INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTS) IN THE TEACHING-LEARNING OF ORGANIC CHEMISTRY

Linda Mariuxi Flores Fiallos\textsuperscript{1}, Adriana Isabel Rodríguez Basantes\textsuperscript{2}, María Augusta Guadalupe Alcoser\textsuperscript{3}, Paul Marcelo Manobanda Pinto\textsuperscript{4}, Mishell Andrea Collaguazo Fiallo\textsuperscript{5}, Selena Alexandra Coronel Parra\textsuperscript{6}, Juan José Flores Fiallos\textsuperscript{7}

\textsuperscript{1}ESCUELA SUPERIOR POLITECNICA DE CHIMBORAZO (ESPOCH). Facultad de Ciencias, linda.flores@espoch.edu.ec
\textsuperscript{2}ESCUELA SUPERIOR POLITECNICA DE CHIMBORAZO (ESPOCH). Facultad de Ciencias, adriana.rodriguez@espoch.edu.ec.
\textsuperscript{3}ESCUELA SUPERIOR POLITECNICA DE CHIMBORAZO (ESPOCH). Facultad de Ciencias
\textsuperscript{4}Universidad Estatal Amazónica. Facultad de Ciencias de la vida, pmanobanda@uea.edu.ec.
\textsuperscript{5}Investigadora Independiente, lu_94lu@hotmail.com.
\textsuperscript{6}Investigador Independiente, coronel.selenaa@gmail.com.
\textsuperscript{7}Investigador Independiente, juanjof2016@gmail.com.

Abstract
A documentary review was carried out on the production and publication of research papers related to the study of the variables Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry. The purpose of the bibliometric analysis proposed in this document was to know the main characteristics of the volume of publications registered in the Scopus database during the period 2018-2022, achieving the identification of 160 publications in total. The information provided by this platform was organized through graphs and figures categorizing the information by Year of Publication, Country of Origin, Area of Knowledge and Type of Publication. Once these characteristics have been described, the position of different authors towards the proposed theme is referenced through a qualitative analysis. Among the main findings made through this research, it is found that the United States, with 60 publications, was the country with the highest scientific production registered in the name of authors affiliated with institutions in that country. The Area of Knowledge that made the
greatest contribution to the construction of bibliographic material referring to the study of Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry was Chemistry with 160 published documents, and the Type of Publication that was most used during the period indicated above was the Journal Article with 105 documents of the total scientific production.
Keywords: Information and Communication Technologies ICTs, Teaching-Learning Process, Organic Chemistry.

1. Introduction

One of the fundamental aspects to take into account when selecting the content of a subject or course is the way in which students will be presented with the information they must learn or memorize to achieve new skills and abilities that allow them to advance towards more complex topics. Although in some cases it is easier due to the characteristics of the information, after the health emergency experienced as a result of exposure to COVID-19 it was more than proven that as long as there is creativity it is possible to adapt any information to the use of technological tools that capture the attention of the student and meet the expectations of the teacher.

In general, the use of technologies called Information and Communication ICTs is made in educational processes, which according to Julio Cabero could be defined as follows:

They revolve around three basic media: computing, microelectronics and telecommunications; but they revolve, not only in isolation, but what is more significant in an interactive and interconnected way, which allows to achieve new communicative realities. (Cabero, 1998)

Although in the past the use of these technologies may have been complex, today there are a variety of alternatives that facilitate the communication and dissemination of multidisciplinary information essential for the training of competent professionals. In the specific case of organic chemistry it is no different since it can be considered overwhelming by the number of names, reactions and compounds that compose it and that must be analyzed in detail by whoever has chosen it as an object of study. "The term or orgánico literally means "derived from living organisms" (Wade, 2017) so at the beginning it was stated that "the science of organic chemistry was responsible for the study of compounds extracted from living organisms and their natural products. Compounds such as sugar, urea, starch, waxes and vegetable oils were considered "organic". (Wade, 2017)

Due to the complexity of Organic Chemistry, teachers are expected to be trained to provide students with access to information in an updated way and as far as possible through simple mechanisms or tools that are
related to the emphasis chosen by the teacher in order to facilitate the understanding of terms, formulas and instructions that subsequently guarantee an effective solution of problems. Taking into account the above and in order to meet our general objective, this research article seeks to describe the main characteristics of the set of publications attached to the Scopus database and that are directly related to the variables Information and Communication Technologies ICTs in Teaching – Learning of Organic Chemistry as well as the description of the position of certain authors affiliated with various institutions during the period between 2018 and 2022.

2. General objective

Analyze from a bibliometric and bibliographic perspective, the elaboration of works on the variables Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry during the period 2018-2022.

3. Methodology

This article is carried out through a mixed orientation research that combines the quantitative and qualitative method.

On the one hand, a quantitative analysis of the information selected in Scopus is carried out under a bibliometric approach of the scientific production corresponding to the study of Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry.

On the other hand, examples of some research works published in the area of study indicated above are analyzed from a qualitative perspective, starting from a bibliographic approach that allows describing the position of different authors against the proposed topic.

It is important to note that the entire research was carried out through Scopus, managing to establish the parameters referenced in Figure 1.

3.1 Methodological design

Figure 1. Methodological design

Source: Authors.
3.1.1 Phase 1: Data collection

Data collection was executed from the Search tool on the Scopus website, where 160 publications were obtained from the choice of the following filters:

- information AND communication AND technologies AND teaching AND learning AND process AND organic AND chemistry AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) ) AND (LIMIT-TO (SUBJAREA, "CHEM"))

- Published documents whose study variables are related to the study of Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry.
- Limited to the years 2018-2022.
- No limit of countries.
- Limited to Chemistry.
- Regardless of type of publication.

3.1.2 Phase 2: Construction of analysis material

The information collected in Scopus during the previous phase is organized and subsequently classified by graphs, figures and tables as follows:

- Co-occurrence of Words.
- Year of publication.
- Country of origin of the publication.
- Area of knowledge.
- Type of Publication.

3.1.3 Phase 3: Drafting of conclusions and outcome document

In this phase, we proceed with the analysis of the results previously yielded resulting in the determination of conclusions and, consequently, the obtaining of the final document.

4. Results

4.1 Co-occurrence of words

Figure 2 shows the co-occurrence of keywords found in the publications identified in the Scopus database.
The data in Figure 2, exported from Scopus, shows us our variables and their relationship with other terms which we will explain below.

Organic Chemistry, like any area of study, has undergone changes that have led to the adaptation of Technologies that facilitate the Teaching-Learning process of which teachers and students are part. For this reason, we can observe terms such as molecular modeling, multimedia-based learning, computer, on websites with cooperative collaborative characteristics, which have undoubtedly allowed the obtaining of theoretical and instructive premises to be carried out almost automatically, improving student participation and performance.

4.2 Distribution of scientific production by year of publication

Figure 3 shows how scientific production is distributed according to the year of publication.

Source: Own elaboration (2023); based on data exported from Scopus
In figure 3 we find the scientific production concerning the variables Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry during the period between 2018 and 2022 at the Latin American level, which resulted in the publication of 160 documents, in the Scopus database, containing the keywords. Likewise, it is evident that some changes were experienced throughout the period. We started with the year 2018 with 13 documents, a number that increases during the following years reaching the highest number of publications in 2021 with 51 documents. However, in the last year it is characterized by the decrease in the figure reaching 38 texts.

From the year 2021, the article entitled "Game-based learning and just-in-time teaching to address misconceptions and improve safety and learning in laboratory activities" stood out, (Borreguero, et al., 2021) confirming the effectiveness of implementing new learning methods based "on serious games along with just-in-time teaching strategies by offering six different questionnaires to assess students' knowledge" on safety issues and theoretical concepts and protocols of laboratory exercises" (Borreguero, et al., 2021) from the high grades obtained by the students before starting their visits to the laboratory, emphasizing the importance of knowing the safety standards of the same and the theory before starting the practice.

4.3 Distribution of scientific production by country of origin.

Figure 4 shows how scientific production is distributed according to the nationality of the authors.

**Figure 4. Distribution of scientific production by country of origin.**

![Distribución de la producción científica por país de origen](image)

Source: Own elaboration (2023); based on data provided by Scopus.

In the study of Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry, the United States leads
the list of published documents with a total of 60 records in the Scopus database during the period of the years 2018-2022, followed by the United Kingdom and Germany with 26 and 19 documents respectively.

From the year 2022, the article "Reading is the challenge—Perspectives of the 100-day reading challenge, 100 articles in chemistry education research(Gallardo-Williams, Graulich, Rost, & Schultz, 2022)" presents the results of a novel challenge published on Twitter that had as "goal of reading 100 articles in 100 days attracted the attention of several members of the research community in chemical education(Gallardo-Williams, Graulich, Rost, & Schultz, 2022)". In general, the most recurrent themes of these articles were "focused on students, learning and chemistry, with emphasis on the validity of research and the role of technology in the teaching of chemistry". (Gallardo-Williams, Graulich, Rost, & Schultz, 2022)

At this point, it is important to note that the preparation of scientific publications in many cases is carried out from collaborations that may involve private and/or public institutions from one or more countries. Therefore, the same publication can be linked to one or more authors with different nationalities and thus to more than one country simultaneously, being part of the total number of articles or publications of each of them in the final sum. Next, in Figure 5, you will see in greater detail the flow of collaborative work carried out by several countries.

**Figure 5. Co-citations between countries.**

Source: Own elaboration (2023); based on data provided by Scopus.

Figure 5 shows the grouping of research according to the collaboration between authors belonging to various international institutions. There is evidence of outstanding participation among authors affiliated with
institutions in the United States, United Kingdom, Italy, Spain, Brazil, Japan, India, among others.

4.4 Distribution of scientific production by area of knowledge

Figure 6 shows the distribution of the elaboration of scientific publications from the area of knowledge through which the different research methodologies are implemented.

**Figure 6. Distribution of scientific production by area of knowledge.**

Due to the nature of our variables and the repercussions they can generate in an entire community, it is not surprising that most of the publications found in the Scopus database, on these are made from chemistry occupying the main position in the publication of documents. Other areas such as social sciences and chemical engineering have contributed to the study of these variables, publishing 72 and 28 papers respectively.

As we can see in Figure 6, the variables object of this study are relevant in various areas of knowledge, since they can be analyzed from the different approaches that emphasize the influence that Information and Communication Technologies (ICTs) have in today's life.

4.5 Type of publication

In the following graph, you will observe the distribution of the bibliographic finding according to the type of publication made by each of the authors found in Scopus.
Figure 7. Type of publication.

<table>
<thead>
<tr>
<th>Tipo de Publicación</th>
<th>Artículo</th>
<th>Revisión</th>
<th>Libro</th>
<th>Libro Capítulo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artículo</td>
<td>105</td>
<td>39</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: Own elaboration (2023); based on data provided by Scopus.

Figure 7 clearly shows that the predominant type of publication in the study of Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry was the journal article with a total of 105 documents. In second place, the reviews are located with 59 documents followed by the book with 10 publications.

The article called "The effect of smart-pbl learning strategy and academic self-regulated learning on metacognitive and problem-solving skills in chemistry learning" in which it is ensured that "metacognitive and problem-solving skills are affected by students' academic self-regulated learning (ASRL)(Kamdi, Kuswandi, Setyosari, Ulfa, &; Utami, 2020)" (Kamdi, Kuswandi, Setyosari, Ulfa, &; Utami, 2020) so we wanted to know more about the effects that the use of augmented reality technologies would cause in these skills, specifically SMART-PBL, which was modified by the Problem-Based Learning (PBL) strategy, which helped Augmented Reality technology as a visual medium. Managing to conclude that implementing this technology "not only improves metacognitive and problem-solving skills, but also evokes creative and critical thinking, communication and scientific reasoning skills that appear in students" (Kamdi, Kuswandi, Setyosari, Ulfa, &; Utami, 2020).

5. Conclusions

From the bibliometric analysis carried out in the present research work, it was possible to establish that the United States is the country with the highest number of records published in the face of the variables Information and Communication Technologies ICTs in the Teaching – Learning of Organic Chemistry with a total of 60 publications, each, in
Scopus database during the period 2018-2022 and that the area of knowledge with the greatest contribution was chemistry with 160 texts.

After reviewing the bibliography found in the Scopus database, we can conclude that the use of Information and Communication Technologies ICTs have been fundamental in the teaching-learning processes of Organic Chemistry, since it has managed to capture and maintain the motivation and attention of students through mechanisms that make the interaction between the parties involved more flexible. Likewise, in the article "Challenges of digitalization in education focused on chemical areas" (de la Peña, Fuentes García, Pérez Yera, Prado Salazar, & Rodríguez López, 2022) it is ensured that:

Using ICT for the teaching of chemistry allows the student to be in contact with a virtual environment, where it will allow him to develop practical skills, ranging from the basics such as knowledge of laboratory materials, to the most specialized such as making a determination of the yield of a chemical reaction. For this, virtual platforms have been identified, where practices similar to those carried out in person in a chemical laboratory are carried out. (de la Peña, Fuentes García, Pérez Yera, Prado Salazar, & Rodríguez López, 2022)

Due to the wide variety of Information and Communication Technologies that exist and that can be used in educational processes, their implementation by teachers has been significant allowing the achievement of high levels of satisfaction when evaluating the knowledge shared with their students. Hence, "100.0% of teachers in training state that they would like other subjects to use this type of activities as a means of supporting the teaching-learning process". (Barajas Perea & Gutierrez Mosquera, 2019) For this reason and in order to continue generating awareness of the importance of guaranteeing access to this type of information in a transparent way by anyone, we hope to promote with this article the participation of scientific communities in the study of these variables from any scientific profile and area of knowledge always seeking to provide more alternatives that contribute to the research of topics of general interest.

Bibliography


