Fusing Information Literacy Skills in STEM Courses

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Abstract

This article explores integrating information literacy skills in science; technology, engineering, and mathematics (STEM) undergraduate courses. The article also provides information literacy-based instructional strategies STEM faculty can employ in the college classroom.

Keywords: information literacy, pedagogy, scientific databases, STEM, undergraduates.

1. Introduction

Enhancing students' ability to conduct cutting-edge research in the digital information age is an important objective in science, technology, engineering, and mathematics (STEM) courses. The scientific research enterprise is a multi factorial process that involves more than simply understanding how to conduct specialized experiments and operate state-of-the-art equipment but also how to locate and utilize literature and empirical data to formulate hypotheses and design elegant experimental methodologies to address research questions. To that end, integration of beneficial information literacy skills in traditional and online STEM courses will prepare students for future success in other courses, graduate school, professional school, or the STEM workforce (Jang, 2016). As college educators, we observe countless students who demonstrate poor information literacy skills. Moreover, observational evidence from several decades of STEM teaching has revealed that a large majority of students lack even the most basic information retrieval skills. Students' inability to identify the most appropriate source of data and inability to understand how to exploit electronic resources for scholarly gain typically result in less than stellar academic performance and marginal professional performance after graduation. This article provides helpful websites, Smartphone applications, and information literacy teaching strategies that will undoubtedly help faculty overcome challenges associated with information retrieval instruction (Leckie, 1996) and help STEM students at all classification levels gain confidence in locating and synthesizing essential information for course assignments and projects beyond the use of basic search engines most familiar to undergraduate students (e.g., Google or Wikipedia) (Laurent & Vickers, 2009; Peters, 2011).

2. Information Literacy Skills

Since its inception in 1989, the National Forum on Information Literacy (NFIL - http://infolit.org) continues to promulgate the incorporation of information literacy skills in educational and occupational sectors. Additionally, the Information Literacy Competency Standards for Higher Education developed by the Association of College and Research Libraries (ACRL - http://www.ala.org/acrl) provide a detailed operational definition of information literacy for science, engineering, and technology disciplines as well as standards, performance indicators, and outcomes for student assessment procedures. Information literacy is broadly defined by library and information science scholars as the ability to find, evaluate, and integrate critical information from print literary resources, scientific databases, electronic archives, media, and the Internet into scholarly works (Addison & Meyers, 2013). Information literacy also addresses major issues such as the ethical and legal documentation of information to avoid plagiarism and noncompliance with institutional policies.

The acronym FUSE which stands for finding information, using technology, synthesizing knowledge, and evaluating material succinctly characterizes the skills STEM students must have in order to succeed in the academic and professional world. It was demonstrated in a phenomeno graphic study by Diehm and Lupton (2014) that postsecondary students learn information literacy skills through hands-on learning, experiential learning, and faculty interactions. While the literature points to successful examples of the incorporation of information literacy instruction in science-related disciplines (Ferrer-Vinent & Carello, 2011; Flaspohler, Rux, & Flaspohler, 2007; Fosmire, 2012; Jacobs, Dalal, & Dawson, 2016; Scaramozzino, 2010), literary examples of information literacy integration in mathematics education for example are infrequent suggesting that more work is required in STEM disciplines to prepare students for 21st century information procurement demands (Bussmann and Bond, 2015).

Not only does differential incorporation of information literacy instruction exist within STEM disciplines but previous research also demonstrates that there are perception differences among STEM faculty regarding the most appropriate undergraduate level in which to integrate information literacy instruction within the course framework. According to Leckie and Fullerton (1999), an overwhelming majority of science and engineering faculty thought that information literacy instruction was necessary at the junior and senior level and less important at the freshman and sophomore level. Additional anecdotal and research-supported evidence suggests a reluctance of STEM faculty to include significant course assignments that promote effective information literacy competencies in their course designs. Leckie and Fullerton's study revealed that only 51% of the responding science and engineering faculty require library research in all of their courses. The current article attempts to provide pedagogical support for STEM faculty who believe, as we do, that inclusion of information literacy instruction is paramount for undergraduate students and requisite for improving student research capabilities. The pedagogical recommendations and other research-based evidence presented herein are designed to encourage undergraduate student exploration of electronic/non-electronic resources and information access methods to foster the development of essential information literacy skills.

3. Basic Pedagogical Methods to Promote Information Literacy Skills

The next section provides basic information literacy instructional strategies designed to familiarize students with fundamental skills to enhance knowledge acquisition and retention. It is important to note that STEM faculty must provide detailed assignment instructions to both lower-level and upper-level students in the initial stage of the information literacy course assignment to account for students' limited previous research experiences and potential information-gathering misconceptions (Leckie, 1996).

3.1 Evaluation of Internet-Based Resources

Today, unlike previous generations, STEM students are more likely to find information from electronic resources and therefore web-based information evaluation techniques should be a central component of information literacy skills training. Students should be equipped with stringent procedures for adequately determining the reliability and trustworthiness of websites needed to perform research. To facilitate website evaluation skills, instructors can employ student-centered course strategies that focus on improving students' understanding of website appraisal criteria such as the credibility or qualifications of the website author(s), fidelity of website content, and frequency of website updates and revisions to name just a few. Course assignments in which students are instructed to use the above criteria to assess websites could help promote website evaluation skills. The Cornell University Library offers helpful electronic information for properly evaluating websites (http://www.library.cornell.edu/olinuris/ref/research/webeval.html). A thorough discussion of the types and function of the diverse scholarly literature available (e.g., primary versus secondary) will allow students to make more informed decisions regarding the type of sources to use during the information-gathering phase of course projects.

3.2 Information Technology and Scientific Databases

Information technology skills are inherently connected to information literacy skills in light of the rapidly proliferating technology used to archive and organize scholarly information. Information technology skills focus on the utilization of computer hardware, software applications, and various databases to obtain precise information. Academic institutions typically offer a wide variety of scientific databases that students may employ to acquire course-specific information.

Course lectures that review major scientific databases and stress the importance of using appropriate keywords and Boolean operators (e.g., and, or, not) to yield more beneficial results would improve students' information acquisition outcomes. Keywords that are too broad will yield a considerable amount of mostly unrelated articles and information. Alternatively, keywords that are too narrow will produce a limited number of relevant articles.

STEM course assignments that focus on the use of a specific scientific database to generate relevant primary and secondary sources would stimulate understanding of the power of using the correct keywords and scientific database to find useful information. Teaching students how to find literary sources using scientific databases and how to evaluate literature to determine its suitability for a particular purpose is paramount in the development of students' research skills. As a basic assignment to teach information literacy and critical thinking skills, faculty and instructors could require students to locate and carefully read a specific research article. This initial activity would be followed by a discussion of the research article during class or by using the discussion board feature found in many virtual course management systems (e.g., Blackboard). Below are helpful websites to scientific databases that contain mostly free content that may be used by students and faculty for course projects and assignments.

- http://www.ncbi.nlm.nih.gov/pubmed (National Center for Biotechnology Information)
- http://www.highwire.stanford.edu/lists/freeart.dtl (High Wire)
- http://agris.fao.org/agris-search/index.do (International System for Agricultural Science & Technology)
- https://scholar.google.com (Google Scholar)
- https://eric.ed.gov (Education Resources Information Center)
- http://www.science.gov (Science.gov)
- http://scitation.aip.org (Scitation)
- http://www.webofknowledge.com (Web of Science)
- http://arxiv.org (Arxiv)
- http://pubs.acs.org (American Chemical Society)

A course assignment requiring students to first construct a comparative analysis report of several different scientific databases followed by oral presentations in which students present the most salient features of specific electronic literature repositories will improve knowledge of specific databases and enhance analytical, writing, and communication skills. Debates are not only an excellent tool for improving student engagement for liberal arts and humanities majors but can also be a beneficial instructional approach in STEM courses. Structured student debates on contemporary STEM issues will allow students to research and defend important topics in a specific area and enhance communication skills and information literacy skills.

3.3 Information Literacy Tutorials

Virtual and face-to-face lectures from library staff offer an excellent strategy to educate students on the many institution-specific scholarly resources available to them. In terms of virtual or online information literacy mediation, lectures can be synchronous using Face Time and Skype or asynchronous using video-recorded lectures from library staff. Alternatively, most college and university libraries offer library instruction or bibliographic instruction (BI) sessions to improve students' information-retrieval skills either at the library or in the classroom environment. For BI sessions to be truly fruitful for student development BI sessions, must take place on a regular basis during the semester and be targeted to a specific subject matter or discipline. The literature indicates that collaborations between academic professors and library personnel can be extremely constructive in terms of the development, implementation, and evaluation of information literacy objectives (Bond, 2016; Flaspohler, Rux, & Flaspohler, 2007; Waters, Kasuto, & McNaughton, 2012). Many college and university libraries also have virtual library tours that can be accessed directly from the library homepage to further improve students' use of the library and its many resources. Additionally, there are many YouTube videos that cover a variety of information literacy-related topics, from the use of scientific databases to locate indispensable information to the incorporation of carefully selected information in research reports. The Internet is also replete with well-constructed training videos designed to improve students' note-taking skills and paraphrasing proficiency which can easily be incorporated into specific science education learning modules. Research performed by Gonzales (2014) revealed that computer-mediated information literacy tutorials are just as effective as traditional teaching methods in terms of improving student information literacy learning outcomes.

3.4 Electronic Anti-Plagiarism and Citation Resources

Conjugated with the main theme of this article is the detection of plagiarism and falsification in STEM courses. It is well documented that plagiarism violations are on the rise in postsecondary classrooms around the country. Plagiarism, when exposed, leads to a variety of negative academic consequences for students and may lead to expulsion from the academic institution. STEM professors should encourage students to utilize free plagiarism detection programs to improve paraphrasing skills and to avoid the adverse penalties associated with violation of institutional academic integrity policies. Free plagiarism recognition websites include: http://www.plagscan.com/seesources/analyse.php (Plagscan) http://www.plagiarism-detect.com (Plagiarism Detect) ,http://www.checkforplagiarism.net/free-checking (Check for Plagiarism), and http://smallseotools.com/plagiarism-checker (Plagiarism Checker). Additionally, several Smartphone applications such as Plagiarism Checker (Plagiarisma.net) and Plagiarism (Plagtest.com) will benefit students by providing convenient, easy-to-use software to improve course assignments. Lectures and course assignments that raise student awareness regarding the purpose and correct use of in-text citations and reference citations are also crucial. Discussions of the different types of citation formatting styles (e.g., American Chemical Society [ACS], American Psychological Association [APA], Chicago, Council of Science Editors [CSE]) will benefit student learning and promote effective communication of scientific knowledge.

A very helpful website that automates the citation development process is www.citethisforme.com. This user-friendly website will automatically produce perfect citations for many different formatting styles used in the scientific community and create bibliographies effortlessly. Additionally, commercial and free citation management resources include Easy Bib (http://www.easybib.com), APA Citation Generator (www.refme.com), Cite U Like (http://www.citeulike.org), Ref Works (http://www.refworks.com), and End Note (http://endnote.com). For introductory STEM students, the construction of an annotated bibliography based on an instructor-assigned research question or experimental design would serve as a straightforward course assignment to introduce students to scientific databases and proper citation design skills. Alternatively, in advanced STEM courses, instructors may require students to design their own research questions or experimental methodology followed by the production of an annotated bibliography that addresses the specific question or research methods. The use of written assignments such as literature reviews and journal article reviews will provide an opportunity for students to search the literature and present a comprehensive argument that explores a relevant topic. Faculty may also consider assigning students a specific and narrow topic (e.g., term, process, mechanism, theory) that relates to the lecture material and require students to use various scientific databases to investigate the topic by presenting a chronological citation history of the topic. Scientific database utilization, citation design, and concept exploration skills will be enhanced from such an assignment.

4. Conclusion

It is clear from our extensive interactions with STEM students and our examination of the literature that integrating information literacy assignments in STEM courses is a necessary and advantageous pedagogical endeavor for undergraduate students at every stage of their academic career. In addition to helping students improve performance on course assignments, the targeted information literacy skills described in this article will also help students prepare for STEM job interviews and aid in meaningful knowledge building techniques. Keep in mind that the term information literacy encompasses many attributes, therefore it is important for STEM faculty to first identify specific information literacy-based student learning outcomes and to ensure that those outcomes are measurable and aligned with the institutional mission statement and departmental competencies. Next, faculty must develop and employ specific instructional strategies designed to achieve the documented learning outcomes. Moreover, it is highly recommended that STEM professors collaborate with library professionals to design, implement, and evaluate information literacy skill-building techniques that are discipline-specific. It is also important to note that the key to success for implementing any pedagogical strategy involves the design and dissemination of a well-written rubric prior to the activity engagement phase that informs students about the precise criteria for measuring student performance (Jastram, Leebaw, & Tompkins, 2014). Further, it is suggested that whether the final course assignment is relatively basic (e.g., locating one research article) or complex (e.g., producing a literature review or laboratory report) it is best to employ an incremental coverage approach. This approach encompasses breaking the assignment down into simpler, more manageable elements (e.g., topic selection, literature/data retrieval, first draft of the writing assignment, etc.) and assessing completion and student understanding at each stage of the process and correcting problems at the point of origin.

Lastly, research studies that explore STEM student and faculty perceptions of information literacy learning strategies and technology are necessary to improve information literacy science education and the design of future sustainable models and techniques to expand students' information literacy skills in STEM courses.

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