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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.

INTRODUCTION

This section serves as an introduction to the concept of Course-Based Undergraduate Research Experiences (CUREs) and emphasizes their significance in the field of chemistry education (Alkaher, & Dolan, 2014). CUREs have become increasingly important in the past decade, playing a pivotal role in advancing inquiry-based learning, collaborative learning, and other active learning strategies for undergraduate chemistry courses (Thiry, & Laursen, 2011). By engaging students directly in research activities, CUREs help develop critical thinking, problem-solving skills, and practical scientific methodologies, bridging the gap between theoretical learning and practical application.

From 2010 to 2023, CUREs have evolved considerably, with a growing trend toward integrating research experiences within standard coursework (Hanauer, Graham, & Hatfull, 2016). These developments are aimed at enhancing students' understanding of scientific processes, as well as promoting active learning. The shift has allowed students to gain hands-on research experience early in their academic journey, fostering an environment where inquiry is encouraged and collaborative problem-solving is a fundamental part of the curriculum.

One of the key benefits of CUREs is their capacity to help students develop strong research skills. Through these experiences, students learn how to design experiments, analyze data, and present their findings effectively, contributing substantially to their academic growth. Additionally, CUREs make research opportunities more accessible to a broader range of students who may not have

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access to traditional research internships, thus democratizing the research experience and allowing for more inclusive academic development.

The relevance of this bibliometric analysis lies in its ability to identify and map the trends in the implementation of CUREs in chemistry, providing insights into how such programs have been incorporated into undergraduate education. By examining the development of CUREs and their impact, the analysis aims to identify best practices, patterns, and emerging themes that have shaped the current landscape of chemistry education.

However, there remain gaps in the literature that need to be addressed, particularly regarding the effectiveness and challenges of CUREs across different institutional settings and demographic groups. Current research on CUREs often lacks a comprehensive understanding of their long-term impact on student learning outcomes, retention in STEM fields, and skill development. Therefore, a bibliometric analysis is needed to systematically review the existing studies and identify areas where further research and improvement are necessary.

In summary, this section highlights the growing importance of CUREs in undergraduate chemistry education and sets the stage for a comprehensive analysis of the literature to identify trends, opportunities, and challenges in implementing these research-based learning experiences. By doing so, it aims to provide a clearer understanding of how CUREs have developed over time and how they contribute to enhancing students' research skills, fostering a deeper connection to the field of chemistry, and promoting active, experiential learning within the classroom setting.

METHODS

This section provides a comprehensive explanation of the research design and methodology employed in conducting the bibliometric analysis (Espinosa, 2011). The data for this analysis were extracted from the Scopus database, a renowned and extensive source for academic publications. The search strategy involved selecting specific keywords related to course-based undergraduate research experiences (CUREs) in chemistry, and the selection criteria were based on relevance, quality, and publication type. The time frame for the study was limited to publications between 2010 and 2023 to capture recent trends and developments in CUREs (DeChenne-Peters, & et al. (2023).

VOSviewer, a software tool for constructing and visualizing bibliometric networks, was used to analyze and visualize the extracted data. It facilitated the mapping of related publications, identification of key authors, institutions, and countries involved, and analysis of emerging topics within CUREs in chemistry education. The software's ability to create network visualizations helped in pinpointing collaborative relationships and highlighting core themes and trends in the research landscape, allowing for an in-depth understanding of the field's structure and its evolving focus areas.

RESULTS

The findings of the bibliometric analysis reveal that a total of 67 publications were examined, offering insights into key themes within course-based undergraduate research experiences (CUREs) in chemistry education. The central themes identified include course-based undergraduate research experiences, inquiry-based learning, and upper-division undergraduate courses, which were the

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most frequently discussed topics. Additionally, novel and emerging areas were highlighted, such as collaborative/cooperative learning, discovery learning, problem-solving, decision-making, first-year undergraduate research, organic chemistry, and chemical education research.

To provide a deeper understanding, visual representations such as charts or network maps generated by VOSviewer were utilized. These visualizations illustrated thematic clusters, showing how the topics were interconnected, as well as highlighting the relationships between authors, institutions, and key terms in the field. Additionally, the temporal distribution of publications was mapped, allowing for the identification of trends over the analyzed period from 2010 to 2023. These visual tools were crucial in demonstrating the evolution of themes, the emergence of new research areas, and the collaborative nature of the field.

The analysis shows how CUREs have broadened in scope, with more research focusing on early undergraduate experiences, interdisciplinary approaches, and innovative teaching methods in chemistry. The thematic clusters reveal the interdisciplinary nature of CUREs, encompassing pedagogical approaches like cooperative learning and problem-solving as well as specific topics within chemical education. This mapping of research provides a clearer view of the development and priorities within the CUREs community in chemistry education.

DISCUSSION

The results of the bibliometric analysis offer important insights into the current state of CUREs in chemistry education. The alignment of central themes, such as inquiry-based learning and undergraduate research experiences, with existing educational strategies demonstrates that CUREs have become a core element in fostering active learning and scientific skill development. These themes reflect a growing emphasis on experiential learning, encouraging students to engage deeply with the scientific process.

Emerging topics, including collaborative learning, discovery learning, and first-year undergraduate research, indicate new trends and shifts in how CUREs are being implemented. The increased focus on early undergraduate exposure to research experiences suggests a move towards integrating scientific exploration earlier in academic programs. This shift also suggests that teaching practices are evolving to accommodate diverse learning styles, promoting inclusivity and greater student engagement in research.

The implications of these findings present both challenges and opportunities. While integrating CUREs into standard curricula provides a pathway to enhanced student learning, logistical challenges, such as time, resources, and faculty training, remain significant barriers to implementation. However, these challenges offer opportunities to explore modular or scalable CUREs, allowing flexibility in various educational settings and potentially broader access for students. The findings underline the necessity of developing supportive infrastructures and institutional support to overcome these obstacles.

The analysis of the trends identified reveals that CUREs are gaining traction as a key strategy in developing practical and critical thinking skills within chemistry education (Wei, & Woodin, 2011). When compared to existing literature, these results align with the broader push towards active learning and student-centered pedagogies in STEM fields. The growing body of work supports the notion that students participating in CUREs gain increased self-efficacy, scientific literacy, and readiness for further research or industry roles.

These trends also underscore the relevance of incorporating research experiences throughout a student's academic journey, not just at advanced levels. The comparison with existing literature

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affirms that CUREs positively impact student outcomes, such as retention in STEM disciplines, improved research skills, and increased interest in pursuing research careers. Therefore, there is a strong case for expanding CUREs across varying levels of chemistry education, addressing diverse topics and student groups.

In conclusion, the findings of the bibliometric analysis provide a deeper understanding of the role and impact of CUREs in chemistry education, revealing both current practices and future directions. Emphasizing active learning, skill development, and early exposure to research, the evolving trends highlight the transformative potential of CUREs. These insights point toward the need for ongoing research to refine CURE methodologies, optimize their implementation, and maximize their benefits for a diverse range of students in chemistry and beyond.

CONCLUSION

The bibliometric analysis of CUREs in chemistry education highlights key findings that shed light on the development and impact of research-based learning in undergraduate courses. These findings reveal important themes, such as the integration of inquiry-based and active learning, and identify emerging topics that indicate evolving pedagogical approaches. The analysis is significant in understanding how CUREs enhance skill development, scientific thinking, and student engagement in chemistry.

The implications for educators, researchers, and policymakers are substantial, suggesting a need to support and expand CUREs to enhance teaching and learning outcomes. For educators, the findings encourage the adoption of research-integrated curricula, while researchers are prompted to explore diverse and inclusive CURE models. Policymakers can utilize the insights to provide institutional support and resources for developing CURE programs.

For future research, recommendations include investigating best practices for CURE implementation across different educational contexts, exploring long-term impacts on student outcomes, and identifying strategies to address barriers such as resource limitations. Moreover, further studies should focus on refining CURE methodologies to maximize their effectiveness and inclusivity, ensuring that diverse student populations can equally benefit from research experiences in chemistry.

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