APPLICATION OF CHEMSKETCH SOFTWARE FOR THE TEACHING OF CHEMISTRY UNDER A TRANSVERSAL APPROACH INTEGRATING COMMUNICATIVE COMPETENCES IN ENGLISH

MASTER'S REPORT

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UNIVERSIDAD ICESI

MASTER'S IN TEACHING ENGLISH AS A FOREIGN LANGUAGE SCHOOL OF EDUCATION SCIENCES

SANTIAGO DE CALI

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Dedications and Acknowledgments

To my wife Angelica, who with her unconditional love, support, patience, and sacrifice has given me the support and strength that I have needed in difficult times.

To my children Camila and Alejandro, who with their smiles, hugs, and kisses, smiles illuminated my endless working days.

To my dear parents, Gladys and Hebert, for trusting me and giving me their unconditional support in this adventure.

To my thesis supervisor, Diana Margarita Diaz, for having given me the honor of working with her and the opportunity to begin this learning path.

My enormous gratitude to all the ICESI staff, for their welcome, hospitality, and collaboration in this formation process, making me feel at home from the beginning to the end of this adventure of knowledge.

To my classmates, for their friendship and constant support.

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Abstract

In this research, the author shares his experience as a chemistry teacher and his intention to integrate the teaching of chemistry with the English subject in a public school in Cali. This research was an exploratory study using the action research methodology through which the teacher acquired epistemological, theoretical, methodological and strategic training to study, understand and transform his educational practice to improve cognitive competencies in organic chemistry under a transversal approach, fostering at the same time communicative competences in English. The findings provided teachers and the school with relevant information for possible implementation in the curriculum of an integrated approach between content and foreign language. The research was developed with eleventh-grade students who participated in the process of strengthening the use of English and Chemistry concepts as well as the appropriation of technology. It also showed that it is possible to create new methodologies to strengthen the use of the foreign language in other subjects under the CLIL approach. The conjugation of these findings makes it relevant for teachers of other subjects to promote English language learning, making it more interesting, attractive and meaningful for students.

Keywords: ICT, abilities, cognitive, competencies, chemistry, communication, skills

1. Introduction

The importance of Information and Communication Technologies ICT is known to all as one of the most prominent and characteristic elements of the knowledge society. This makes it inevitable that some of the aspects that are part of it are configured, influenced and determined by the educational reality. La Esperanza Educational Institution, as part of the public school system of the city of Santiago de Cali and a training center for future university students, should not be left out of the incorporation of these technologies and the language socialization should even delegate this responsibility to other entities and/or corporations. This initiative has been promoted through the implementation of mechanisms that guarantee.

To put into action this initiative through the implementation of mechanisms that promote and guarantee the development of competencies in Chemistry and English, from the academy arises the idea of implementing the use of technological tools to improve cognitive competencies in chemistry and promote the use of English to explain chemical phenomena. With this study, it was possible to give students the technological tools they needed to energize their learning process, and it was possible for them to apply their own knowledge of chemistry, technology and English in their comprehensive training process. All this was possible through two instruments of collecting data, an observation guide, a questionnaire, and an online survey through Google form.

The following document is structured in several chapters. Chapter 2 presents a description and statement of the problem to be studied, in addition to the objectives that guide this research. Chapter 3 shows basic concepts related to the teaching of natural sciences in the Colombian context. Chapter 4 describes the use of technology in the teaching of natural sciences, specifically in chemistry. Chapter 5 shows the student interaction in the classroom under the CLIL approach taking advantage of the transversal nature of this research. Chapter 6 shows the findings of each instrument, and the analysis and discussion. Finally, in chapters 7 and 8 conclusions and recommendations are presented respectively.

2. Research problem

2.1 Research statement

The most of students don't understand chemistry in regular class didactics, and they do not have enough opportunities to use English outside the English classroom, they are not motivated to take part in either English or Chemistry classes, which hinders their learning process. There is a situation going on that requires intervention. As an experienced teacher I have noticed that students respond well when technology is used in the class, and the type of technology that I found to support Chemistry lessons is only available in English. Therefore I saw an opportunity to integrate the teaching of Chemistry with English class through the use of ChemSkecth.

In public schools, the number of hours for high school students is three hours a week, insufficient time to promote communication skills, especially when since primary school they bring a lag in language learning. On the other hand, organic chemistry is a subject that have complex concepts that requires effective teaching materials that allow the teaching-learning process to be taken to stages that respond to the demands of the 21st century. The use of ChemSkecth offers the possibility of harmoniously integrating the needs of the two subjects that institutionally have had low levels of performance and, as an added value the possibility of practicing the language outside of English classes.

2.2 Justification

This research offers the institution the possibility of integrating new intervention proposals in the educational field of natural sciences under a transversal approach that integrates content (like Chemistry) and foreign language (English in this case). This could be the beginning of a great curricular transformation that contributes to the integral formation of children, teenagers, and adults that the educational establishment in its area of influence serves. Such a challenge raises great concerns when it comes to integrating technology in the teaching-learning process. Lewis (2003, pg. 8) establishes that the use of ICT can open a window from the classroom to other worlds of sciences, especially in chemical issues like molecular structures, macroscopic phenomena and the capability of transformation of chemical elements.

As part of the training process in natural sciences and the biological, physical, and chemical sub-processes, the latter involves building and contemplating models that try to explain the behavior of particles at the molecular level or their macroscopic effects in everyday situations. This is how the use of ICT can provide other ways of modeling this kind of phenomenon through Web 2.0. Chemistry is often perceived by upper-grade students as a challenging, dry, and boring subject. This perception is probably due to the traditional teaching method still prevalent in public schools due to factors like resources such as static textbooks, lack of interactivity, and difficulty in visualizing abstract chemical concepts (Hsiung, 2018, pg. 86). Under this paradigm, there is an urgent need to use technology to stimulate and innovate educational processes from the first grades of schooling. Research like that of Arumugan (2020) examined the use of smartphones in science teaching and learning to propose a model for the use of these artifacts to improve these processes. This study revealed that the mobile phone had great potential as a learning tool that could be used positively for teaching and learning purposes in scientific areas, awakening curiosity and motivation in students. Nevertheless, in our school environments, the mobile phone is seen as a threat to the training process of the students, by teachers, coordinators, and directors.

After this brief description of the benefits that the use of ICT brings to the teaching of natural sciences, the idea arises of creating digital resources in the subject of chemistry. Tools such as ChemSketch software have been used to improve the understanding of students in higher grades. One way of contributing to innovation is by promoting more dynamic, interactive classes and putting into practice all those elements necessary to provide a quality education that responds to the demands of the new world.

2.3 Question

As a science teacher at high school level in a public school located in a vulnerable sector of the city of Santiago de Cali, I work with students whose ages range between 11 and 16, according to the level of schooling. Given the conditions of the social, economic, and cultural context of the educational community that influences the Institution, students lack spaces where they can put their knowledge of English into practice for educational purposes. At most, communicational needs derive from the use of social networks, the fact that in most cases do not contribute to their training process, in addition to the risk they represent for their physical and emotional integrity (Collins & Halverson, 2018). Understanding this precedent I had the idea of implementing the use of technological tools in English for the teaching of science such as simulators and programs for molecular diagramming. The barriers evidenced in practice led me to ask myself the following question:

How can the use of ChemSkecth software articulated with the English subject help to improve cognitive competencies relating the structure of carbon with the formation and chemical behavior of hydrocarbons as well as communicative competences in English?

2.4 Objectives

2.4.1 General

To analyze the effect of the implementation of ChemSketch software in the comprehension of the structure of the carbon with the formation of the organic compounds and its properties under a CLIL approach promoting the use of English in students of 11th grade at La Esperanza Public School in Cali.

2.4.2 Specific

- To design and apply a teaching intervention based on CLIL principles using the software ChemSketch for the elaboration of organic molecules.
- To assess students' level in the elaboration of organic structures, prediction of properties, and report creation.
- To analyze the effect of the implementation in students' communicative performance.

3. Literature Review

Taking into account the nature of this research, a multidisciplinary approach was necessary to provide solidity to the ideas presented from a technological, scientific, and linguistic perspective. With this study, it was possible to give students the technological tools they needed to advance in the consolidation of their learning in the digital age with the need to do it in a second language. The development of the theoretical framework of this research project includes three major references given its interdisciplinary nature. In the first place, reference will be made to the Teaching of Natural Sciences in the Colombian context and its relation with the Knowledge society. Secondly, the use of technology in the teaching of natural sciences will be addressed, more specifically in the acquisition of the cognitive competencies in chemistry. Finally, the integration between chemistry and English is based on a communicative language integrated learning (CLIL) approach for the explanation of phenomena in the scientific discipline. In the broad sense of the word, the discussion of theoretical referents is intended to go beyond their prescriptive nature. Aware of the paradigm shift that the knowledge society represents in the 21st century, education is widely recognized as the enabling element for the progress and development of a country. Following the above, the National Ministry of Education (MEN for its initials in Spanish) has issued a series of documents that seek to generate a significant change at the curricular and pedagogical levels.

3.1 The teaching of natural sciences in the Colombian context

The teaching of natural sciences in Colombia is guided by three key documents. The first of which is the curricular guidelines. This document offers a macro view of the theoretical and epistemological aspects that must be taken into account for the teaching of sciences based on the concept of the world of life raised by the philosopher Edmund Husserl. The first is that whatever is asserted within the context of a scientific theory, refers, directly or indirectly, to the student as the center of learning. On the other hand, the teacher recognizes the previous knowledge that the student has of the world from his perspective.

In a greater level of detail, we have the basic standards of competence and basic learning rights in natural sciences that complement and guide the teaching of science in a more specific way. The proposal seeks to create conditions so that students know what natural sciences and social sciences are, and also so that they can understand them, communicate and share their experiences and their findings, act with them in real life and make contributions to the construction and improvement of their environment, just like scientists do (MEN, 2004). It should be noted that both documents were created through systematic work by the National Ministry of Education which involved academics from the main universities of the country, but in my view, the most important is that the teachers of the Public schools across the country were taken into account.

3.2 Knowledge society

Laurillard (2002) and Gilbert (2005) recognize education as a fundamental axis for the transformation of the knowledge society. They endorse the idea to promote other forms of education to respond to the needs of jobs. The use of different qualifiers to refer to the knowledge society at a universal level is due to advances in science, technology and society, which is immersed in a continuous process of economic globalization. As a general characteristic, the communicative act that permeates all spheres of society thanks to the media, communication networks, and of course, the new information and communication technologies stands out. According to Jacobi (2007) “we live among determined, well-educated, and strongly motivated competitors for international standing and markets, not only with products" (p. 44). Under these arguments, the importance that knowledge society plays today is undoubtable.

Ranga and Etzkowitz (2013) illustrate "the concept of the triple helix of university-industry-government relationships initiated in the 1990s" (p.238). With the potential for innovation and economic development of the Knowledge Society, the importance of the university is highlighted, but at the same time its relationship with the industry and the government. Only through the articulation of these three levels can new models be generated for the production, transfer, and application of knowledge. The Innovation focuses on research actions that ask about what happens in the day-to-day educational context. Knowledge is transformed into results, and it is closer to inquiry processes that allow the construction of responses, renovating approaches and models of work that break with existing paradigms. Another important aspect that cannot be left behind is innovation, situations arise with the opportunity for change and are established in processes of research and social and cultural transformation.

In 2017 Sterberg established that innovation is a process that has to do with generating and combining ideas to make a relationship between present accomplishments and past experiences to solve a future problem (cited in Rincon, et.al. 2020. P, 95). For their part, Lugo and Kelly (2015) relate the concept of innovation to that of technology highlighting that innovation does not simply imply the incorporation of technological resources in the classroom. It means a cultural transformation in the way of managing and building knowledge, in teaching strategies, in new institutional configurations, in the roles of teachers and students, and even in the creative way of thinking about education, technology, and the schools. Thus, educational innovation implies changes in the curriculum, in the ways of seeing and thinking about disciplines, in the didactic strategies deployed, and of course, in the management of the different dimensions of the educational environment. Under the paradigm of the knowledge society, this research is assumed as a strategic bet from the educational field to respond to problems such as the globalization of the use of technology and English as a means of communication in public education.

3.3 Use of technology in the teaching of natural sciences

The teaching of natural sciences in Colombia is based on the study of biological, physical, and chemical processes at the levels of schooling that go from basic primary to secondary education. Of the processes mentioned above, chemistry will be highlighted due to the great concerns that exist for its understanding. Bakhshi and Rarh, (2012) declare that "chemistry education in a formal sense means the teaching-learning process of chemistry and involves three important components viz. curriculum/syllabi, teaching-learning, and examination" (p.38). Furthermore, there is a constraint of time within which this whole process has to be completed at each level. Of course, the teaching of chemistry has not been alien to the use of technology. On the contrary, the use of programs and computers is increasingly common both in research centers and in schools and universities.

There are different approaches to the use of technology in natural sciences. For example, Learning Science, Environment, Technology and Society (SETS), combine those factors as reciprocal and integrated. Hairida (2017) in her study "Using SETS Local Wisdom and based Colloids Teaching Material" points out that the students in high school learning Pontianak are less interested in studying this science due to the difficulty that students have in relating disciplinary knowledge with aspects such as the environment, health, and technology. Based on this study, it is very important for teachers to articulate the objects of study typical of science with the context and with students' everyday situations.

From the technological field, one of the main threads of this research is the SMAR model proposed by Puentedura (2006), which is based on substitution, augmentation, modification and redefinition, which guides the staggering use of technology in the classroom. Used at a low level, technology merely serves as a substitution, for instance using a graphics processor instead of paper and pencil to draw a chemical formula. The next level is augmentation, in which technology improves on a learning task similar to what students could do without the technology, such as using the formatting tools in a word processor to highlight areas of interest. In the modification and redefinition levels, teachers and students work together to demonstrate knowledge empowerment.

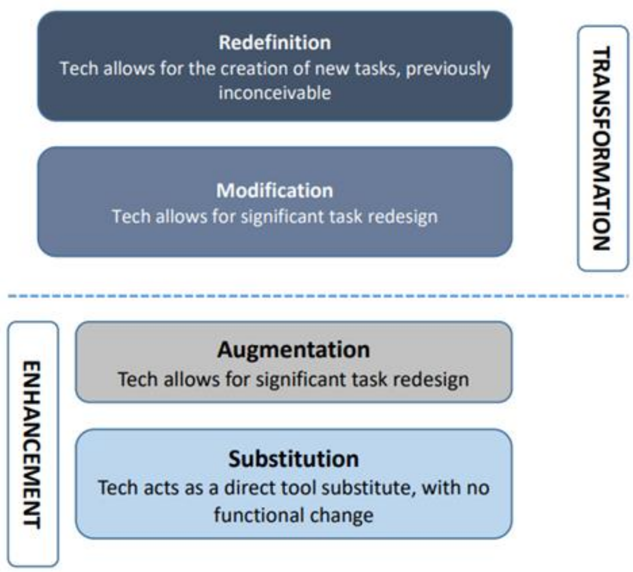


Figure 1: SMAR model, source Puentedura (2006)

In contrast, Phillips (2015) points out the benefits of emerging digital technologies for teachers who choose to adopt these tools as part of their classroom practice. Before the pandemic, the use of technology was done tangentially by most teachers, however, the closure of educational establishments worldwide triggered the use of information and communication technologies at its highest level. The use of technology as a tool to transform lessons into meaningful learning experiences means going beyond the technological tool to the learning objectives, increasing the level of commitment, collaboration, and self-efficacy in the learning process (McGinnis, 2019; Patton, 2015). Furthermore, technology is in the process of promoting the 21st skills among which creativity, innovation, and the ability to solve problems stand out. The major shifts are evident when from the educational praxis the methodology and the contents are transformed by the teachers incorporating technology-driven instructional activities within classroom instruction in order to meet the needs of the ever-changing technology-driven learning society.

SAMR model was developed to examine how technology is infused into teaching and learning activities. Besides, it is used to stimulate teachers to optimize instructional activities by using technology. If we analyze the chemical transformation of substance A to a substance B under the SAMR model, the following considerations could be made: In the substitution level, students might use technology to substitute a notebook for a text editor or a video recorder that allows them to register the transformation that they are seeing (cellphones, note pads). The next step up, augmentation, includes tools that give students time to analyze data rather than merely collecting it. In this regard, the web offers several options for the analysis of chemical transformations with the help of the periodic table (www.chemicalelements.com). The third level corresponds to that of modification, in which teachers redesign significant tasks. For instance, the teacher could ask students to create a video or a podcast explaining changes that they looked at during the reaction (using tools like Screen-castify, Google Podcast). Finally, in the redefinition level, learning tasks such as having students assess, evaluate and critique their partners' work using online tools like Voice Thread, where they leave messages and videos to each other and that are available all the time, are examples of redefinition of learning tasks.

The training process in natural sciences involves building and contemplating models that try to explain the behavior of particles at the molecular level or their macroscopic effects in everyday situations. This is how the use of ICT can provide another way of modeling this kind of phenomenon through web 2.0. Chemistry is often perceived by upper grades students as a challenging, dry, and boring subject. According to Hsiung (2018) "this perception is probably due to the traditional teaching method still prevalent in public schools due to factors like resources such as static textbooks, lack of interactivity, and difficulty in visualizing abstract chemical concepts" (p. 86). Although this study was carried out with university students from Malaysia, the situation in Colombia is similar, the students do not seem to be interested in the study of chemistry.

In regards to the use of specialized software for chemical sciences, Maarebia et al (2020) in their study "Analysis of Student Response to the Utilization of Chemsketch Media in Hydrocarbon Materials", show a high degree of acceptance of technology in Chemistry lessons. They explain that "the use of the tool in the three-dimensional visualization of organic structures is difficult to interpret with the resources of a conventional classroom" (p. 443). The study revealed improvements in the level of understanding in the formulation and nomenclature of organic compounds, one of the most complex topics for eleventh-grade students at the secondary level. The experience encouraged the students to continue using the tool in their organic chemistry class and enhanced cognitive competencies. Similarly, Mitee and Obaitan (2015) "provided feedback on the learning outcomes of Nigerian upper secondary school students in chemistry" (p.34). This study showed that most students are unable to move to a more advanced level due to poor performance. Studies like the ones developed by Edomwonyi-Out and Avaa (2011) confirm that poor performance is due to multiple factors, but one of the most influential in this type of situation is the teacher. Their methods, materials, and strategies are key to the achievement developed in the subject. This situation is aggravated in contexts where the lack of technological resources and connectivity are the common denominator of public or rural schools.

Regarding the teaching of chemistry in English, the literature provides us with a broad view of this phenomenon. Alshehri (2017) point out the importance of the use of a foreign language in the science learning process for NNS, her study show the complexity of science simultaneously promotes the development of processes such as analysis, understanding and communication of scientific phenomena. On the other hand, it is important to take into account the barriers that students have for the use of language, chemistry itself is a language but also a body of content, therefore it is approach must be done from a holistic view. Kelly (2010) states that "an awareness of these languages, as well as a pedagogy for dealing with the language, is important for the science teacher working with learners in an additional language" (pg.4). In accordance with the above, there must be clarity in the pedagogical current and in the methodological aspects that lead students to articulate the codes of each language with a cognitive purpose. In summary, students must have a higher level of disciplinary language exposure to organic chemistry and time inside and outside the class to practice the language among peers and with the teacher's accompaniment.

From another perspective, all around us people are learning with the aid of new technologies: "children are playing complex video games, workers are interacting with simulations that put them in challenging situations, students are taking courses at online high schools and colleges, and adults are consulting Wikipedia" (Collins & Halverson, 2009, p. 1). Moving educational practices away from the realities of the context and the demands of the knowledge society is not a good educational strategy, then it becomes necessary for teachers to change educational practices, especially those where the mainstreaming of knowledge is promoted. Czerniak and Johnson (2014) acknowledge the effort of the teachers to promote an integrated curriculum in their courses to help them meet state and national standards. In public schools in Colombia, that is an issue that still seems distant, since individual and isolated educational practices prevail. However, initiatives such as those enshrined in this research leverage educational change.

3.4 Communicative Languages English in the classroom

Taking into account the cross-sectional nature of this research, the other point of view is the possibility that arises from the explanations that students give in English about chemical phenomena in the classroom. This pedagogical initiative seeks to integrate the areas of English and chemistry to promote interactions between peers concerning the application of organic compounds in daily life situations under the content and language integrated learning approach. The focus on CLIL is not to equip learners with the language they need to transact every life task. According to Marsh (2012) "the main challenge for the development and implementation of a teacher training curriculum in CLIL is its integrative nature" (p.5). This is the case of La Esperanza Educational Institution at all educational levels, as its monolingual nature makes it difficult to use English in other subjects. Kerr (2019) confirms that educators are required to rethink their policies on the language of instruction to promote a quintessentially bilingual approach. This is a complex issue in the context of public education in Colombia, but achievable in the long term with the cooperation of the government, principals, and teachers.

Public school students often lack pedagogical settings other than English class to practice the language in controlled environments. That is why they are asked to interact with their classmates to comment on something about the subject or any topic of the organic compounds in their daily lives taking advantage of the instructions and features that the software provides only in English´, they put up big barriers claiming to have a lot of pronunciation errors. Adams (2018) emphasizes the learning opportunities students have by speaking and substantially producing more language interactions with peers despite them being simpler and having more errors than native speaker input or rather than simply accepting guidance from a teacher. The learning environment where students work among peers allows them to have more confidence in the interaction by creating a space where the new forms of the language they are learning are questioned and tested.

Sridhar (2000) and more recently Khansir (2012) assert that the mistakes that students make in the process of learning a second or foreign language have always been the focus of interest of researchers, teachers, and textbook writers, among others. Taking into account that the contrastive analysis is the systematic comparison of two or more languages, intending to describe their similarities and differences (Johansson, 2000), it is necessary to highlight the role of the mother tongue in the learning process based on the evidence in the oral interaction of the students of eleventh grade in chemistry classes. The main cause of error in foreign language learning is interference coming from the learners' native language. Based on the evidence obtained in chemistry classes, it could be stated that the most common errors are of interlingual type. Richards (1971) classified errors according to their causes. The interlingual error occurs when these errors are caused by mother tongue interference. Intralingual developmental errors when this kind of errors occur during the learning process of the second language at a stage when the learners have not acquired the knowledge (cited in Heydari 2012). The main argument is based on poor pronunciation caused by intralingual errors because as Spanish speakers they only use five vowels. Errors like incomplete applications of rules, simplification, and omission of rule restrictions also were observed.

Loewen (2007) points out that second language instruction can be conceptualized as falling into two broad categories: meaning-focused instruction and form-focused instruction. Meaning-focused instruction is characterized by communicative language teaching and involves no direct, explicit attention to language form. The L2 is seen as a vehicle for learners to express their ideas. Under this precedent, the need to seek joint strategies to improve the student-speaking dynamic becomes prevalent. Following the above, teaching the fundamentals of phonetics is a necessity demanded by students and not an optional task for the teacher. According to Marr (2015), knowledge of Phonetics is a basic skill for a language teacher and allows you to describe accurately and represent sounds. This applies particularly if your students are Spanish speakers.

3.5 Conclusion

To conclude, the implementation of ICT tools in science classes under a CLIL approach provides a wide range of possibilities to improve cognitive competencies in chemistry and promote the use of English. It takes advantage of the benefits offered by specialized computer programs for the subject of chemistry which are in English and promotes active participation on the part of the students. Using Chemsketch software in the science classroom is a strategy that allows teachers to challenge their convictions about teaching organic chemistry and the possibilities offered by the use of a second language to promote meaningful learning in response to the needs and interests of the students. Integrating subjects into public classroom teaching requires teachers to reflect carefully on their own practices, considering how to adjust their methodology to promote mainstreaming. Both approaches are reflected in the curriculum, which makes the mainstreaming of knowledge must be complex and more relevant than ever.

4. Research Design

This project adopts the action research methodology taking into account the benefits it brings to the educational field. Action research is an excellent method to respond effectively to situations that arise in the classroom. It follows a process that includes steps such as planning, observing, applying, and reflecting. According to Feldman and Minstrell (2000), the first benefit of the use of Action research is that it increases the time of application of the new knowledge in the classroom. The second is the intrinsic capacity that teachers have to investigate, taking into account their level of training and experience.

4.1 Context

The Educational Institution "La Esperanza" has four educational campuses, it is located in the southwest part of Santiago de Cali - Colombia hillside area of the comuna 18. The creation of the School started with the arrival of the first settlers of the neighborhood, without doing anything until 1991. The school was the product of community work that served different strengths to provide a solution to basic needs, such as health, aqueduct, ways, and education. In the first instance, the educational space for adults was established as a collective literacy need. Thus, in September 1990 with the support of the community, the adult education program “Compartir” was started. Operating the locative headquarters of the Community Action Board.

Currently, the institution has four campuses that serve vulnerable populations in the lower, middle, and upper areas of the Alto Meléndez, Alto Jordán, and Polvorines neighborhoods in the levels of basic primary, basic secondary, and technical secondary education in coordination with SENA. In the field of pedagogy, the Institution has been designed in collaboration with the entire educational community and in the lead of its teachers, a pedagogical model named “Liberating and Transforming Pedagogical Model”. It responds to the updating and transformation of learning taking into account new perspectives and pedagogical trends that is, favoring biolearning.

Regarding ICT, the school is one of the focalized institutions by the Municipal Education Secretary, so it has received benefits like laptops, tablets, and extra training courses for teachers and materials for all classes. For example, Computadores para Educar, tit@ and STEM have provided a lot of benefits for the school. On the other hand, the English teachers at school also had the opportunity to work in a collaborative way with teachers of other subjects, and they are active participants in the activities carried out by the Secretary of Education and the Bilingual Teachers’ Network in Cali.

4.2 Sample

The population of this research project is made up of 23 of 28 students who correspond to 85.7% of the total population of eleven grade, group number 2 of the educational center where the research was applied. The students excluded from this study were those who finished the school year in virtual mode. The rest of the students were informed about their participation, which took place during the alternation model classes[1]. They were asked to participate in a survey after having signed informed consent.

The main characteristic of these students is that they show a good disposition in chemistry classes especially when they work in groups. Now, the use of technology has generated a high

[1] Due to the pandemic, all students could not attend school at the same time, therefore, the Colombian government stated that students had to take turns coming to school, alternating the days that they could come to study.

degree of motivation and commitment in them, taking them to levels of understanding of greater complexity. On the other hand, it has been observed that in some activities most of the students had problems interacting with the language and a few parts of the group showed insecurity when they were in front of their classmates or their teacher.

These students had an intensity of 3 hours of Chemistry English respectively per week. They had access to officials' laptops of Colombiaprende, e-books, classroom platforms, and the internet provided by the Institution.

Inclusion criteria

-Students officially enrolled in SIMAT 2021

- Students of both sexes

Exclusion criteria

- Students of the night working day

- Students with irregular enrollment

- Students who did not wish to participate in the research

- Students in virtual modality

4.3 Data collection methods and instruments

In order to collect data for this project, the following instruments were used:

Field diary: Used during classes to record information on students' attitudes towards the pedagogical strategy in correspondence.

Videos and pictures: These kinds of instruments were used to register students' productions of molecular models made by the students and the explanation of chemical phenomena in English during the classes.

Grades of students: The academic performance of the students in the pre-and post-application of the pedagogical intervention in order to compare the effectiveness of the use of ChemSketch software. On the other hand, to establish the effectiveness of the implementation of the didactic sequence. These grades were used to compare the pre-and post-application of ChemSketch.

ASSESSMENT TOOL	DIMENSION	EVIDENCE OF LEARNING
Written reports	Elaboration of structures	Students to relate the structure of the carbon with the formation of organic molecules
		Students make aliphatic chains of saturated hydrocarbons
		Students make aliphatic chains of unsaturated hydrocarbons
		Students make aliphatic chains of aromatic hydrocarbons
	Properties prediction	Students relate functional groups with the physical and chemical properties of substances
	Report creation	Students make reports of the chemical structures that they have made.
	Communicative	Students express orally his/her point of view about an organic chemistry subject previously studied with their peers.
Midterm exam	Integrated	Students answered to some questions about the study of the hydrocarbons and functional groups in organic chemistry
Final exam	Integrated	Students answered 20 questions about all the topics seen in the period.

Table 1: Dimensions evaluated during the didactic sequence

ChemSketch Software

According to the students' characteristics, it was decided to include ChemSketch software in its free version to teach chemistry having in mind the relevance of the use of technology to innovate the learning process in chemistry classes. ACD/ChemSketch Freeware is a drawing package that allows you to draw chemical structures including organics, organometallics, polymers, and Markush structures. It also includes features such as calculation of molecular properties (e.g., molecular weight, density, molar refractivity, etc.), 2D and 3D structure cleaning and viewing, functionality for naming structures (fewer than 50 atoms and 3 rings), and prediction of log*P*.

4.5 Procedure

For the development of this Action Research, it was necessary to create and follow 4 moments as is observed in the following diagram.

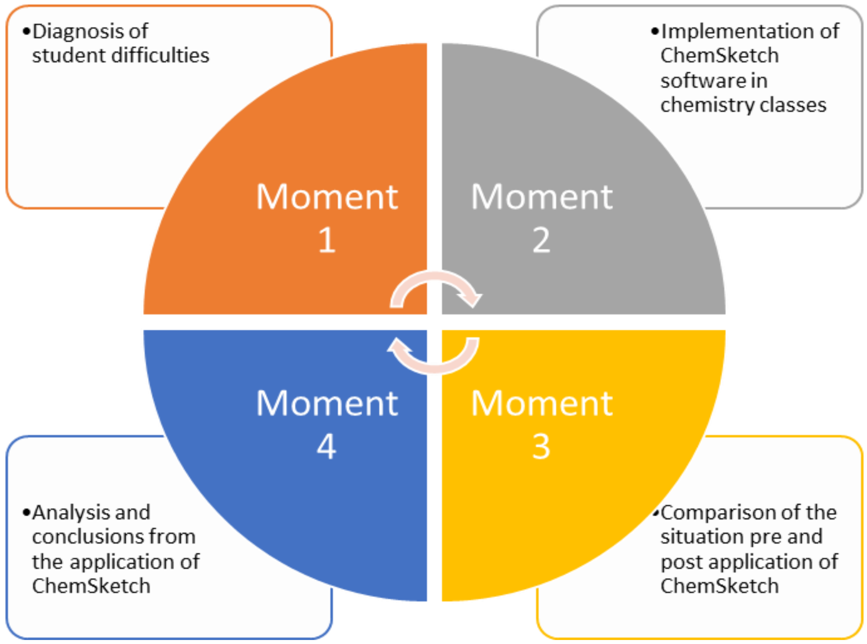


Figure 2: Moments of the didactic sequence

Moment 1: Diagnosis of the difficulties of students

To establish students' difficulties before the implementation of the didactic sequence, the students' final grades from the first trimester were taken into account, but also the attitudes of the students towards the proposal to integrate two subjects of the curriculum. From the chemistry subject, the students were very motivated when they noticed that they were going to work with new software for them and that it offered the possibility of diagramming highly complex organic molecules and respecting the standards of the International Union of Pure and Applied Chemistry (UIPAC). Additionally, since it is only in English, the discourse of the use of language became more common in chemistry classes. For instance, when students start the software pop-up windows immediately open with tips for basic handling.

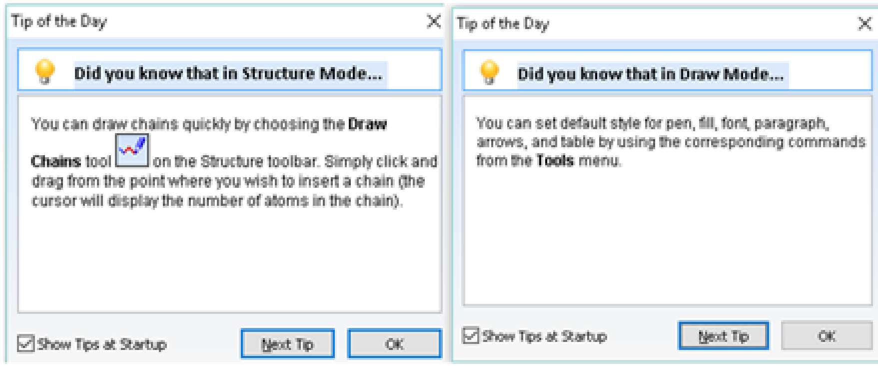


Figure 3: ChemSkecth Tips, source: www.acdlabs.com

To analyze the diagnoses of difficulties, four dimensions were taken into account:

- Elaboration of structures: the basis for the understanding of organic chemistry is the structure of the carbon atom and the forms it has to bond with atoms of the same or different nature. In this order of ideas, aspects such as the elaboration of structural and molecular formulas, the aromaticity of the benzene ring, and the prediction of properties and isomers were analyzed before implementation. In general terms, with the conventional classroom materials, the students showed some level of understanding of the concepts.
- Report creation: The elaboration of chemical structures and their subsequent presentation were part of the reports that the students delivered during the sequence. Aspects such as the handling of IUPAC rules, the type and quantity of atom, among other characteristics, were explained in pairs.
- Properties prediction: the basic organic reactions and how they are carried out in aliphatic, aromatic, and alicyclic hydrocarbons were analyzed.
- Communication: The promotion of the use of English for the explanation of the structures that the students themselves had elaborated and some chemical phenomena. Prior to the pedagogical intervention in the chemistry classes, useful expressions in English were used to generate a climate of trust with the students. The

use of quantifiers, such as asking when you have a question and the pronunciation of some elements in English became the prelude to the project in general terms.

Moment 2: implementation of ChemSketch The use of quantifiers, such as asking when you have a question and the pronunciation of some elements in English became the prelude to the project at a general level.

ChemSketch software is one of the most widely used programs in the world by researchers and educators. The relevance of its application in the context of this research lies in preparing students for today's workplace with an introduction to industry-standard scientific software and creating rich teaching materials for virtual and face-to-face classes. During the implementation, it was necessary to use the laptops in the systems room. The first step was to download the program on each computer following the developer's instructions. In the second step, we proceeded to show the interface of the program, the scope, limitations and possibilities of drawing structures, reactions, and schemes in 2D and 3D among other functions. In the third step, the teacher-researcher developed examples diagramming some saturated, unsaturated, and aromatic hydrocarbons to give students greater clarity in understanding the tetravalence of carbon and its different forms of hybridization emphasizing in the use of the language. Finally, the students practiced freely elaborating different types of structures and expressing their opinions in Spanish and English.

Moment 3: Comparison of the situation pre and post-application of ChemSketch

After the implementation of the software, the comparisons between the information obtained in each dimension were established, thus managing to determine the scope of the objectives set by the researcher-teacher. For this step, multiple data sources were taken into account to better understand the scope of the proposal and its impact on students and the academic community of the educational institution. Data from field notes, photos, videos, individual files, and samples of students' work were used.

Moment 4: Analysis and conclusion from the applications of ChemSketch

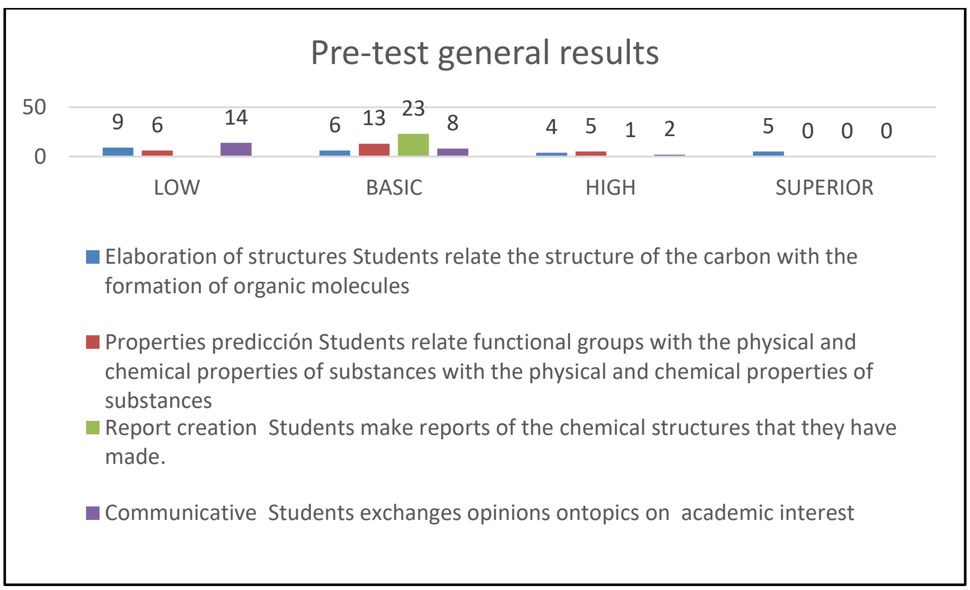
Important findings could be deduced after the application of the software from the two perspectives raised by the researcher's teacher. The most important are the possibilities that arise at the curricular and methodological level for the institution given its public nature.

5. Results and discussion

This section presents the results of the research. It is organized following the moments explained in the previous section.

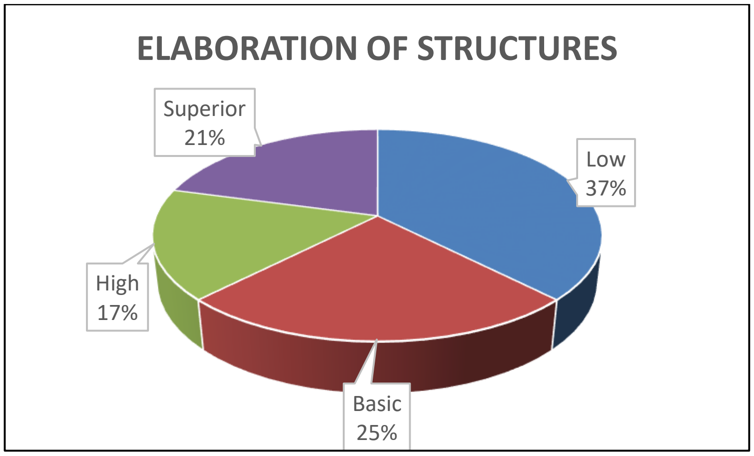
5.1 Moment 1: Diagnosis of the difficulties of students

Each graph describes the percentage of students located in one of the four academic levels proposed by La Esperanza Public School. On a scale of 5.0 as a maximum grade, the low level goes from 1.0 to 2.9, the basic level from 3.0 to 3.9, the high level from 4.1 to 4.5, and the superior level from 4.6 to 5.0. Also included in the graph related to the final grade shows the weighting of all the grades obtained in each dimension at the end of the term. The next graph shows the general results in each dimension.



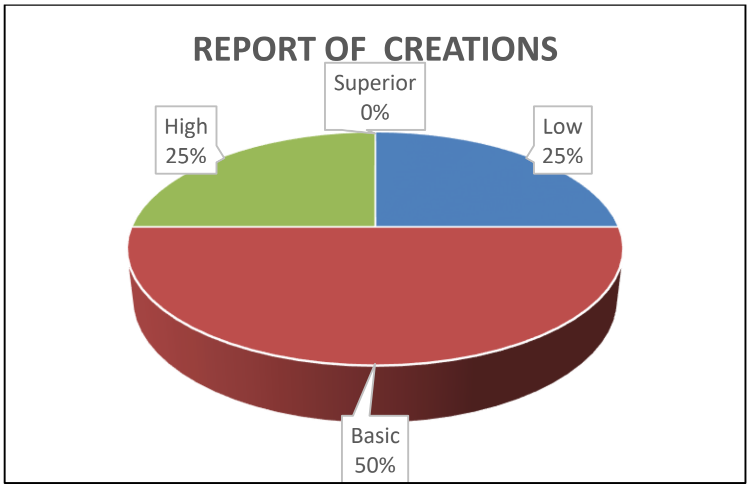
Graph 1: General results per dimension

The following graphs show results in more detail. Increasing the level of detail, the results of each category were analyzed with the following results:



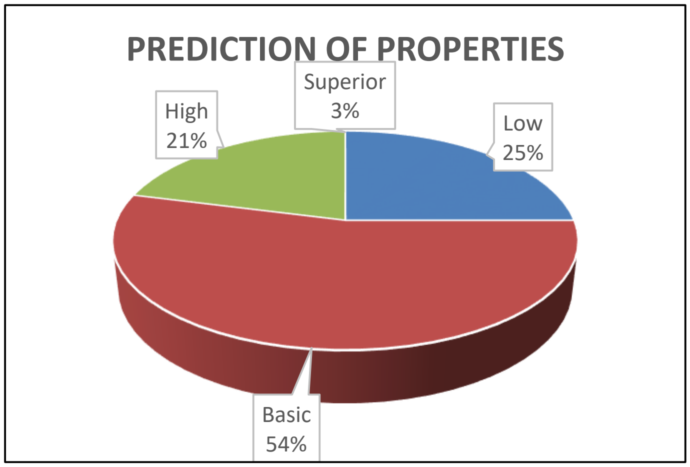
Graph 2: Elaboration of structures before the didactic sequence

As can be observed in the above graph, most of the students are located in a low level (37%), followed by 25% of students in basic, 17% in high and 21% in a superior level.



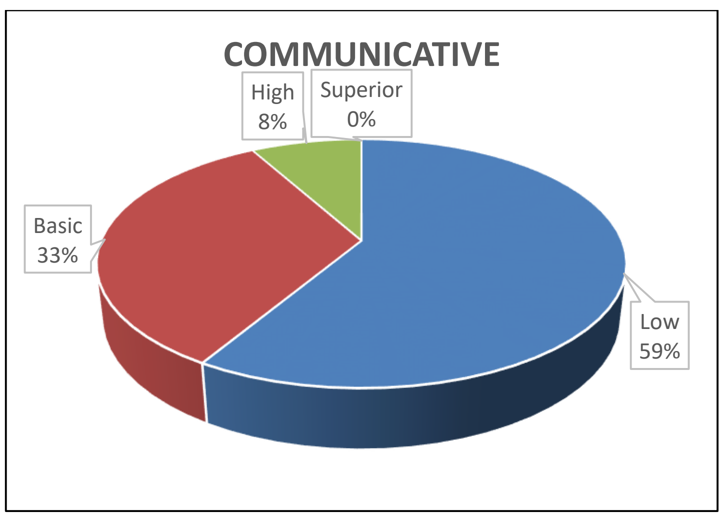
Graph 3: Report of creation before the didactic sequence

The evidence obtained in this dimension shows that half of the group (50%) are located at a basic level, followed by 25% of students at low and high levels respectively.



Graph 4: Prediction of properties before the implementation of the didactic sequence

Most of students' are located in a basic level (54%), followed by 25% of students in a low level, 21% in a high level and 3% in a superior level.



Graph 5: Communicative Dimension before the didactic sequence

Taking into account the above grades and the information gathered during the classes before the implementation of the didactic sequence, the difficulties, and their possible causes were characterized as shown below:

<table>
<tr><th>Dimension</th><th>Aspect</th><th>Description of the difficulty</th><th>Cause</th></tr>
<tr><td rowspan="5">Elaboration of structures</td><td>Structural formulas</td><td>The students did not make the developed or semi-developed formulas of open-chain aliphatic hydrocarbons.</td><td>Students had difficulty applying the property of carbon tetravalence.</td></tr>
<tr><td>Molecular formulas</td><td>The students did not make the condensed formulas aliphatic and/or aromatic hydrocarbons.</td><td>Students had difficulty counting the numbers of atoms of each element in the structure.</td></tr>
<tr><td>Aromatic ring resonance</td><td>The students did not make aromatic rings with or without substituents.</td><td>Students had difficulty identifying the delocalization of π electrons in the aromatic ring.</td></tr>
<tr><td>IUPAC rules</td><td>The students presented confusion in the handling of prefixes, suffixes, and roots used for each chemical function.</td><td>Students had difficulty applying the basic rules for each group of compounds.</td></tr>
<tr><td>Isomers</td><td>The students did not make transitions between isomeric structures</td><td>Students got confused by changing the shape of the main chain and saturating the carbon with hydrogen’s.</td></tr>
<tr><td rowspan="2">Report Creation</td><td rowspan="2">Structures presentation</td><td rowspan="2">Students did not present elaborate structures on paper or in other materials</td><td>Students did not like to make structures in class or at home.</td></tr>
<tr><td>Lack of responsibility.</td></tr>
<tr><td>Properties prediction</td><td>Chemicals properties</td><td>Students did not understand the types and reaction mechanisms of basic organic reactions</td><td>Students had difficulty understanding the breaking and formation of chemical bonds in the formation of new substances.</td></tr>
<tr><td rowspan="2">Communicative</td><td rowspan="2">Use of English</td><td>Most of the students had a hard time not using the language</td><td>Students presented interlingual errors to express their ideas.</td></tr>
<tr><td>Spanish to express themselves about some organic compounds</td><td>Words with your mother tongue sounds. Lack of vocabulary.</td></tr>
</table>

Table 2: Difficulties and its causes per dimension.

5.2 Moment 2: Design and implementation of ChemSketch

In order to identify and carry out an adequate intervention of the detected problems, I proposed the following didactic sequence.

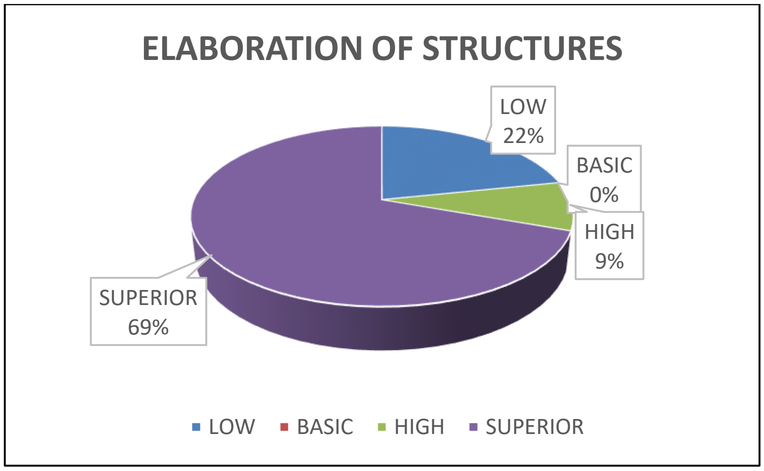
Dimension	Activity	Objective	Indicators	Time
Elaboration of structures	Students make hydrocarbon structures.	To learn the basic use of the design of the structure.	1. Select the structure or drawing mode according to the work to be done.	5 hours
			2. Identifies the chemical components of the structure according to IUPAC standards.	
			3. Identifies and locates the toolbar of radicals and chemical elements used by the software	
			4. Visualize organic structures previously designed in 3D	
Prediction of properties	Students abstract properties.	To predict properties of different compounds.	5. Processes molecular structures.	5 hour
			6. Manages correctly the types of bonds according to the molecular structure.	
			7. Shows the global formula, the percentage composition, and the macroscopic properties of the designed compounds.	
Report creation	Students generate reports	To learn basic procedures to generate reports	8. Import chemical structure files in different formats.	5 hours
			9. Export chemical structure files in different formats.	
			10. Create animated files using the 3D viewer of previously designed structures	
Use of the English	Students talks about the molecules designed	To promote the use of English	11. Explains the structure of previously designed compounds	5 hours
			12. Talks about the properties of organic compounds of general interest	
			13. interact with their peers in relation to the application of organic compounds y daily life situation	

To carry out this research proposal, several pedagogical scenarios were necessary where students could express their ideas and take actions in front to the project. The most recurrent of them was the classroom, the place where the students began to talk timidly about the mainstreaming chemistry knowledge in English. Aware of the limitations in the use of the language, the students began to take their first steps in knowing the software and practicing the pronunciation of bioelements such as carbon, hydrogen, oxygen, nitrogen among and some organic compounds. Additionally, the order of complexity of molecular diagramming required students to do better use of the language. The second stage was the systems room, a space in which the necessary instructional part for the use of the software was carried out. At this stage, the support of the teacher in charge of the site was key, since there was a need to move other groups to conventional classrooms while the 11th grade students did their work. Finally, the playgrounds in which the students felt more confident to talk about the sensations that speaking in English caused them in front of their peers.

Throughout the classes, there was a good working environment; the students first made their molecular models manually, a fact that took them a lot of time and money. After knowing the benefits of the software, little by little, they were creating better digital models and with it, the explanations in English about their structure and function of this compounds. The students self-recorded practicing the knowledge shared in class, gradually overcoming the anxiety generated by this challenge. The students self-recorded practicing the knowledge shared in class, gradually overcoming the anxiety generated by this challenge. They were also able to work in small groups and make short presentations in class, generating more level of participation in the classroom.

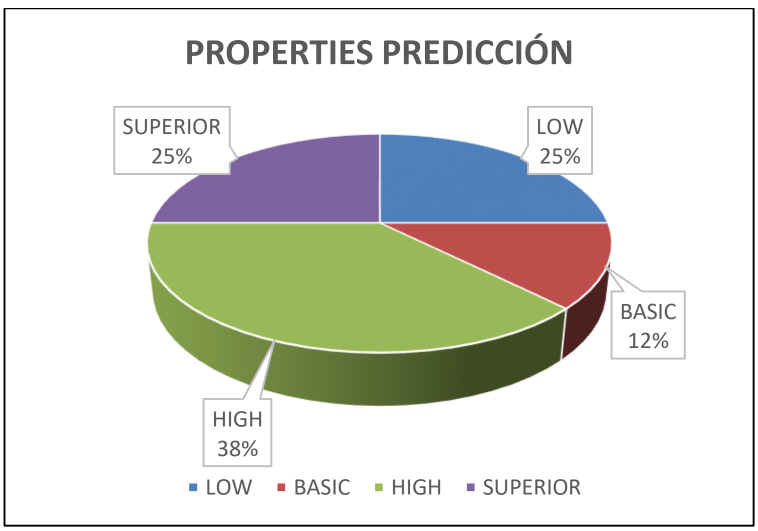
5.3 Moment 3: Comparison of the situation pre and post-application of ChemSketch

The information gathered corresponds to "Moment 3": Comparison of the situations pre- and post-application of the application of ChemSketch software. The information gathered is going to be described according to each moment of the didactic sequence and instrument used. First of all the elaboration of structures, secondly, the properties prediction, thirdly report creation, and finally, the use of English. During the description, some information was heard and collected in the log during the discussion of the students while they applied the technological tool.



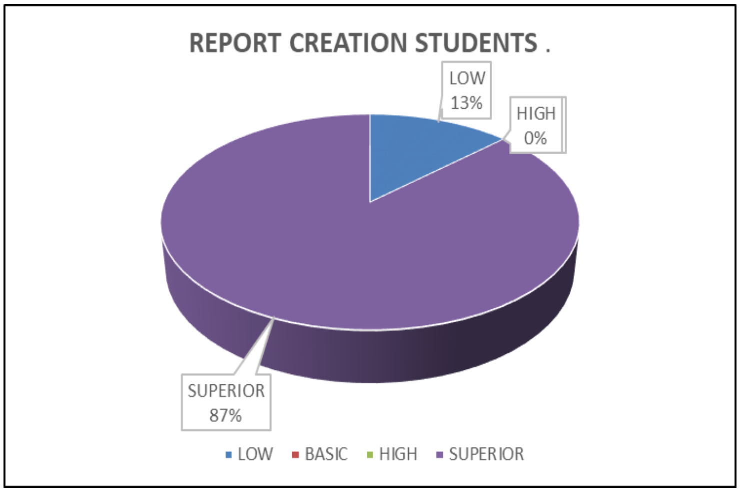
Graph 6: Elaboration of structures after of the application of the didactic sequence

In the final grades of the elaboration of structures after the implementation of the didactic sequence, 69% of students were located in a superior level, 9% in a high-level



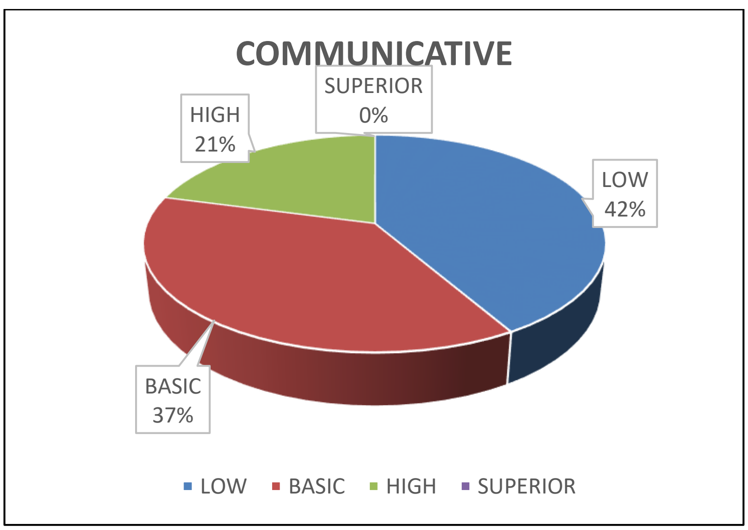
Graph 7: Prediction of properties after of the application of the didactic sequence

In the final grades of the properties prediction after the implementation, 25% of students were located in a superior level, 38 % in basic, 12 % in a basic level while 25% of students were located in a superior level.



Graph 8: Report creation after the application of the didactic sequence

In the case of the report of student's creation, 87% are located in the superior level and, 13% in low level, finally none of the students was located in a basic and low level.



Graph 9: Communicative aspect after the application of the didactic sequence

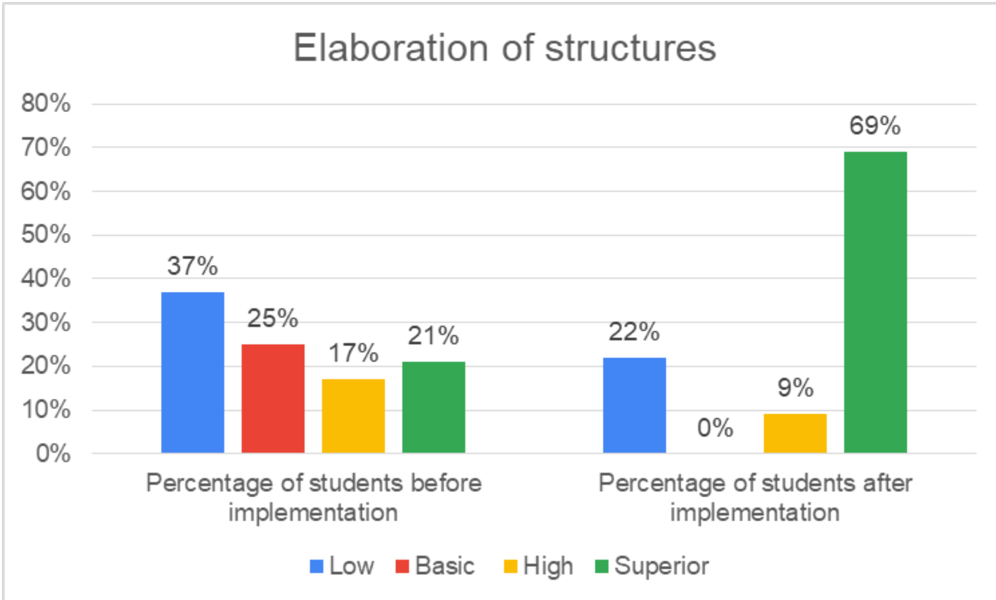
In the communicative dimension, it is possible to observe that 42% of the students were located in a low level, followed by 37% of students located in a basic level, 21% in a high level; finally, none of the students was located in a superior level.

According to the data gathered in each dimension, it is possible to analyze in a comparative way the results before and after the implementation of the didactic sequence.

Comparative chart before and after the implementation of the didactic sequence			
Dimension	**Level**	**Percentage of students before implementation**	**Percentage of students after implementation**
Elaboration of structures	Low	37%	22%
	Basic	25%	0%
	High	17%	9%
	Superior	21%	69%
Prediction of properties	Low	25%	25%
	Basic	54%	12%
	High	21%	38%
	Superior	3%	25%
Report creation	Low	25%	13%
	Basic	25%	0%
	High	50%	0%
	Superior	0%	87%
Communicative	Low	59%	42%
	Basic	33%	37%
	High	8%	21%
	Superior	0%	0%

Table 1: Low: 1.0 to 2.9; Basic: 3.0 to 3.9; High 4.0 to 4.6; Superior: 4.7 to 5.0

Following the data provide in the previous table, a graph of knowledge mobilization was elaborated for each dimension studied in this investigation, so for example



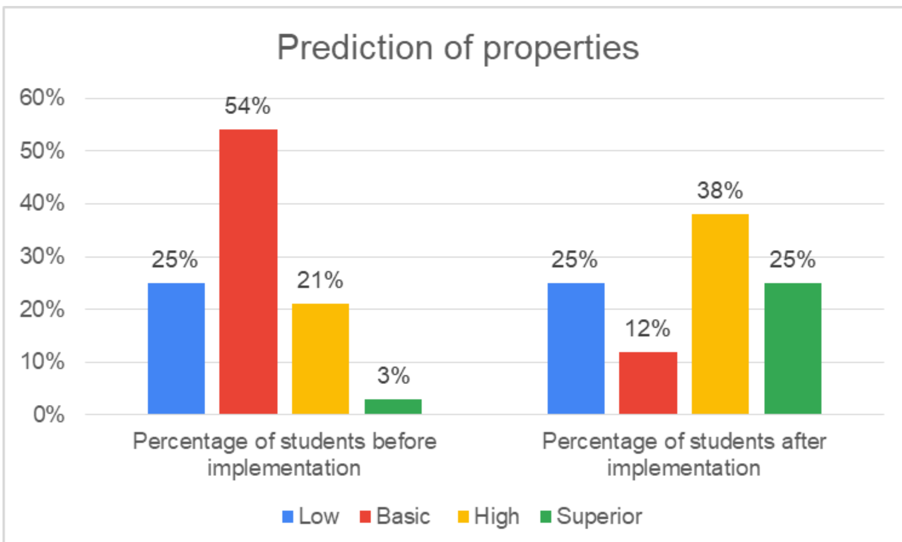
Graph 10: Knowledge mobilization in the dimension of the elaboration of structures

According to the results, the dimensions that showed a great improvement were in chemistry class. This result is related to the activities developed in the planning stage of the didactic sequence in correspondence with the SMAR model in which the students learned the basic management of the software (see annex 1). The dimension of the **Elaboration of Structures** reflected a remarkable improvement showing a positive change since 21% of the group was at a high level before the implementation compared to 69% after the implementation. In the other categories of analysis, the percentages decreased, thus contributing to the higher level. According to Maarebia, et.al (2020) Chemsketch as a computer-based learning media is software for modeling and visualizing the structure of chemical compounds, a fact that allowed students to identify clearly the different forms of hybridization in saturated, unsaturated, and aromatic hydrocarbons (see annex 2). Another aspect was the ability to convert between developed, semi-developed, and condensed formulas with the added value of being able to visualize them in 3D in an optimized way (see annex 3). Li, et. al (2004) insist that ChemSketch templates are the most powerful and easy to use, therefore, a great acceptance of the use of the tool by students could be noted.

Based on those ideas, from the isomeric perspective, great progress was found in understanding the creation of positional and chain isomers and, to a lesser extent, functional isomers (see annex 4). During the application of the didactic sequence, some difficulties could be identified to carry out the transition of functional groups from one compound to another given its heteroatom nature. The chemical structure drawing software used by students is specialized in the information, editing, processing, and rendering of chemical structures making use of the elements of the periodic table and organic radicals (Marpaung & Siregar, 2020). Finally, the use of the IUPAC standards to name hydrocarbons was improved due to the exercise that the students carried out when comparing the name generated by them manually and in Spanish with the name generated by the software in English (see annex 5). This exercise became the starting point for practicing the pronunciation of radical names and organic functions in the classroom.

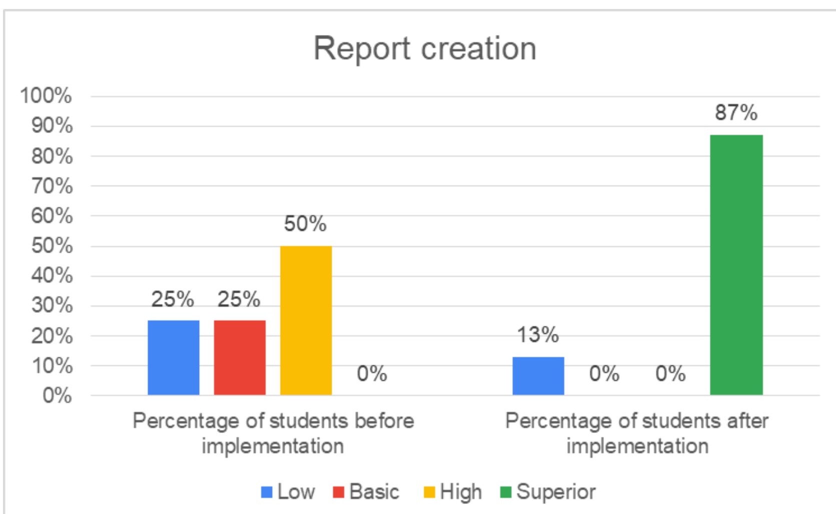
Other experiences in the classroom were, for example, students had to introduce themselves to their classmates indicating their full name, age, name of the institution and the subject for which they were doing the work. Many were embarrassed to do it in front of their classmates because the laughter and comments were immediate, however little by little an atmosphere of respect and trust was created to participate in the class. On the other hand, the pronunciation of the bioelements was a very interesting exercise because the pronunciation errors were discovered and corrected, at this point the fundamentals of phonetics acquired during the linguistics course were key. Comments such as: it took me a long time to do it but I did it, I know I should practice more at home, I don't like English but I know that it provides better opportunities for those who speak it and I like chemistry and software, but I don't like English very much were some of the most common comments of the students during the classes. In sum, during the application of the proposal, it was necessary to make the curriculum more flexible in order to respond to the performance of the students, respecting the process that each one carried out in the subject.

In relation to the **Prediction of Properties,** the data reveals positive results after the implementation of the didactic sequence. Before the implementation, students were located as follows: 25% low, 54% basic, 31% high, and 3% superior. Comparing the results after the implementation showed that 25% of the students remained in a lower level, 12% in basic, 38% in high, and 3% in a superior level.



Graph 11: Knowledge mobilization in the dimension of prediction of properties

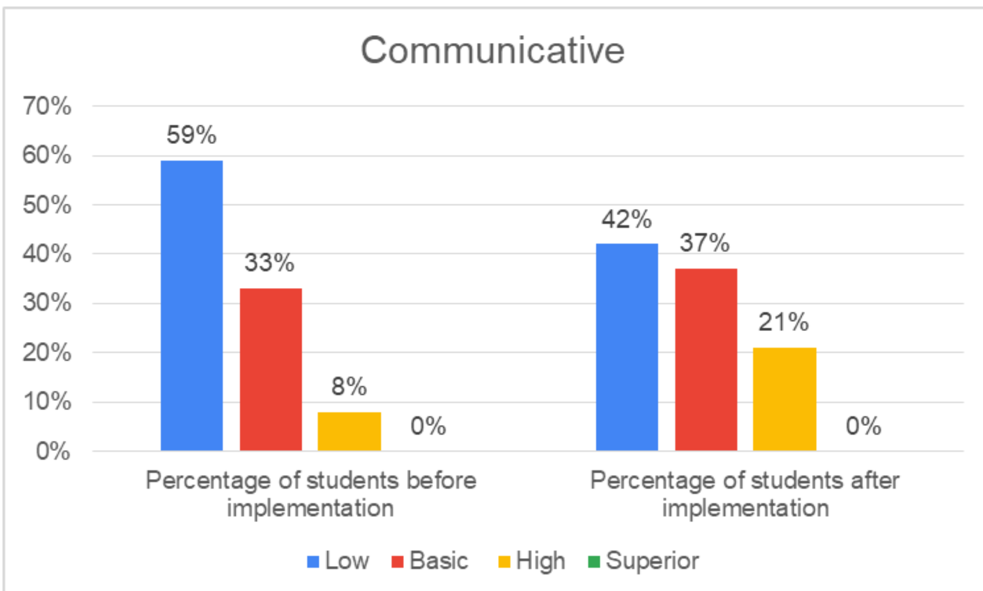
The foundations for these results lie in understanding the general mechanisms of substitution, elimination, and elimination reactions. In the case of alkanes and aromatic compounds, students can understand, among others, the halogenation and nitration reactions (see annex 6), preserving the stoichiometric proportions and identifying the characteristic reactivity orders of each compound. On the other hand, in the case of unsaturated hydrocarbons (alkenes and alkynes), the identification of the π bond as the center of attack allowed us to understand the formation of new substances such as alcohols, a topic that served to promote the generation of ideas regarding their consumption. As Pongkendek, et.al (2021) points out, the difficulty of learning chemistry from students is based on the presentation of learning material that does not involve situations that are useful in the context of the students. The researcher professor was able to recognize in his students a good level of acceptance towards the use of the tool since it is very intuitive, it occupies little space in the storage units of the computers, tutorials are found on the network for its easy handling, it does not require machines high performance. This made it possible for students who had a PC at home to download the software and work independently and with their peers without being conditioned by a grade. Additionally, the pedagogical transposition between IUPAC nomenclature in English and Spanish was very interesting because through this exercise the students were able to start the integration of knowledge. The use of the technological tool goes beyond technicality, since its pedagogical sense to achieve the connection between the chemical substances that are created with the tool and its relationship with situations of daily life or other contexts.



Graph 12: Knowledge mobilization in the dimension of report creation

In relation to the student's creation report the statistic showed that a big part of the group improved in this dimension increasing from 0% to 87% the percentage in a higher level. As an effect of this behavior, the rest of the categories of analysis decreased. Low 25% to 13%, basic 25% to 0% and high 50% to 0%. To be coherent with the issues of this dimension, students presented elaborate structures made on paper or in other materials but with defects in the spatial arrangement of the atoms or in the bond angles among other important characteristics (see annex 7). However, the teacher-researcher recognized the potential of his students to make more and better molecular models. This attribute of the group was capitalized through the use of the software and its ability to generate files in different formats and share them through the use of educational platforms in a simple way with their peers and with the teacher. These advances can be supported from multiple perspectives; however, the most accurate is proposed by Puentedura (2006) in his SMAR model, who considers four levels of new technology integration with varying impacts on the changes in the teaching-learning process. At the substitution level, students changed the traditional ways of preparing their tasks in chemistry for the use of digital models created with the tool. At the augmentation level, the students were able to optimize their digital creations with the 3D viewer with functional improvements in the use of the tool consolidating the enhancement process. On the other hand, at the modification level, the technological tool allowed redefining the way in which learning is generated and shared in chemistry class. It should be noted that the platforms for collaborative work were key to enriching the way students interact. For instance, the use Voice Thread allowed the students to work in pairs, upload their models and talk about them in a more private way, then through Google meet they shared how they felt in the activity, if they liked it or not and what suggestions they left for future activities. Finally, the evidence shows little progress at the level of redefinition, however, the first approach to this superior state of tool use was the relationship that students were able to establish between stereoisomers and their clinical applications.

Finally, the communicative dimension had the least impact; statistics showed stability thus 12% of the students remain at a lower level before and after the implementation. At the higher level, there were no students either before or after the implementation of the didactic sequence. On the other hand, the most remarkable fact is that students passed from 8% at a high level to 21% after the implementation. The rest of the group passed from 33% to 37% in a basic level and 59% to 42% in a low level.



Graph 13: Knowledge mobilization in the communicative dimension

This is the most complex dimension of this study because due to the monolingual and public nature of the school and its context, the student population comes from vulnerable communities where the use of English is very limited or almost non-existent. The main challenge of this research was to implement an integrative pedagogical proposal that would make us reflect on the need to promote essentially bilingual approaches (Marsh (2012); Kerr (2019)). The first step towards promoting communicative competence was to return to basic aspects of English seen during high school to take into account the progressive development of communicative competence in English throughout grades 6th to 11th establishing short conversations in which students provide information about themselves, about people, places, and opinions about science (MEN, 2018). It was an exercise that allowed us to identify major pronunciation and grammatical problems in addition to the negative attitudes towards the use of the foreign language in classes other than English.

To begin the discussion of this point, it is necessary to mention that at the curricular level, English has an intensity of three hours a week in secondary education and two in primary. Additionally, the majority of basic primary teachers do not have training in English or as English teachers. That was the first barrier that had to be overcome by the students when the proposal was socialized. Comments and questions such as: “Chemistry in English? Is this a bilingual school?” ”We don't understand chemistry in Spanish, much less in English" and so on, were expressed by the students. However, the professionalism with which the research teacher handled this situation led his students to accept the proposal and make it a meaningful experience. English is the most widely used foreign language internationally as a medium of instruction in fields such as business, health, social media, politics and education. Progressive learning presented in a foreign language in communities where it is rare to talk about it, can have a great long-term impact if these types of initiatives are increasingly embraced by teachers of other subjects (Firmayanto. et al, 2020).

The motivation was an emerging and implicit aspect of the use of the technological tool since the latter challenged students to become familiar with the technical vocabulary that is only found in English and on the other hand, the concerns are generated by using scientific vocabulary to communicate between peers.

Dörnyei (2003) states that motivation is an intrinsic aspect of human nature, responsible for determining behavior, empowering it, and guiding it to reach achievements. Motivation plays a very important role in the achievement of student learning outcomes since it can stimulate, or not, interest and participation in learning activities of students. Based on these ideas, the teacher-researcher resorted to the use of useful expressions, and didactic and authentic material in English in order to motivate students to overcome fears and enjoy the pedagogical proposal. After achieving a more comfortable school climate for students, along with the advancement of organic chemistry content, the software was presented, which generated a high level of interest. The molecular models made by the students before the didactic sequence served to promote interaction between pairs narrating everyday situations or their own experiences using scientific knowledge. Although there was a respectful environment in the classroom, the use of English continued to lag behind. Finally, tasks and exams were assigned with a little more formality to determine if the indicators proposed in the didactic sequence were achieved and to what extent (see annex 8).

As a conclusion, statistics showed that most dimensions evaluated were affected positively after the implementation of the didactic sequence. In general terms, the dimension of elaboration of structures was the most outstanding one, followed by the report creation and prediction of properties. The communicative dimension had a small change during the implementation of the didactic sequence, which was understood taking into account the preparation of human talent, organizational resources, and educational policies dissonant with the realities of the context of public education.

5.0 CONCLUSIONS

The following conclusions correspond to a critical look at the implementation of the ChemSketch software in the subject of organic chemistry under mainstreaming approach. Based on the results found during this investigation, it is possible to affirm that the implementation of the didactic sequence, based on the application of the technological tool ChemSketch, resulted in a useful strategy to help the students of the participating groups to improve their knowledge in organic chemistry. And, to a lesser extent, interactions with the use of English.

When students in their last year of high school are provided with the necessary technological resources for better performance in their learning process, they will use the most relevant functions of the technological tool to advance in the understanding of concepts and theories of organic chemistry. In turn, the students will develop a higher level of familiarity with English because the software is only in this language and it is necessary for them to understand the vocabulary, practice the pronunciation and develop expressions that allow them to make their opinions known referring to a scientific situation.

The dimensions selected in both subjects were key to achieving the objectives of this research. For its part, the elaboration of organic structures and the properties derived from them allowed the creation of an optimal learning environment mediated by technology, which resulted in a high level of motivation for the pedagogical proposal. Additionally, the students improved their pronunciation and overcame the barriers to the target language with a certain degree of self-consciousness. The connection of chemical concepts with situations typical of the students' daily lives was key to involving the learning of English as a foreign language.

It was possible to notice an improvement in most of the skills analyzed during the implementation of the didactic sequence. Therefore, it was observed that the application of the software provided students with a new horizon in which the learning of chemistry and a foreign language was more dynamic and meaningful. Firstly, the transcendence of traditional methods for teaching chemistry towards avant-garde and integrative models such as SMAR and CLIL had an unprecedented response in the institution. Secondly, the use of the L2 in the exercise of trying to explain every day and emerging situations of the use of the tool allowed a redefinition of the importance of the use of language.

On the other hand, the stages proposed by the methodology based on action research were relevant and adjusted to reality. , maintaining a logical and sequential order, taking into account the interests and needs of the students. In accordance with the above, the teacher-researcher had the opportunity to critically reflect on their own practices in order to strengthen them and thus improve the performance of their students in an integral way. Own practices in order to strengthen them and thus improve the performance of their students in an integral way. The students of the La Esperanza School lack pedagogical spaces where the use of technology and L2 is promoted, which is why transversal initiatives such as this one motivate the rest of the educational community to overcome paradigms that do not allow the institution to move towards the 21st-century skills.

The elaboration of this research represented one of the greatest challenges in his career as a teacher due to the contextual factors that surrounded this research. The reality of teaching English in public schools in Colombia, being able to motivate students to use the language outside of English classes and integrate the use of technology through specialized software for chemistry was really a significant experience. Nowadays, this is reflected in the subsequent pedagogical practices of the teacher, even with natural science students in lower grades who have already begun to use simulators for science learning and to practice using the language outside the English classroom.

In conclusion, the selective use of ICT in the chemistry classroom provides students with the opportunity to learn in a meaningful and cross-cutting way in the face of the challenges of a globalized world where knowledge is built collaboratively and is disseminated mainly through communication use of English.

6.0 RECOMMENDATIONS

- In relation to the use of the technological tool for the teaching of chemistry, it is necessary to improve the installed capacity of the computers in the institution since the existing ones are only used for computer science classes.
- It is necessary to promote the use of English in different subjects from the first years of schooling, which implies modifications at the curricular level and an enormous effort to train teachers in L2.
- It could be useful to create transversal projects that articulate the contents of the English subject with the dynamics of the school, for example, sports and cultural events that involve the families of the students.
- To make the use of ChemSketch more effective, it is necessary that teachers of lower levels know the software and apply it in their classes, because it not only serves to teach organic chemistry, it also serves to teach the periodic table and chemical bonds among others.

7. References

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8. Annexes

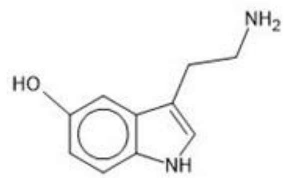
Annex 1: photographic evidence of the implementation

Annex 2: Molecular designs and its properties

Name : juan manuel sanchez ruiz

Molecular Formula: $C_{10}H_{12}N_2O$

Formula Weight: 176.21508

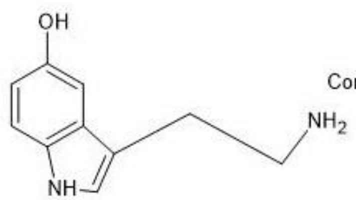


Composition: C(68.16%) H(6.86%) N(15.90%) O(9.08%)

3-(2-aminoethyl)-2,3-dihydro-1*H*-indol-5-ol

Molecular Formula: $C_{10}H_{12}N_2O$

Formula Weight: 176.21508

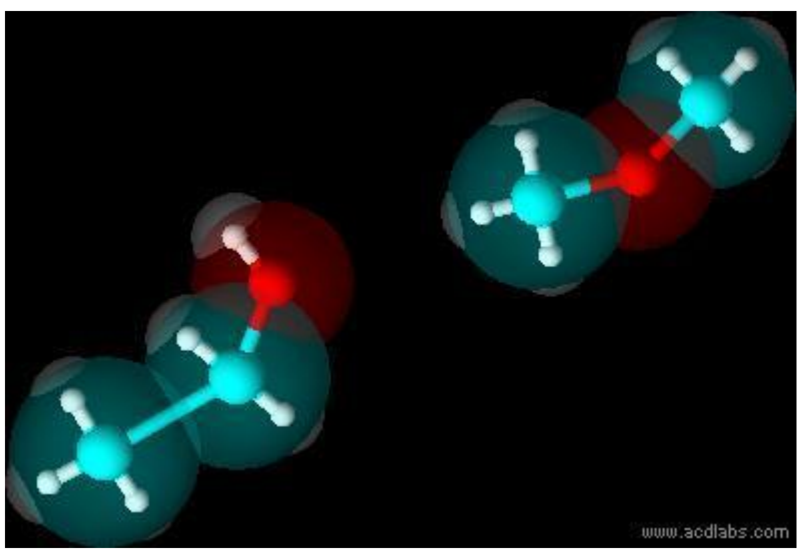


Composition: C(68.16%) H(6.86%) N(15.90%) O(9.08%)

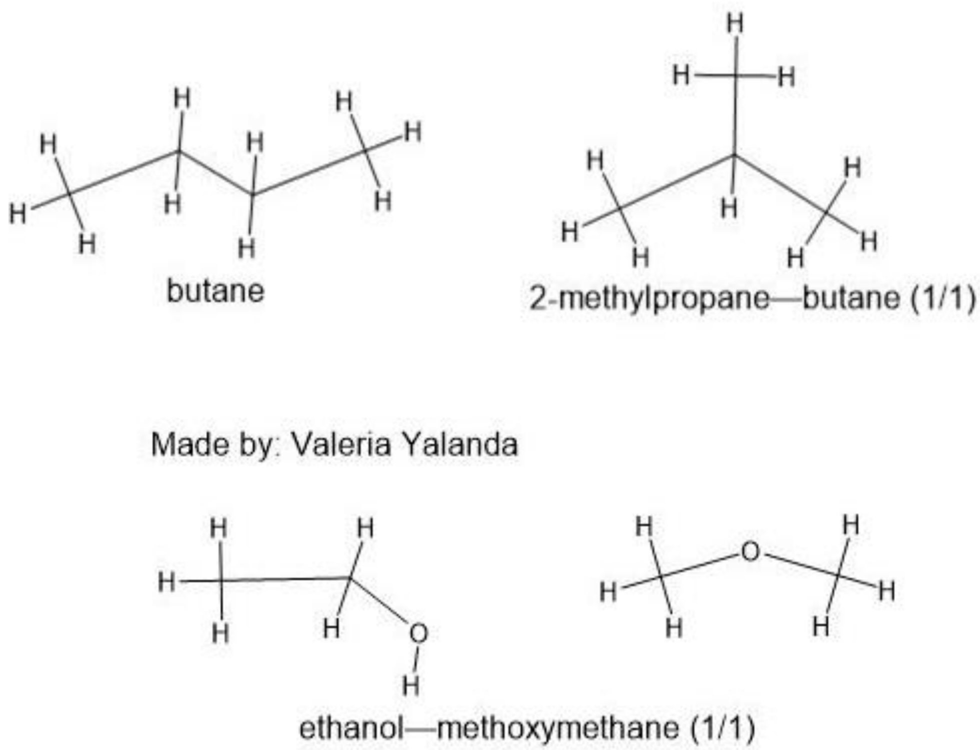
NICOLLE TAMAYO

3-(2-aminoethyl)-1*H*-indol-5-ol

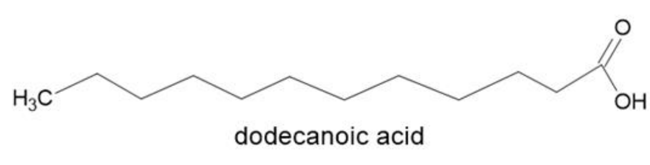
Annex 3: 3D optimization sample



Annex 4: Structural and functional isomers sample

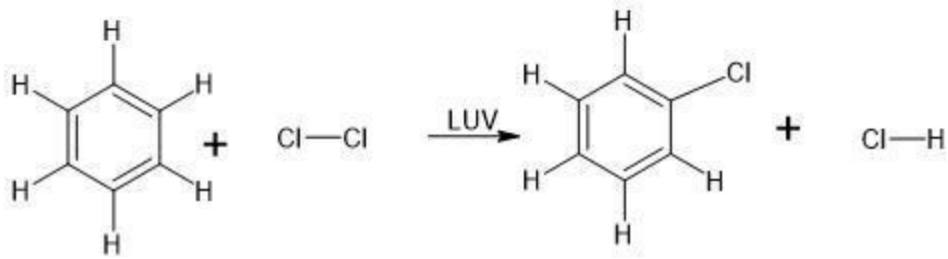


Annex 5: comparison between hand model and digital model



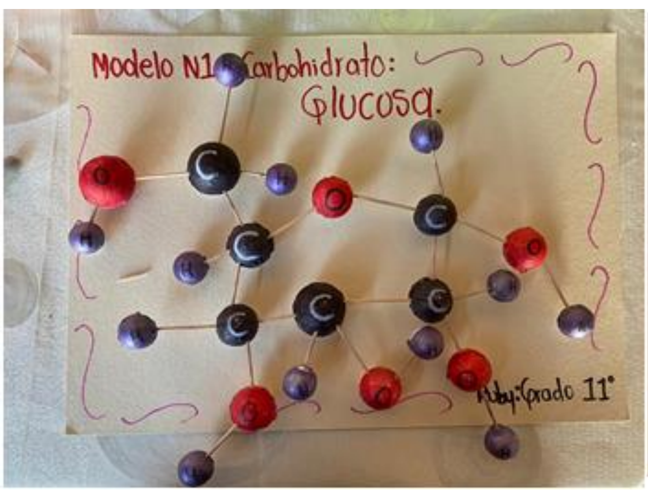
Annex 6: aromatic reactions

Name : Sebastian Benavidez



Chlorination of benzene

Annex 7: Biomolecules models



Annex 8: Speaking about biomolecules