"Practice Makes Perfect" – Curriculum Integration into a Third Year Biology Course: Collaboration between Faculty and Librarian

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Abstract

In biology as in other disciplines, it is important that students acquire sound research and critical thinking skills to be able to participate in the research culture of the university and the science community at large. This requires that they develop expertise in the use of sophisticated finding tools and resources in their subject area. Instruction needs to be designed so that the acquisition of library research skills is demonstrable, measurable and transferable to other courses and programs.

Scope

This paper reports the findings from a two-year collaborative study with a professor in biology and the biology subject librarian that have greatly enhanced the process of integrating Information Literacy (IL) skills into the Biology curriculum, and tied them to measurable outcomes at York University, Toronto, Canada.

Results and Conclusions

When students receive contextual, staged instruction on the use of library resources as an extension of their critical thinking and scientific reasoning, they subsequently change the way they approach research for their courses. Once they have the tools to conduct discerning literature searches, to read critically and to evaluate the information they find, students recognize the benefits of these processes and are able to transfer these skills to other courses and assignments. To be effective, assignments have to be tied to the subject content, and allotted marks for process. Librarians are increasingly becoming purveyors of information literacy skills that enable students to conduct research on a topic, find a focus for their research, and generally become more science literate.

Key Findings

1. Student perceptions of the benefits of the library instruction sessions

- Students felt that the systematic approach to library research coupled with handouts and instructions gave them a good understanding of the research process and prepared them better for completing assignments in other courses.
- Students were particularly satisfied with the skills they had acquired for database searching, formulating a search strategy, citation searching and researching a researcher, and writing annotations. Having a process for reading, understanding and engaging with scientific literature gave students more confidence in their research and writing skills.

2. Effect of sessions on students' selection of resources

- Once they become aware of scholarly resources and learn to use them as an extension of their critical thinking processes, many students no longer rely on Google and Wikipedia, but rather turn to specialized databases for literature searching.

3. Students' recommendations and feedback

- Students recommended that this kind of IL instruction be incorporated into the Biology curriculum in first and second year of university rather than towards the latter half of their education.
- They would have liked more time spent on learning how to write reports and research papers, as well as how to prepare and give presentations.

Background

There is an emerging paradigm in post-secondary education around the world, where a shift is taking place from being primarily instructor-centered to becoming student centered. It is driven by increasing stakeholder demands for accessibility, consistency, accountability and relevance, and it involves incorporating learning outcomes into courses and programs – a move from what is being taught (instructional inputs) to what students are able to do (learning outcomes) at the end of a course or completion of a program. At the core of this movement are accountability and the assessment of competencies that are based on the expected outcomes in courses and programs, and that are aligned with appropriate assessment strategies.

As part of this international trend to assess academic quality in terms of program learning outcomes, the Ontario Council of Academic Vice-Presidents (OCAV) have drafted a degree qualifications framework describing the general learning outcome competencies expected at each degree level of university education. These threshold degree standards are presented in the form of six guidelines that articulate specific learning outcomes (York University, 2007c). Libraries are also involved in this movement as Information Literacy (IL) skills and learning outcomes associated with them are peppered throughout the guidelines for both the general Bachelor's degree and Bachelor's Honours degree requirements. Specific reference is made to IL in the statement: "This degree is awarded to students who have demonstrated an ability to gather, review, evaluate and interpret information relevant to one or more of the major fields in a discipline". The OCAV website lists examples of universities in other jurisdictions that have already developed program learning objectives for their curricula (York University, 2007b). They include a range of disciplines that articulate the importance of Information Literacy skills as being essential to post-secondary education, among them Biology.

York University along with other Ontario universities is also currently in the process of aligning its programs and curricula with the OCAV Degree Level Expectations (DLEs). The Centre for the Support of Teaching (CST) at York University is instrumental in, among other things, providing faculty support with curriculum development and evaluation, especially with regard to OCAV implementation and Undergraduate Program Reviews, and this includes providing a venue for faculty-librarian collaboration, and highlighting the libraries as purveyors of information literacy skills[1] (York University, 2007a).

A critical component for the successful implementation of recommendations and programs is assessment of whether the desired learning outcomes have been achieved. Librarians at York have long been involved in the assessment of library service provision through running focus groups, obtaining student evaluations of IL classes, and on a broader scale, being involved in studies such as LibQual (users' opinions of service quality, (Association of Research Libraries, 2009)) and SAILS (Standardized Assessment of Information Literacy Skills, (Kent State University, 2008)). This ties into the rising culture of assessment and accountability to stakeholders, students and society.

[1] The librarian, Ilo-Katryn Maimets is a faculty associate for the Centre for the Support of Teaching (CST) at York University, and has received extensive support from the Centre for conducting research and disseminating the results of this project. Thank you to Ros Woodhouse (Academic Director) and Cherie Bova (Associate Director) for their ongoing support.

Identifying the Need for Instruction

In the fall semester of 2007, science graduate student focus groups were conducted by a team of instructional librarians at Steacie Science and Engineering Library, and 14 students were asked to describe how they approached library research in their subject areas (unpublished). Students who understood how library research tied in with scientific thinking, methodology and research in the lab, and who used their library research skills as part of their subject research process, appeared during the interviews to have more control over their work, to choose better projects, to communicate with peers and professors on a higher level, and to generally express higher confidence levels and more expertise in their fields. They were able to follow research trends in their areas of interest, giving them a distinct edge over students who had little or no grasp of how to find, access, evaluate and use the information produced in their disciplines. In stark contrast to them, students who had not availed themselves of library instruction and services, had little knowledge of how to identify, access and use library resources and expressed in several cases extreme frustration and feelings of inadequacy. They were much more dependent on their thesis supervisors for direction and supervision, and generally were much less confident in their abilities as researchers. The Focus Groups revealed that many graduate students are quite frustrated because they receive very little guidance in learning the process of searching and their awareness of library resources and services is very minimal.

These findings confirmed what was already known in the literature: that students and faculty find information in very different ways (Leckie, 1996; Leckie & Fullerton,1999). Professors rely on resources that they have identified through their invisible colleges and peers, the papers they read and publish, journals that they subscribe to, and other current awareness venues. Students, on the other hand, are new to the study area, lack the personal and professional relationships and connections to researchers in their fields of study, and therefore need to learn how to find, evaluate and use information in databases, through the internet, and other resources. A few faculty at York University have worked with subject librarians to incorporate information literacy into their curricula, but most sessions have not been tied to course outcomes and assignments. Likewise, research support provided by the library is not frequently accessed by students, particularly undergraduates, on a voluntary basis. Unless they are prompted or motivated by marks, students do not usually think of coming to the library to find out how to conduct research and find information sources.

However, science research is enhanced when students know what research is being done, where the gaps are, who the major players are, and how to evaluate this research. Students don't have the advantage of the invisible college of colleagues that they keep in touch with and share information with. While some are closely mentored and introduced to the field and the literature by their professors, most are left to their own curiosity, creativity and savvy to find the information they need to inform their research decisions. Having the tools for searching is beneficial in this process.

How it Began

In the summer of 2007, the biology librarian was contacted by a York University biology professor [2] who was grappling with students' very poor quality of writing and referencing and lack of understanding of the research process. He wanted to devise a systematic

[2] Dr. Roberto Quinlan, Associate Professor, Department of Biology, York University

approach for teaching students library research, evaluation, writing and presentation skills on an appropriate level for students preparing for their fourth year research theses and who were heading for graduate and professional schools. Some of the desired outcomes for the course that emerged from these conversations were to teach students:

- How to search for and evaluate relevant primary, secondary and tertiary literature as well as grey literature
- How to read and interpret research articles
- How to properly write a research paper
- How to properly give a research seminar

This required integrating library research with subject learning in context so students would develop a sense of how the scientific method is related to the library research process as well as the publication cycle. Our goals were to impart knowledge and expertise in the use of specialized tools and resources in their subject areas, and to foster the development of sound research, reading, evaluation and critical thinking skills that could be applied to all academic contexts and professions. Thus began a collaboration that has helped to focus attention on the importance of library involvement in teaching and learning at York University.

This study presents the results of two consecutive years of providing course-integrated, staged IL classes to Honours Biology students enrolled in Biology 3100: Current Topics in Biological Research, a prerequisite course for students continuing on to conduct a fourth year research thesis. This paper will describe the outcomes, instruction and assignments for the library sessions, and will focus on the results of the student evaluation surveys collected in the two years.

Methodology

Framework:

In September of 2007, three 90-minute library Information Literacy classes, and in September of 2008, four 90-minute IL classes were conducted. In the first year, the sessions were scheduled at the beginning of the course in three consecutive classes. In the second year, in response to student feedback, the classes were scheduled every other week, giving students more time to assimilate information and complete the assignments. Library instruction was integrated into the course by teaching students library research skills alongside subject content, the mastery of which was required as an integral part of the course work, assignments and testing process. 46 students completed this course in 2007-8 and 82 students completed it in 2008-9.

Students were given pre-tests to assess their initial understanding of IL principles, and identical post-tests to determine whether they had learned some of the fundamental IL skills over the course of the weeks that they received instruction and completed extensive in-depth assignments that incorporated those skills. These results will be published at a later date, but preliminary results indicate that basic testable IL skills improved by 17%.

The student evaluation form was designed to inform the instructional librarian about student perceptions of the benefits of the library instruction sessions. What influence did they have on the way students subsequently began to use library resources and services and how transferable were the skills that they had acquired? In the second year, students were also surveyed for recommendations about when in their university

careers would it be best to offer these sessions, and what kinds of sessions should be offered at each level.

Student Evaluation Survey:
The student evaluation survey included 9 questions in the first year, and 22 questions in the second year. In 2007, the test was administered on paper, and the response rate was close to 76% since it was completed in class and allotted 1% for being submitted. In 2008, it was administered online using the Survey Monkey tool, and due to a disruption in the classes brought about by a campus-wide strike, was not allotted class time, nor was it given a mark. The response rate was 45% - lower than expected. However, in the online environment, the students who did respond offered extensive feedback and comments, some of which will be highlighted in the results section.

Instruction Room:
All but the final class were held in a fully-equipped computer lab with instructor and student stations, overhead projector and screen. Internet access was required for the library website and catalogue, databases Biological Abstracts, Web of Science, SCOPUS and Medline, and bibliographic management software RefWorks.

Outcomes-driven Instruction, Assignments and Assessment:
It was recognized that while Information Literacy instruction is a linear process of imparting research skills to students, it needed to be tied to the iterative process of research, and would only be useful to students if they developed enough proficiency to be flexible and able to easily transfer the learned skills to other contexts and tasks. They needed to understand IL as a component of the scientific research process. Instruction had to be incremental, relevant and rewarding (Shorten, Wallace & Crookes, 2001).

A hierarchy of necessary skills was developed from the library instruction, adult education and science education literatures, from discussions with the course instructor, and from compiling personal experience with student learning spanning 9 years at the reference desk and teaching one-off library research classes to Biology and Nursing students. Each library session was collaboratively planned with a list of outcomes that were coupled with instruction designed and delivered in incremental components and hands-on practice. The outcomes for each class were closely tied to the assignments and assessment. The material covered in each session built on the knowledge acquired in the previous session(s) and comprised the basic skills students would need to be able to conduct in-depth research for their fourth year honours thesis. The learning and practicing of every new skill was ensured by the development of detailed assignments requiring recorded evidence of the processes that were taught for assessment purposes. The library assignments tested both research process as well as subject content, and together were allotted 38% of the final mark in the course. The following presents a summary of the outcomes, instruction and assignments as revised for the second year.

Session 1 provided a roadmap for students by conceptually linking the process of science research based on the scientific method with the publication/communication cycle and then with ways of organizing and accessing that body of information (Parrott, 2008). This set the stage for in-depth searching in subsequent sessions. RefWorks was used to create and organize reference lists, and producing them in Council of Science Editors (CSE) style was expected in all the assignments.
Session 2 involved more in-depth concepts such as how databases are structured, what their common features are as well as how they differ, for example in the limits, facets, citation searching, etc. The principles of keyword searching, including nested Booleans and truncation were covered and applied to searches in the library catalogue, Biological

Abstracts and Web of Science. Student assignments included recording their research strategies as well as notes describing their decisions and reasoning as they developed their searches.

Session 3 introduced the concept of controlled vocabularies, and in particular, Medical Subject Headings. This session focused on biomedical topics, and demonstrated broader uses of the scope notes in Medline(Ovid) as a source of keywords (related terms, synonyms and alternate spellings) for searching a range of databases including SCOPUS.

Session 4 focused on how to read papers for information, how to evaluate results and identify gaps in the research (Pechenik, 2007). Students were given lists of guiding questions that helped them to engage with their readings.

Outcomes for Session 1:

- To understand the scientific method as a thinking and communication process and see how it forms the basis of the publication cycle in Science
- To identify different types of scientific publications: what purposes they serve, and how they are used to disseminate scientific information to various audiences
- To recognize citations of different publication types
- To understand the importance of evaluation, and how it is structured in science:
    - formal process: peer review – evaluating content for publication
    - informal process: evaluating grey literature and websites
- To navigate the York University Libraries Homepage and the Steacie Library Homepage to find Resources for Biology.

Instruction for Session 1:

- Publication Cycle in Science – following an idea from inception through publication layers to accepted theory published in tertiary literature
- Identifying a topic, asking and refining a research question
- Getting around the library
- Managing references with RefWorks – an introduction

Assignments and Exercises for Session 1:

1. Active learning large group in-class session on identifying citations (multiple choice – show of hands)
2. Small-group exercise on comparing publication types:
    - Groups of 4-5 students examined different document types and compared them with a “traditional” research article. Analysis was guided by questions under the broad headings of: Initial Appraisal and Content Analysis
    - Each student was supplied with “Guidelines on Critically Analyzing Information Sources” (used and modified with permission from the Reference Department at Cornell University (Ormondroyd, 2004)) and an accompanying “Article Comparison Table” that could be used for note taking.
    - Each group presented their findings to the class.
3. Scavenger Hunt take-home exercise (used and modified with permission from Prof. D. Bazely, Dept. of Biology, York University)

Outcomes for session 2:

- To understand rationale for using subject-specific databases
- To develop a Keyword Search Strategy from a research topic using nested Boolean operators and truncation
- To modify and apply the Keyword Search Strategy to:
    - Library Catalogue
    - Biological Abstracts
    - Web of Science

- To conduct general and facetted searching and setting limits
- To understand citation searching in Web of Science
- To review the Biology Research Guide for locating additional sources of biological information

Instruction for Session 2:

- Indexing and subject-specific databases
- Constructing search strategies for keyword searching. Using Boolean Operators, truncation and nesting.
- Common themes in many databases (including the library catalogue)
    - Searching the library catalogue, Biological Abstracts and Web of Science

Assignments for Session 2:

4. Formulating a search strategy for a research topic
5. Gathering background information to write a summary of the topic using tertiary print and online sources
6. Searching Biological Abstracts for secondary and primary literature
- Refining and redefining your research question

7. Citation searching and special features in the Web of Science

Outcomes for Session 3:

- To master Subject Heading searching in Medline(Ovid)
- To use the controlled vocabulary and scope notes as a basis for constructing keyword search strategies that can be applied to searching the Biomedical literature in any other database such as SCOPUS, Biological Abstracts and Web of Science.
- To discover and be aware of a range of sources of keywords for conducting comprehensive searches on a biomedical topic
- To introduce the different search refining tools available such as using Subheadings and Limits
- To master Keyword searching in Medline and SCOPUS

Instruction for Session 3:

- Subject headings and keywords – how they differ.
- Constructing MeSH and keyword search queries in biomedical databases: Medline and SCOPUS

Assignments for Session 3:

8. Students completed and handed in a worksheet and their search history with notes outlining their logic in constructing Subject Heading and Keyword searches in MEDLINE(Ovid), and refining searches with subheadings and limits. They also described sources of keywords (alternate spellings, related terms, synonyms), and transferred the terms to run keyword searches in SCOPUS. Citation searching was included as was producing a bibliography in RefWorks that demonstrated the use of additional features of the software.

Outcomes for Session 4:

- Summarizing articles and writing annotations for bibliographies:
    - Reading a paper to engage with and interpret research results (Pechenik, 2007)
    - Evaluating an article
    - Thinking about the findings, identifying gaps, and reflecting on the author's interpretations of the results
    - Reflecting on how an article relates to your research topic or thesis, and how you would use it in your writing

Instruction for Session 4:

- The annotated bibliography as a tool to assist with writing
- Reading for information and analyzing the parts of an article for writing annotations
- How to identify gaps in the literature and in research

Assignments for Session 4:

10. A small-group in-class exercise involved each group analyzing a different part of the research article already encountered in session 1. The analysis was guided by questions categorized by section: Introduction, Materials and Methods, Results, Conclusions, Discussion.
    - Each group recorded and presented their analysis to the class.
11. In the final take-home assignment, students selected 3 articles found in their previous assignments for analysis, and filled out an article analysis table for each. They then selected one from which to write a 250 word annotation.

Summary of Results of Student Evaluation Surveys

This section summarizes the noteworthy findings from the student evaluation surveys. After the data were collected and analyzed in 2007, many questions still remained unanswered, and so in 2008 more questions were added to fill the knowledge gaps.

Resource Selection:

In both study cycles, students reported that their usage of scholarly databases covered in the library sessions increased as a result of becoming aware of them and using them in class and for assignments. Many students were aware of some of the resources provided by the library, but some less known and less obvious resources such as the Biology Research Guide and Web of Science once discovered, were much more heavily used, going from 7 to 22 users of the Biology Research Guide and from 12 to 31 users of Web of Science among students in the 2007 class (N=35). In 2008, a similar trend was seen as the usage of SCOPUS went from 0 before the sessions to 23 users after the session (N=37). It was interesting to note that in 2007 there was no change in the reported use of Medline or Google as they had never been mentioned in class in any context. Google Scholar was mentioned by the instructor in one sentence in one class, and its usage went up by three users confirming that a lack of awareness of the existence of a resource is the first obstacle to overcome if we want students to use resources. In 2008, students were asked about their usage of Google and Wikipedia, and they reported that they tended to use these resources less, going from 32 users before the sessions down to 10 users for Google and 11 users for Wikipedia. It was also significant that the usage of the Library Catalogue and the Steacie Library website decreased after the sessions, while usage of the Biology Research Guide containing resources compiled by the subject librarian in Biology, that collates biology-specific databases, dictionaries, e-books, multimedia etc., increased from 11 to 26.

> "I had never been to the library website before the sessions, now I use the Biology Research Guide all the time."
>
> [Quote from a student]

Student Perceptions of the Value of Assignments:

Students found most of the assignments very useful, and were appreciative of the systematic approach to the research process as it was presented and practiced. The Library scavenger hunt, Searching Biological Abstracts, Formulating a search strategy, Web of Science citation searching, Searching a researcher, and Writing annotations were perceived to be very useful. The article comparison exercise and gathering tertiary

information were perceived to be less useful. However, when asked about how their understanding of the publication cycle was influenced by the library sessions and about how and when to use Tertiary, Secondary and Primary literature in their course work, students expressed a very positive correlation. As a result, the article comparison exercise and gathering tertiary information exercise were repeated in the second year. Students commented on the benefits of the annotated bibliography as being very beneficial and applicable to other courses and assignments:

> "In class exercises provided me with the ability to filter out relatively unimportant details and outline key points of the scientific paper."
>
> "The … sessions really pointed out which parts of the articles (ex. discussion, results) are very important and this is very useful and saves time when doing research on broad topics."

Several students who found the work uninteresting still saw the benefits of the assignments:

> "The assignments were extremely tedious...but to be fair and honest I can't myself think of a better way to teach the material in a meaningful way."

Student Perceptions of Learning Outcomes:

Students generally felt that their library research skills had improved in many areas. In both years, students responded that they had developed a better understanding of the information gathering and research process, including how to formulate a research strategy and run it in different databases. When asked about the transferability of the skills learned, students felt that they were better prepared to conduct systematic research in other courses and assignments. Some students commented that the handouts and class materials would be useful for their work in other courses.

> "The material in this course, especially the library sessions and handouts, have made finding articles and papers much easier thus providing a great deal of help on essays/assignments in other courses."
>
> "These library sessions have greatly strengthened my research skills which has given me a better understanding of scientific literature and allowed me to apply the material from the literature to my own scientific writing."
>
> "My ability to gather research has vastly improved and will certainly help me in the future. Great curriculum!"

Student Recommendations:

1. When asked about the kinds of workshops students felt they would benefit most from, they responded that *Writing for Biologists*, where they would be taught to write reports, research papers, etc., was highest on the list. Next were *Subject-specific database workshops* such as Biological Abstracts, Web of Science, SCOPUS, followed by a *Research Course* that combines biology research with library research.
2. When asked about when, in retrospect would they have needed or wanted to learn this material, most students said that it would have been most beneficial to learn within the first two years of their schooling. *Drop-in workshops on general topics*, *Class-integrated workshops and lectures with assignments* that include

marks for library searching, *Special topic workshops (Google, Web2.0, new technology, etc*.), and *Special software workshops (RefWorks, SPSS statistical software, Microsoft Excel, etc.)* were deemed to be best taught in first year. More advanced topics such as a *Research course* that combines biology research with library research, *Assignments combining biology research with library research* and *Writing for Biologists (reports, research papers, etc)* were deemed to be best taught in second year.

Discussion

Third year Honours Biology students are an academically very highly motivated group. When asked how many were hoping to go on to graduate school or a professional school of some kind, there was a great show of hands in the first class. Considering this, it may come as a surprise to some that our findings demonstrate that these students generally do not have the expertise to use scholarly databases, or to identify, analyze, evaluate and incorporate scholarly information into their scientific research and writing. Faculty have been increasingly distressed at the poor level of research/writing, evaluation/analysis and synthesis skills demonstrated by students particularly in upper level courses. This has revealed the need to purposely teach research skills in the context of course assignments. Furthermore, the assignments have to be structured and graded in such a way that the research process is given equal weight with subject content. Students in third year biology are intrinsically motivated, have very specific needs, and are able to articulate them in ways that have uncovered some general recommendations based on their feedback.

Recommendations

1. Students need to be taught IL skills in a staged and systematic way and integrated into core courses in first and second year.
2. Librarians and faculty members need to work collaboratively to build awareness of subject specific resources particularly in fields such as Biology, where leading edge research is paramount.

In fact, the students who were part of this study were able to reflect upon their research needs and felt strongly that these classes should be taught in first and second year instead of being introduced in their third year. These students realized that they didn't have previous awareness of the resources provided by the library. They also realized that this significantly impacted their knowledge base and scholarly activities in a negative way.

Conclusion

Library research is an important component of comprehending the full extent of research in a given subject area. When students are faced with having to choose topics to write about, and projects to conduct research in, it is imperative that they first understand the communication processes and tools in their subject areas. Secondly they need to develop an informed understanding of their topic that enables them to identify the major experts and researchers, as well as locate the research that has already been done and the research that is in process. Only armed with this information, will they be able to find gaps and niches where they can express their creativity and where they can focus their research interests both at an undergraduate as well as graduate level. The ultimate goal is to teach students to carry out their research independently in context.

Next Steps

1. These findings have been shared with the General Education Committee for the Faculty of Science and Engineering, and plans are underway to develop a 1000 or 2000 level course for undergraduates that integrates IL skills with subject content.
2. This study will be followed up with a longitudinal study of the retention of IL skills acquired by students enrolled in Biol3100 into the next year when they are involved in research for their fourth year Honours Theses.

Fostering close collaborations between faculty and librarians to integrate library research instruction into courses will enable students to fully participate in the research culture at their institutions and in their scientific communities.

> "The best thing I learned was how to properly use research databases and how to critically analyze and understand a primary research article. I now feel much more confident in my ability to conduct scientific research and understand scientific literature, which was something that I did not feel so confident about before taking this course."
>
> [Quote from a student]

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