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ACTIVE TECHNOLOGICAL LEARNING

APRENDIZAGEM TECNOLÓGICA ATIVA

APRENDIZAJE TECNOLÓGICO ACTIVO

Bruno Silva Leite[1]

ABSTRACT: Active methodologies, and Digital Information and Communication Technologies (DICT) in education are increasingly present in the pedagogical practices. A broad scientific literature highlights the positive impacts on learning of these elements. However, the number of teachers who make a combined and simultaneous use of them turns out to be low. In this sense, this paper describes a new paradigm learning, known as Active Technological Learning (ATL), which is supported by the combined use of digital technologies and active methodologies. For this, a qualitative research was carried out considering a descriptive, interpretative and deductive approach, making possible to understand the phenomena within its context, discovering links between concepts, as well as determining characteristics of the active technological learning model, using the content latent corpus. The results of this research point out that the proposed model leads to a reflection on the use of articulated DICT with the active methodologies, attending to the needs of a digital and active education, centered on the student. Finally, some applications found in the literature are presented as a way to propose some guiding principles for their use in Education, especially in Chemistry Teaching, in order to further improve the understanding of the Active Technological Learning model.

KEYWORDS: Digital technologies. Active methodologies. Active technological learning.

RESUMO: As metodologias ativas e as Tecnologias Digitais da Informação e Comunicação (TDIC) na educação estão cada vez mais presentes nas práticas pedagógicas. Uma ampla literatura científica destaca os impactos positivos na aprendizagem de ambos os elementos. No entanto, o número de professores que fazem o uso conjugado e simultâneo dessas ainda é baixo. Nesse sentido, este artigo descreve um novo paradigma de aprendizagem, conhecido como Aprendizagem Tecnológica Ativa (ATA), que é apoiado pelo uso combinado das tecnologias digitais e das metodologias ativas. Para isso, realizou-se uma pesquisa qualitativa considerando uma abordagem descritiva, interpretativa e dedutiva, possibilitando compreender os fenômenos dentro de seu contexto, descobrindo ligações entre conceitos, bem como determinando características do modelo da aprendizagem tecnológica ativa, utilizando o *corpus* latente de conteúdo. Os resultados desta pesquisa apontam que o modelo proposto pode ajudar a refletir sobre o uso das TDIC articulada com as metodologias ativas, atendendo às necessidades de uma educação digital e ativa, centrada no aluno. Por fim, apresentam-se algumas aplicações encontradas na literatura, como uma maneira de propor alguns norteadores para sua utilização na Educação, em especial no Ensino de Química, de modo a aprimorar ainda mais a compreensão do modelo da Aprendizagem Tecnológica Ativa.

PALAVRAS-CHAVE: Tecnologias digitais. Metodologias ativas. Aprendizagem tecnológica ativa.

RESUMEN: Las metodologías activas y las Tecnologías Digitales de la Información y Comunicación (TDIC) en la educación están cada vez más presentes en las prácticas pedagógicas. Una amplia literatura científica destaca los impactos positivos en el aprendizaje de ambos elementos. Sin embargo, el número de profesores que hacen el uso conjugado y simultáneo de estas todavía es bajo. En este sentido, este artículo describe un nuevo paradigma de aprendizaje, conocido como Aprendizaje Tecnológico Activo (ATA), que es apoyado por el uso combinado de las tecnologías digitales y de las metodologías activas. Para ello, se realizó una investigación cualitativa considerando un enfoque descriptivo, interpretativo y deductivo, posibilitando comprender los fenómenos dentro de su contexto, descubriendo vínculos entre conceptos, así como determinando características del modelo del

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aprendizaje tecnológico activo, utilizando el corpus latente de contenido. Los resultados de esta investigación apuntan que el modelo propuesto puede ayudar a reflexionar sobre el uso de las TDIC articuladas con las metodologías activas, atendiendo a las necesidades de una educación digital y activa, centrada en el alumno. Por último, se presentan algunas aplicaciones encontradas en la literatura, como una manera de proponer algunos orientadores para su utilización en la Educación, en especial en la Enseñanza de Química, para perfeccionar aún más la comprensión del modelo del Aprendizaje Tecnológico Activo.

PALABRAS CLAVE: Tecnologías digitales. Metodologías activas. Aprendizaje tecnológico activo.

INTRODUCTION

The beginning of the 21st century is described, under various terminologies, as the Information Age, Digital Era or Knowledge Society. Perhaps we were or are at a point in history where technological advances, as well as economic, demographic and pedagogical trends, converges and reinforces each other to create a context that results into an accelerated changes with the passing of the years.

In this context, the need for changes in pedagogical practices is increasingly emerging. If these practices are not renewed, the methods, processes and educational contents that we know (and admire) will become irrelevant because they will not attend to the demand for their context. It is believed that the maintenance of practices considered obsolete has contributed to a teacher-centered teaching, in which it has distanced students from the process of building their knowledge. Interesting data released by the survey on innovation measurement in education (OCDE, 2014), after researching 34 countries between 2000 and 2011, reveal that teachers have been innovating in their pedagogical practices. However, the most recent report highlights that Brazil has young teachers facing less favorable working conditions, lower salaries, larger classes and may have fewer opportunities to do other activities (OCDE, 2017). It is also observed that the lack of qualification of teachers (many of them "attached" exclusively to the so-called traditional teaching methods) has made it difficult to adopt them in relation to the use of different teaching methodologies.

Undoubtedly, teacher's education (mediator, facilitator, educator) influences how he exercises his pedagogical practice. The teacher must adopt a flexible attitude towards teaching strategies and assessment both in the moment of organization and planning, as in the development process, due to the unpredictability and uncertainty, and in the decision-making that will have its practice. Traditionally, classrooms have been designed to meet the needs of teachers (layout, format, structure, organization, etc.). We need to rethink the classroom. It is important to note that there is something essentially wrong in school, as it exists nowadays. As time passes, our students, who should be increasingly involved in the learning process, are increasingly distant. It is necessary in order to focus the learning on the student, because, for decades, education was centered on what the teacher transmits to the student. Then, we go through a period of discovery of technologies in education.

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In this way, it has become a challenge for teachers and students, as well as for schools, higher education institutions, and companies to adjust to the complexity of these changes. A new profile has been observed in Brazilian schools and universities where the teacher ceases to be the "transmitter of knowledge" and becomes the facilitator and mediator of knowledge. The students are no longer part passive recipients of information and act as collaborators and participants in the collective construction of knowledge. It is within this context that active technologies and methodologies have grown and become prominent in the process of knowledge construction. In terms of production in the form of articles, the increase (still) is not significant in some areas, for example in the Teaching of Chemistry, with sparse attendance in some magazines. In other areas, such as pedagogy, the production of articles is much more pronounced.

Considering the high number of publications in the area of technologies and the relevant increase involving active methodologies, the aim of this paper is to introduce and explore the Active Technological Learning model, highlighting some applications in the Teaching of Chemistry. To achieve this, we first elucidate the technologies in education, taking recent research as a reference. After, we present and discuss the theoretical references involving the active methodologies, which related to the digital information and communication technologies postulate the Active Technological Learning model. We conclude with the presentation of some research results that present characteristics of the active technological learning model in the teaching of chemistry, in order to provide subsidies to teachers and students (future teachers) who seek to innovate in their pedagogical practice.

TECHNOLOGIES IN EDUCATION

Adoption of Digital Information and Communication Technologies (DICT) in the teaching and learning process in higher school and high education has sometimes been contradictory among teachers. Many teachers, by recognizing its value in the knowledge construction process, experience difficulties in incorporating in their pedagogical practice. Currently, the use of digital technologies is a central component of most forms of contemporary educational offerings and practices (SELWYN, 2017). Digital technology has clearly had an impact in many areas of society, and the use of DICT for pedagogical practices is very common. Its use promotes learning, facilitates interaction and encourages students to learn meaningfully.

Digital technologies (mobile, connected and ubiquitous) are not only a resource for teaching, they are also the structuring axes of creative, critical, personalized and shared learning. They bring numerous problems, challenges, distortions, and dependencies that should be a part of the teaching and learning process. In relation to problems, it is harmful to ignore an education averse to a connected world.

Report of the *Campus Technology* in 2017, conducted with 232 teachers from various colleges in the United States of America, highlights the use of technology in teaching by these teachers. The report presents an overview of the use of technologies in education, being considered by 80% of respondents as positive (KELLY, 2017). In addition, it presents a perspective of the technologies that will disappear and which will be important in the next decade (Chart 1).

Chart 1. Technology Perspectives in the next decade.

Top 10 technologies that will be dead and gone in the next decade	Top 10 technologies that will become important in education over the next decade
1) Desktop computers and laptops	1) Virtual/augmented/reality
2) Clickers	2) Mobile devices and apps
3) Non-interactive projectors and displays	3) 3D modeling/scanning/printing
4) Document cameras/overhead projectors	4) Adaptive, personalized learning
5) CDs and DVDs and their players; Chalkboards/whiteboards (tie)	5) Video and streaming
6) Printed textbook and handouts	6) Collaboration tools and social media; Wearables and Internet of Things (tie)
7) Learning management systems; Traditional presentation/productivity software (tie)	7) Cloud based tools; Interactive whiteboards and projectors (tie)
8) Printers, scanners and copiers	8) Audio/videoconferencing
9) Computer labs and dedicated workstations; Interactive whiteboards and projectors (tie)	9) Next-gen learning management systems
10) Telephones and fax	10) Free, fast, safe internet

Source: Kelly (2017).

Researchers in Brazil already know many of these technologies proposed for the next decade, but few have been used in teaching practices, mainly in Chemistry Teaching. This fact corroborates the recent research by Reis, Leite, and Leão (2017) on the appropriation of information and communication technologies (ICT) in science education (Chemistry Teaching). The authors performed a systematic review in the period from 2007 to 2016, stating that limited studies were developed with interest in the strategies of ICT use. Most of the published works focused on the interest in the functionality of ICT and the interest in the use of ICT, that is, the productions were more engaged in the use of some material supported by ICT, without the concern of whom (the teacher) will use or how will it be used (what strategy). In this context, more research on ICT use strategies in the classroom is required, investigating how they perform an important role in the construction of knowledge.

ACTIVE METHODOLOGIES

Built on the assumption that active methodologies are not new, they have been highlighted reflecting on the role of teacher and student in the teaching and learning process, seeking to provoke about changes in classroom practices that are often rooted in the model traditional teaching. Traditional education involves the dissemination of information directly from the teacher to the student. This passive learning environment is not propitious to the multiplicity of learning styles. (COOREY, 2016). Dewey (1950) already emphasized the importance of the active student in building his knowledge and the need to overcome the traditional lecture, whose purpose is to reproduce and memorize the content of teaching. This role of the student is also described in the National Curriculum Parameters (NCP) and corroborates the consolidation of the four essential pillars of education: learning to learn, learning to do, learning to live and living together and learning to be (BRASIL, 2002).

The word Methodology has been registered in the Portuguese-language since 1858. Etymologically the methodology comes from the Greek, of the terms: *metá* (behind, then, through); *hodós* (way); and *logos* (science, art, full exposure, systematic treatment of a theme) (HOUSSAIS, 2001). The methodology can be understood as a treatise, arrangement or ordering on the path through which one seeks, for example, a given teaching objective or even an educational purpose (ARAÚJO, 2015). Active Learning, as opposed to passive, banking learning, based on the transmission of information, the student assumes a more active posture, in which he solves problems, develops projects and, with this, creates opportunities for the construction of knowledge. According to Barbosa and Moura (2013, p. 55), "active learning occurs when the student interacts with the subject under study (listening, speaking, asking, discussing, doing and teaching) being stimulated to construct the knowledge instead of receiving it passively from the teacher". In an active learning environment, the teacher acts as the supervisor, facilitator of the learning process, and not only as the single source of information and knowledge. In this approach, the learner needs to be an active participant in order for learning to occur.

It is important to emphasize that the terminologies methodology or active learning vary depending on which literature we take as a reference (in Brazil). In many cases, the term active methodology has been more used to refer to "pedagogical strategies that put the focus of the teaching and learning process on the learner, in contrast to the pedagogical approach of traditional teaching, centered on the teacher, which transmits information to students". (VALENTE; ALMEIDA; GERALDINI, 2017, p. 463). Already active learning term is used to "characterize learning situations in which the student is active" (VALENTE; ALMEIDA; GERALDINI, 2017, p. 463).

Dewey (1950), Bruner (1976), Piaget (2006), Vygotsky (1998) Rogers (1973), Ausubel et al. (1980), Freire (1996), among many others and in a different way, have shown how each person (child or adult) actively learns, from the context in which they are, of what is significant, relevant and close to them at the level of competencies it possesses. All of these authors also question the school model of transmission and uniform information evaluation for all students. Besides, in books, articles, lectures, presentations, it is widely emphasized that students remember 10% of what they hear, 20% of what they read and these percentages

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of retention increase by multiples of 10 depending on the type of applied methodology (MASTERS, 2013). It has been assigned to the National Training Laboratories (NTL) and Edgar Dale the construction of the Learning Pyramid (Figure 1), although this pyramid has been modified over the decades (MASTERS, 2013). This pyramid suggests how students learn. An important principle of learning is that people learn best when they are **actively** involved in the learning process. How much "lower in the pyramid" the student is, more he learns (DALE, 1969).

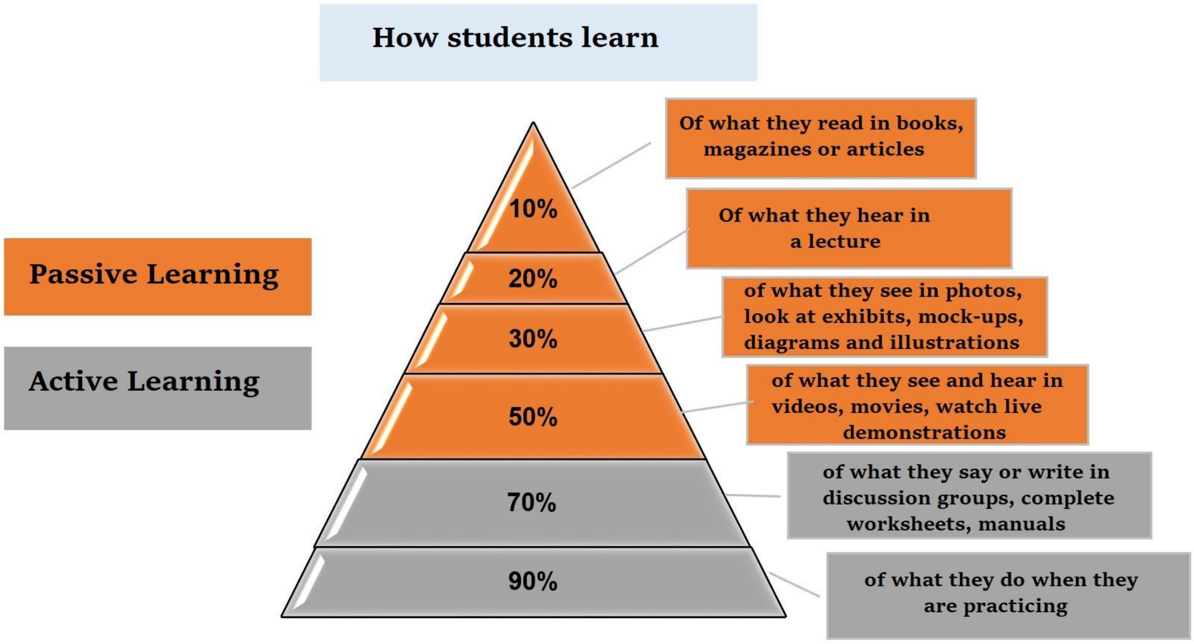

Figure 1. Learning Pyramid.
Source: Adapted of Dale (1969).

Active Methodology is a strategy that put students as the main agents of their learning. In active methodology, the stimulus to criticism and reflection is encouraged by the teacher who conducts the class, but the center of this process is in the student. The transition of the passive to active learning environments is becoming more common in the academic world (COOREY, 2016). Active methodologies emphasize the protagonist role of the student, his direct involvement, participatory and reflexive in all stages of the process, experimenting, drawing, creating, with the guidance of the teacher.

In the literature, we find some definitions for Active Methodology. One of them says that the active methodology is to focus on the transfer of information, stimulating the search for knowledge in an autonomous way. It can also be defined as the set of activities that the student occupies to do something while thinking about what he is doing (MEYERS; JONES, 1993), having the student as the subject that promotes their own (active) learning. For Leite (2017a, p. 1), active methodologies "enable the appreciation of the critical and reflexive formation of the student who participates in the construction of his knowledge, in the process of teaching and learning, favoring its autonomy". In this sense, the active methodologies suggest that the student seeks out the content, researches and seeks solutions to the problems they confront, and thus learns to select their answers. They generate interactions between teachers and students in academic activities for that there is not a single full and absolute holder of knowledge. Miter *et al*. (2008, p. 2135) point out that "active methodologies are based on a significant theoretical principle: autonomy". According to the authors, the active methodologies use the "problematization as a teaching and learning strategy, with the objective of reaching and motivating the student, because in the face of the problem, he pauses, examines, reflects, relates its history and begins to re-signify its findings" (MITRE *et al*., 2008, p. 2135). For Gaeta and Masetto (2010, s.p.), active methodologies "are learning situations planned by the teacher in partnership with the students that provoke and encourage participation, an active and critical attitude towards learning". In the application of the Active Methodology, the student is exposed to problems or challenges in which solutions require identification of the main intervening variables.

When the student reads, writes, questions, discusses, solves problems, he actively engages in the learning process. In this way, strategies that promote active learning can be defined as activities that occupy the student in doing something and at the same time lead him to think about the things he is doing (BONWELL; EISON, 1991; SILBERMAN, 1996). Paiva *et al*. (2016) identify several strategies of application of the active methodologies, from those widely discussed in the literature, as well as those that have few references on the subject. The authors report 22 different types of operationalization of active methodologies. Therefore, the diversity of proposals that present principles guided by active methodologies is quite significant in education. These methodologies carry on students to take a more responsible position in the conduct of their learning process, becoming intensively used in education, some of these are: Flipped Classroom (FC), Peer Instruction (PI), Just-in-time Teaching (JiTT), Design Thinking (DT), Problem-Based Learning (PBL), Project-Based Learning (PBL), Team-Based Learning (TBL), Game-Based Learning (GBL). Of these proposals, in this article we will highlight three - involving the teaching of chemistry (FC, PI, and DT) - that are subsidized by the TDIC.

METHODOLOGY

According to Thiollent (2005), the methodology is the item that guides the investigation process in decision-making, hypotheses, and research techniques. Demo (2006) emphasizes that the methodology problematizes critically, besides showing the ways of the process, investigating the limits of science in knowing and intervening in a given reality. That way, this research, of the qualitative nature, involves a descriptive and interpretive approach, in which the natural environment is a direct source of data and gives the researcher the role of the main research instrument (LUDKE; ANDRÉ, 1986). Furthermore, the qualitative methodology allows the description, analysis, and evaluation of data in an articulated and in-depth way. Besides being sufficient to understand the phenomena within its context, discovering links between concepts and behaviors, and generating and refining the theory (BRADLEY; CURRY; DEVERS, 2007). Opting for this methodology, a direct relationship is made to the interpretative paradigm and a deductive approach is also developed to filter concepts, indicators, categories and implications of the literature. As noted by Bradley, Curry and Devers (2007, p. 1763), a deductive analysis "allow new inquiries to benefit from and build on previous insights in the field", but this does not exclude new categories. This process ensured that individual interpretations of the literature were discussed and collectively explored in detail, before completing the deductive process of determining the characteristics of the active technological learning model.

The research was carried out in four steps: (i) Review of the literature on active technologies and methodologies. At this stage, we sought to analyze the current stage of the academic contribution around digital technologies and active methodologies, which served as a theoretical-methodological contribution to the conceptualization of active technological learning; (ii) Proposition of the explicative model of active technological learning. The concept and characteristics of the proposed model (intrinsically related to the previous phase), as well as the pillars that anchor it, are elucidated at this stage; (iii) Survey and analysis of publications involving technologies and active methodologies in the teaching of chemistry. Considering the nature of the material to be analyzed (articles published in journals), we choose to use the latent *corpus* on content. Latent *corpus* is a research model that analyzes information contained in the Internet, extracting them from the analysis of the Internet itself, that is, on the available content (PINA; SOUZA; LEÃO, 2013). From the Google Scholar's database, we researched papers that involved active methodologies, chemistry teaching, and technologies. For our analysis we extracted the sample using the keywords "Metodologias Ativas e Química", "Ensino aprendizagem metodologias ativas", "Aprendizagem ativa na Química", "Tecnologias ativas no ensino de química", "*Active Methodologies and Chemistry*", "*Teaching learning active methodologies*", "*Active learning in chemistry*", and "*Active Technologies in Chemistry Teaching*". According to Pina and collaborators (2013), the use of random or representative samples allows the application of statistical analysis techniques. The option for the English and Portuguese versions of the same search word was due to the assumption that a greater number of works would be available in English, although our focus is on Portuguese language works; (iv) Discussions about the model of active technological learning in chemistry teaching. The choice in the field of chemistry teaching is due to the implications that it is a discipline that is difficult to understand and abstract (SOUZA; LEITE; LEITE, 2015), and that it does not motivate students to learn (SANTOS *et al*., 2013). Thus, the model of active technological learning leads us to believe that there are several possibilities of this model to contribute to the teaching of this matter.

From the investigation obtained in the first step of the research, the model of active technological learning (second step) is proposed. Subsequently, using the data obtained in the survey and the analysis of the publications in the latent corpus (third step), characteristics of the model in the Teaching of Chemistry (fourth step) are presented.

ACTIVE TECHNOLOGICAL LEARNING

Given the new type of interactions that the Internet facilitates and mediates, it seems to us relevant to consider a model that supports the use of active methodologies with the technologies, which has some characteristics that intersect with those previously mentioned, has other distinctive aspects, which put this type of model on a different level. Thus, from the use of the DICT with the Active Methodologies has been observed a growth of new practices in the classroom, facilitating the process of teaching and learning, leading to Active Technological Learning (ATL).

Active technological learning is an explanatory model on how the incorporation of digital technologies to the active methodologies in the process of teaching and learning aims to improve the performance of the student, who assumes the protagonism of his learning, with autonomy and commitment. An explanatory model can be validated when it presents clear, coherence, completeness, simplicity, explanatory power, justifying power and decisive power (BEAUCHAMP; CHILDRESS, 1994). A model consists of a description of a system and/or phenomenon that responds to something already known. The ATL model proposes that students take control of their learning by accessing digital content (in the cloud) anytime, anywhere, instead of relying solely on the teacher to follow instructions. Active technological learning, in a connected and digital world, is expressed through hybrid teaching models with many possible combinations. The combination of active methodologies with technologies brings important contributions to the design of current solutions for today's learners. In active technological learning, students can meet in an online space with the purpose of speaking, learning, sharing information or collaborating on projects. They mutually promote proactive participation to meet the needs of others.

The conceptual framework of the active technological learning is based on constructivist, constructivist and connectivist approaches. ATL endorses a constructivist view, when at the end of the evolutionary process of learning, the individual becomes autonomous, questioning, adaptive and interactive in his/her environment (PIAGET, 2006). In the constructionist aspect, ATL ponders that knowledge is constructed when the individual is engaged in the construction of something external. When he “puts his hand in the mass” (PAPERT, 1986), besides learning occurs in the interaction between the individual and the world. Finally, the connectivist relationship is observed when the ability to make distinctions between important and unimportant information is vital (SIEMENS, 2004), having as starting point the individual, explaining how he communicates and how he learns.

Composition of active technological learning consists of five pillars that are considered necessary for the teaching and learning process in an active way. These five pillars are: 1) Teacher's role; 2) Protagonism of the Student; 3) Support of Technologies; 4) Learning; 5) Evaluation. In summary, each pillar presents a degree of importance for the constitution of an active technological learning and forming the acronym **TSTLE** (Figure 2). We briefly describe each pillar below.

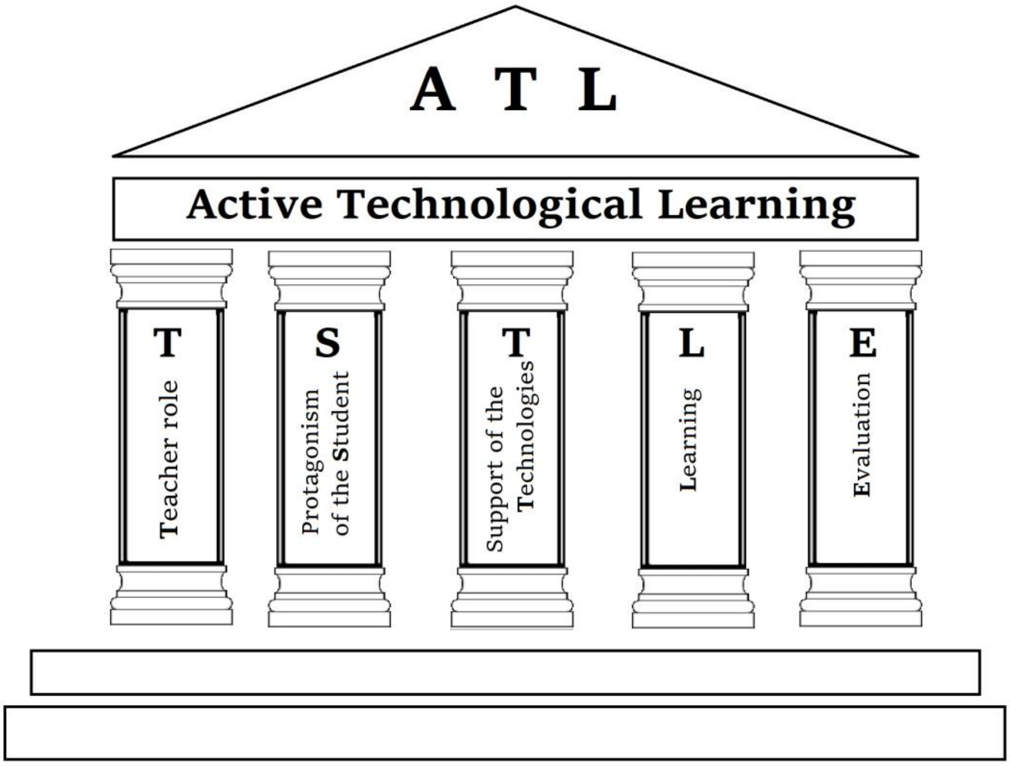

Figure 2. ATL Pillars
Source: Prepared by the author

The first active technological learning support pillar refers to the **Teacher role (T)**. Considering that for the ATL to occur it is necessary that the first step is carried out, and the teacher is primordial in this execution. In the active technological learning the teacher acts as a supervisor, facilitator of the learning process, not just as a single source of information and knowledge. In order to help the student, the pedagogical facilitator must first have a clear understanding of the construction of knowledge as a dynamic and relational process, coming from the reflection on the real world. This posture of the teacher is one of the characteristics of the active methodology. It is necessary for teachers to dissociate themselves from hierarchies and to be willing to "cross the red lines," that hinder their new role. The teacher in using the technologies with his students can teach to select, analyze, criticize, compare, evaluate, synthesize, communicate, inform. These are complex thought processes that the mediating teacher must teach so that his students build their knowledge. It should be noted that the student in contact with the instrument (computer, smartphone, laptop etc.) and the information is not led to knowledge, it will copy and paste. It is necessary that the teacher be the mediator of this process. It should help the student to decide on the direction of his learning and to choose between multiple options to learn the required concepts. The circumstances and learning needs of students are as different as themselves, there is no single definition for the ideal teacher. However, the teacher must go beyond pre-formatted teaching and help the students to complete their work, that is, fill the academic orientation gap (HORN; STAKER, 2015). The role of the teacher, in ATL, is close to a conception of the professional that facilitates the construction of meanings on the part of the student in his interpretations of the world.

The second pillar constitutes the **protagonism of the student (S)**. 21st-century students are entering a connected world in which they need a teaching system centered on them. In order to stimulate the student to participate actively, it is necessary to involve him and motivate him, so that he interacts with the teacher and the other students, making him a protagonist in the construction of his knowledge. It is necessary to consider in this protagonism two critical elements of the learner-centered learning, the possibility of the learner to learn in a personalized form and to learn by competence (HORN; STAKER, 2015). Personalized teaching refers to that the learning is adapted to the particular needs of the student, that is, it can happen where, when and how the student wants. The second critical element postulate the idea that "students must demonstrate domain of a particular subject" (HORN; STAKER, 2015, p. 9) before passing by next, implying aspects of perseverance and determination, because students have to work about problems until these are solved successfully. If students move on to a new concept without fully understanding the previous one, this creates gaps in their learning. The protagonism of the student provokes him to do things, to put his knowledge into action, to build knowledge about the contents involved in the activities that are performing. Causes him to think, to develop cognitive strategies, to conceptualize what he does, not only as a reproduction but with a critical and reflexive capacity over his action, in order to present feedbacks, interacting with the teacher and colleagues, as well as exploring attitudes and social and personal values. It is added to the premise that the protagonism of the student evokes his ability to make decisions about his own learning, that is, his autonomy. Student's ability to develop a personal learning plan, to find resources for studying in their own personal/collective environment, and/or to decide alone when progress has been satisfactory, is imperative for an ATL. Accepting the idiosyncrasy and independence of students as a valuable resource is fundamental.

The third pillar describes the **support of Technologies** (T) to promote an ATL. The development of DICT promotes the creation of new learning scenarios and that alternative to formal education is to receive information, to transform it into knowledge and to share it, that is, to connect with other people. There is no doubt that educational platforms are sufficiently robust and consistent to enable the implementation of pedagogical principles in the teaching and learning process in an innovative and successful way. Knowing that knowledge is distributed in a network of connections and that learning consists in the ability to build such networks and circulate in them - principles of connectivism (SIEMENS, 2004) – active technological learning makes use of the knowledge that is in the network. Therefore, the action of learning using the technologies can occur from the obtaining of external information to the primary knowledge of the individual, resulting from the connections established in the networks that are part of, for example, active learning in social networks. It is also worth noting that Web 2.0 has provided support to the use of technologies by the prosumers, that is, by producers and consumers of information (TOFFLER, 2007). Thus, web 2.0 has the potential to radically change the nature of teaching and learning and, through the creation of learning networks controlled by the prosumers, modify the role of technologies, as a result, in the form that is learned. Given the above, the teacher must know the contributions and limitations that each technological resource presents, so that it can use it in the pedagogical projects of the discipline and adapt it to the teaching strategies, besides allowing the conscious choice of the technology that best adapts to the content to be taught, promoting an ATL.

Active technological learning is not restricted to a single **Learning** model **(L).** In it several learning can be used and blended. Although it is based on active learning (MARTÍN, 2017), the fourth pillar of ATL presents four types of learning, non-exclusive, nor unique, which are commonly observed: Individual learning (that the student learns in an autonomous and personal way), Collaborative learning (in which it favors peer collaboration, reaching a certain objective), Social Learning (in which the student learns by observing others), and Ubiquitous Learning (the student has his learning happening anytime and anywhere), all centered on the student. We describe each of them in a concise manner.

- ✓ **Individual Learning (IL)**: is any systematic change in individual behavior occurring over a certain period of time and is completed when the individual reaches a stable pattern of behavior (REIS, 1975). According to McWhinney (1963), individual learning relates to the individual's ability to perform a given task. Individual Learning is derived from academic conditions (of relationships with the teacher and colleagues) and structural (of the organization of information, of the structural and conceptual details of what is learned). Learning is a complex neural process that leads to the building of memories. We learn by reading, listening, making mistakes, practicing, experiencing and observing others. There are countless ways to learn and each person is unique in this process. We learn intentionally and spontaneously. Fleury and Fleury (2001, p. 192) affirm that the learning process occurs "first at the level of the individual, charged with positive or negative emotions, across diverse paths". Leite (2015, 2016) has been highlighting the Learning 2.0 model (learning by doing, learning by interacting, learning by searching and learning by sharing), whose feature enriches web-based activities, consequently, highlight active technological learning.

Of course, the way the individual learns has often been discussed in several learning theories;

- ✓ **Collaborative Learning (CL)**: believes that the exchange of knowledge can lead to the achievement of the proposed objectives. It is necessary to distinguish collaborative learning from cooperative learning (ONRUBIA; COLOMINA; ENGEL, 2010). Cooperative learning is essentially a process of division of labor, in which participants have agreed to help one another. On the other hand, in the CL, Each member of the group "contributes to jointly solve the problem" (ONRUBIA; COLOMINA; ENGEL, 2010, p. 210). Collaboration depends on the establishment of a common language and meanings with regard to the task, as well as a common aim for all participants. In this context, it is necessary to consider the contributions of personal learning environments that are centered on social interaction and collaboration, beyond which its concept is attributed to the conditions of autonomous learning of learners, based on the use of technologies from Web 2.0 (LEITE, 2016). Furthermore, the personal learning environment represents "an important step towards student-centered learning with the use of technologies" (LEITE, 2015, p. 165). The relationship between the personal environment and collaborative learning is evidenced when knowledge is viewed as a social product, and the educational process is facilitated by social interaction in an environment provides to collaboration, cooperation, and evaluation. In fact, CL contributes to the development of critical capacity through debates, discussions and the socialization of ideas with other colleagues. A CL known in the literature is Computer Supported Collaborative Learning (CSCL) because it combines the notion of collaborative learning with the potential of DICT to support it, that is, it is anchored with the assumptions of active technological learning;

- ✓ **Social Learning (SL)**: is centered on the needs of the individual, is a concept that refers to learning that occurs through observation, conversation or questioning. In this learning, we learn "from" and "with" the "experts", as well as developing through conversations, social networking, and Web 2.0. Bandura (1979) proposed that SL may occur due to the observation of others. People learn new things when they observe the actions of others. They acquire new behaviors (learning) through observation of others. Social learning (currently Social Cognitive Theory) occurs in contexts of stable interactions, often on the Web around problems or actions, in which there are things to be done, known, understood, and dominated. It is collaborative in that the participants speak (write etc.) about what they are doing and try to understand, getting to understand concepts, principles and procedures through their interactions and communications. When trying to create something, students are confronted with situations and problems that are new to them and do not know how to act. They will explore and attempt to solve the problems, seeking alternatives to this. In addition, when they do, they often share online or face-to-face with the peers involved in the same activity. When they share online, usually on sites, blogs, forums, social networks, etc., other people may also be discussing the problem, suggesting solutions and explaining them, considering the comments and feedback provided by other colleagues (ROMANCINI, 2015). These students are looking for information about what is valid for the content in question and can find through ATL;

- ✓ **Ubiquitous Learning (UL)**: has as a principle to allow anyone, to learn anywhere and at any time, made possible by digital technologies and continuous connection, directly affecting the way of teaching and learning. In this sense, UL refers to the environment that allows a mobile device to access teaching and learning content through wireless networks anywhere, and anytime. Ubiquitous learning environment allows students to learn from a PDA (Personal Digital Assistant), smartphone, Tablet, PC or laptop, in internal, external, individual and group situations. According to Yahya *et al*. (2010, p. 120), the objective of the UL is to "provide the right information at the right time and place for accommodating life and work style". The authors highlight some characteristics such as: permanence (students never lose their jobs, the learning process is continually remembered, unless it is removed), accessibility (access to data, videos, documents from anywhere, that is, information is available whenever students need to use them), immediate information (at any time the student may have access to information), interactivity (students can interact with colleagues, teachers, and experts efficiently and effectively through different media), situated activities (educational, learning "integrates" daily life, the problems encountered and the knowledge required is present naturally and authentically). Just like in collaborative learning, in ubiquitous learning the teacher is present, but he is not the holder of knowledge, his function is to mediate the construction of knowledge, utilizing digital technologies. Furthermore, in the ubiquitous learning the most important point is the access to the networks and, the communication can occur at any time through mobile devices. The UL is always in the "here and now, being by nature, dispersed, casuistic, which may lead many to deny that there are learning processes" (SANTAELLA, 2014, p. 21). Hence, learning occurs when the student uses networked mobile devices, transforming information into learning (SANTAELLA, 2014). Characteristics that ubiquity presents endorse its importance in active technological learning.

In active technological learning, these four types of learning can be observed simultaneously in a proposal, depending on the type of strategy that the teacher incorporates.

Last, but not least, we have the pillar of **Evaluation** (**E**) that is present in active technological learning. Evaluation plays an essential role in education, consists in reflecting, requires analyzing your results, and make decisions about what to do so that students overcome their difficulties and move forward. In active technological learning, several types of evaluation can be observed: classificatory, diagnostic, formative, summative, self-evaluation etc. It is important to establish that in ATL, a formative evaluation is fundamental to identify the difficulties of the students in order to help them discover means that will allow them to advance in their learning (HOFFMANN, 2014). On the other hand, evaluate in ATL should occur through understanding and mediation, rather than verification and measurement. Comprehensive and mediating evaluation consists in broadening students' possibilities of learning from a follow-up of their actions in digital environments (in which learning is centered on them). It helps students to study their progress (for those who have succeeded), showing at the same time those aspects that can still improve. The error, in this case, is not considered as negative, it is constructive, it is part of the process of active learning. In addition, the evaluation process can occur in two ways: formal evaluation (occurs with a pre-established date and time) or informal evaluation (happens without pre-established time and space), both possible in active technological learning. Also, it is necessary to consider that collaborative learning can contribute to the evaluation of an active technological learning, by providing mentoring relationships through the interaction of “advanced” students (which present a level of in-depth knowledge about a certain content), “beginner” students (those who are knowing the content or present level of understanding of the incipient content) and “intermediate” students (who have a good knowledge of the content, in which they can help "beginner" students who have difficulties, however in the face of a complexity of content they need the help of "advanced" students), so that the increase in the performance of evaluations is fostered through the exchange of experiences and collective learning.

The pillars described above, in a concise manner, synthesize the complexity of active technological learning in education. Although there are innumerable benefits associated with it, educators should be aware of possible obstacles. To get students involved in active technological learning and maximize benefits, teachers must consciously coordinate the learning activity. In face of this discussion, considering that the focus of the active technological learning is the construction of knowledge using the digital technologies through of the active methodologies, we find some proposals that contemplate this approach (step 3). We describe in the next section a brief analysis in the area of Chemistry Teaching.

ACTIVE TECHNOLOGICAL LEARNING IN THE CHEMISTRY TEACHING

Research using the latent *corpus* on content provided works that used the technologies and methodologies active in Teaching Chemistry. Although, Google Scholar has an infinite character of data for the latent content *corpus*, that is, if we perform of a search a period later the presented results will have a high probability of being different. However, according to Souza (2010) the obtained samples make possible a representative analysis of the production of ATL in Teaching Chemistry. We analyze the latent *corpus* of the articles in relation to their objectives, areas of concentration and reports of experience, including their contributions. Their abstracts were read, considering that these presents a good way to identify the

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objectives of the work. When this information was not explicit in the abstract, it was necessary to read the complete text, making it possible to highlight the characteristics of the ATL.

Flipped classroom in the Chemistry Teaching

The first type of active technological learning that we highlight is the flipped classroom model. For discussing flipped classroom is necessary to differentiate it from inverted learning. In a nutshell, in the flipped classroom, proposed by chemistry teachers Bergmann and Sams (2016), the student does what he traditionally did in the classroom. The flipped classroom means a change in the way of teaching, serving as a starting point to put the teacher and his students on the path of a flipped learning. By inverting the classroom the way the teacher teaches evokes flipped learning (MARTÍN, 2017). According to Martín (2017, p. 21), flipped learning "consists in creating a new environment of the relationship between teachers and students in which traditional roles change and the protagonism is reversed". The flipped classroom is a type of Rotation Model present in blended learning in which the student studies a didactic content at home and the classroom is used to the resolution of activities, discussions about the content, among other proposals.

Flipped classroom encompasses a whole series of methodologies based on the transmission of information to be learned by electronic means outside the classroom (MARTÍN, 2017). This information that students should learn is transmitted in hypertext and hypermedia with links to documents, presentations, videos, and podcasts. In this way, the class time is used for a bidirectional dialogue, instead of wasting all class time in an uninterrupted explanatory monologue of information that, on the other hand, students can find in the different didactic materials (books, videos, games, articles etc.). The students' preparation for the class is "stimulated and encouraged in different ways in each of the media described to arrive at a flipped learning" (MARTÍN, 2017, p. 21). Implementation of a flipped learning implies to enrich the bidirectional communication through virtual means, that is, using the DICT, between teachers and students before the lessons. Although, it is necessary for the teacher to establish an effective system of "bi-directional communication with his students so that he can obtain very valuable and pertinent information about the difficulties and reactions of his students" (MARTÍN, 2017, p. 91) when discussing the proposed materials and the interaction about classroom content.

Four pillars, denominated FLIP (created by Flipped Learning Community Network), describe the understanding of the various aspects associated with the change in the role of the teacher in the flipped learning. These pillars are:

1) Flexible environment (**F**): In this pillar, the flipped learning adapts to the variety of methodologies available to the learning space to discuss a content or unit. Flipped

Learning allows for a variety of learning modes;

2) Learning culture (**L**): In this pillar, one must produce a paradigm shift from the traditional model of teaching (centered on the protagonism role of the teacher) to the new paradigm centered on the protagonism of those who learn.
3) Intentional content (**I**): Teachers should use content to be learned to "achieve the understanding of essential ideas and long-term student development" (MARTÍN, 2017, p. 97). Teachers should identify what should be taught and what concepts should be studied.
4) Professional educator (**P**): As already noted, the role of the teacher is more complex than what he had in traditional teaching. According to Martín (2017, p. 97), the teacher "ceases to be just information presenter and evaluator of his assimilation". In the time used in the classroom, the teacher leads the students, guides them, observe them and evaluates their work, providing them with relevant feedback at the moment the students need.

Implementing the inverted model involves learning to diagnose the problems of the students in order to learn and develop solutions for the class.

In the semester of 2007-2008 Bergmann and Sams (2016) were the first disseminators of some flipped classroom techniques in Chemistry, using video as a material for prior study, with the advantage that each student can watch it at their own pace, as often as necessary. They recorded all chemistry classes for this semester. The experience served as an incentive for chemistry teachers to seek to apply the flipped classroom in their classes. The five pillars (TSELT) of the ATL are contemplated in the flipped classroom, as we observed in the articles analyzed (step 3). In English, we found countless researches utilizing the flipped classroom as a methodology for Teaching Chemistry. Since proving the effectiveness of the flipped classroom in large classes (YESTREBSKY, 2015), its impact on the performance and retention of students in the discipline of General Chemistry (RYAN; REID, 2016), and in the notes of the students of Organic Chemistry (CORMIER; VOISARD, 2018), as well as in the evaluation of a Course of Organic Chemistry (MOORING; MITCHELL; BURROWS, 2016), courses in chemistry in higher education (SEERY, 2015), and high school (SCHULTZ *et al*., 2014).

The first experiment treating the flipped classroom in the Teaching of Chemistry, in Portuguese language, observed in the latent *corpus*, was described by Leite (2017b). The article presents an account of the importance of the contributions of the flipped classroom in the teaching practice, although little has been discussed in the Chemistry teaching. The article suggests some possibilities and contributions that the use of the flipped classroom in the teaching of chemistry can cause. Many of these suggestions present characteristics of the ATL, such as the use of digital didactic resources, pertinent to the contents and accessible to all students. To Leite (2017b, p. 1594) the "use of software and hypermedia can contribute to student learning". From the same point of view, the use of hypertexts and podcasts focused on the content of chemistry are configured as an appropriate strategy in terms of education and or the ATL. In addition, it highlights significant potential of the video - as Bergmann and Sams (2016) have used - in the methodology of the flipped classroom.

Another work on the Portuguese-language on the flipped classroom was produced by Chaparro (2016). This work was not analyzed in the research of the Leite (2017b), because it was a publication in congresses and was not the focus of his research. Chaparro (2016) applied the methodology of the flipped classroom for the study of Atomic Models in High School, indicating that the results of this proposal provided the students a collaborative and meaningful learning, corroborating with the assumptions of ATL. It is interesting to note that the proposed activities (use of YouTube® videos, hypermedia, simulations, and animations) were made available in a social network, that is, the activity made possible, for example, the interaction in the networks (characteristics of the ATL). The author points out that one of the contributions of the flipped classroom was the incentive to concentration and reading, relating to the fact that the students were also motivated by their familiarity with the tools used (digital didactic resources, social networks, etc.).

Melo and Sánchez (2017) reported an experiment in which they analyzed students' perceptions about the flipped classroom methodology for teaching advanced techniques in waste laboratories. The research presents the use of video as an ATL, considering the usefulness and ease of this resource, causing in a greater interaction of students with the teacher and between them, and that the dedication of the teacher in the creation of videos was positively valued by the students. It is also necessary to emphasize that some students were resistant to the implementation of this model for preferring a more “traditional class” (MELO; SÁNCHEZ, 2017). The authors indicate that the flipped classroom is an alternative to teaching and learning of the experimental work and involves students in their own learning, allowing them to interact constantly with their educational environment, solving problems and making decisions, corroborating with the fundamentals of ATL.

To discuss the content of radioactivity in 3rd-year high school students, Lima-Júnior and collaborators (2017) applied the flipped classroom in the Chemistry discipline. The strategy used to promote ATL in classes was through the use of quizzes, videos and a wiki as a virtual learning environment. According to the authors (2017, p. 137) “there was a more active participation of the students in the classroom activities, which, when reading the texts present in the online platform, watch the video lessons and answer the quizzes before of the classroom”. In addition, the inverted classroom provoked in the students a more active participation, making them to present placements “more substantiated, critical and argumentative in the classroom discussions” (LIMA-JUNIOR *et al*., 2017, p. 137), besides of the obtaining a performance superior to a class (of the same year) that did not use the flipped classroom during the intervention of the proposed content.

Peer Instruction in the Chemistry Teaching

Based on pre-lesson reading related to the proposed theme, the teacher encourages and mediates the debate among the students, introducing conceptual questions based on the difficulties of the class. The classes, thus, become directed and effective, providing mutual assistance among students in the construction of their knowledge. This activity description is based on the Peer Instruction model (PI), proposed by Eric Mazur (in the 90's). This model aims at the understanding and applicability of the Concepts, using the discussion among the students. However, care should be taken with the translation "peer instruction", as it may give the false impression that students should necessarily work in pairs, which are not true, since they can be formed (also) groups of students. To achieve "improved group dynamic, small groups (under six) are proven to be more effective" (COOREY, 2016, p. 344). Small groups prevent passivity and are less likely to fall under the dominance of some members as large groups often experience.

This methodology requires that students read, think, and reflect before class (TOLEDO; LAGE, 2013). In fact, the teacher can dialogue with his students through the virtual learning environment of the discipline, which also provides a follow-up of the entire process, characteristic of an ATL based environment. Peer instruction engages students in the class through activities that require each student to apply the basic concepts that are being presented and then explain those concepts to their peers (CROUCH; MAZUR, 2001). It consists of providing background material so that the student can study the content before attending the classroom. Based on the material studied, the student answers a set of questions in a virtual learning environment. The teacher, before giving the lesson, checks the most problematic questions that must be worked in the classroom. The methodology of application of the peer instruction, predicts the use of the technology to achieve her objectives, thus reinforcing one of the pillars of the ATL. This methodology presupposes that the learning is also conducted through the interaction between the students themselves, another ATL attribute.

Peer instruction can occur as follows: First, it is important that the student has studied the proposed content before going to class. After the previous reading of the contents, in the class the teacher makes a quick exposition of the theme (already studied at home), with duration of 7 to 10 minutes and applies the *ConceptTest* on the content that they studied through software and applications, where the teacher instantly access each student's performance through the computer. These tests are answered in the interactive response system, clickers, forms (such as Google Docs or Monkey Survey) or flashcards, enabling the class and the teacher to follow the level of understanding of the concepts in the discussion. Before they take the test, students have one or two minutes to think about the question and formulate their own answers. It is important that at the first moment colleagues do not know each other's responses, that they are not mutually influenced. In this way, is possible to check the main difficulties and then make the necessary explanations about the theme of the lesson. Appropriate *ConcepTests* are essential to the success of this methodology (CROUCH; MAZUR, 2001). They should be elaborated to give students the opportunity to study important concepts, in lieu of testing smartness or memory, and expose common difficulties with the material. It is necessary to emphasize that from the level of correct and errors of the students, the class adopts different directions. If the percentage of accuracy is less than 30%, the teacher repeats the exposition, presenting other elements (not discussed at the beginning of the lesson). If the percentage of correctness is between 30% and 70%, the peer instruction occurs, that is, groups of students are formed to discuss the content approached. The idea is that they agree on the correct answer. This process leads students to think about the arguments to be prepared and allows them to evaluate (just like the teacher) the level of understanding about the concepts before they even finish the lesson. From this, it is reapplied the *ConceptTest* to evaluate the level of understanding of the students and if the percentage of correctness is above 70%, the teacher makes an explanation about the answers, and then introduce a new question or introduce new content (Figure 3). We emphasize that the five pillars of ATL are explicitly present in these stages.

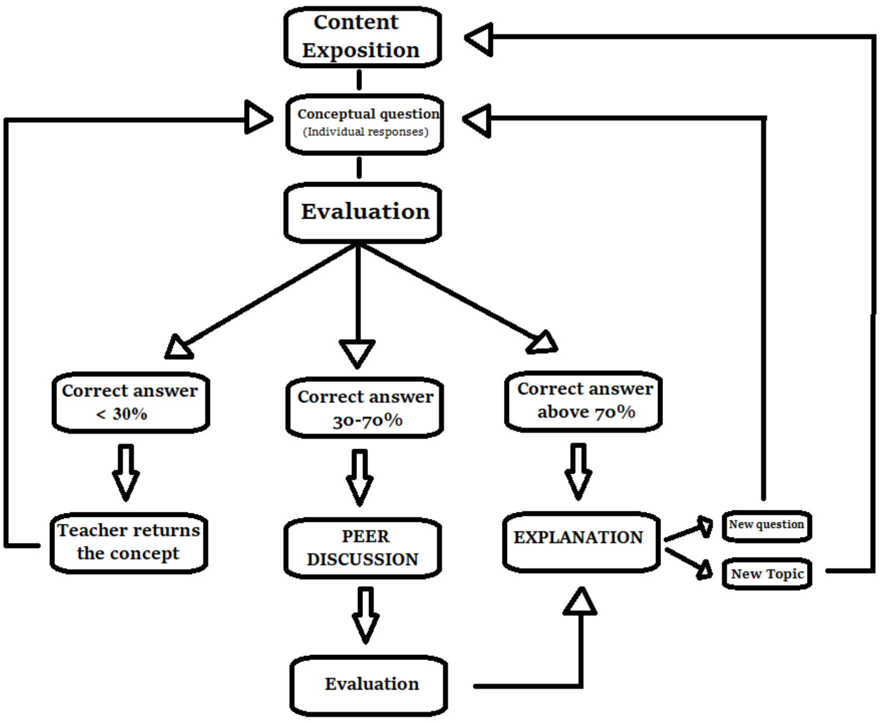

Figure 3. Steps of the Peer Instruction
Source: Prepared by the author

In summary, according to Crouch and Mazur (2001), in peer instruction the teacher proposes questions based on the student's responses about your "pre-class" reading. The student thinks about these questions, practice solving exercises individually. The teacher corrects the student's responses. He discusses his ideas and answers questions with his peers, re-solving exercises individually. Finally, the teacher again reviews the answers and decides whether further explanation is needed before going to the next concept. Peer instruction promotes classroom interaction to engage students and to approach critical aspects of the discipline (ROCHA; LEMOS, 2014). It makes students learn as they debate with each other, provoked by conceptual questions (which can be multiple choice), aimed at indicating students' difficulties and promoting in the student an opportunity to think about challenging concepts.

The first report of peer instruction in chemistry teaching, from our survey in the latent *corpus* was in 2006, when Golde, McCreary, and Koeske (2006) evaluated student learning from peer instruction in the General Chemistry laboratory. The activity led students to discover a general and effective way to carry out activities in the laboratory, involving them in building their own knowledge. The authors indicate that improvements were observed in student performance, highlighting the teacher-student relationship, allowing "the adoption of a small group-based approach in the pre-lab introduction, and the widespread use of structured student-instructor discussions at the lab bench" (GOLDE; MCCREARY; KOESKE, 2006, p. 810), interaction and collective work, present ATL attributes.

After ten years, the first (and only one) Portuguese language work on peer instruction in chemistry teaching was published by Moraes, Carvalho, and Neves (2016), which report the results of an exploratory study in four chemistry classes, approaching the content of stoichiometry. According to the authors, the experience of peer instruction with the students was positive, in which the students presented an engagement and motivation with the proposal approached in the classroom (according to ATL precepts). It was considered as a suitable method for chemistry teaching, allowing students "the elucidation of important and underlying concepts" (MORAES; CARVALHO; NEVES, 2016, p. 1), as well as providing new strategies for teaching chemistry.

We show in our survey that in Portuguese, related to chemistry, only one paper was published. The lack of work on peer instruction in chemistry teaching indicates the need for more research that reports the contributions of this methodology. Is notorious your relevance and when incorporated into strategies involving ATL, it will certainly result in student autonomy (that studies and research about the content before going to class), in the individual learning (studying the content previously) and collective (when studying and discussing your opinion and thoughts with the other colleagues). With this in mind, it should be emphasized that peer instruction promotes a collaborative learning community (one of the pillars of active technological learning), increases leadership skills and creates lifelong learners.

Design Thinking in the Chemistry Teaching

Finally, we highlight Design Thinking (DT) that presents possibilities for an active technological learning. DT is a new way of thinking and problems approach or, in other words, a people-centered thinking model. It may be an approach that decentralizes the practice of the hands of the designing specialized professionals by allowing their principles to be adopted by people working in varied professional fields (CAVALCANTI; FILATRO,

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2016) or a methodology to propose creative and innovative solutions to problems that use the designers' way of thinking. For Tim Brown (one of the greatest advocates of design thinking), the DT is a model that "is based on our ability to be intuitive, to recognize patterns, to develop ideas that have emotional and functional meaning, to express us in media beyond words or symbols" (BROWN, 2009, p. 4). In the literature, we find some proposals for the stages of DT in education, which is basically similar. The first described by *Bootcamp Bootleg* (D.SCHOOL, 2011) considers five stages for its execution: create empathy (sometimes divided into understanding and observing), define, devise, prototype and test. Another proposal is from Ideo (2009) being presented in the *HCD Toolkit* at Hear, Create, and Deliver (acronym of HCD and analogously to *Human Centered Design*). Already *Design thinking for educators* (IDEO, 2013) proposes the following phases: discovery, interpretation, ideation, experimentation, and evolution. In some cases, these phases are outlined in immersion (discovery and interpretation), ideation, and prototyping (experimentation and evolution).

In education the DT can be observed in three applications (CAVALCANTI; FILATRO, 2016):

1) As an innovation approach: Based on the idea of innovating, creating something, reorganizing ideas or improving products, processes and services. Without necessarily considering the learning that occurs during the innovation process. The focus is on the results of the implementing of one or more innovations. Of the three types of application, this is the least observed in education, on the other hand, is one of the most used in marketing and management companies;
2) As a methodology for solving problems: The DT presents itself as "an adequate methodology for education because it proposes the solution of problems from the practice of empathy, which puts people involved at the center of the process and within the context of the challenging situation" (CAVALCANTI; FILATRO, 2016, p. 61);
3) As a teaching and learning strategy: In this application, the DT has been pointed as "an alternative ingredient that breaks the rigidity of pedagogical approaches centered on transmissive teaching" (CAVALCANTI; FILATRO, 2016, p. 65). DT as a teaching and learning strategy allows students to work in groups and, in a creative way, project solutions to real problems, identified in a specific context.

DT can be adopted as an ATL since, in its stages, groups of students are given the opportunity to not only proposing solutions to a problem identified but also of prototyping them, making use of DICT. Design Thinking has much to contribute to education by encouraging that problem solving, innovation and the adoption of student-centered teaching and learning strategies, promoting more meaningful and effective pedagogical practices and considering the DICT, it becomes a powerful strategy for ATL.

For being more complex in its realization in the educational field, works involving DT in education are still scarce, especially when it involves technologies. In our search for the latent *corpus*, only a Portuguese language work involved chemistry. This paper describes the elicitation process and requirements documentation for mobile learning virtual environments (SOUZA; SILVA, 2014). The action was based on DT concepts, provoking customer need, producing fast and simple prototypes that eventually converge to innovative solutions. The authors followed the steps proposed by Ideo (2013), considering immersion, ideation, and prototyping, besides to emphasizing that "a reasonable number of participants is necessary so that we can find interesting proposals" (SOUZA; SILVA, 2014, p. 13). It is necessary to emphasize that in the DT to obtain good results, how much more proposals are made in the brainstorming stage (ideation), more solutions are found, and technologies (based on the ATL principles) make it possible to achieve a resolution considered adequate to the initial problem.

FINAL CONSIDERATIONS

The incorporation of Active Technological Learning allows teachers and students to deepen the contents of interest, providing a learning gain in relation to the traditional methodology, independent of the discipline. The ATL represents a remarkable effort to explain how the incorporation of the DICT the active methodologies in Education occurs. Indeed, the ATL has in its favor, as has been observed, a collection of considerable possibilities of applications to promote active learning, in contrast to the passivity highlighted in the traditional teaching model.

To the extent that it satisfies a deeply felt need, this research discussed the ATL model highlighting the pillars that influence its approach, while identifying characteristics and clarifying possibilities in Education. Hence, we believe that this research may evoke in teachers a change in their posture and that they incorporate in their pedagogical practice the active technological learning.

In relation to the survey and analysis of the publications, this research made it possible to identify some works involving the ATL in the Teaching of Chemistry, indicating ways for teachers to use it in the construction of their students' knowledge. Although the results of the described latent *corpus* have been used for Chemistry Teaching, this study can serve as a model for other areas that integrate technology in the classroom or for educators who seek to incorporate active technological learning into their teaching practice. It is pertinent to highlight and understand the results described through the latent *corpus* of content that can provide satisfactory results, not only in the investigations of the Sciences (Chemistry), but in all areas of knowledge.

From what was presented in this research, it is possible to understand the importance of ATL in the current educational context, despite the fact that many professors express themselves saying that they prefer not to modify their pedagogical practice. Thus, when reflecting on ATL, we consider it important that teachers promote activities that value student-centered learning, and propose strategies for their application. In this context, it is also important to emphasize that we must use ATL based environments to improve results in the teaching and learning process, that provide opportunities for students to engage in the presence and virtually, and foster connections with one another, and foster connections with each other. Moreover, observations and research data indicate that the use of technologies by the students allows a better performance of themselves in an active technological learning.

Finally, it is important to reinforce that the active technological learning model does not contradict other learning models; however, its integration in the teaching and learning process can generate good results. We think that the proposed model presents a comprehensive view of the concomitant use of digital technologies and active methodologies in Education. Future research and the development of further studies will be relevant to understand and consequently to insert the ATL in the various educational contexts.

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About the Author

[1]***Bruno Silva Leite***
E-mail: leitebrunosilva@gmail.com
Universidade Federal Rural de Pernambuco – Brasil
PhD in Chemistry – Universidade Federal de Pernambuco [UFPE].