

## Trends of Course Based Undergraduate Research Experiences: A Bibliometric Analysis

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**Abstract:** This study aims to provide a bibliometric analysis of course-based undergraduate research experience from 2010-2023. Data were extracted from the Scopus database and analyzed using VOSviewer. A total of 67 related publications were analyzed and mapped. According to bibliometric analysis, course-based undergraduate research experience, inquiry-based learning, and upper-division undergraduate become the center of the topic in the study of course-based undergraduate research experience in chemistry. It also shows that collaborative/cooperative learning, discovery learning, problem-solving/decision-making, first-year undergraduate, organic chemistry, and chemical education research. are among the novel and emerging topics in course-based undergraduate research in chemistry. This research is expected to provide a better understanding of the challenges and opportunities of studying course-based undergraduate research experience in chemistry.

**Keywords:** Bibliometric analysis, Chemistry, Course-based undergraduate research experiences, Trends.

### 1. INTRODUCTION

Course-based undergraduate research experiences (CUREs), by definition, are learning experiences in which an entire class of students answers a research question or problem with an unknown outcome or solution (Watts & Rodriguez, 2023). The first description of research-based lectures in undergraduate programs is from Fromm (Fromm, 1956), which describes Mount Mercy College's transformation of chemistry seminar courses to include laboratory sessions in which students conduct publishable research. Since then, there has been an increase in the development of research-based lectures (CUREs), especially in biology and chemistry, and the debate over what CURE is and how CUREs can be seen in its form of laboratory learning (Alaimo et al., 2014; Auchincloss et al., 2014; Fukami, 2013).

To date, CUREs have primarily been used in laboratory programs. There is a consensus on CUREs in natural science (e.g., biology, chemistry, physics, mathematics, earth, and planetary science) laboratories. The CUREs have five defining characteristics: 1) There is an element of discovery, so students work with new data. 2) Iteration is built into the lab. 3) Students engage in a high level of collaboration. 4) Students learn scientific practice. 5) This topic is so widely relevant that it has the potential to be published as a research scientific article (Auchincloss et al., 2014).

CUREs differ from traditional experiments (students follow an experiment procedure to confirm known results) and inquiry or discovery-based experiments (students are guided to carry out experiments where the instructor already knows the results while the students do not)

(Blumling et al., 2022; Boyd-Kimball & Miller, 2018; Hosbein & Walker, 2022). CUREs Engage students with authentic research characteristics such as collaboration, iteration, and practice of science in developing hypotheses or research questions, designing methodologies to answer research questions or to prove hypotheses, reviewing key literature, and disseminating results (Buchanan & Fisher, 2022; Watts & Rodriguez, 2023)

## 2. LITERATURE REVIEW

Bibliometrics is the quantitative analysis of academic publications by identifying the most influential researchers and publications. Bibliometrics are essential for pointing out gaps in research topics (Tomaszewski, 2023). In this situation, consistent bibliometric study over time is vital to give insight and trends of research on the target topic. Thus, bibliometrics helps researchers understand the novelty of the investigated topic. Some review has been done in CUREs (Buchanan & Fisher, 2022; Watts & Rodriguez, 2023), but there is a lack of recent bibliometric research related to the CUREs, especially in chemistry.

This study aims to analyze the spread of bibliometric maps and research trends on CUREs in chemistry using VOSviewer. This study is done to guide future studies and help researchers choose appropriate research themes, particularly for studies in the CUREs in chemistry.

## 3. METHODS

This study aims to see trends in the study of CUREs in chemistry. A reliable way of collecting data and appropriate bibliometric methods are identified to achieve this. The framework methodology of this study is adopted from Pan, Xu, and Skare (Pan et al., 2023). Figure 1 shows the framework methodology of the study.

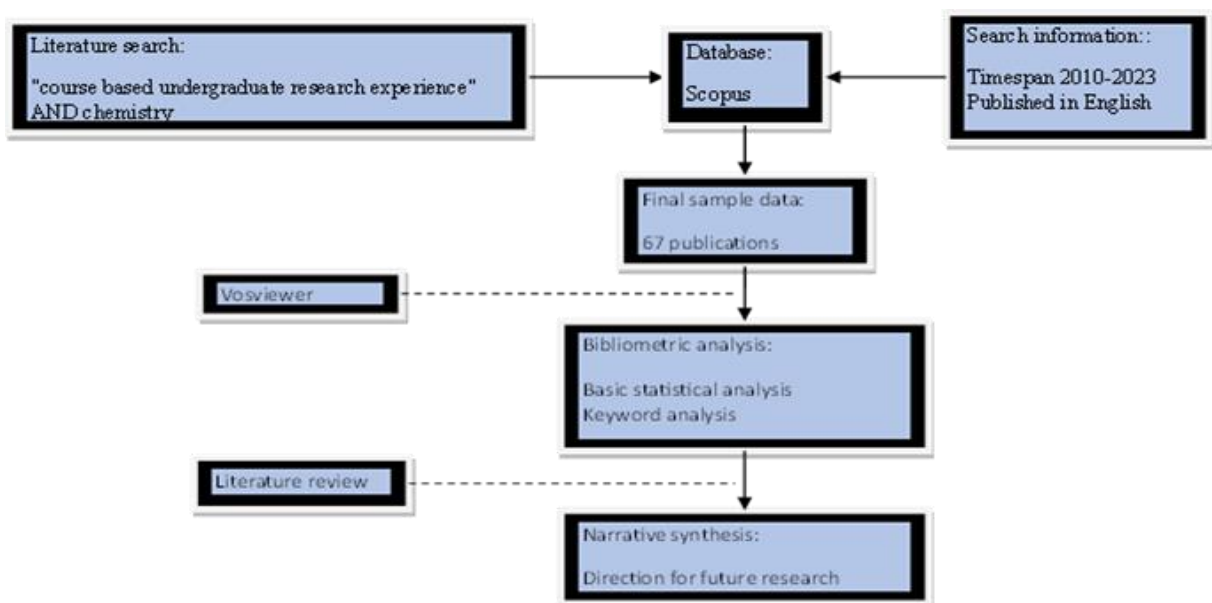


Fig. 1. The methodological framework

## Data collection

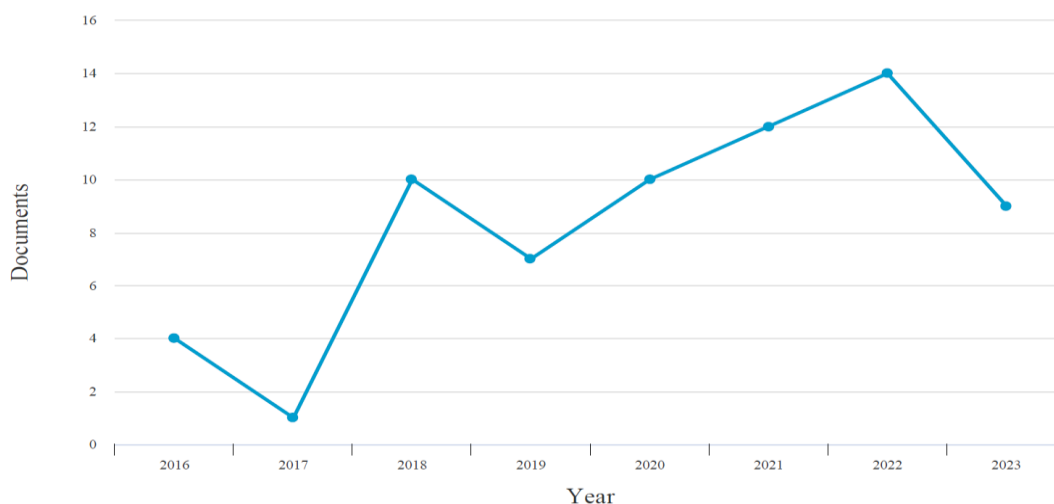
Data were extracted from Scopus because it has a comprehensive and extensive collection of documents (Mongeon & Paul-Hus, 2015; Pan et al., 2023; Pham-Duc et al., 2020). The data collection strategy consisted of a topic search = "course-based undergraduate research experience" AND chemistry; language = English; publication stage = final. This literature materials were obtained on October 20, 2023, and 67 publications were extracted for bibliometric analysis. For analysis using VOSviewer, CSV format file data was extracted.

## Bibliometric analysis

Bibliometric is a mature and practical study to reveal the process of development and knowledge structure of publication. (Diane Cooper, 2015). Based on the bibliometric theory, this study analyses the characteristics of CUREs in chemistry using two procedures: (1) it explores the statistical characteristics of publications consisting of the annual productivity based on recognized bibliometric indicators such as the number of publications, types, and research direction; and (2) it conducts science mapping analysis to reveal the conceptual structure and development trend of publications using VOSviewer (van Eck & Waltman, 2010; Watts & Rodriguez, 2023)

## 4. RESULTS AND DISCUSSION

The number of publications on the topic of CUREs is shown in Figure 2. Fig. 2 shows the increase in publications over time despite a slight decrease in 2023. This result indicates that CUREs in chemistry publications have attracted much attention recently. There are 67 publications related to CUREs in chemistry consisting of article (56), book chapter (6), conference paper (3), editorial (1), and review (1). This finding indicates that articles, book chapters, and conference papers are the main types of research. Figure 3 portrays the distribution of types of publications.



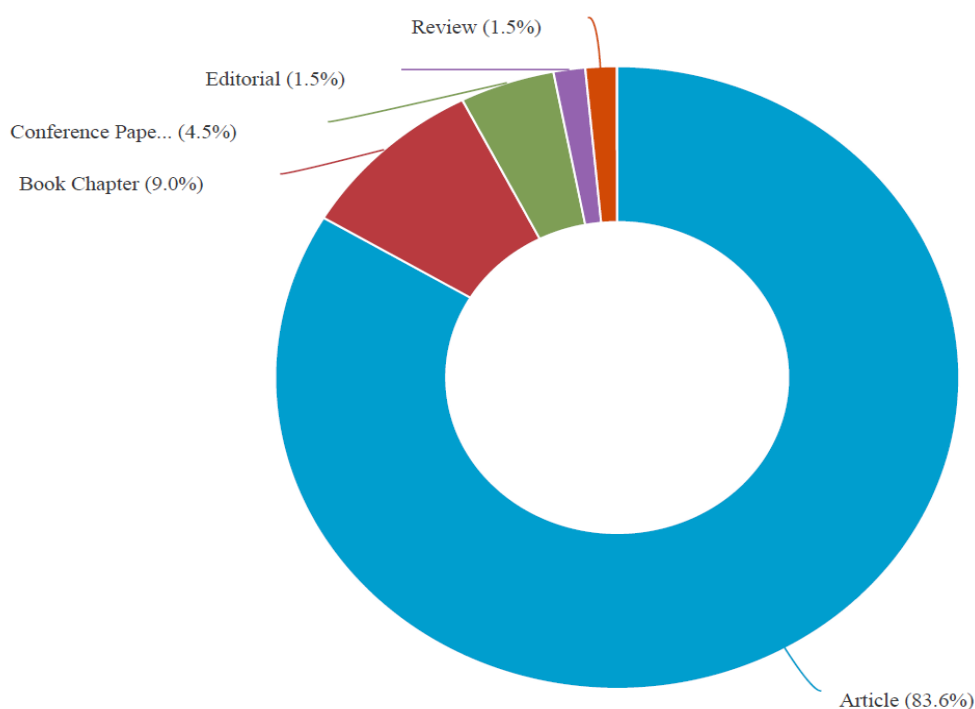
**Fig. 2. Publications regarding CUREs in chemistry**

According to Table 1, the United States is the most productive country. No researcher from Indonesia has published in Scopus regarding the study of CUREs in chemistry.

**Table 1. Number of publications based on country/territory on the topic of CUREs in chemistry**

Country	Freq.
United States	62
Canada	2
Australia	2
United Arab Emirates	1
Qatar	1
Puerto Rico	1
Netherlands	1

A co-occurrence analysis is carried out to determine the conceptual structure of CUREs in chemistry. Figure 4 shows the topics which researchers have done so far. Each topic is connected with lines, which means a relationship among them. The bigger the nodes, the more researchers do such topics (Donthu et al., 2021). As seen in Fig 4, CUREs topic has become the center of the topic regarding the study of CUREs in chemistry. The topic of CUREs is also connected to inquiry-based learning and upper-division undergraduate as the second and third biggest nodes after CUREs, respectively. This finding explains that the study on CUREs is mainly related to inquiry-based learning and upper-division undergraduates. Three clusters represent the three main themes in this study. The first theme is CUREs, inquiry-based learning, second-year undergraduate, and analytical chemistry. The second theme is upper-division undergraduate, laboratory instruction, biochemistry, and chemical education research. The third theme is represented by curriculum, organic chemistry, application of chemistry, and discovery learning.



**Fig. 3. The distribution of types of publications regarding CUREs in chemistry.**



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