The role of medical libraries in undergraduate education: a case study in genetics*

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Between 1996 and 2001, the Health Science Center Libraries and Department of Zoology at the University of Florida partnered to provide a cohesive and comprehensive learning experience to undergraduate students in PCB3063, ''Genetics.'' During one semester each year, a librarian worked with up to 120 undergraduates, providing bibliographic and database instruction in the tools that practicing geneticists use (MEDLINE, GenBank, BLAST, etc.). Students learned to evaluate and synthesize the information that they retrieved, coupling it with information provided in classroom lectures, thus resulting in well-researched short papers on an assigned genetics topic. Exit surveys of students indicated that the majority found the library sessions and librarian's instruction to be useful. Responses also indicated that the project facilitated increased understanding of genetics concepts and appreciation for the scientific research process and the relevance of genetics to the real world. The library benefited from this partnership on a variety of fronts, including the development of skilled library users, pretrained future clientele, and increased visibility among campus research laboratories. The course and associated information instruction and assigned projects can be considered models for course-integrated instruction and the role of medical libraries in undergraduate education.

GENETICS INFORMATION SERVICES AND THE MEDICAL LIBRARY

Modern breakthroughs in molecular and cellular biology and genetics are transforming all fields of the life sciences and are leading to new improvements in human health and well being. Research in areas such as gene therapy, stem cells, human cloning, and the human genome impact both science and society. Such achievements and controversies have catapulted the teaching of these subject areas to the top of the life sciences curricula of any university or college. This is particularly true of the academic programs served by medical libraries.

Medical librarians are taking the lead in providing instruction about molecular-information resources and consultation services to researchers, clinicians, and graduate and professional students. Several librarians

* Based in part on a paper presented at the Eighty-eighth Annual Conference of the Special Libraries Association, Seattle, WA, June 11 1997 [1], and a poster presented at the Ninety-eighth Annual Meeting of the Medical Library Association, Philadelphia, PA; May 25, 1998 [2].

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and information specialists have published papers on the central role of medical libraries in meeting the information needs of their patrons in these subject areas. Lei and Martinez have discussed the role of health information providers in dealing with bioinformatics and genetic information [3]. Owen has described an introductory course in genome informatics offered at the University of California, San Francisco [4]. Yarfitz and Ketchell have presented the extensive bioinformatics and genetics services provided to researchers, clinicians, and students at the University of Washington [5]. A host of papers has been written by medical educators and librarians describing the use of various information tools to assist in the teaching of genetics to medical students [6–12]. Courtois and Handel have described a collaborative approach to teaching genetics resources to upper-level undergraduate and graduate students [13]. However, few reports of medical libraries working with undergraduate genetics students have been published. Recently, Delwiche [14] has described several Web-based information resources in molecular genetics and plans for their integration into an undergraduate genetics course at the University of Vermont.

The authors' current study describes a similar program that has been in existence at the University of Florida Health Science Center Libraries (HSCL) since the spring semester of 1996. A detailed description of the program, enhancements made over the last five years, and student responses from exit surveys provide insights into the success of such an approach.

THE COURSE: PCB3063, "GENETICS"

Since 1996, a professor from the Department of Zoology, College of Liberal Arts and Sciences (CLAS), and a librarian from the HSCL have partnered to bring genetics information resources into the classroom for more than 100 undergraduate genetics students each spring semester. PCB3063 is one of several genetics courses undergraduates at the University of Florida may take and is generally considered the one of choice for life sciences and pre-health professional majors. Roughly 100 to 120 undergraduates register for the course in the fall and spring semesters, with 50 to 60 attending during summer session. Most of the students are junior and senior science majors (Table 1).

One author (Miyamoto) was offered the opportunity to teach PCB3063 for the first time in the spring semester of 1996. The course had previously been taught primarily through lectures and assigned textbook readings and genetics problems. This professor wished to enhance the course, so that students augment what they learn in class lectures and through their textbook readings with information from the scientific literature. Students would synthesize the information and write short papers about genetics topics. Given the interests of the students who enrolled in PCB3063 and the discoveries promised by the Human Genome Project, the professor thought human genes and genetic disorders would be appropriate and relevant areas of study for the students. Additionally, this particular project would provide early MEDLINE and information-skills training to the many pre-health professional students in the class.

Table 1
Reported academic ranks, majors, and response rates for PCB3063 students

	1996	1997	1998	2000
Freshmen	1.0%	—	—	—
Sophomores	—	9.2%	6.7%	8.9%
Juniors	42.9%	48.7%	40.0%	51.1%
Seniors	54.1%	37.0%	43.3%	33.3%
Post-baccalaureates and graduate students	1.0%	5.1%	10.0%	6.7%
Science majors	91.5%	97.3%	96.4%	97.8%
Pre-health professional students	77.5%	63.4%	62.5%	80.0%
Number of students completing course	106	100	88	82
Number of respondents	98	76	60	45
Response rate	92.5%	76.0%	68.2%	56.1%

Rather than give the students a predefined list of journal articles, the professor reasoned that they should use the same tools that practicing geneticists use to solve their research questions: the literature and primary genetics data. He also reasoned that students would first need to learn to find and evaluate the information for their papers. The professor invited the librarian (Tennant) to become involved in the class to provide instruction in information skills and resources.

As upper-division science majors, it was expected that most of the students would have already received some library instruction at the university, although it was unclear at what level their skills would be. It was also unclear how much of the primary literature undergraduates would be able to understand. The journal literature of science is difficult for nonspecialists to grasp, as it is filled with jargon and is written with the expectation that the audience has a deep understanding of the topic. As difficult as it is to read, the journal literature would also have advantages for the assigned project. Because published articles tend to focus on single experiments or series of experiments, their use would allow the students to present and discuss in their papers the particular lines of evidence, the ways scientists learn what they learn, and the specific research tools and methods they employ. It would be difficult to get this level of detail without using the primary literature. Although the course was available to sophomores, the majority of students were juniors and seniors, with a scattering of post-baccalaureates and beginning graduate students, and the authors hoped that the literature would not be completely be-

yond their comprehension. In any case, the first semester of the class would clearly be a learning experience for the authors as well as the students; neither instructor had previously been involved in such a comprehensive project. How well prepared were students to use the tools and how much would they need to learn? How would they feel about a project that involved significant library work and some guest lectures provided by a librarian?

For the students to take the library instruction and subsequent project as seriously as did the instructors, the authors agreed to follow the conventions of course-integrated instruction [15], which include strong partnerships between the teaching faculty member and the librarian, instruction tied to assignments, required attendance at the library sessions, and graded student assignments.

THE PROJECT

The intent of the project is to extend the students' learning outside the traditional classroom and textbook or test vision. The authors expect students to learn to find information in the literature and on the Internet, to become independent learners of genetics concepts, and to evaluate and then synthesize the information to write a focused paper on the genetics of a particular disorder. The project is worth 25% of the point total in the class, with the rest of the points coming from three equally weighted written examinations. Although the project has evolved and been enhanced over the years, the basics of the assignments and library instruction have not changed significantly.

Library lesson 1

Around the third week of the semester, students attend lesson 1 in the HSCL computer classroom. Depending on the number of students enrolled, between five and seven sessions are required to cover the entire class in the fifteen-computer classroom. At this two-hour session, students learn to use Online Mendelian Inheritance in Man (OMIM) [16], identify Medical Subject Headings (MeSH), and learn to search the genetics literature in some version of MEDLINE (the most recent class learned PubMed [17]). Students are also introduced to the library's online catalog.

Students are assigned at random a genetic disorder to research for their semester-long projects; the disorders are drawn from a grab bag during this first session. Prior to the session, all 100 or so disorders are searched by the librarian to ensure that they have MeSH terms, are available in OMIM, and are well-represented in the literature. In this way, students are assured of finding enough information on their topics to avoid frustration. The students complete two assignments following this session. Part A requires the students to locate their disorder in OMIM and identify its proper MeSH term. Part B is due after part A has been graded and returned to students, thus ensuring that they have found the appropriate MeSH term before they begin their literature searches. Part B requires students to search for papers on the genetics of their disorder. Students explore concepts such as subheadings, exploding, major MeSH, limiting to publication type and date, and Boolean logic. Students must turn in their search strategies and one citation from each search. Students must also present the five citations that will be most important to use in their paper and justify why those papers are the ''best.''

Library lesson 2

Students return to the library at about week eight of the semester. The beginning of this session is used to describe to students the structure of the professor's assigned four-page paper and the content that should be included (history of the disorder, phenotype, mode of inheritance, cytogenetics, molecular genetics, population genetics, and possible gene therapy). Students are expected to discuss in their papers experiments and genetic or molecular techniques described in the articles they have located. Students are currently expected to use and cite at least ten resources, thus requiring them to synthesize the information that they locate. They are asked to choose a particular journal style from an approved list for writing their paper and dealing with citations. At this library session, the journal's ''house style'' is discussed, usually using one of the professor's current publications as an example.

The timing of this session is critical to ensure that the course lectures have covered enough material for the students to understand the science being presented in the library session. By week eight, molecular genetics, gene sequences, and protein structure have been covered in lecture and text readings. The bulk of the session is spent working with several of the genetics resources that are available through the National Center for Biotechnology Information (NCBI) [18]. In this session, the librarian leads the students through hands-on retrieval of DNA and protein sequences using Entrez [19]. The class then uses one of the retrieved sequences as the query sequence for a Basic Local Alignment Search Tool (BLAST) [20] search. The examples used in class are sequences that have been collected by the professor's laboratory. Students also explore Structure [21] to visualize three-dimensional protein structures. Finally, a series of other evaluated Web pages are introduced to provide students with reputable clinical genetics and consumer resources. The consumer resources are easier to read and often provide students entry into the more difficult journal literature. Web pages covered in lesson 2 include GeneTests, GeneClinics, Genes and Disease, Gene-

Cards, Information for Genetics Professionals, Understanding Gene Testing, Blazing a Genetic Trail, and the National Human Genome Research Institute Web page [22–29].‡ Finally, the session ends with a discussion of the importance of evaluating Web-based information. Students then complete part C of the project, which includes searching exercises in Entrez, BLAST, and Structure. Students are encouraged to discuss in their final papers the sequence and structure information that they retrieve.

Library lesson 3 and the final paper

Two to three weeks before the final papers are due, the librarian attends one of the class lectures and spends about thirty minutes answering questions and addressing last minute concerns about the paper. These questions generally concern house style and how to cite electronic resources, who the intended audience of the paper should be, and how to incorporate figures, tables, and the recommended glossary into the papers.

Then students are on their own to complete writing the final papers. The professor and class teaching assistants are available to help the students understand the genetics in the articles and sequences that they have collected. However, a substantial amount of self-learning and reflection is expected of the students at this point. The scientific articles are difficult to read, and students are encouraged to sit with articles, class notes, and genetics dictionaries to wade through this technical literature and truly understand the papers. Students are cautioned to begin their reading early in the semester, immediately following the first session at the library, after they are shown how to find articles. Every semester, however, students scurry around the HSCL up to a few hours before the papers are due, trying to get in their last bits of reading.

COURSE EVALUATION

Standard college-level University of Florida teaching evaluations of the professor indicated that the students were very satisfied with the course and with the instruction and support provided. In fact, the professor recently won a university-level teaching award based primarily on his work in this class. However, these general course evaluations did not specifically address the project or library component of the course and did not provide the detail needed to refine the course. Therefore an exit survey was given to students at the end of the spring 1996 semester. The survey was not intended to serve as a year-to-year research tool but instead was considered to be the best way to determine whether this ''experimental'' project was a good learning experience, what changes to consider, and whether the project should be repeated in subsequent semesters. The authors have found the student feedback to be quite valuable and have therefore continued to collect the information yearly. Due to a clerical error, surveys were not collected in 1999.

The survey is anonymous and covers all aspects of the project (Appendix). Students are asked to comment on how successful they feel the project has been in meeting its stated goals. Demographic information on students (major, academic rank, previous experience, computer ownership, future career plans, laboratory work experience, etc.) is also collected. Students answer objective questions but also are given extensive space to ''explain'' their responses. These responses, especially to the open-ended questions, have been essential in helping the authors learn whether they have been successful in their goals and in helping them reshape the project each semester. It is expected that the students would gain several skills and benefits from the course, some that related primarily to information literacy and others concerning genetics.

Evaluation of the library component

Through the library sessions and take home exercises, it is expected that the students would learn basic literature searching and evaluation skills. Evidence for success would come from two sources: the students' performance on parts A and B, as well as their responses to the related questions on the exit survey. Students routinely perform well on parts A and B, with the majority scoring 80% or higher. Students, however, often overestimate their performance, equating time spent on the assignment with their presumed deserved score. The importance of MeSH terms and exploding tend to be the concepts that students have the greatest difficulty understanding.

Several hypotheses concerning the library sessions were explored. The first was that a large number of undergraduate students still felt some level of anxiety using the library. After the library sessions, hands-on exercises and hours of research spent in the library, it was expected that many of those students would feel less anxiety. Between 57.4% (1998) and 73.4% (2000) of students indicated they felt some anxiety using the library prior to PCB3063. Of those who felt anxiety, between 81.8% (2000) and 95.2% (1996) reported feeling less library anxiety after taking PCB3063. Open-ended survey responses backed up the notion that familiarity reduces stress.

A second hypothesis was that library use would also increase students' confidence in being able to find what they needed in the library. Responses (Figures 1 and 2) seemed to bear this out. Between 17.3% (1996) and 30.0% (1998) of students reported feeling very

‡ See Delwiche for an excellent introduction to some of these resources [30].

Figure 1
Students reporting confidence in using the library, before and after PCB3063

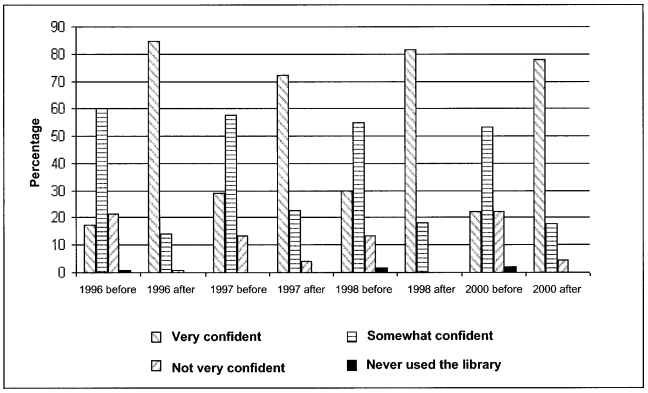
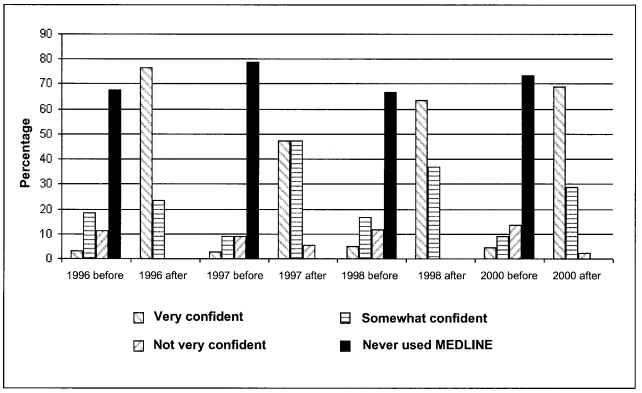


Figure 2
Students reporting confidence in using MEDLINE, before and after PCB3063



confident in their use of the library prior to the class; between 72.4% (1997) and 84.7% (1996) reported being very confident following the class. Additionally, between 66.7% (1998) and 78.9% (1997) of students indicated they had never used MEDLINE before PCB3063. Between 47.4% (1997) and 76.5% (1996) of students felt very confident in their MEDLINE searching skills following the course.

One unexpected finding related to computer experience and literacy. It was expected that students would be competent computer users, even if they were not experienced in information retrieval and evaluation. The University of Florida is known to attract high-quality students. For example, in the year 2000, the university ranked third among public institutions in the number of National Merit Scholars recruited and sixth in National Achievement Scholars [31]. However, it soon became apparent working with the students on the MEDLINE assignments that several students in the class lacked computer experience. Starting in that first semester, special computer help sessions were held by the librarian for any students who wanted to attend.

Open-ended comments by students acknowledged that some were uncomfortable with their computer skills, but suggested that the class has helped in this area.

''Computers scare me! Now, at least, I know more applications and understand the different sources available.'' Senior pre-med zoology major.

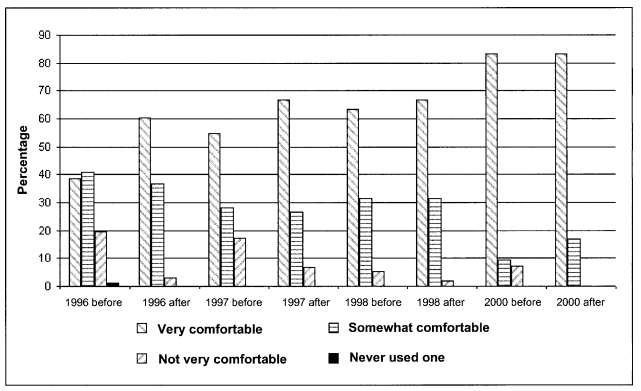
''First of all, I'm afraid of computers. I hate computers. After this class, I at least feel they can be helpful.'' Senior pre-med nutritional science major.

''I am a returning student and the switch to computers has been a bit intimidating—when I was in school before, we used the card catalog.'' Senior pre-med nutrition major.

Survey results indicated that the number of students who started the class without computer skills has been decreasing over time (Figure 3). The percentage of students who reported being very comfortable at the beginning of the course has increased every year, while the percentage who lacked skills has decreased most years. This increase in computer literacy might be due to the computer requirement imposed by the university in summer B term of 1998 [32].

Another unexpected finding was the high number of students who reported they had received no formal library instruction prior to PCB3063, between 38.4% (1996) and 48.0% (1998). More troubling, the percentage of seniors who indicated a lack of training ranged from 48.6% (1997) to 58.8% (1998). Because these students took PCB3063 in the spring semester, it was likely that this was their last chance to receive information-skills instruction during their undergraduate ca-

Figure 3
Students reporting comfort in using computers, before and after PCB3063



reers. These data were highly surprising, as Library West and Marston Science Library on the main campus provide extensive bibliographic instruction to undergraduates in freshman English and basic biology courses, among others. Apparently, there were significant numbers of students who for legitimate reasons (transfer students who arrived at the university after these beginning courses and students who tested out of these early courses) did not receive library instruction. Added to these numbers, the students who illegitimately skipped the opportunities for library instruction in their basic courses, and the students' lack of experience with the library came as less of a surprise.

Most students who responded to the open-ended questions in the survey indicated that the library instruction in the class was useful, and many indicated that between the library instruction and writing of the paper, they had gained many skills that would serve them in their future academic programs and careers.

''Did a superb job; I've learned a lot, it made my senior thesis research much easier, and I'm not so afraid of a Ph.D. dissertation, anymore.'' Senior pharmacology/physiology major accepted to graduate school.

''I really enjoyed the project. I feel I learned a lot and I now know all the resources available! I feel prepared for professional school in terms of being able to write a research paper Thanks! Overall I am very grateful that a paper was assigned.'' Junior pre-dent zoology major.

''I think it was very effective—especially because effective library research is key to writing a good science paper. And that's what I feel more comfortable with after this class—library research. It's a good idea; I think many students in this class (probably most) weren't too jazzed about the idea of the paper and the library instruction initially, but once they put it to use, most students really appreciated what they had learned.'' Senior zoology major accepted to graduate school.

''Extremely well. Good participation between class-library.'' Senior pre-med pharmacology major.

In each of the four semesters surveyed, there were fewer than five students whose responses suggested that they did not gain an appreciation for the various levels of quality of information, or why that might be important. The following quotes are representative.

''I think the paper was a terrible waste of time. Sorry, but it's true. I could have found everything I needed in one book. Ten sources in a three page paper is crazy.'' Senior human nutrition major, no career plan indicated.

''Let the students gather the info anyway they can. I received most of my info from the Internet, not MEDLINE or Genbank.'' Junior pre-med microbiology major.

This last response demonstrates one of the most frequent comments the authors hear from other faculty concerning students' use of information. It appears that many students believe that all worthwhile information is available over the Internet, and that all information available over the Internet is worthwhile. Although evaluation of Web-based information has been covered in lesson 2 since the beginning of the course and has been covered in even greater depth since 1998, it is clear that some students still do not understand that all information is not created equal. This student mindset is one of the greatest challenges that librarians and professors face in terms of developing the information literacy of their students.

Evaluation of the genetics component

The professor had several goals for the students concerning the genetics side of the class. Some of these goals were gauged by grading part C and the final genetics paper: students would learn how to use real fact-based genetics tools employed by scientists (i.e., GenBank), and they would use the wealth of information they located to write focused, informative papers. Students did perform well on the GenBank assignments, with nearly every student locating sequences for their disorders, if those sequences existed in GenBank. Each year, the librarian searched sequences before the class for each disorder. In 1996, the state of knowledge of disease genes was less than today, and only about 45% of the students were able to be assigned disorders with sequence information. The students without sequences were given alternatives to search so they could complete part C; however, these students would not be able to discuss sequences in their final papers. By the year 2000, each assigned disorder had associated sequence information.

The final papers submitted by the students met the expectations of the professor. Overall, students were able to wade through the literature and learned about genetics. Most were able to connect the experimental evidence from the specific papers with what they had learned in class to develop successful explanations of the genetics of the disorders, from gene to protein to phenotype. Although some papers were much better than others, the successes and failures followed the same bell-shaped pattern as other assignments. The answer to the question concerning whether students would be able to handle the scientific literature seemed to be ''yes.''

Student responses to the survey tended to agree. The final survey expressed the following goals, and asked students to respond to how well the project met them:

The intent of the class project was to teach you to find genetics information, synthesize information from many sources, use the knowledge gathered in class to understand the

information, and then write a summary of what you have discovered. Please give an overview of how well you think the project accomplished this goal.

Over the four recorded semesters of the class, 231 students have taken the time to write answers to this question. Of these students, 83.5% responded positively, 8.7% responded negatively, and 7.8% of answers were mixed. The following quotes represent the positive responses.

''I think it did a great job. I found that I did understand the articles because of what I'd learned in genetics and other classes.'' Senior pre-med zoology major.

''Everything was very well targeted to the above mentioned goal—this part of the class was a definite enhancement in my understanding and learning of genetics and its application today.'' Junior pre-med microbiology major.

''The project definitely covered this goal. This was easily seen by the writing process when I began to see things come together—reading about a mutation and recalling details from class, etc. The scope of the project seemed to have a very good balance, enough to push me to really use what I had learned, yet not too overwhelming. I found it to be a 'realistic' experience as these intended goals reflect.'' Senior pre-graduate school neuroscience major.

''The project was very successful at achieving this goal. I learned just as much genetics trying to write the paper as I did from Dr. Miyamoto, which was a lot . . . This paper should always be part of the course.'' Sophomore pre-med/Ph.D. chemistry major.

Some students realized late in the course that the assignment, lecture material, and journal articles could work together to provide a cohesive learning experience.

''I think I could have done a much better job on the paper if I had kept up with the lecture material better. I didn't understand much of what the project articles were talking about. I'm now studying for the final and I see we've covered much of what I didn't understand.'' Post-baccalaureate pre-veterinary student.

However, each semester between two to four students remained unconvinced of the value of the project and its relationship to learning genetics. This quote represents those students.

''As stated here, the purpose of the project was accomplished but I did not learn anything new concerning genetics from this project. I therefore fail to see the relationship it has to this class.'' Senior pre-med nutrition major.

Another of the professor's goals was to give the students an appreciation that these resources were used by real geneticists in the scientific research process and that genetics and genetic information were relevant to all members of society. He tried to make this clear by using his publications and sequences as class examples and by bringing ''genetics in the news'' into his lectures. Many students' comments suggest the class successfully meets these goals.

''The most surprising thing to me was the fact that what we learned in the lectures was actually being used and practiced in the real word.'' Junior pre-med zoology major.

About the GenBank session: ''The whole concept was amazing—that all of that is available. I think being exposed to real-life stuff is a very nice part of the course.'' Senior pre-med nutrition major.

''I thought the project was really worthwhile—it gave me the opportunity to synthesize what I learned . . . real, up to date, relevant info. It was nice to do a paper that actually had some relevance.'' Senior pre-med nutrition major.

STUDENT RECOMMENDATIONS AND CLASS ENHANCEMENTS

Over the years, open-ended responses provided on the students' exit surveys have been considered when updating the project for the following year. Two concerns of students in the 1996 survey had to do with technological limitations at the HSCL computer classroom. The computers in the classroom were not equipped with Internet access, therefore the GenBank sessions could not be live and hands on. The classroom at that point in time was equipped with only ten computers, so the sessions in the first year were held with three students per computer; even the hands-on MEDLINE session was not hands on for all! Furthermore, the help sessions for GenBank could not be held in the HSCL computer classroom, again because of the lack of Internet access. Instead, optional help sessions were held in a tiny room in the Zoology Department, in which there were five computers and one printer. Most of these limitations were overcome over the next few years. Internet access was added to the classroom by the spring of 1997, so all sessions from then on were live. Five additional computers were added to the classroom in 1998 for a total of fifteen. In the same year, two undergraduate student assistants joined the instructional team. The addition of the computers and the student assistants allowed students to work alone at computers, while relieving the librarian of half of her teaching duties.

Survey responses in 1997 indicated that a vast majority of students (75.7%) felt that they already had a thorough understanding of using Netscape or other browsers. Additionally, they felt that they knew how to search with various Web search engines. In 1998, instruction in these areas was dropped in deference to

more complete instruction in the evaluation of Web-based information.

In 1998, a class email distribution list and class electronic reserves were made available at the request of students on the 1997 surveys. Of responding students, 84.2% (1998) and 90.2% (2000) said that the email distribution list was useful or very useful. The numbers were 87.3% and 92.1% for the electronic reserves.

Instructional support for the class has been extensive, with the professor providing office hours every week. During the first two semesters of the course, the librarian attended every lecture. This was useful for two reasons: she had not taken a course in genetics since 1989, and she felt it was essential that she be a visible resource to the students. From 1996 through 1998, the librarian held optional help sessions before each assignment was due as well as weekly office hours. With the addition of a graduate-level teaching assistant to the course, combined with the two to three undergraduate assistants, the librarian decreased her level of contact in the course. She no longer attends the lectures, and she now turns the optional help sessions and weekly office hours over to the teaching assistants. The librarian remains available to students by appointment and over email. She now teaches approximately half of the required sessions, with the teaching assistants each teaching one of the two lessons (MEDLINE / OPAC, Genetics Web resources).

In 2000, the co-director of the university's Gene Therapy Center presented a guest lecture on gene therapy. This session, which has become a standard component of the class, promotes great enthusiasm and excitement among the students and helps prepare them to write that section of their final papers. Because gene therapy has not been tested on or proposed for all of the assigned disorders, it is often necessary for students to speculate in this part of their papers. This session provides students with an opportunity to learn how gene therapy works and the types of genetic defects in which it is most likely to be successful. Students are then prepared to reason out the likely success of gene therapy on the particular genetic disorder they have been assigned.

Several student suggestions, while educationally worthy, have not been implemented strictly due to logistical limitations. Students have requested that rough drafts of the papers be collected, evaluated, and returned with comments, so that they would have a better idea of what the professor looks for in the final papers. Students have also recommended that the length of the paper be extended to six to ten pages, as they find so much information that limiting the paper to four pages is difficult. Finally, students have requested that class time be given for them to present their findings orally to the rest of the class. While these are all excellent suggestions, the sheer size of the class and university grading deadlines make such endeavors impossible.

Other student suggestions have not been implemented, because the authors believe they would lead to a diminished educational experience. Some students have indicated that parts A to C (the searching exercises) are ''miserable'' or irrelevant experiences and that they should be dropped from the course or not graded. On the other hand, some students have indicated that parts A to C are important aspects of the class, as they require the students to use and explore the workings of the resources and prevent students from waiting until the last minute to do their entire term project. The authors agree that without the assignments, students would be unlikely to try all of the resources available to them and that they would not get as much out of the course as they do with the assignments. Along similar lines, some students have suggested that the required library sessions be made optional. However, more than 90% of students have indicated that the required sessions are helpful. Given the attendance rate for non-required sessions of PCB3063 in the fall semester of 1999 (around 62%) versus the attendance rates (96%–98%) for the required sessions in the spring semesters, the authors have agreed that the library sessions will remain required.

BENEFITS TO THE HEALTH SCIENCE CENTER LIBRARIES

Given the extensive amount of time the library provides to PCB3063, it was hoped that the HSCL, as well as the students, would benefit from this partnership. Benefits did occur, and some of them were of the self-preservation variety. Whether the library was involved in the class or not, the professor would assign papers to the students. Having the library involved ensured that the assignment provided by the professor was ''doable.'' The library owned the books and journals necessary to complete the project; information on the genetics of the assigned disorders was actually available in the literature; and the individual component assignments made sense and were reasonable in length and complexity. Library involvement also gave the library a ''heads-up''; in semesters when the project was assigned, genetics materials were not sent to the bindery unless they were also available as full text from the library's Website. Having an understandable assignment and available materials saved the students (and the librarians) a great deal of frustration.

Students in PCB3063 are expected to search the literature as well as fact-based databases to find information for their projects, and HSCL librarians have expertise in MEDLINE and NCBI and other Web-based genetics resources. Students, by default, would approach the HSCL librarians for assistance in the use of these resources. Group hands-on instruction is pre-

ferred by the librarians to having students individually approach the reference desk for assistance in using the resources. Approximately 100 undergraduate students, many with little library or database knowledge, descending on the reference desk and the computer classroom each semester would not be an efficient use of resources. Group database sessions also provide a good learning environment, where the librarian and students can interact, ask each other questions, and build a synergy. Finally, the in-library sessions demonstrate to the students that the professor finds the project worthwhile. Why else would he give up precious class lecture time?

The library also benefited in ways that were not anticipated at the beginning of the project. First, future primary clients were trained. Between 62.5% (1998) and 80.0% (2000) of the respondents to the exit survey have indicated that they expected to pursue a career in one of the health professions (Table 1). Many of the students who enrolled in health professional schools at the University of Florida were undergraduates at the university. For example, in the year 2000, 42.7% of the ninety-six incoming medical students had received their undergraduate degrees from the University of Florida [33]. Introducing these students to the information resources and their proper use gives them a head start on their professional education. It is equally important to develop a good relationship with these students, to help them gain confidence in the library that they will be using for the next several years of their academic careers.

The library also gained indirect benefits through the students who were employed by or performing research in laboratories in the Health Science Center. During the four semesters that surveys were given, between 12.5% (1997) and 29.9% (1996) of respondents reported that they were employed or volunteered in HSC laboratories. Several students and faculty members indicated anecdotally that the class and project were discussed among students, faculty mentors, and other laboratory members, fostering genuine intellectual excitement. For the last several years, the PCB3063 librarian has been the liaison librarian to these basic science researchers and laboratories. The librarian's efforts with the genetics class worked hand-in-hand with the HSCL's efforts to expand its visibility with and services to these faculty researchers. PCB3063 provided excellent publicity for the library.

Several former genetics students were subsequently hired as student assistants for the technical services departments of the library. Working closely with students on the projects allowed the librarian to evaluate students and to get them excited about working in the library. This interaction provided a ready-made pool of potential student workers.

THE ROLE OF ACADEMIC MEDICAL LIBRARIES IN UNDERGRADUATE EDUCATION

Although the benefits to the HSCL now seem obvious, there was much early discussion concerning the appropriateness of the partnership. The HSCL are funded to meet the information needs of the students, staff, faculty, clinicians, and administrators of the six health-related colleges (dentistry, health professions, medicine, nursing, pharmacy, and veterinary medicine) of the Health Science Center. The genetics undergraduates are not included in that client base; instead, they are part of the College of Liberal Arts and Sciences and are well served by the university's Marston Science Library. Initially, it was unclear how the HSCL would justify such an expenditure of time for students whom they were not specifically funded to serve. Many issues came into play to resolve the situation. First, the students would come to the HSCL in any case, as the majority of the books and journals that they would need to complete the project reside at the HSCL. Because the Health Science Center and the main campus are contiguous and the libraries of the two campuses have reciprocal borrowing privileges for all students, it seemed reasonable that the students would expect assistance from library staff. Again, the self-preservation mode was invoked, and it became obvious that it would be most time- and cost-effective for the HSCL to become involved in the instructional sessions. Many of the HSCL's faculty and students work in fields such as biochemistry and the behavioral sciences. Materials and some expertise in these areas may actually reside at other campus libraries, even though these clients may officially ''belong'' to the HSCL. In any university environment with a diversity of research and educational programs, a certain reciprocity in services must be expected.

In addition to the funding concern, there were other questions. Would approximately 100 undergraduate students descending on the relative calm of the HSCL cause any difficulties for the ''official'' HSCL library patrons? Over the five semesters that the library has been involved with the course, there has not been a single problem with the behavior of the students. One legitimate concern, however, has been the use of the library's computer classroom for the instructional sessions. This room is often used as a spill-over computer laboratory when the lab is full. To avoid inconvenience to the HSCL's official patrons, the librarian routinely schedules the instructional sessions during off hours for the computer classroom; either first thing in the morning or after 5:00 P.M.

There was also some question as to whether or not the librarians at Marston Science Library would feel as though their ''turf'' had been invaded. This issue was addressed through a meeting with some of Marston's biology and chemistry librarians prior to final agree-

ment to the partnership. Because the expertise in MEDLINE and NCBI resources resided at the HSCL, the Marston librarians did not express concern about the HSCL's work with ''their'' students. In subsequent semesters, in fact, the director of Marston has asked the PCB3063 librarian to present a session on NCBI resources to an undergraduate CLAS course in biophysical chemistry, for which the director taught chemistry bibliographic resources. This has developed into another fruitful partnership.

Over the last several years, medical librarians have made great efforts to become familiar with genetics and bioinformatics concepts and terminology and to learn to use the related resources. In 1997, the Medical Library Association welcomed the Molecular Biology and Genomics Special Interest Group (SIG) [34] and, in 1998, this SIG cosponsored a symposium on the ''Impact of Genomics on 21st Century Medicine'' [35]. At least four genetics-related continuing-education (CE) courses have been awarded MLA CE credit [36–39]. Furthermore, the publications introduced in the second paragraph of this paper demonstrate that medical librarians are not just learning about this burgeoning field and its resources, but they are actually putting what they have learned into practice and are providing useful services to their library users. The authors encourage this knowledgeable group of professionals to embrace partnerships with undergraduate and other libraries and academic faculty as needed, even if those instructed are not necessarily their primary clientele. The rewards for students and librarians alike are plentiful.

SUMMARY AND CONCLUSIONS

For the last five years, the University of Florida Health Science Center Libraries have successfully partnered with the Department of Zoology to provide instruction supporting genetics information skills to undergraduate genetics students. These students have performed well on the rigorous associated term project, have learned to search the literature and genetics databases that will be of use to them in their future careers, and have produced informative papers on their assigned genetic disorders. Class performance demonstrates that this combination of finding, evaluating, reflecting on, and synthesizing genetics information has been successful in helping students learn more about genetics than they may have given only their textbooks, lectures, and other traditional assignments. Student responses to the exit survey indicate that the majority find the project a worthwhile experience and that some of the professor's elusive goals, such as helping students see how real science works and how genetics is relevant in the real world, have actually been met. The authors believe that this project can serve as a model for other undergraduate biomedical science courses and that medical libraries and librarians, with their subject-related expertise and information resources, can and should be effective partners in undergraduate education.

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APPENDIX A

PCB3063 questionnaire

Hello genetics students! Below you will find several questions related to the Health Science Center (HSC) Library's role in PCB3063 and your term project. Your answers to these questions will help us determine whether current library support is appropriate. Please help us improve this class. Your participation in this survey is entirely voluntary and all information will remain anonymous. Your answers to this questionnaire will have no bearing on your grade in the class. *Do not* include your name, social security number, or other individual identifying information on the form. You may return the forms to any of the teaching assistants in the class, via campus mail (Dr. Miyamoto, Box 118525, or Dr. Tennant, Box 100206), or by dropping them in departmental mailboxes in the Department of Zoology or at the HSC Library. Thank you for your time and help!

1. Basic data:
_____ Freshman _____ Sophomore _____ Junior _____ Senior _____ Graduate student _____ Other (please describe): _____
Are you a transfer student? _____ Yes _____ No
University of Florida (UF) college _____
UF major _____

2. Prior to PCB3063, have you needed to use the library for any of your science classes? _____
If so, which classes? _____
Which libraries on campus did you use? _____
What type of library instruction did you receive prior to PCB3063? _____
3. Before you took PCB 3063, how *confident* were you that you would be able to find the information that you needed at the library?
_____ Very _____ Somewhat _____ Not very
_____ Never used the library
How *confident* are you now that you would be able to find information at the library?
_____ Very _____ Somewhat _____ Not very
Do you feel less anxiety now using libraries than you did before? _____ Yes _____ No _____ Never felt anxiety using libraries
Please explain your answers: _____
4. Prior to PCB3063, how *confident* were you in your ability to use MEDLINE?
_____ Very _____ Somewhat _____ Not very
_____ Never used MEDLINE
Following PCB 3063, how *confident* do you feel about your ability to use MEDLINE?:
_____ Very _____ Somewhat _____ Not very
Please explain your answers: _____
5. How *helpful* did you find the required MEDLINE session to be in terms of your final project?
_____ Very _____ Somewhat _____ Not very
_____ Did not attend
Please explain your answer: _____
6. What did you like *best* about the required MEDLINE session? _____
What did you like least about the required MEDLINE session? _____
7. How *helpful* were the optional MEDLINE help sessions?
_____ Very _____ Somewhat _____ Not very
_____ Did not attend
Please explain your answer: _____
8. How *helpful* did you find the required GenBank session to be?
_____ Very _____ Somewhat _____ Not very
_____ Did not attend
Please explain your answer: _____
9. What did you like *best* about the required GenBank session? _____
What did you like *least* about the required GenBank session? _____
10. How *helpful* were the GenBank help sessions?
_____ Very _____ Somewhat _____ Not very
_____ Did not attend
Please explain your answer: _____
11. How *difficult* was it for you to attend the required MEDLINE and GenBank sessions?
_____ Very _____ Somewhat _____ Not very
_____ Did not attend
Please explain your answer: _____
12. Check the computer products below with which you had experience prior to PCB3063 (please check all which are applicable):
_____ LUIS/UF Library catalog
_____ MEDLINE
_____ Netscape
_____ Internet (other than Netscape)
_____ Current Contents
_____ Using Windows
_____ Using a mouse
_____ Other (please describe): _____
_____ Do you own your own computer? If so, do you have Netscape access from your own computer? _____
13. How *comfortable* were you in using a computer prior to PCB 3063:
_____ Very _____ Somewhat _____ Not very
_____ Never used one
How *comfortable* do you feel using computers now?
_____ Very _____ Somewhat _____ Not very
Please explain your answers: _____
14. In how many of your science classes have you been required to write a paper? _____
Which classes? _____
Were these papers primarily lab reports? _____
How many science papers have you had to write in which you have been expected to find information, synthesize the information, and write a paper? _____
15. How *helpful* would it have been to have a session on using the scientific literature or writing a paper?
_____ Very _____ Somewhat _____ Not very
Please explain your answer: _____
16. The intent of the class project was to teach you to find genetics information, synthesize information from many sources, use the knowledge gathered in class to understand the information, and then write a summary of what you have discovered. Please give an overview of how well you think the project accomplished this goal. _____
17. What do you think can be done to improve the project and make it more closely fulfill the above stated goal? _____
18. When you finish (have finished) your undergraduate degree, you will be (are) attending:
_____ Graduate school: department _____
_____ Medical school _____
_____ Dental school _____
_____ Pharmacy school _____
_____ Veterinary medicine school _____
_____ Other: describe _____
19. Your career plans are to become a: _____
20. Which of the following do you think you will be using during your post-baccalaureate education (check all that are applicable)?
_____ MEDLINE
_____ Current Contents

_____ Internet
_____ GenRef
_____ NCBI home page
_____ Other computer or information systems (please describe) _____
21. Do you work in a lab on campus? _____ Yes
_____ No
If so, in which department? _____
In which college? _____
22. How useful was the email distribution list?
_____ Very _____ Somewhat _____ Not very
_____ Did not join list
Please explain your answer: _____
23. How useful was the electronics reserves system?
_____ Very _____ Somewhat _____ Not very
_____ Did not use
Please explain your answer: _____
24. Any other comments on the project and the support instruction given for the project? _____
Thank you for your time!