Library Value in the Classroom: Assessing Student Learning Outcomes from Instruction and Collections

Denise Pan a,⁎, Ignacio J. Ferrer-Vinent b, Margret Bruehl c

a Technical Services, University of Colorado Denver, Auraria Library, 1100 Lawrence Street, Denver, CO 80204, USA
b University of Colorado Denver, Auraria Library, 1100 Lawrence Street, Denver, CO 80204, USA
c University of Colorado Denver, Department of Chemistry, Campus Box 194, P.O. Box 173364, Denver, CO 80217-3364, USA

ARTICLE INFO

Article history:
Received 2 March 2014
Accepted 28 April 2014
Available online 23 May 2014

Keywords:
Value of library services and resources
Assessment
Information literacy
Student learning outcomes
Library instruction
Collections assessment

ABSTRACT

What is the value of library services and resources in the college classroom? How do library instruction and collections contribute to academic teaching and learning outcomes? A chemistry instructor, instruction librarian, and technical services librarian collaborated to answer these questions by combining chemistry education and information literacy pedagogy to assess student learning. The authors developed curriculum units that teach information literacy skills and scientific literature research in a General Chemistry Laboratory course for Honors students. Their study extends beyond examining library instruction and collections assessment in isolation. Rather, their research protocol intends to contribute to student learning outcomes assessment research. The authors propose that an embedded, mixed-methodology, and longitudinal approach can be used to collect data and assess outcomes in terms that describe and measure the value of library services and resources.

© 2014 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-SA license (http://creativecommons.org/licenses/by-nc-sa/3.0/).

INTRODUCTION

The institutional goal of research universities should be a balanced system in which each scholar – faculty member or student – learns in a campus environment that nurtures exploration and creativity on the part of every member (Boyer Commission on Educating Undergraduates in the Research University, 1998, p. 10).

This story began with a simple email and lead to an interdisciplinary study conducted over three academic years. At the University of Colorado (CU) Denver, in the summer of 2010, a technical services librarian contacted a chemistry instructor and asked: “In the current economic climate, when university administrators are looking for ways to balance the budget, it is imperative that libraries provide evidence of value and demonstrate their contribution to university priorities. Are you available to discuss your potential participation in a study?” By fall term, the survey participant became a co-researcher and with the help of an instruction librarian, the library was embedded into two chemistry classes. Together the three like-minded faculty members from different areas of academia and librarianship collaborated to produce curriculum units for Honors students in General Chemistry Laboratory I and II courses, administered over fall and spring semesters. The authors exposed first-year students to scientific literature and assigned information literacy activities that help build problem-solving and critical thinking skills to engage and promote student success. Moreover, they developed and implemented a research protocol that enabled them to gather and analyze data on student learning outcomes over time.

At the conclusion of a three-year study, the three faculty members asked themselves three questions: Can we generalize this methodology? Will it scale? Does it contribute to the organizational goals of student retention and success? Their answer was, “we believe so.” This article is an invitation to practicing librarians and Library and Information Science researchers to implement the CU Denver research protocol for gathering and analyzing data to measure the value of library services and resources. In this article, the authors will explain how their article contributes to the growing body of literature focused on student learning outcomes assessment; describe their research protocol and curriculum units; and provide a summary of study results. Companion articles address the case study methodology, implementation, and student performance assessments (Ferrer-Vinent, Bruehl, Pan, & Jones, submitted for publication); and describe the curriculum units developed and their connection to building information literacy (Bruehl, Pan, & Ferrer-Vinent, submitted for publication).

STUDENT LEARNING OUTCOMES ASSESSMENT

Like a rally call to the troops, the Association of College and Research Libraries (ACRL) and Megan Oakleaf created The value of academic
libraries: A comprehensive research review and report (2010). In essence, the report encourages campus level conversation on assessment, accountability, and value. Within the context of institutional mission and outcomes, they identify “Student Success” as one of the top ten areas of library value on which to focus a research agenda. In response to the question – “How does the library contribute to student learning?” – Oakleaf states that the current literature on information literacy is “voluminous,” but a majority is “sporadic, disconnected, and reveals limited snapshots of the impact of academic libraries on learning.” Instead, she recommends that “Academic librarians require systematic, coherent, and connected evidence to establish the role of libraries in student learning” (ACRL, 2010, p. 118). In her review and analysis of the literature, Oakleaf introduces several practical suggestions (p. 37–42). The authors distill these concepts into three words that describe the essence of their foray into student learning outcomes assessment: collaboration, purposefulness, and longevity.

COLLABORATION

Comprehensive and meaningful assessment of student success is impossible in isolation. A learning ecosystem can be cultivated between student and instructor; student and librarian; and instructor and librarian. Poetically described by the Boyer Commission report, Reinventing undergraduate education, “The ecology of the university depends on a deep and abiding understanding that inquiry, investigation, and discovery are the heart of the enterprise, whether in funded research projects or in undergraduate classrooms or graduate apprenticeships. Everyone at a university should be a discoverer, a learner” (Boyer Commission on Educating Undergraduates in the Research University, 1998, p. 9).

Throughout library literature, these sentiments have been echoed for more than a decade.

When evaluating the 21st century library, Smith (2001) describes the changing environment of higher education. The concept of learning has shifted from the “teacher’s knowledge to the student’s understanding and capabilities...it requires the faculty to bring the strength of the research paradigm into the learning process” (2001, p. 29). Academic faculty members are being asked to become learning experts by focusing on outcomes assessment — developing individual students’ competencies and demonstrating collective programmatic success. As part of the academic community, the mission of the library must change from “a content view (books, subject knowledge) to a competency view (what students will be able to do)” (p. 32).

No longer gatekeepers to materials or tools, academic librarians must take a more active role in the learning process and contribute student learning outcomes for academic programs across the curriculum.

Similarly, Nimon recognizes the expanded role of librarians in measuring the outcomes of academic programs. To do so, she encourages developing partnerships between the library and academic departments to teach information literacy. Moreover, the success is contingent on including assessment criteria that reflect the goals of all stakeholders — librarian, academics, and students. She explains, “Student evaluation of the program must be appropriately tailored to show whether its goals were readily visible to the learners and whether the learners considered them met...It will be necessary for the assessment of student work to be at least in part a joint responsibility” (Nimon, 2001, p. 50).

Participation in pedagogy and assessment activities is not just the role of academic librarians, but their obligation. Bundy asserts that they “can no longer responsibly disengage from why students want to what use they put it” (2004, p. 2). Instead, both academic teachers and librarians should be immersed in the total educational process — including program and curriculum development, learning design, pedagogies, assessment, and the scholarship of teaching and learning.

Information literacy is an important concept that should be owned by all educators (Bundy, 2004, p. 7). However, this terminology may not be recognizable outside the library walls. Some examples of synonyms and overlapping concepts that may resonate more widely include the following: information, research, or 21st century skills; independent scholarship or research; lifelong learning; scientific method; research processes; and Bloom’s taxonomy. As Oakleaf explains, “For those facing greater challenges, establishing and using a common language that emphasizes shared campuswide values may produce greater success” (2011, p. 65).

In his model for academic libraries, Lewis (2007) proposes a strategy for maintaining the central library position on campus in the digital age. One of his top five strategies is to “Reposition library and information tools, resources, and expertise so it is embedded into the teaching, learning, and research enterprise...Emphasis should be placed on external, not library-centered, structures and systems” (2007, p. 3). By focusing on student learning, academic libraries and librarians have new opportunities to reestablish their place on campus, engage with their colleagues, and maximize their contribution to their institutions and higher education as a whole.

PURPOSEFULNESS

When developing student learning outcomes assessments, academic librarians, and faculty members should proceed with purpose. In other words, they are intentionally gathering and analyzing particular types of data. Specifically, Dugan & Hernon (2002) assert, “student learning outcomes are concerned with attributes and abilities, both cognitive and affective, which reflect how the student experiences at the institution supported their development as individuals” (2002, p. 377). In addition, “outcomes assessment alerts us to what students know or do not know about research,” Carter explains, “thus allowing librarians to adapt instruction to the needs of the students” (2002, p. 41). This requires a commitment to document, evaluate, and communicate impacts on student learning, as well as improving one’s own teaching and assessment skills (Oakleaf, 2011, p. 70).

The literature on information literacy assessment identifies numerous techniques and tools. These tactics require a range of resources or experiences and assess various perspectives. Radcliff et al. describe three different learning domains: affective assesses how students feel or their opinions; behavioral evaluates what students can do; and cognitive measures what students know. They classify performance assessments, such as report writing, as part of the behavioral domain (2007, p. 19–20, 115). In contrast, Oakleaf describes performance assessments as “real-life applications of knowledge and skills” and “they reforce the concept that what students learn in class should be usable outside the classroom” (2008, p. 239). All can agree that assignments with an information literacy component can be used to measure higher-order thinking skills, and to achieve greater integration and contextualization in an academic course. While the results can offer a high degree of validity, they may have limited generalizability (Radcliff, Jensen, Salem, Burbanna, & Gedeon, 2007, p. 115–17; Oakleaf, 2008, p. 242–244).

The literature on assessment of information literacy is quite bountiful — well documented in monographs, handbooks, manuals, guides, and articles. The focus is nearly exclusively on library instruction, and overlooks other areas of librarianship. Library collections are included in the broader context of library assessment and emphasize cost effectiveness (Hufford, 2013, p. 20–26). Kimnari’s article “E-metrics and library assessment in action” is a rare example that highlights the significant role electronic resources play in demonstrating the value of libraries and impacting on student learning outcomes (2009). There is ample opportunity to expand this area of the scholarship into a new line of inquiry that captures the complexity of the learning environment and inspires more rigorous and critical investigation.
LONGEVITY

More than library instruction, information literacy extends outside the confines of the library and extends to the classroom, campus, and beyond. Each level requires more collaboration and complex logistics (Iannuzzi, 1999, p. 304). To be truly meaningful, outcomes assessment is an ongoing process. It requires time, effort, resources, and collaboration with academic faculty. The research process can be simple or elaborate, but must be based on meaningful data. From each experience, researchers can learn, refine, and improve assessment procedures (Carter, 2002, p. 41). Oakleaf & Kaske (2009) recommend that librarians follow best practices, use multiple methods and strategies, adjust goals and objectives, and repeat assessments continuously over time (2009, p. 283).

CU DENVER RESEARCH PROTOCOL & CURRICULUM UNITS

The literature describes collaboration, purposefulness, and longevity as key ingredients to achieve student learning outcomes assessment. This article continues this conversation. The authors at CU Denver adopted these assessment perspectives and adapted them to their local circumstances. Specifically the authors summarize their student learning outcomes assessment research protocol in three components: collaborating internally and externally; articulating outcomes; and assessing over time. By doing so they are able to expand beyond their silos and approach student learning outcomes assessment from an interdisciplinary perspective. The results of their study demonstrate the rich data and insights that are possible from their approach.

COLLABORATING INTERNALLY AND EXTERNALLY

The CU Denver researchers identified multiple opportunities for collaborations within librarianship, academia, and the campus. They found commonality with academic faculty and librarians from diverse areas and expertise. In addition, they also created teaching, research, and learning opportunities between faculty and students. A visual representation of these connections is available in Fig. 1.

At CU Denver, librarians have faculty status. The library and chemistry departments are two separately administered academic units reporting to the Office of the Provost. Although the departments often cooperate on collections and instruction initiatives, the authors’ research study represents a new level of collaboration. Library instruction and collections assessment activities are embedded into two Chemistry courses. More specifically, the researchers focused on shared values and appreciated other perspectives from different disciplines. In essence, they are proponents of a “golden triangle” approach to curriculum design “where everyone contributed to each component with the outcome being more robust than if they used the more linear model” (Fox & Doherty, 2012, p. 151–2).

Within the library context, a technical services librarian and an instruction librarian from the same academic library developed a partnership to conduct a student learning outcomes assessment research study with a chemistry instructor. This experience may be atypical. Bundy states that “few university libraries or librarians directly engage with, or reach out to, other parts of the profession…the focus tends to be on information resource sharing and access, rather than on learning collaborations and strategies” (Bundy, 2004, p. 9).

Most significantly, the CU Denver faculty developed a research relationship with their students. With Colorado Multiple Institutional Review Board approvals, they were granted permission to gather data from the students. In her Post Laboratory Assignment, Bruehl specifically invited her students to participate in the study and assured them that no additional work would be assigned, “Simply completing this assignment is all that is required.” All personal identification was removed by Bruehl before Pan and Ferrer-Vinent analyzed the student data. Bruehl also explicitly told the students that they could contact her during lab or via email to opt out of the study and their data would be excluded from the study (Bruehl et al., submitted for publication).

ARTICULATING OUTCOMES

Sharing common values and goals, the authors found exciting synergies for developing student learning outcomes assessment. All three researchers aspired to develop a project that could provide compelling evidence of supporting the institution’s mission for campus administrators. They surmised that an assignment that concentrated on information literacy could help them achieve this objective. In doing so, they developed a research instrument that enabled them to gather data on students’ ability to find, access, and evaluate scientific literature.

When developing her Honors General Chemistry I and II Laboratory courses, Bruehl aims to create a student centered learning environment. This teaching philosophy encourages active participation by students while the learning process is facilitated by the instructor. The investigative and inquiry-based laboratory courses emphasize teaching students problem-solving and critical thinking skills through open-ended experiments and using specialized techniques and instrumentation. This teaching and learning strategy builds on the CREATE (Consider, Read, Elucidate hypothesis, Analyze and interpret data, Think of the next Experiment) method.

Typically, the real language and research process documented in primary scientific literature is not presented to students until their upper division course or not at all during their undergraduate education. This delay is recognized as a missed opportunity at best, or a loss of science majors at worst. Using the CREATE pedagogy exposes students to scientific research literature and demonstrates the creative and exploratory nature of collecting and interpreting data for research. By doing so, students are being taught how to think like scientists, increase engagement, and could help with retention (Hoskins, Stevens, & Nehm, 2007; Gottesman & Hoskins, 2013). Findings from one study indicate that the CREATE method “increases students’ confidence in their ability to read and understand primary literature, improves their self-assessed understanding of the nature and processes of science, and encourages their development of more sophisticated epistemological beliefs” (Hoskins, Lopatto, & Stevens, 2011, p. 375).

The CU Denver research study has two overarching goals. The first is to demonstrate that teaching information literacy skills in first-year chemistry courses can provide immediate and long-term benefits to student performance. The second is to quantify the benefits students received in their educational activities by using library collections. Long term, the authors hope to be able to provide campus administrators...
with evidence that their efforts contribute to meaningful outcomes, such as student retention, graduation rates, and economic benefit.

To achieve these goals, the authors developed two complimentary curriculum modules to establish a foundation of information literacy skills for beginning science students using scientific literature and laboratory experiments. The first unit, administered in the fall semester, is entitled “Introduction to Scientific Literature” and is comprised of three components: 1) formal library instruction by a science librarian; 2) reading and in-class discussion on a scientific journal article; and 3) pre- and post-lab exercises to research an idea for a new general chemistry experiment. The students are asked to develop information literacy skills by searching the scientific literature for concepts, recording their research process, refining their premise, writing a brief description of their proposed experiment, and citing three resources in American Chemical Society (ACS) format that directly support their proposal.

Building on the skills and information they learned in the fall, in the spring semester they are asked to conduct a multi-week project entitled “Design your own General Chemistry Lab.” Again students explore the scientific literature for ideas on which to base their experiment, and record the reference for any resources they downloaded and read. Their final project includes a formal proposal; documented laboratory procedure that has been designed, developed, and tested by the student; citation list in ACS format; and presentation of results to the class.

In both semesters, students are conducting research in the scientific literature. To record their research process, Bruehl requires students to complete a research process template. The format of the template is a table with three separate columns to record: 1) database/search tool name; 2) search terms/refinements; and 3) resources viewed. The third column instructs the students to “paste ACS or specific journal format citation here.” Table 1 includes an example of a completed research process template, with good searching and narrowing values, provided by a student in spring 2012.

The research process template is an essential assessment tool for the authors to gather data to evaluate the students’ ability to find, access, and evaluate scientific literature. Bruehl required the student to record all resources viewed, even if the student only read the abstract or the table of contents, and not the article itself. She explains that, “Some resources that you record in this template will be more important to your project. These resources help to formulate your design, and they must ALSO be listed in your formal citation list” (Bruehl et al., submitted for publication).

By documenting the names of database/search tool name, search terms, and resources viewed, the authors could see how students are selecting the resources viewed — rejecting or accepting results that fall in and out of the scope, or distract or meet the needs of their topic. Broad subjects are narrowed with keywords, and then filtered down by publications focused on science experiments, such as the Journal of Chemical Education. Combining the expertise from academic faculty and library professionals, the authors analyze and compare the data from the research process templates and citation lists. Bundy summarizes this partnership and librarian contributions to teaching pedagogy as “Disaggregated roles, such as assessing learning resources for quality, overlap with what librarians do now, and the subject expertise of the academic teacher is being married with the librarian’s navigation and sense making of the information universe” (Bundy, 2004, p. 9).

ASSESSING OVER TIME

Realizing that outcomes assessment is a continuous process, the CU Denver researchers intentionally developed the project to be repeatable over multiple semesters and academic years. The project encourages collaborative teaching and learning from the students and one another. The authors refine and improve instructional strategies and assessment methods at each encounter. For example, during citation analysis, Ferrer-Vinent and Pan observed that a few students were citing articles that were not available full-text from the library. While it is possible that the students could have requested the article from interlibrary loan, the librarians were worried that these students did not understand the difference between an abstract and the full-text article. They shared their concerns with Bruehl who added this information to her lecture on scientific literature.

Exposing students to information literacy concepts over multiple semesters reinforces skills and the interconnectedness of information. The importance of the research skills and process is reiterated over two terms of an academic year. In the spring semester “Design your own General Chemistry Lab” assignment, Bruehl reminds students to expand their understanding beyond their own experience, and to use the research expertise they developed the previous semester. Scientific literature offers “a vast array of resources” to assist them with their assignment, which in turn helps them to develop and recognize sound scientific procedures, evaluate experimental methods, and draw appropriate conclusions. As a result, beginning chemistry students are fine tuning their ability to use the scientific method to investigate a scientific question.

Moreover the CU Denver study was conducted over three academic years. The researchers analyzed consistencies and variations over the same and consecutive semesters across multiple academic years. For example, they could examine data for each term (e.g. Fall 2010 and Spring 2011), or comparison between terms (e.g. Fall 2010 versus Spring 2011), and within an academic year (e.g. 2010–2011). Most importantly, since the chemistry students agreed to participate in the research project, the researchers surveyed the same students 1–2 years after they finished the Honors General Chemistry II Laboratory course. Therefore, with the CU Denver research protocol, the researchers gathered quantitative and qualitative data from the students at different points of their academic careers — during their first-year and beyond.

Table 1

Sample research process template.

<table>
<thead>
<tr>
<th>Database/search tool name</th>
<th>Search terms/refinements</th>
<th>Resources viewed (paste ACS or specific journal format citation here)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google</td>
<td>Vitamin C titration equations</td>
<td>Bacon, J.R. Determination of vitamin C by an iodometric titration. Western Carolina Univ. 2006.</td>
</tr>
</tbody>
</table>
CU DENVER RESEARCH STUDY RESULTS

On their own, the researchers could have independently assessed outcomes from their own disciplines’ perspectives. By collaborating internally and externally, articulating outcomes, and assessing over time, the authors developed and implemented their research protocol from fall 2010 to spring 2013. Expanding beyond their silos and using an interdisciplinary perspective and mixed methodology approach enabled them to produce distinct student learning outcomes assessment data and analysis.

Prior to their partnership, each author individually engaged in assessment activities. Bruehl conducted student learning outcomes assessment by grading students’ assignments, exams, and overall performance in the class. Ferrer-Vinent provided in-class library instruction, surveyed student perceptions, and assessed students’ post-instruction performance. With no direct contact with students, Pan measured the library’s potential contributions by analyzing usage statistics of electronic resources.

Together they leveraged personal expertise to enhance their shared research project. Their interdisciplinary approach allowed them to develop and evaluate richer data sets. The CU Denver researchers apply the quantitative citation analysis data from the research process template and qualitative surveys to address their research inquiries. Specifically, they intend to demonstrate that teaching information literacy skills in first-year chemistry courses can provide immediate and long-term benefits to student performance; and to quantify the benefits students received in their educational activities by using library collections. Research outcomes are summarized in three subsequent sections: 1) quantitative information literacy study results; 2) quantitative collections ROI study results; and 3) qualitative student benefits survey results. As previously mentioned, details on the authors’ research methodology is described in their companion case study article (Ferrer-Vinent et al., submitted for publication).

QUANTITATIVE INFORMATION LITERACY STUDY RESULTS

By recording the references of resources viewed and cited in their assignment, the authors could begin to quantify and aggregate how students are developing information literacy skills. For example, Table 2 demonstrates that they were able to calculate the average number of resources viewed per student to complete the fall and spring term assignments and their average course grade. For the fall semester assignment, students were instructed to use their library skills to view resources and select three upon which to base a proposed experiment. In spring, students received no guidance on how many resources should be viewed or selected to support their experimental design. Excluding the first semester, during which the authors were still refining the assignment guidelines, students on average looked at almost 10 resources in the course of their assignments and their average grade was 87.5%.

The researchers intentionally collected grades to enable them to correlate academic performance and use of library resources. Said another way, they hypothesize that there is a relationship between the extensive use of library resources and a high score. If students consulted multiple databases, reviewed many articles, and selected the best three resources, they should receive a higher score than a student who only used one database and looked at a few articles. The authors collaborated with Galin Jones – Associate Professor at the University of Minnesota, School of Statistics – to determine that there is a statistically significant positive relationship between resources viewed and the students’ final grade for the course. The full explanation on the linear regression analysis is available in the case study companion article (Ferrer-Vinent et al., submitted for publication).

QUANTITATIVE COLLECTIONS ROI STUDY RESULTS

The authors also use the citation analysis data to calculate the cost benefits of purchasing scientific literature to support learning objectives. To do so, they measure library value by deriving value using return on investment (ROI). According to Tenopir (2012), “Derived values, such as return on investment (ROI), use multiple types of data collected on both the returns (benefits) and the library and user costs (investment) to explain value in monetary terms” (2012, p. 6). In order to measure return on investment, the authors needed to assign a monetary value to having access to non-market resources/services or library collections. They applied contingent valuation as defined by Megan Oakleaf to assign value to library collections and to determine potential willingness to pay to maintain the existence of library collections (ACRL, 2010, p. 50). Many publishers, including ACS, sell individual articles online. If the library did not provide these articles, students could purchase these ACS articles on their own. The authors utilize the price to download an article to derive a market value for the library service of providing access to collections. In turn, this calculated value enabled the researchers to calculate student benefits for the ROI calculations.

The CU Denver Student ROI Model is based on established ROI and cost benefit analysis (CBA) formulas. ROI is calculated as a percentage. It shows the return or increase in value on dollars spent to achieve a benefit. The generic formula is benefits minus costs divided by costs and multiplied by 100.

\[
\text{ROI} = \left( \frac{\text{Benefits} - \text{Costs}}{\text{Costs}} \right) \times 100 = \text{ROI.}
\]

CBA uses the same values as ROI. However, CBA is the ratio showing the dollar value of benefits gained for dollar value of costs. The basic formula is benefits divided by costs.

\[
\text{Benefits} \div \text{Costs} = \text{CBA.}
\]

Benefits are the estimated cost for students to buy cited articles directly from the publisher with pay-per-view. Costs are the Library costs to supply cited online journals. This methodology is based on a parallel CU Faculty ROI Model and multi-campus study Pan conducted

<table>
<thead>
<tr>
<th></th>
<th># of students</th>
<th>Total # resources viewed</th>
<th>Min # resources viewed</th>
<th>Max # resources viewed</th>
<th>Average # resources viewed</th>
<th>Average final grade %</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2010</td>
<td>26</td>
<td>174</td>
<td>3</td>
<td>16</td>
<td>6.7</td>
<td>89.8%</td>
</tr>
<tr>
<td>Spring 2011</td>
<td>21</td>
<td>197</td>
<td>1</td>
<td>28</td>
<td>9.4</td>
<td>90.7%</td>
</tr>
<tr>
<td>AY2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2011</td>
<td>37</td>
<td>369</td>
<td>3</td>
<td>39</td>
<td>10.0</td>
<td>84.5%</td>
</tr>
<tr>
<td>Spring 2012</td>
<td>36</td>
<td>341</td>
<td>0</td>
<td>66</td>
<td>9.5</td>
<td>87.1%</td>
</tr>
<tr>
<td>AY2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2012</td>
<td>25</td>
<td>248</td>
<td>5</td>
<td>26</td>
<td>9.9</td>
<td>87.5%</td>
</tr>
<tr>
<td>Spring 2013</td>
<td>16</td>
<td>155</td>
<td>4</td>
<td>13</td>
<td>9.7</td>
<td>87.1%</td>
</tr>
<tr>
<td>Total</td>
<td>161</td>
<td>1484</td>
<td>0</td>
<td>66</td>
<td>9.2</td>
<td>87.5%</td>
</tr>
</tbody>
</table>
to measure the institutional value of library resources used by faculty in their research (Pan et al., 2013).

The authors analyzed the citations and determined that students viewed 1489 resources over three years. Most of these articles were searched on the ACS Journal Database 58.0% of the time (863 out of 1489). Collectively the students looked at 1153 journal articles from 200 unique journal titles, and they consulted the *Journal of Chemical Education* (JCE) 66.7% of the time (769 out of 1153). Since a majority of the students used the JCE, the use and cost estimates for this journal title was used to calculate the ROI and CBA for the course. The authors derived the student costs from the number of times JCE was viewed, multiplied by the pay-per-viewed cost. The library cost for JCE was estimated by taking the database cost divided by the number of titles in the database.

Since ROI is calculated as a percentage, values over 100% are a positive ROI. Similarly, since CBA is a ratio showing how much is gained for every dollar spent, $1.00 is the breaking point. Values greater than $1.00 are a “positive” CBA. The results of the CU Student ROI Model for Honors General Chemistry I and II Laboratory courses at CU Denver from fall 2010 to spring 2013 are summarized in Table 3. Overall, the results indicate a very strong ROI and CBA for the *Journal of Chemical Education* with the greatest ROI of 2324% and CBA of $24.24 in fall 2011.

### QUALITATIVE STUDENT BENEFITS SURVEY RESULTS

In addition to collaborating on quantitative citation and cost benefit analysis, the researchers also conducted qualitative assessments. After the students completed the Honors General Chemistry II Laboratory course, Bruehl emailed them an anonymous survey. This was an opportunity to gather data on the impact of teaching information literacy to first-year chemistry students over the long term. The questionnaire reminded the students that “as part of your lab work, you used the [scientific] literature and captured your on-line searches in a research process template,” and invited them to participate in the survey as a “follow up to those activities.” A copy of the longitudinal student survey is available in the companion article focused on the curriculum units (Bruehl et al., submitted for publication).

The responses to the survey were overwhelmingly positive. Over 40% (37 out of 88) of the students completed the questionnaire. When asked about their experiences before and after Honors General Chemistry Laboratory, more than half stated that they searched a scientific literature database since course completion. In addition, this was nearly a 40% increase over their experience prior to taking the course (see Table 4).

Surprisingly, students reported that they searched the American Chemical Society (ACS) journals for scientific literature more frequently than Google (77.4% and 71.0% consecutively). SciFinder, ScienceDirect, and Web of Science were also identified as scientific literature databases that they used after finishing the course. The two other resources identified were PubMed and JSTOR (more details provided in Table 5).

More or less than half of the students responded that they did the search for their own curiosity or for a research project/internship (see Table 6). The vast majority of students, however, conducted these database searches for another course. The knowledge they acquired was directly applied to 17 other Chemistry courses. More significantly, their information literacy skills transferred to 21 courses in Biological Sciences, 2 in English, and 1 in Psychology. These findings support the authors’ hypothesis that teaching information literacy skills can provide students with long-term benefits.

### CONCLUSION

With the CU Denver student learning outcomes assessment research protocol, three researchers from different areas within librarianship, academia, and the campus collaborated to explore the value of library services and resources in the college classroom. Moreover, a chemistry instructor, instruction librarian, and technical services librarian sought to create a methodology for describing and measuring the benefits of library instruction and collections to academic teaching and learning. They discovered that their process includes three components – collaborating internally and externally, articulating outcomes, and assessing over time; and echoes the elements identified in the student learning outcomes assessment literature – collaboration, purposefulness, and longevity.

This study demonstrates the possibilities when academic faculty and librarians move beyond established roles and responsibilities, and attempt student learning outcomes assessment from an interdisciplinary perspective. The authors developed a research process template to gather data used to evaluate the students’ ability to find, access, and evaluate scientific literature. In turn, this citation analysis was used to assess the efficacy of teaching information literacy skills in first-year chemistry courses and the value of purchasing scientific literature to support learning objectives. With their mixed methodology approach, the research also combined qualitative assessments with their quantitative citation and cost benefit analysis.

The CU Denver research protocol has just begun to scratch the surface by focusing on assessing information literacy outcomes within the library and the chemistry laboratory. What would happen if similar curriculum units were adapted and applied to different disciplines? Can we teach students to think like historians, sociologists, economists, etc. by exposing them to the research literature? There is ample opportunity to extend this protocol to other disciplines and beyond their institution. Iannuzzi explains that, “…if we want to ensure that those skills are

### Table 3

Students ROI study results for *Journal of Chemical Education*.

<table>
<thead>
<tr>
<th></th>
<th>ROI</th>
<th>CBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2010</td>
<td>626%</td>
<td>$7.26</td>
</tr>
<tr>
<td>Spring 2011</td>
<td>884%</td>
<td>$9.84</td>
</tr>
<tr>
<td>AY 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2011</td>
<td>2324%</td>
<td>$24.24</td>
</tr>
<tr>
<td>Spring 2012</td>
<td>1100%</td>
<td>$12.09</td>
</tr>
<tr>
<td>AY 2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2012</td>
<td>1971%</td>
<td>$20.71</td>
</tr>
<tr>
<td>Spring 2013</td>
<td>288%</td>
<td>$3.88</td>
</tr>
<tr>
<td>Total</td>
<td>1144%</td>
<td>$12.44</td>
</tr>
</tbody>
</table>

* The researchers attribute the low ROI of 288% and CBA of $3.88 in spring 2013 to low student enrollment due to a scheduling conflict and cancellation of one section of the course.

### Table 4

Reponses to follow up survey.

<table>
<thead>
<tr>
<th></th>
<th># of students</th>
<th># of student responses</th>
<th># of responses that searched database prior to class</th>
<th>% of response prior</th>
<th># of responses that searched database prior class</th>
<th>% of responses prior class</th>
<th>% change increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY 2011</td>
<td>23</td>
<td>8</td>
<td>4</td>
<td>50%</td>
<td>8</td>
<td>100%</td>
<td>50.0%</td>
</tr>
<tr>
<td>AY 2012</td>
<td>40</td>
<td>18</td>
<td>9</td>
<td>50%</td>
<td>17</td>
<td>94%</td>
<td>41.5%</td>
</tr>
<tr>
<td>AY 2013</td>
<td>25</td>
<td>11</td>
<td>1</td>
<td>50%</td>
<td>6</td>
<td>55%</td>
<td>37.5%</td>
</tr>
<tr>
<td>Total</td>
<td>88</td>
<td>37</td>
<td>14</td>
<td>38%</td>
<td>31</td>
<td>84%</td>
<td>38.0%</td>
</tr>
</tbody>
</table>

* Answered “yes” to the question “Prior to your enrollment in Honors General Chemistry Laboratory, had you ever searched a scientific literature database?”

b Answered “yes” to the question “Since you have completed Honors General Chemistry Laboratory, have you searched a scientific literature database?”
Table 5
Database usage since completing Honors General Chemistry Laboratory.

<table>
<thead>
<tr>
<th># of responses that searched database since class</th>
<th>Scientific literature databases used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACS</td>
</tr>
<tr>
<td>AY 2011</td>
<td>8</td>
</tr>
<tr>
<td>AY 2012</td>
<td>17</td>
</tr>
<tr>
<td>AY 2013</td>
<td>6</td>
</tr>
<tr>
<td>Total #</td>
<td>31</td>
</tr>
<tr>
<td>% of Total</td>
<td>77.4%</td>
</tr>
</tbody>
</table>

Table 6
Explanation for database searches.

<table>
<thead>
<tr>
<th># of responses that searched database since class</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Course</td>
</tr>
<tr>
<td>AY 2011</td>
<td>8</td>
</tr>
<tr>
<td>AY 2012</td>
<td>17</td>
</tr>
<tr>
<td>AY 2013</td>
<td>6</td>
</tr>
<tr>
<td>Total #</td>
<td>31</td>
</tr>
<tr>
<td>% of Total</td>
<td>90%</td>
</tr>
</tbody>
</table>

applied within other courses, that there is meaningful transfer to other learning environments, and that ultimately the quality of the student's work is improved, the assessment methodology moves beyond library control into collaborative efforts with teaching faculty (Iannuzzi, 1999, p. 304). The CU Denver experience is an example of engaging with faculty, asking for input, suggesting a partnership, and co-creating an interdisciplinary study. In essence, exciting opportunities can be possible when librarians leave the library, meet and engage with academic faculty, and capitalize on serendipity.

ACKNOWLEDGEMENT

We would like to thank the University of Colorado Denver Honors General Chemistry I and II Laboratory students who provided the data for this article.

REFERENCES