Engaging and Sustaining Information Fluency in Science Students

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INTRODUCTION

Information fluency is defined as the intersection of computer literacy, information literacy, and critical thinking.[1] The crux of the concept relates to the "habits of mind" that allow students to use the literature and data to solve problems across disciplines and levels of academic coursework.

A science librarian and a genetics instructor at The Citadel, the Military College of South Carolina, collaborated in the use of a role-playing case study to engage and sustain information fluency in students enrolled in Biology 308 (Genetics) and Biology 624 (Recombinant DNA), during Fall 2005 and Spring 2006 semesters. Class activities focused on using the scientific literature to research and support different perspectives related to breast cancer gene testing.

This paper describes specific approaches (group activities, written assignments, and learning gains assessment) to develop and sustain information fluency in students studying science.

SETTING

The Citadel is a state-supported military college that offers undergraduate and graduate degrees in business, education, engineering, humanities, mathematics, and science for more than 2000 cadets and 1200 non-residential civilians. The college strives to "produce graduates who have insight into issues, ideas, and values that are of importance to society…It is equally important that Citadel graduates are capable of both critical and creative thinking, have effective communication skills, and apply abstract concepts to concrete situations, and possess the methodological skills needed to gather and analyze information."[2]

The Daniel Library works closely with course instructors to integrate library instruction into classroom assignments, and to develop activities that foster higher-order thinking. Several Daniel Library faculty participate actively in the Citadel Academy for the Scholarship of Teaching, Learning, and Evaluation (CASTLE) which focuses on classroom research projects related to critical thinking and active learning.

BACKGROUND

While Bonwell and Eison state that some faculty consider all learning, including listening, to be active, they define active learning as engaging students in such "higher-order thinking tasks as analysis, synthesis, and evaluation."[3] Active learning activities that require use of higher-ordered thinking "help students construct new knowledge, make meaningful connections with previous knowledge through the use of real-life examples, and allow for deeper understanding."[4]

Scientific case studies can be used to help students think like scientists, and engage them more profoundly than traditional lectures on the same subjects. Compelling and contemporary stories that feature different perspectives help students to relate to familiar and unfamiliar content, and assist in the transition from student to scientist. Ramaley argues that "science does not always have to be introduced in a hierarchical and sequential way."[5] Well-constructed cases introduce information in ways similar to how problems unfold in life. People with different backgrounds, education, and life experiences seek advice from friends and relatives, seek information to fill gaps in their knowledge, and form opinions. Students learn that scientific knowledge is fluid rather than static. As students work progressively through their chosen field of study, they learn that novices and experts alike seek answers from the scientific literature. Through practice, they start thinking like scientists.[6]

METHODS

The genetics instructor was a past participant in the Case Studies in Science workshop <http://ublib.buffalo.edu/libraries/projects/cases/workshop/> sponsored by the University of Buffalo which maintains a peer-reviewed collection of cases. Each case includes teaching notes for the instructor and detailed role-playing information for students. These scientific case studies present compelling, contemporary, and sometimes controversial subjects that challenge students to think and apply knowledge.[7] A case about breast cancer gene testing <http://ublib.buffalo.edu/libraries/projects/cases/genetic_testing/genetic_testing.html> was chosen because it meshed with genetics course content and expectations for using the scientific literature.

The librarian and the genetics instructor collaborated to incorporate this role-playing case study into library instruction planned for Fall 2005 and Spring 2006 semesters, and to measure student perceptions of learning gains before and after library instruction.

The librarian equipped a large instructional area with tables that seated four to six students each, wireless laptop computers for each student, an instructor's workstation and projector, flipchart, index cards, and handouts. Students entering the class were assigned randomly to one of four groups: Martha, Mary, John, or Peter, reflecting perspectives described in the case study, and directed to sit at a table labeled with the assigned name.

An introductory sheet explained each group's role in the session. According to the case presented, Kathy has risk factors for breast cancer and seeks the advice of her friends. Mary is a minister, Martha is a bioinformatics researcher at a pharmaceutical company, John is a genetic disease carrier, and Peter is a yoga instructor. The case also included a fifth friend who is the daughter of a man with Huntington's disease, but the instructors excluded this role based on the projected size of the classes.

The course instructors then explained that during the two-hour session students were expected to work in groups, and use three resources (ScienceDirect, Wiley InterScience, and PubMed) to find useful abstracts. The genetics instructor focused on abstracts rather than full-text articles in an effort to demonstrate the usefulness of abstracts to busy scientists, and to reduce the amount of reading necessary during the active learning sessions. Students were told to print/e-mail search results pages from at least two resources and print/e-mail five abstracts by the end of the instructional session.

The course instructors asked the students to vote. Based on the beliefs and biases of their assigned character, would they advise their friend Kathy to get tested for the breast cancer gene? Voting results were tallied on a flipchart located at the front of the room.

The purpose of assigning students randomly to one of four groups was explained briefly in terms of gaining different perspectives. Each group's perspective served as an example for searching a particular resource. A volunteer from each group used the instructor laptop and projector to walk the entire group through a search of a specific resource (ScienceDirect, PubMed, Wiley InterScience, any Internet resource). As each volunteer did this, the instructors prompted, encouraged, and asked questions. During the PubMed example, the student volunteer used the Clinical Queries feature to filter search results to genetic counseling, molecular genetics, and genetic testing of breast cancer. After each example, students were directed to try their group's perspective and to find useful abstracts.

In between the second and third group examples, students participated in a think/pair/share activity, reflecting on an unanswered question or something learned about the resources, and writing it down on individual index cards. After doing so, students found someone from another group, with one person as the interviewer and the other as the talker. The interviewer asked the talker about any unanswered questions or what s/he learned. After thirty seconds, the interviewer and talker switched roles. Students reported back to the group at large about lingering unanswered questions and/or learning. This allowed students to ask clarifying questions about the assignment or the subject.

If an instructor asks an entire class to define peer review, for example, a confident student answers correctly, incorrectly, or incompletely. By using think/pair/share, each student thinks, writes, and shares the answer with another student. The instructor can then ask for responses from each student or each group. Throughout the library instruction sessions, students were asked to write a definition, explanation, example, or evaluative comment. Depending on the knowledge and comprehension of the subject matter, students were asked increasingly complex questions based on Bloom's taxonomy. Figure 1 shows an example of increasingly complex questions that can be asked in class.

Figure 1. Increasingly Complex Questions Based on Bloom's Taxonomy

Thinking Levels	Learning Activity
knowledge	Define peer review.
comprehension	Who reviews the manuscripts? Explain how peer review is critical to scholarly communication, especially in the sciences.
application	Find an example of a peer-reviewed publication.
analysis	Describe the value of peer-reviewed publications for students, scientists, and laypersons alike
synthesis	What criteria can be used to compare peer-reviewed and non-peer-reviewed publications?
evaluation	Using the criteria developed above, compare the features and usefulness of at least two articles

Adapted from McWhorter, Kathleen T. (2003). *Study and Critical Thinking Skills in College*. 5th ed. New York: Longman.

A volunteer from the fourth group demonstrated a favorite database or Internet resource, and explained how the results compared to abstracts retrieved from ScienceDirect, PubMed, or Wiley InterScience. Typical favorites included Google Scholar, AskJeeves, and WebMD. Students compared information found in the different databases, and discussed the relative usefulness of each for different perspectives.

Jigsaw technique is a way to compose and compose small groups for developing mastery[8] and reducing passivity.[9] The homogeneous groups recomposed to feature one person from each of the four groups. With one Martha, one Mary, one Peter, and one John at each table, students spent three minutes presenting their opinions to their table group. Based on what they learned, would they advise Kathy to be tested? Did they change their minds based on the research they conducted? Each table reported back to the group at large.

Near the end of the class, instructors confirmed that students had printed/e-mailed results lists from at least two resources and printed/e-mailed at least five abstracts. The final elements of the class including taking a second vote on whether Kathy should be tested. Based on what had been researched and discussed in the session, would they advise testing? Did they change their minds based on class activities? Thinking back over the resources covered, students used an index card to complete the following statement: “during this session, I was surprised….”

LEARNING GAINS

The course instructor used and adapted Student Assessment of Learning Gains (SALG) <http://www.wcer.wisc.edu/salgains/fac/default.asp> as an online assessment of students enrolled in Biology 308 and Biology 624. Prior to library instruction, students answered a series of questions about their confidence about scientific thinking and finding journal articles. Near the end of the semester, questions focused on the usefulness of class activities and assignments for learning course content. Figures 2 and 3 show perceptions of learning gains in students enrolled in Biology 308 and Biology 624.

Figure 2. Learning Gains - Biology 308 (Genetics) – Spring 2006

Presently, I am CONFIDENT I can understand….			**Pre-Instruction *N*=19**		
	1=Not Confident	2=A Little Confident	3=Somewhat Confident	4=Highly Confident	5=Extremely Confident
How scientists think about problems	0%	10%	42%	37%	11%
How to identify good scientific reasoning and use of appropriate evidence to prove a point	5%	16%	26%	37%	16%
Find data or articles in journals or elsewhere	0%	0%	32%	42%	26%
How much did each of the following aspects HELP YOUR LEARNING? **Post-Instruction *N*=18**					
	1=No help	2=A little help	3=Moderate help	4=Much help	5=Very much help
Discussions in class	0%	0%	17%	56%	28%
Group work in class	0%	16%	17%	50%	17%
Hands-on class activities	0%	0%	6%	44%	50%

Most students enrolled in Biology 308 reported being somewhat or highly confident about their understanding of how scientists think about problems, how to use evidence to prove a point, and how to find data or articles. Most students found that class discussions, hands-on class sessions, and group work helped their learning.

Figure 3. Learning Gains - Biology 624 (Recombinant DNA) – Fall 2005

Presently, I am CONFIDENT I can….				**Pre-Instruction *N*=16**	
	1=Not Confident	2=A Little Confident	3=Somewhat Confident	4=Highly Confident	5=Extremely Confident
Make an argument using scientific evidence	6%	12%	12%	58%	12%

Find scientific journal articles using library/Internet databases	0%	6%	6%	38%	50%
Think critically about scientific findings I read about in the media	0%	18%	25%	38%	19%
How much did each of the following aspects HELP YOUR LEARNING? **Post-Instruction *N*=16**					
	1=No help	2=A little help	3=Moderate help	4=Much help	5=Very much help
Discussions in class	0%	12%	19%	38%	31%
Group work in class	6%	0%	44%	38%	12%
Hands-on class activities	0%	0%	6%	44%	50%
After finishing this class, I am CONFIDENT I can… **Post-Instruction *N*=16**					
	1=Not Confident	2=A Little Confident	3=Somewhat Confident	4=Highly Confident	5=Extremely Confident
Make an argument using scientific evidence	0%	0%	6%	75%	19%
Find scientific journal articles using library/Internet databases	0%	0%	0%	25%	75%
Think critically about scientific findings I read about in the media	0%	0%	12%	44%	44%

Most students enrolled in Biology 624 were highly confident about using scientific evidence to make an argument, extremely confident about finding scientific articles, and highly confident about thinking critically about scientific findings presented in the media. This group of students also found that class discussions, group work, and hands-on class activities helped their learning. Upon completing this course, confidence in making an argument, finding scientific articles, and thinking about scientific findings reported in the media increased dramatically. In this group of students, confidence in making an argument increased from 56% being highly confident to 75% being highly confident. Extreme confidence in finding articles increased from 50% to 75%. Confidence in thinking critically increased from 57% highly or extremely confident to 88% highly or extremely confident.

The librarian and course instructor looked at what students had written on the index cards as another way to assess what they had learned. Typical index card comments expressed surprise about the abundance of authoritative, scholarly articles about scientific subjects, and the ease of retrieving useful abstracts. Others commented on the high number of students changing their votes after researching the topic and participating in group discussions.

The course instructor asked students to submit a written assignment about why or why not their character would encourage Kathy to be tested, other advice they would give, and how Kathy's decisions would affect her. Students were expected to cite the scientific literature. Typical assignments were serious, thoughtful, and well-researched, and indicated appreciation of the subject's complexities.

CONCLUSION

Well-constructed and -paced case studies that feature scientific concepts of interest and value to people from all walks of life can engage and sustain student interest and increase confidence related to scientific thinking and learning. Library instruction that reflects higher-ordered thinking reinforces rigorous expectations of students studying science, and offers keen insights into how students construct search queries and select scientific articles. Think/pair/share and jigsaw techniques can be used judiciously to keep students active and engaged throughout a two-hour period. The instructors plan to use this experience as a starting point for future collaborations related to peer learning and critical thinking during class, and to continue to measure and build confidence in student learning. Use of a discipline-based case study is a viable way to promote information fluency when teaching students how to search and use the scientific literature. As a mechanism to help students at all levels of their education to develop information fluency, the case study is a powerful tool, since cases are written for all levels of students.

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