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Literature Reviews as Learning Tools in Technical Fields

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Abstract: ***Literature reviews are a valuable teaching tool for undergraduate STEM education. Literature reviews are secondary sources derived from existing primary and secondary sources, such as articles, government data, books, and other information sources. Literature reviews are emerging as optimal pedagogical practices to reinforce STEM undergraduates' critical thinking, writing, and communication skills. The purpose of this article is to highlight the importance of focusing on information literacy skills and literature review writing skills in STEM courses. Focusing on faculty-guided literature reviews offers an effective technique to potentiate department-wide implementation of a cost-effective approach to increase student publications and workforce competitiveness. A series of coordinated educational research studies targeting students and faculty will elucidate the benefits of using this pedagogical approach to strengthen students' professional skills.***

Keywords: literature review, information literacy, database, primary sources, secondary sources

1. Introduction

Improving STEM students' writing skills is a standard student learning outcome at most colleges and universities. The addition of literature reviews, research papers, and research proposals as capstone assignments can stimulate outcome achievement. Literature reviews are a type of scholarly writing designed to assemble and summarize previous work to provide new insights that inform and catalyze the production of new research questions and investigations. A literature review is composed of both primary and secondary sources. Primary sources include research articles, conference proceedings, interviews, dissertations, first-hand observations, government data, and theses. Secondary sources include review papers, books, magazine articles, government reports, literature reviews, organizational reports, and textbooks. A literature review can also be called a review article, review paper, literature summary, or literature survey. Unlike primary research articles, secondary sources do not have detailed materials and methods sections and tend to have an extensive reference or works cited section. Secondary sources usually do not contain a results section, which is a required element of primary research articles. There is no clear rule regarding the percentage of primary and secondary articles included in a literature review; however, typically, in a literature review, most of the cited literature is derived from primary sources.

Teaching literature review writing skills to college students has long been viewed as a valuable gambit to improve student outcomes (1-3). The three major types of literature review papers especially suited for undergraduate students are current topics literature reviews, chronological literature reviews, and theoretical or conceptual model-building literature reviews. Current topics or state-of-the-art literature reviews compile recent scholarly articles on a specific topic. Current topics literature reviews are the simplest type for new and advanced college students (4). Chronological literature reviews examine a subject or issue by presenting the earliest information on the topic and discussing its development through the years, and explicating how previous trailblazing observations have led to modern discoveries or present-day understanding. These types of literature reviews are more challenging for undergraduates than state-of-the-art reviews, but are typically less complicated than writing theoretical or conceptual model-building literature reviews. Theoretical or conceptual model-building literature reviews bring together articles containing previous data that help build new theoretical or conceptual models or revise existing theories or models. These types of literature reviews are the most problematic for students because they require substantial background knowledge that most students do not possess in the early stages of their academic career.

Faculty should break down the literature review instruction period into multiple parts to ensure student comprehension at each step. Faculty have different opinions on the best way to introduce literature review assignments; however, there is general agreement that, before writing, students must understand the components of a standard literature review and how to develop quality literature review topics that increase completion percentage and are relevant to educational and research communities. Moreover, before writing, students must learn the best approach to finding literary evidence using academic abstracts and article databases. Students must also be proficient in carefully extracting vital data, observations, methods, and conclusions from articles that support the topic statement or investigatory question. Course discussions on how to develop an informative and concise literature review title is equally necessary when implementing this pedagogical writing approach.

Common academic databases that contain primary and secondary academic content include, but are not limited to, PubMed, Journal Storage (JSTOR), Institute of Electrical and Electronics Engineers (IEEE) Xplore, and the Education Resources Information Center (ERIC). Abstracts and articles found on these digital repositories are readily accessible for student use, and many of the articles found on these electronic libraries contain content that is free to students regardless of an institution's information infrastructure. A brief lesson on the use of appropriate Boolean terms and keyword strategies may help students find essential information at a faster rate.

Contact the library services department on campus to schedule database utilization workshops. These types of library workshops are often conducted virtually and introduce students to another helpful human resource for locating critical sources. Faculty-centered and student-centered mixed methods educational research studies will help resolve the benefits of literature review assignments in technical STEM courses. The overarching purpose of this pedagogical methods article is to consolidate previous strategies and articles regarding the use of literature reviews as a teaching tool to improve STEM undergraduates' scholarly writing skills. Improving students' ability to locate, analyze, and assimilate information efficiently is particularly important for future career development activities such as interview preparation and company exploration.

2. Literature Review in STEM Teaching

The literature review is a comprehensive summary and analysis of published research. STEM graduate students and professionals utilize the literature review to synthesize and interpret experimentally-derived research findings. Exposure to the literature review composition process provides undergraduates with critical skills necessary to tackle graduate school and the STEM workforce. The literature review is similar to a book report featured in elementary, middle, and high school, with the exception that instead of reviewing one source (e.g., book), students review many primary and secondary sources on a particular topic. There are numerous literature review writing strategies to ensure student success. First, it is paramount that student literature review preparation instructions are presented clearly and concisely. Including literature review section submission due dates encourages students to complete separate sections of the literature review in sequential order, providing checkpoints that clarify misconceptions and aid in the removal of any writing barriers students may confront.

A brief lecture-style literature review overview presentation and assessment via quiz, followed by a debriefing or in-class discussion period, is sufficient to provide helpful information before the writing process commences. Also, include peer review opportunities during the writing period. Peer-to-peer teaching, training, and tutoring opportunities are valuable approaches to improve a host of student outcomes, such as collaboration and communication skills, according to a previous review (5). Additionally, the preparation of a quality literature review rubric is necessary to demonstrate content and writing standards. Detailed literature review preparation information and rubrics are especially important for students writing a literature review for the first time.

The development of literature review videos that cover locating helpful literature sources using academic databases, extracting essential information from sources, and composing the literature review is recommended.

Understanding the differences between primary and secondary sources is critical in selecting relevant articles for inclusion in the literature review. Another tangential skill involves undergraduates' ability to meticulously read previous literature and harvest essential informational building blocks needed to support the main objective of the literature review. Historically, students have found it easier to understand information presented in secondary sources, as these sources often resemble textbooks and Internet blogs that are familiar to modern-day students. However, elucidating key information from primary research articles is far more daunting for students. Most STEM majors lack access to advantageous undergraduate research experiences that provide students with real-world exposure to primary research articles directly connected to the objectives of their academic project. Murray (6) developed a process-oriented guided inquiry learning (POGIL) approach, utilizing pre-class, in-class, and post-class learning activities to provide an evidence-based method for enhancing student comprehension of vital information in primary sources, thereby supporting the construction of the literature review. POGIL is a student-centered group-focused teaching strategy frequently employed in STEM disciplines that enables groups of students to construct knowledge during the process of discussing course material and answering scaffolding questions (7). Post-activity grades from assessments designed to probe knowledge gains indicate that the POGIL-based literature review instruction technique was appropriate. Student surveys also revealed that writing self-efficacy improved for undergraduate participants in the study.

A literature review writing project was implemented in an organic chemistry laboratory course (8). Following the implementation of the writing project, students were reported to demonstrate better critical thinking skills and literature search skills. Researchers also noted that students' ability to link organic chemistry concepts with biomedical applications was enhanced after completion of the literature review. Hunter and Kovarik (9) developed an effective teaching method employing Bloom's and Marzano's taxonomies to improve students' ability to understand primary research papers and interpret experimental data presented in the paper. This framework promotes critical thinking skills and can be conducted during class or disseminated as online course assignments. Eden (10) devised a novel literature review writing assignment for college students on how to utilize primary scientific literature to generate a review paper. The assignment also required students to write a review paper, respond to editorial feedback, and create a response letter to the editor. Developing writing assignments that reflect real-world publishing requirements is an excellent approach to adequately preparing undergraduates for STEM careers. The only limitation of this work is that the author failed to conduct a post-assignment educational research study to capture student perceptions regarding writing self-efficacy or other academic constructs derived from professional engagement. Ownership is another critical variable that promotes student satisfaction and aids in preserving students' attention on academic endeavors (11). STEM undergraduates should select literature review topics of interest with faculty guidance to ensure issues are not too broad or too narrow.

3. Conclusion

Literature reviews are an ingenious tool to convert consumers of knowledge into producers of knowledge. High-quality instructions and rubrics will improve student comprehension and completion of the literature review. Moreover, one major shortcoming of most student instructional writing plans is that

faculty fail to leave sufficient time for editing and proofreading, which typically results in a marginal literature review. Embedding two or three weeks dedicated to editing and proofreading during the semester will improve the quality of the final product. Consider forming interdisciplinary STEM faculty committees to create literature review instructions and rubrics that apply to all STEM majors. The overt and latent skills manifested by writing a literature review are consistent with job skills desired by employers at STEM companies (12-13). Moreover, well-written literature reviews can lead to student publications and national presentations, which are effective strategies to prepare undergraduates for STEM jobs. Variations to the traditional literature review assignment may include the point-counterpoint group design, where one group of students prepares a literature review arguing one point, and another group of students develops a literature review discussing the counterpoint. A focus on literature reviews is a feasible proxy for research training for institutions that have difficulty sustaining functioning research labs throughout the academic year.

Information literacy skills are essential for producing literature reviews. In general, information literacy skills refer to the ability to locate relevant information and the ability to evaluate literature effectively to collect valuable data and observations. Information literacy skills also refer to the integration of extracted information into written documents (e.g., literature review) and oral presentations. Faculty assistance is also needed to prevent unethical scientific communication practices resulting from artificial intelligence interloping. A future article will explore the role of artificial intelligence in finding sources, elucidating research questions, generating hypotheses, and recommending evidence-based experimental procedures. While artificial intelligence can be a complementary ally during the information collection phase of the literature review, human intervention and the utilization of seminal information literacy skills are necessary to ensure fidelity of the recovered information (14). Literature review training workshops are particularly beneficial during STEM intervention programs, such as summer or academic internship programs, which aim to increase the number of students earning graduate degrees. Ongoing mixed-methods educational research will also be essential to help promote the development of additional literature review pedagogical methods, more writing courses in the STEM curriculum, and to unearth beneficial student outcomes that are not yet known.

Compliance with ethical standards

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