engineering course at the State University of Minas Gerais (UEMG) and 32 students of the 3rd year (6th level ) of course materials engineering from the Federal University of Itajuba (UNIFEI). The age profile of the students ranged from 16 years of school studies at least and the age range between 20 and 29 years old. The time period was from February 2012 to December 2013 (TEIXEIRA; TEIXEIRA, 2017).

The corrosion course was planned not only to allow the maxim participation of the students, but also to be centered on promotion of deep learning and reasoning skills by the students. To allow this, the curricular plan was designed to involve different methodologies to each specific learning outcome. To accomplish this, students were organized into groups according to high school enrollments. The teacher has the added responsibility of ensuring the observation of a set of working rules, of reading and correcting all documents produced to ensure consistency among the work done, and of promoting cooperation and mutual aid between members of groups. At the end of each activity, each student assesses not only his own performance but also the one of each of his group (TEIXEIRA; TEIXEIRA, 2017; PINHEIRO; SIMÕES, 2012).

The experiments have been realized with steel materials: nails, screws, nuts and plate pieces for the study of the corrosive phenomena in different aggressive environments as alkaline solution, saline solution, acid solution and atmospheric environment. During these experiments, there was an adaptation of the work of Matos (FONSECA; SANTOS, 2016) and the proposed Merçon (MERÇON; GUIMARÃES; MAINIER, 2004) for the practice of corrosion.

Samples of carbon steel and stainless steel have been selected for immersion in four different chemical solutions (two different acidic solutions, an alkaline solution and a saline solution) over a period of one semester. Each sample of steel was immersed in a solution separately with the aim of estimating the losses due to corrosion over time in relation to the mass and thickness originals.

As complementary objectives of the practice, it was understood that besides the students determine experimentally the corrosion rate (mass and thickness) of the samples submitted to different solutions, they are able to interpret and analyze the findings of this corrosion phenomenon in different chemicals environmental.

As shown in the practical and laboratory report, it could be seen the construction of the investigative constructive knowledge, combined with the results of the qualitative and

quantitative assessment of coherent corrosion rate with the literature (MERÇON; GUIMARÃES; MAINIER, 2004; GENTIL, 2011; VARELA; YONGJUN TAN; FORSYTH, 2015; NACE, 2013).

After completion of the initial experimental procedure, the students were encouraged to explain, with the teacher monitoring, the different behaviors of corrosion of the same type of metal in different environment.

Thus, the students perform investigative activity with the use of theoretical knowledge of the electrochemical (2<sup>nd</sup> year) and general chemistry (1<sup>st</sup> year) by redox equations, Faraday equation, polarization curves, Pourbaix diagram and the equation of corrosion penetration rate for each environment and thermodynamic condition. So, it was the basis of discussion of the results of metal corrosion for each environment and sample (carbon steel and stainless steel).

The result was a thorough report on the qualitative and quantitative results of corrosion in different media for steel. The conclusion presented aims to highlight the main succinct explanations about the corrosive phenomenon seen in different types of metals and corrosives environmental, but also to check which concepts the students already appropriated for research more effective of knowledge about phenomenon of corrosion.

It held later interviews with the students using forms with Likert scale in order to see how they understood the practical work and how these influenced learning. For the compilation of the data, it sought to quantify the results of the answers "I like the laboratory classes because I see the theory in practice" and "I like the practical classes because it improves my learning in relation to corrosion" through a Likert scale with five (5) possible alternatives to each question (VIEIRA; DALMORO, 2008; POLYDORO, S. A. J. et al, 2016; RONDINI et al, 2016). This scale is used in researches and it is one of the most accepted worldwide to quantify phenomena with qualitative response. The Likert answers were not graded Grades. Grades in the course were based on aforementioned experiments and literature, two exams, and a cumulative final exam. All exam questions were novel, meaning no items had occurred previously in any homework or exam. This study thus intends to identify the relationship between experiments involving measures of retention of information after the end of a course, measures of problem solving, thinking, attitude change, or motivation for further learning, the results tend to show numbers favoring active methods over learning. These active learning may include one or more of the following: students are involved in more than passive listening, students are engaged in activities (e.g., reading, discussing, writing), there is less emphasis placed on information transmission and greater emphasis placed on developing student skills, there is greater emphasis placed on the

exploration of attitudes and values, student motivation is increased, students can receive immediate feedback from their instructor, students are involved in higher order thinking (analysis, synthesis, evaluation)(WHITE et al., 2016).

#### **4. Results**

The realization of practical work by students was recognized as a substantial relevance to learning as statement:

“It was the first time that a practical corrosion was performed in which I could actually visualize the theoretical concepts.” Student 1.

From the account of one of the informants, it can be seen that when it works only theoretical questions, the students often learn mechanically or cannot correlate in any way, theory and practice, which hampers the learning. Many courses work mainly the theoretical aspects of the lack of laboratories and reagents, or even support and technical staff to maintain these facilities.

The practices are important for the students perform discoveries and analyze how the phenomenon happens in practice, through the observation. When the students have to carry out research activities, observation, searching for information, they interact with others one. Interaction as regards Wallon (SCHORN, 2015) and Vygotsky (DUARTE, 2017) facilitate learning.

From Figure 1, it realizes the frequency, recorded by the teacher, of the mode of participation more active and cognitively of students of materials and metallurgical engineering in activities in the classroom practice together the theoretical corrosion. It was considered cognitive learning each performing mathematical operations, realize and understand the experiment of corrosion. As skill-learning it was included calculations and obtaining the consistent results. As learning attitudes it was counted each argument involving the explanation of corrosive phenomenon, this count basically involves each against prior argument or changing values, attitudes and new vision of chemical phenomena that were taking place in laboratory practice. Regarding the place where occurred the reported learning, all of them occurred in the classroom and in the chemistry lab.



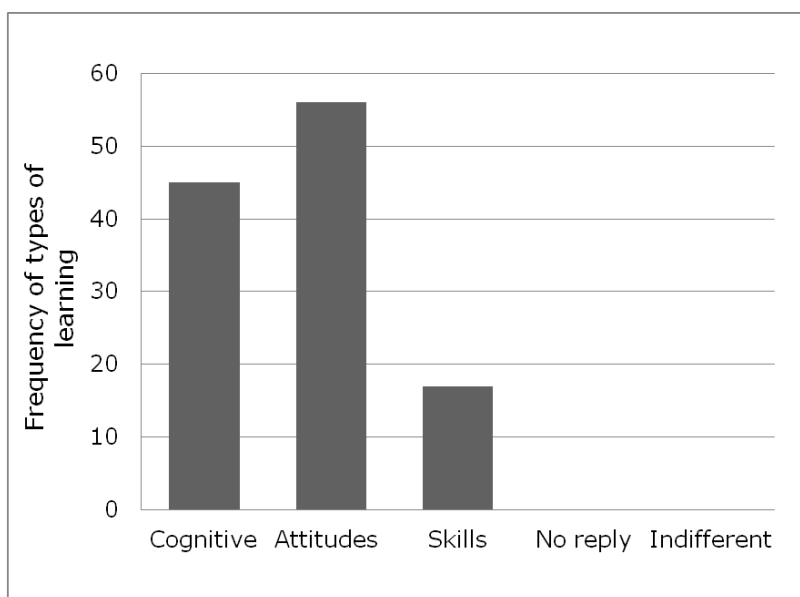


Figure 1. Frequency of types of learning found in the reports of 118 undergraduate students.

The search or browse the information, results and interpretation leads to meaningful learning according to Ausubel (COLL; MARCHESI; PALACIOS, 2016), in other words laboratory practice results presented in accordance with the educational theories.

It is observed that there are five possibilities of response, where 1 is the lowest level of agreement and 5 is the highest level. The students of this research only said they agreed and they liked the practical classes in which, it was reported, the learning in relation to corrosion was favored. In interviews, additionally to statement, the students affirmed that the practice is necessary to set knowledge:

“In the experiments, we see corrosion happening and observe how it happens, the color, the smell, the speed under different conditions, measures the weight loss of material, and it makes us become more secure about what we are learning, in addition the teacher ask questions about it.” Student 2.

In the account of the student 2, it can be seen that many people learn by seeing, other one hearing or writing. It was not intended in this study, however, to compare the various types of learning. It is known, however, that modern education values the multiple intelligences and therefore highlights the importance of the teacher tries to vary the teaching tools so that they promote multiple functions and skills.

Regarding the Likert scale, the Table 2 shows the degree of concordance results regarding the statement:

“The practice of corrosion was a useful tool in the consolidation of concepts.” Student 3.



It is observed in Table 1 and Table 2 that there are five possibilities, where 1 is the lowest degree of concordance and 5 is the highest level. The students of this research only said they agreed and they liked the practical classes in which enhance learning in relation to corrosion. In interviews, additionally to statement, the students affirmed that the practice is necessary:

"Learn and feel the meaning of erosive of the corrosion". Student 4.

Table 1. Student responses in relation to the statement "I like the laboratory classes, because I see the theory in practice."

1	2	3	4	5
0	3	16	32	67

Legend: 1 – I disagree completely; 2 – I disagree partly; 3 – I agree partly; 4 – I agree with the statement; 5 – I agree completely.

Table 2. Results of students in relation to the statement "I like the practical classes because it improves my learning in relation to corrosion."

1	2	3	4	5
0	5	7	60	46

Legend: 1 – I disagree completely; 2 – I disagree partly; 3 – I agree partly; 4 – I agree with the statement; 5 – I agree completely.

The report of practice corrosion was the device used to check teaching if the learning takes place appropriately by the performance of students. The rating was assigned on a scale from 0% (not involved in the practice) to 100% (held to practice successfully in solving all the problems proposed). In terms of performance assessed by the teacher for the practice report it was observed a satisfactory performance without disapproval by note or lack in both of universities evaluated (UNIFEI and UEMG), including minimum final grade of 75%, higher than the 60% required to successfully completing the course, to the objectives of the practice proposed by the teacher, Figure 2. Complementing, the note of student performance for the practice of corrosion consisted in the launch and registration marks for discipline EMT041.2 Special Topics: Metallic Corrosion (Practice) in the second half of 2013 for students UNIFEI and COR (Corrosion) in the first half of 2012 to the first half of 2013 for the students of UEMG.

In Figure 2, the greater dispersion of the average performance of students UNIFEI can be attributed to the fact that the discipline was only taught in one half of 2013, while in UEMG there were three semesters, so a larger sample population. The combined effect of superior amount of semesters wherein the subject has been taught and greater number of students may have reduced the weight of the extreme notes in the evaluation of arithmetic mean and the performance of standard deviation of students UEMG in relation to UNIFEI, at a preliminary analysis of the different dispersion of performance between the means obtained (RONDINI et al, 2016). The in-depth statistical analysis of the different behavior of the performance dispersion among students of UEMG and UNIFEI shown in Figure 2 was not performed in this work.

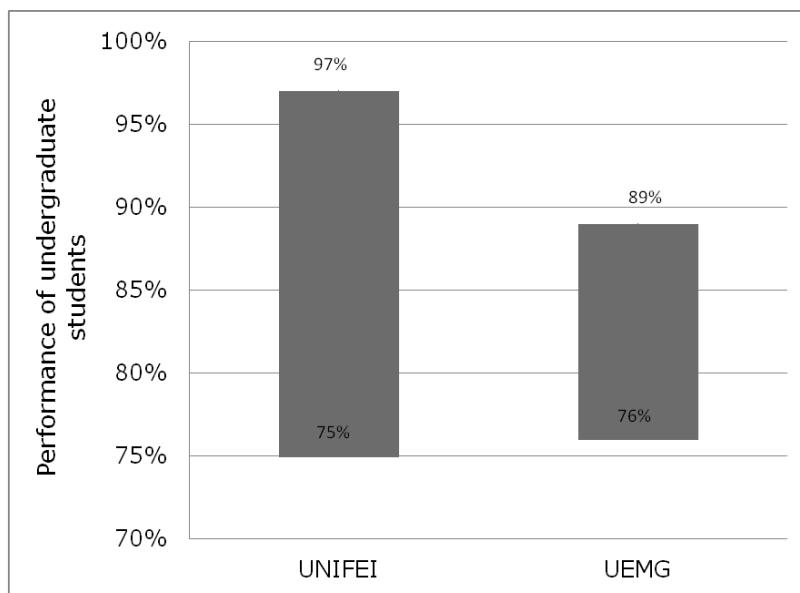


Figure 2. Performance of undergraduate students of UEMG and UNIFEI in practice of corrosion active methodology.

In fact, in practice and in preparing the report, the students work with very similar chemistry and electrochemistry content, besides situations that lead to associations of corrosive phenomena in everyday life in closer to reality situations, either at the gate or wire fence metal rusting in rural areas, or in structures and metal constructions which also oxidizes in urban and industrial or marine environment. This reality meets the Vygotsky's ideas (DUARTE, 2017), who believe that learning occurs in the proximal region of knowledge and also Wellings (IBRAHIM-DIDI et al, 2017), which claims to be able to approach the concepts of academy compared to absorbed by students coming from daily. The approach of these concepts allows occurs lashings actively by students between theory and practice necessary to

make it possible learning meaningful and active way (TEIXEIRA; TEIXEIRA, 2017; WHITE et al., 2016).

## **5. Final considerations**

The approach of active methodology in the research of corrosion practice aimed at fostering in majoring in materials engineering and metallurgy to search for explanations of phenomena that succeed in the practical laboratory with the expected phenomena, based on academic literature, so that it was possible to bring clarifications to the results of corrosion. For this, the teacher was called to urge the students to launch explanatory hypotheses for the different experimental corrosive conditions, assumptions these that might clarify the phenomena observed and recorded in results in the report.

In this study, the qualitative results of the active approach, constructive and investigative knowledge production in relation to corrosion by students, demonstrate that the practical experiment ally theory was significant for the development of the proposed learning in students.

The practice corrosion report was the device used to check the learning that had a success at least 75% of the knowledge expected to be developed in practice. This quantitative record combined with qualitative coming from the Likert diagrams answered by the students indicate the successful combination of theory, as the students learned how to learn and built significantly the concepts involved with the practice of corrosion.

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