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University Biology patrons in the library literature 2000-2010: A Content Analysis & Literature Review

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Abstract

The researcher conducted a content analysis and literature review of papers written from 2000-2010 that focused on university biology students, faculty, and their papers. Scholarly articles were divided into the library research domains. The largest number of papers was from the *Education* domain, followed closely by *Collections*. Only two papers were categorized as *Reference/Enquiries*, and no papers were found in *Management* and *Professional Issues*. This research will enable science librarians to better understand what has already been written about biology subjects in a university setting. Gaps in the literature can help other librarians who are interested in pursuing more research with biology subjects.

Keywords

library and information studies; content analysis; literature review; biology; university; library research domains

Introduction

With its roots in medicine and beginnings in health science librarianship, evidence-based library and information practice is a growing movement that is reaching all library sectors. "Evidence Based Librarianship is a means to improve the profession of librarianship by asking questions, finding, critically appraising and incorporating research evidence from library science (and other disciplines) into daily practice. It also involves encouraging librarians to conduct research" (Koufogiannakis and Crumley, qtd. in Cleyle and McKenna 91).

Crumley and Koufogiannakis developed library domains in an effort to understand the major areas of library research (Crumley and Koufogiannakis 63). Koufogiannakis, Slater and Crumley examined the research literature produced in library and information science, with one of its aims to "determine what type of research is being conducted within LIS, and the relationship of research type to publication and classification by subject" (Koufogiannakis, Slater and Crumley 230). Koufogiannakis et al. made a slight alteration to the original domains to reveal the following six library research categories:

- *Reference/Enquiries* - providing service and access to information that meets the needs of library users.

- *Education* - finding teaching methods and strategies to educate users about library resources and how to improve their research skills.
- *Collections* - building a high-quality collection of print and electronic materials that is useful, cost-effective and meets the users' needs.
- *Management* - managing people and resources within an organization. This includes marketing and promotion as well as human resources.
- *Information access and retrieval* - creating better systems and methods for information retrieval and access.
- *Professional Issues* - exploring issues that affect librarianship as a profession. (Crumley and Koufogiannakis 63; Koufogiannakis, Slater and Crumley 233)

As a science librarian at Carleton University, the author wanted to learn more about how to better meet the information needs of biology students. The author decided to contribute to the evidence by working on a citation analysis of the graduate biology students' theses at the university in order to get a better sense of their collection needs (Newton Miller, istl.org). Inspired by Koufogiannakis et al.'s (227-239) content analysis of LIS literature, the author decided to go further with this research by focusing specifically on scholarly literature related to university biology students and faculty, and their papers.

The author found a paper by Sinn (103-115) to use as a springboard for her own research. Sinn performed a review of the literature related specifically to biology library instruction and found that, at the time, there was "relatively little recent literature describing library instruction to biology classes" (Sinn 104). Sinn found that most were descriptions of specific programs in the form of "one-shots" or entire credit courses aimed at graduate and undergraduate students. Articles were found in both the library literature and the biological literature. In other words, papers were aimed at both librarians and biological instructors.

Objective

The following is a content analysis and literature review of papers written between 2000 and 2010 that focus on university biology students, faculty, and their papers. Scholarly articles were divided into the library research domains listed above. This will enable science librarians to better understand what has already been written about biology subjects in a university setting. Gaps in the literature can help inform other librarians who are interested in pursuing more research with biology subjects.

Methods

The researcher searched the following databases for peer-reviewed articles that used biology students, faculty or their academic papers as research subjects: LISTA (Library, Information Science & Technology Abstracts), Library Literature, LISA (Library & Information Science Abstracts), ERIC (Education Resources Information Center), and Web of Science. (Search strategies are provided in the appendix.) The search was

limited to papers containing data obtained between January 2000 and October 2010 (when the search was conducted). Papers that were written in 2000 but used 1990s or earlier data were excluded. As a result, no papers written in 2000 were actually included in this study. In their content analysis of librarianship research, Koufogiannakis, Slater and Crumley (228) excluded journals published outside North America or Europe. Similar efforts were used in this study, and, in addition, articles were limited to those that were *about* North American or European subjects. The researcher checked *Ulrich's Periodical Directory* to ascertain that a journal was peer-reviewed.

Master's theses, technical reports, conference proceedings, and conference proceedings within a journal were excluded. Papers were also excluded if they were not published in English, and were not university, biology, and library-related. The term "university" was defined as an "institution of higher learning" (Oxford Reference Online). This included any institution offering formalized education after secondary school, such as universities and colleges that grant undergraduate or graduate degrees. Like Koufogiannakis, Slater and Crumley (231), articles had to be research-based in order to be included. Peritz's definition of research: "an inquiry, which is carried out, at least to some degree, by a systematic method with the purpose of eliciting some new facts, concepts or ideas" (Peritz 251-168) was used to identify research-based articles. The researcher prepared structured abstracts for each article and divided papers into library research domains (as noted above) to determine trends in the literature. Some papers very clearly fell into a specific domain; however, sometimes it was more difficult to pinpoint. (For example, it was sometimes difficult to decipher in which domain an "information needs" paper resided). When in doubt, the researcher looked at the introduction and conclusion of a paper to see why it was written and if its implications affected collection development, instruction, reference, etc., or a combination of domains.

Results

After removing duplicate citations, 96 records were left. Once papers were excluded using the criteria described above, 33 articles remained for analysis. These papers were divided among four library research domains: *Collections* (10), *Education* (12), *Information Access & Retrieval* (7) and *Reference/Enquiries* (2). One article fell within both *Collections* and *Education* and another within *Reference* and *Education*, and these were treated as separate categories. No articles fell within either the *Management* or *Professional Issues* domains.

Articles were divided into specific study types. Koufogiannakis, Slater and Crumley (232) found that descriptive studies dominated the LIS research literature. Descriptive research techniques include interviews, focus groups and surveys. The current study also found this prevalence in the *Education*, *Information Access & Retrieval*, and *Reference/Enquiries* domains. Citation analysis was the most common research tool used for the *Collections* domain. Other research study types included comparative analysis, program evaluation, and content analysis. Table 1 shows the breakdown of

domains and study types. Note that number of study types may differ from the total number of articles because of the use of more than one study type within an article.

Table 1: Breakdown of Domains & Study Types

DOMAIN	**TOTAL # ARTICLES**	**STUDY TYPE**	**# ARTICLES**
Collections	10	Citation analysis	9
		Descriptive	1
		Comparative Analysis	1
Education	12	Descriptive	5
		Program Evaluation	7
		Content Analysis	3
		Comparative Analysis	1
Information Access & Retrieval	7	Descriptive	7
		Citation analysis	1
Reference/Enquiries	2	Descriptive	2
Collection/Education	1	Descriptive	1
		Content Analysis	1
Reference/Education	1	Descriptive	1

Although there are eight articles under the *Information Access & Retrieval* domain, it must be noted that five are from the same author and the same initial research study. This will be discussed further in the article.

Research related to biology students, faculty or their papers reached a peak in 2008 when 8 articles were published. These papers included domains in *Education* (1), *Collections* (2) and *Information Access & Retrieval* (5). The second highest jump in publications was in 2005 with 6 papers. Table 2 shows the number of articles published with corresponding library research domains.

Table 2: Research Articles with Corresponding Library Domain

YEAR	**# ARTICLES**	**LIBRARY DOMAIN**
2001	2	Education; Reference/Enquiries
2002	1	Collections
2003	1	Collections
2004	3	Education; Collections (2)
2005	6	Information Access & Retrieval; Collection/Education; Education (2); Reference/Enquires; Collections
2006	4	Education (2); Collections; Reference/Education
2007	3	Information Access & Retrieval; Education (2)
2008	8	Education; Collections (2); Information Access & Retrieval (5)

2009	1	Education
2010 (until Oct)	4	Education (2); Collections (2)

A total of 21 separate journals produced 33 papers involving university biology students, faculty, or their papers. *Science & Technology Libraries* and *Issues in Science & Technology Librarianship* were the top two journals to cite articles related to university biology subjects in this time period. These journals are found in the same four indexes: LISTA; Library Literature, LISA and ERIC. The top cited journals (four of which are tied for fourth place) are listed below in Table 3.

Table 3: Top Journals that Publish Library Research on Biological Subjects (rank out of 23 separate journals)

JOURNAL NAME	**Number of Articles**	**Domain Types**	**INDEXED**
Science & Technology Libraries	5	Collection/Education; Education; Collections (2)	LISTA; Lib Lit; LISA; ERIC
Issues in Science & Technology Librarianship	4	Education (2); Collections (2)	LISTA; Lib Lit; LISA; ERIC
Journal of Academic Librarianship	3	Reference/Enquiries; Reference/Education; Collections	LISTA; Lib Lit; LISA; ERIC; WoS
CBE-Life Sciences Education	2	Education (2)	WoS; ERIC
Journal of Documentation	2	Information Access & Retrieval	LISTA; Lib Lit; LISA; ERIC; WoS
portal: Libraries and the Academy	2	Collections	LISTA; Lib Lit; LISA; ERIC; WoS
Program: Electronic Library & Information Systems	2	Information Access & Retrieval	LISTA; Lib Lit; LISA; WoS

Non-Library Journals

It is important for science librarians to note that although CBE-Life Sciences Education is not specifically library-related, it produced two papers that dealt with university biology undergraduate students and library use. It is also imperative that science librarians realize that one must search ERIC and Web of Science databases (non-library databases) in order to find articles from this journal. Both papers fall (not surprisingly) within the *Education* research domain. Flaspohler, Rux, and Flaspohler (350-360)

assessed the effectiveness of a collaborative effort involving a research and writing project for an upper-level undergraduate biology course at a small, private liberal arts college. The program was assessed using content analysis and questionnaires between 2004 and 2006. Results showed a significant improvement in annotated bibliographies in terms of correct source type used, annotation quality and plagiarism reduction. The students reported "high levels of satisfaction with their instructor, librarians, and their overall experience with writing a scientific research paper" (Flaspohler, Rux and Flaspohler 355). Gehring and Eastman (54-63) developed a tutorial on database searches and literature, followed by specific assignments that focused on information fluency skill development. The students were from an upper-level developmental biology course at Connecticut College. Using pre- and post-tests, focus groups and self-assessment evaluations, the research showed that "the integration of inquiry-based learning with information literacy skill building suggests that intentional assignments using primary literature analysis and investigative projects are useful for the development of information fluency" (Gehring and Eastman 61).

Education Domain

The largest number of biology-focused papers was from the *Education* research domain. All twelve papers within the *Education* domain focused on undergraduate biology students, although one paper also examined teaching assistants (graduate and upper undergraduate). Two papers were already discussed above. Of the remaining 10 *Education* papers, five papers involved a program assessment of a library information-skills project. Four of these discussed faculty-librarian collaborations. Bowden and DiBenedetto (143-149) described an information literacy project that was developed collaboratively between biology faculty and librarians. Groups of 4-5 students were asked to research a particular set of questions on a topic. The librarian met with each of the thirteen labs for a 75 minute session which introduced Expanded Academic Index and PubMed. Students were also given the opportunity to start their own research. Subsequent team presentations were rated highly, and 70% of those who filled out the questionnaire stated that the library instruction session was "helpful in launching them into independent research" (Bowden & DiBenedetto 148).

Kearns and Hybl (39-56) discussed collaboration between faculty and librarians to develop and evaluate a web-based tutorial on various library-related skills (i.e., how to use online databases, perform a keyword search and find journals). The subjects were students from an introductory biology program. After conducting pre- and post-tests, the researchers concluded that "students were developing complex research strategies as a result of the Science literacy lab module" (Kearns and Hybl 48).

Librarians have also been involved in classes throughout a particular course, as opposed to the traditional "one-shot" class. Winterman (istl.org) described a pilot for a credit course involving the use of lectures and exercises to help in the process of writing research proposals. Several classes were devoted to a librarian teaching the students about scientific method, and accessing and retrieving information resources. A biology graduate student then gave lectures on the specifics of research proposals. Pre- and

post-tests revealed an improvement on basic information literacy skill questions and of students' rankings of their own abilities to use the scientific literature for research. Based on the pilot and a working group formed by biology faculty and librarians, a one-credit hour course, called Information Literacy in Biology, was developed.

Firooznia and Andreadis (23-27) discussed an assessment of a collaboratively-driven program delivered in a first year biology class. Professor Firooznia incorporated several library-related exercises into the first half of the semester, with the second half devoted to research and writing of the final research paper. A short quiz based on ACRL (Association of College & Research Libraries) standards was given to students at both the beginning and end of the semester. Although statistically significant, the number of questions out of 10 that students answered correctly improved by only one. The researchers did notice a dramatic decrease in the number of students asking the professor for extra help in finding resources. Although about a quarter of the students suggested that the number of exercises be reduced in the future, the researchers maintained that these types of exercises could easily be integrated into any biology class.

Program assessment was also used to evaluate the role of active learning strategies during library instruction programs to second year undergraduate biology students. Approximately 9 to 23 students were involved in each class. Jacklin and Pfaff (1-27) reported that 64% of attendees who filled out evaluations liked everything about the workshop; 98.5% were comfortable asking questions, and 94% felt that the level of instruction was just right. They found that active learning "can improve students' learning experiences as well as improve the professional experiences of librarians" (Jacklin and Pfaff 14).

Three papers in the *Education* domain endeavoured to understand information-seeking behaviour, information literacy skills, and attitudes toward journal use. All three papers used questionnaires to evaluate undergraduate biology students. Callinan (86-99) used comparative analysis to determine what differences existed between first and final year biochemistry students at University College Dublin. The researcher found that first year students tended to visit the library less frequently than final year students, and that final year students used the e-library much more than first years. Other behaviours were similar among both sets of students. Ferguson, Neely and Sullivan (61-71) discovered that first year biology students stated that they were comfortable creating successful search strategies, even though most were unfamiliar with basic search concepts. Many also had trouble identifying citations in various sources. Keene (2-12) examined the attitudes of undergraduate students from various disciplines (including biology) towards academic journals. She found that although students usually had a positive view of journals, "there were numerous remarks about the difficulty of accessing relevant material" (Keene 2). Results from these papers helped the researchers to include specific material in future library instruction sessions based on various needs of the undergraduate biology student.

Dinkelman (istl.org) used a different approach to understand the needs of undergraduate biology students. The researcher was able to attain a baseline assessment of the amount of research expected of biology majors by using content analysis of course syllabi. This included understanding the number of information literacy-related assignments. The most frequently noted were the lab report, short paper and discussion of scientific literature. Research papers accounted for only 9% of the total number of assignments in the sample.

Only one paper in the *Education* domain used graduate students as subjects, and it is uncertain exactly how many in the group were, in fact, graduate students. Spackman (3-28) used focus groups of 8 teaching assistants (TAs) and 8 students (2 each) to evaluate a Biology 100 information literacy program. The teaching assistants consisted of upper-level undergraduate and graduate students. The students had individual and group poster projects on assigned topics where only scholarly journals could be cited. The librarian worked with professors and the course coordinator to promote a library research guide specific to the class, delivered library instruction sessions to undergraduates, and trained teaching assistants on "terminology and background research, differences between primary, secondary and tertiary resources…the peer review process…and strategies for searching periodical indexes for semester topics" (Spackman 7). The library was able to make improvements to the information literacy program based on student and TA feedback.

Reference/Enquiries Domain

Only two of the 33 papers analyzed fell within the *Reference/Enquiries* domain. Both papers used descriptive study techniques in the form of surveys, focus groups and interviews. As opposed to the *Education* domain that focused mainly on undergraduates, one paper in the *Reference/Enquiries* domain focused on faculty (in several subject disciplines, including biology) (Carpenter, Wallis and Smith 1-35). The other paper within the *Reference/Enquiries* domain studied both graduate and undergraduate biology students (Chen and Choi 469-476). Carpenter, Wallis and Smith (1-35) examined the research patterns of academic and other researchers in the United Kingdom. They found that medical and biological sciences researchers relied on journal literature and primary data, and electronic formats were essential for timeliness and speed. Although they did not necessarily find physical access to the library as important as other disciplines, these faculties did find the use of interlibrary loan, document delivery, and online catalogues to access book collections essential for their research. Chen and Choi (469-476) studied college biology students' learning experiences and perspectives regarding the use of audiovisual materials in their academic work. Most of the students had used and were comfortable with the library's video materials, citing their dynamic presentations and ability to clarify what was learned in class as reasons for their positive experiences. The students noted that accessing the library was not always convenient and that pre-booking library facilities was difficult with so many students wanting access to the same resource. They believed that online videos would help ease the access problem. This research helped provide librarians with important information to move forward with establishing an online video library.

Reference and Education Domains

Kuruppu and Gruber's paper (609-623) is categorized into both the *Reference* and *Education* domains. They used one-on-one interviews with faculty and focus groups with graduate students to understand the information needs related to teaching, learning and research in the agricultural and biological sciences departments. The faculty and grad students frequently used the library website, but opinions on the ease of use were mixed. Their findings were similar to Carpenter, Wallis and Smith (1-35) in that both faculty and graduate students used research published in scholarly journals, used indexes and databases to search for these journals, and rarely visited the physical library building. However, a major difference between the two research studies was that although the faculty in the United Kingdom study (Carpenter, Wallis and Smith 1-35) found interlibrary loan, document delivery and online catalogues to be essential services, most of the faculty and graduate students at Iowa State (Kuruppu and Gruber 609-623) were unaware of these services, even though they were offered by the library. The graduate students suggested that multiple short sessions and online tutorials at the point of need would be helpful. Faculty opinions were mixed in how they preferred to receive library news and communications. The researchers acknowledged that lack of awareness of library services should be a main focus of future instruction and marketing campaigns for the library.

Education and Collection Domains

One paper fell into both the *Education* and *Collections* categories of research. Brown (89-104) examined how much molecular biology graduate students were using bioinformatics databases and scientific journals in their research activities. Of the 154 graduate students from three campuses in Oklahoma, 16% (25 students) completed the survey. To supplement this data, the researcher conducted a content analysis to understand the number of molecular biology articles in these databases, and then conducted a second content analysis for the occurrence of the term "molecular biology" in the journals students said they read regularly. The most highly-read journals included *Nature*, *Science*, *Cell*, *Journal of Biological Chemistry* and *Journal of Bacteriology*. Half of the students had never accessed SciFinder Scholar, Web of Science, Biological Abstracts or Zoological Record. The researcher found a large reliance on NCBI's (National Center for Biotechnology Information) databases, especially Genbank and PubMed, even though Biological Abstracts, Zoological Record and Article First indexed more biology articles than PubMed. Most of the students learned about these databases in the lab and not in the library.

Collections Domain

Citation analysis was used in nine out of the ten studies in the *Collections* domain. Most of these were divided into what materials people used (5), where they published (2), or both (2). One citation analysis also focused on databases where the material was most cited. (Numbers add up to more than nine because more than one method was used in some studies). Five studies used faculty papers, two studied PhD theses,

one examined advanced undergraduate papers, and another compared undergraduate and faculty papers.

Many of the studies were used to help determine if libraries were "on the right track with respect to journal subscriptions" (Bajwa and Salisbury 25). Two papers conducted citation analyses of PhD dissertations in various biological and agricultural disciplines. As in many citation studies in an academic setting, most of their citations were to journal articles. In Kuruppu and Moore's (387-405) study, the highest journal usage occurred in molecular, cellular and developmental biology dissertations, followed very closely by genetics and plant physiology. Lower journal usage was found in the soil science, plant breeding, and entomology disciplines. Kraus (161-179) researched the citation patterns of advanced undergraduate biology students. In a later paper (istl.org), he examined the differentiation in citation usage between undergraduates and faculty in the biology department. Like others, he found that journal literature was cited much more than books and other sources.

Davis (155-166) analyzed where life sciences faculty at Cornell University published their papers in order to develop a core list of titles for the library collection. He discovered that the top 240 e-journals would cover 80% of the articles published by Cornell researchers, and 409 titles would cover 90%. He also noted that society and association journals ranked within the top journals and were significantly less expensive than equivalent commercial journals (Davis 155-166). Stankus (16-33) followed the publications of entomology faculty to determine if those among arts and sciences universities differed in where they published compared to those in agricultural colleges. He found that they tended to use many of the same journals, but their differences in rankings of importance helped in determining prioritization in collection budgets.

Salisbury and Smith (69-82) developed a cross-disciplinary study that included publications by biology faculty. The researchers wanted to determine not only the strength of the current collection but also to examine which of the journals cited and published by faculty were included in packaged journal subscriptions (i.e., Elsevier, Wiley). This research assisted librarians in determining which journal packages were most cost-effective. The 3% of journals that were not in a collection were put on a wish list for future subscriptions. Bajwa and Salisbury (11-25) studied entomology faculty papers to ensure the library had a sufficient collection for teaching and research. The library had all but 2 journals cited, and subscribed to 67.6% of all titles. Biological Abstracts and CAB Abstracts were very similar in terms of indexing of those journals, and although AGRICOLA fell short in its coverage, it did have some unique titles that were not available in the other two databases.

Contrary to the popular belief that those in the sciences cite the newest literature available, Bajwa and Salisbury (11-25) discovered that entomology faculty were using and citing older literature. Kuruppu and Moore (387-405) found that half of the biology citations in various disciplines were less than seven years old, and 90% were less than 24 years old. Nabe and Imre (istl.org) determined that a significant percentage of citations from plant biology and zoology dissertations were to resources dating before

1996, which proved helpful in determining whether or not to purchase online backfiles that started at this date.

A slightly different citation study of faculty papers focused on the use of field guides in scholarly publications. Schmidt (274-285) obtained a non-random sample of 50 field guides and examined the citation patterns in Web of Science between 1984 and 2004. The most heavily cited guides consisted of organisms and regions. *Collins Guide to Animal Tracks* and *Birds of South Africa* were the most cited field guides in scholarly papers, and the top four field guide subjects were ecology, zoology, conservation, and molecular and cellular biology (Schmidt 274-285). Although the researcher admitted that many libraries did not carry field guides, she felt that, by being selective, one could take advantage of this readily available and inexpensive source of information.

Although most of the papers in the *Collections* domain were citation analyses, one lone study used a web-based survey to determine the usefulness and willingness of faculty to use electronic-only resources. Salisbury, Vaughn and Bajwa (36-40) discovered that faculty at Dale Bumpers College of Agriculture, Food & Life Sciences, and the Department of Biological Sciences at the University of Arkansas, Fayetteville were overwhelmingly in favour of using or browsing e-journals. They found that convenience, remote accessibility, reliability, ease of use, ease of printing, back issue availability and friendly interface were all important factors in the use of electronic journals (Salisbury, Vaughn and Bajwa 36-40).

Information Access & Retrieval Domain

Although there are seven articles under the *Information Access & Retrieval* domain, it must be noted that five of these papers stem from the same author using the same initial research study. The author (Mansourian) makes it clear within each paper that these are reports of a wider study. This researcher is not expressing any opinion about this fact. However, in terms of content analysis of library literature published about biological subjects, it is important for readers to understand that the following will be a description of several papers covering several aspects of the same research study.

Mansourian draws on his results from PhD work ("Information Visibility" PhD) of interviews with 37 biologists at the University of Sheffield to examine end users' interactions with search tools on the web. Interviewees consisted of faculty and PhD students in animal and plant science, molecular biology and technology, and biomedical science departments. Biologists were asked to recall a web search event and answer questions such as "which search facilities had been used, what steps they took to conduct the search, what their search topic was, why the search was important to them, how long it took, and so on" ("An Integrative Model" 408). They were also asked to describe successful and unsuccessful searches ("Web Searchers' Attributions" 659-679). Mansourian and Ford found that researchers attributed most cases (82%) to either internal or external factors. Internal factors included elements such as ability or effort, whereas external factors included examples like luck or the information not being available. When faced with unsuccessful searches, Mansourian divided coping

strategies into active and passive categories. Active strategies included seeking help or re-examining the original search. Passive strategies were described as strategies that "entail less action to modify the situation and mainly relate to accepting the existing circumstances" ("Coping Strategies" 28).

Mansourian developed five categories that affect search performance: characteristics of the user, search tool used, "search topic, search situation, and features of the retrieved information resources" ("Contextualization" 202). Context of the web search was important in determining the success of the search. Mansourian and Madden discussed how web searches were either work-related or "everyday life searches" ("Perceptions of the Web" 419). Subjects were more comfortable and confident conducting work-related searches, as opposed to everyday life searches that covered a wider range of sometimes challenging topics. Mansourian et al. found that although interviewees reacted differently when realizing they were possibly missing information in their web searches, the "perceptions of the importance and the volume of missed information varied" ("An Integrative Model" 402). This perception of importance and volume affected whether or not they continued with their search. All of this research helped librarians and web developers gain a better understanding of how users interact with web-based resources.

Bartlett and Toms (469-582) documented a unique bioinformatics process that had previously only been communicated by word-of-mouth. By interviewing 20 bioinformatics experts from across Canada and the United States (including 6 from universities comprising of faculty, graduate students and post-doctoral fellows), the researchers were able to capture and understand how bioinformatics experts "conduct functional analysis of a gene using a wide assortment of data and tools" (Bartlett and Toms 481).

Tang and Safer attempted to "step inside the author's head" (Tang and Safer 267) by asking biology and psychology researchers from many universities across North America to evaluate the importance of all cited references in a recent scholarly article. The researchers also had to give the best reason for citing a reference and indicate the relationship the researcher had to the cited reference. This twist on traditional citation analysis was an effective way of understanding the thought patterns used to choose a citation.

Discussion

The researcher found that 33 of the 96 records found (34.4%) were categorized as research articles. This is similar to Koufogiannakis et al.'s broader study where they identified 30.3% as research articles (Koufogiannakis, Slater and Crumley 231). Although Sinn (104) found very few recent studies regarding library instruction to biology classes, this research reveals that studies in the *Education* domain dominated the research in recent years. Although many library instruction papers were excluded from this study because they did not have a specific research focus, they can also inform biology librarians regarding instruction tools and techniques.

Over half of the *Education* papers involved some form of program assessment. As discussed in the Methods section, this researcher used Peritz's definition of research to find research-based articles: "an inquiry, which is carried out, at least to some degree, by a systematic method with the purpose of eliciting some new facts, concepts or ideas" (Peritz 251-268). Although confident with this definition for this review, the researcher did start to question the differences between assessment and research. Upcraft and Schuh have written a very interesting paper on the subtle differences between the two activities.

> Assessments use research methods, but they have very different reasons for being conducted. Assessments are undertaken to guide practice. As a consequence of the assessment's findings, practice is adjusted. Research is framed by theory. As a consequence of a study's findings, the theory may be re-conceptualized, affirmed or perhaps even rejected until another investigation is undertaken. (Erwin, qtd. in Upcraft and Schuh 17-18)

Evidence-based library and information practice is "a practical approach to finding answers to questions and for professionals to stay abreast of current trends and research" (Cleyle and McKenna 92). Evidence-based advocates have started the discussion regarding links between EBLIP and library assessment. Although they appeared to exist as "two solitudes" (Ryan 77), there seem to be more similarities than differences in the two practices. Booth (66) described linkages between evidence-based practice and performance measurement and explained that "as with performance measurement, EBLIP seeks to bring the best available data to bear on a specific problem and continually to improve the quality of that data for the future, thereby reducing uncertainty" (Booth 66).

Program assessments were useful evidence in the *Education* domain. In the end, Upcraft and Schuh stated that the differences between assessment and research did not really matter because both were using results "to influence decision making, policy, and practice" (Upcraft and Schuh 20). Those in EBLIP and assessment are starting to understand the need for "awareness and understanding of each others' methods, frameworks and processes and that there is keen interest in working together to move forward" (Ryan 79). In a paper describing a comparison of results of a local Penn State University survey with national survey data, Cahoy and Snavely (222) provided very good insight on the value of assessment and evidence-based decision making:

> As funding gets tighter and new initiatives and continued funding are increasingly tied to data and strategic plans, gathering data and using it for evidence-based library decisions is not only wise but essential. What you discover may help keep your library at the heart of your institution. (Cahoy and Snavely 222)

Collections was also an active research domain. Citation analysis remained a popular study type for work in collection development. This form of study was found in past works of biology subjects including studies of faculty papers (Crotteau 67-86; Lascar

and Mendelsohn 422-433 (with older data)), graduate students (Walcott 1-14) and databases where citations were most cited (Delendick 535-543). Even though "the small amount of research in the Reference category was…somewhat surprising given that reference service is a common component of librarianship work" (Koufogiannakis, Slater and Crumley 232), this researcher also found few studies in the *Reference/Enquiries* domain. Could it be because there are more "how we did it" articles in this domain as opposed to papers with a specific research focus? Are there problems specific to this domain that make it difficult to research (i.e., confidentiality issues, time and logistical constraints with studying a "one-off" interaction)? Or is it a deeper issue regarding lack of students (science or otherwise) seeking help from someone at a reference desk, a chat box on their computer, or a text message from their cell phone? Further study is needed to determine the reasons for lack of papers in this domain.

There were no papers categorized in the *Management* or *Professional Issues* domains. There are great opportunities for librarians not only to focus their research on under-represented domains but also to study under-represented subjects. For example, almost all of the papers in the *Education* domain focused on undergraduate students. What are some of the education needs of graduate students and faculty? What management or professional issues arise when working as a biology librarian? Because this research only focused on biology subjects, it is conceivable that some papers that may have dealt with science librarians (but did not specifically state working with biology subjects) may have been missed. This would be a useful area for future investigation.

Conclusion

This content analysis and literature review were conducted in order to better assess what literature had been recently published regarding university biology subjects. This research will help science librarians understand biology faculty, students, and their various information needs. It will also give information professionals an enhanced perspective of which journals and databases publish or index in this subject area. This study will help inform librarians of the need for future research within specific domains and subject groups. Science librarians are encouraged to continue to contribute to a growing body of evidence in order to better understand the research needs of their patrons.

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Appendix

Search Strategies

The following search strategies were used to find peer-reviewed articles that used biology students, faculty or their academic papers as research subjects (Articles were limited to the years 2000-2010 and when available, also limited to "peer-reviewed" or "scholarly"):

Library-specific databases (LISA, Library Literature, LISTA):
(biolog* or life scien*) and (academic or university) and (student or faculty)
biolog* and (academic or university) and (student or faculty)

Non-Library databases (ERIC, Web of Science)
biolog* and (academic or university) and (student* or faculty) and librar*
biolog* and information and (needs or use) and librar*
biolog* and information literacy