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NSF-Style Peer Review for Teaching UNDERGRADUATE GRANT-WRITING

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The Biology Department at Jacksonville State University (JSU) in Alabama has incorporated an undergraduate research experience (URE) into its curriculum for both BA and BS degree programs. This experience involves the following semester courses:

- BY 370 (Introduction to Research in Biology): two semester credits, sophomore level
- BY 327 (Directed Studies in Biology) or BY 427 (Independent Study in Biology): variable credits, junior year
- BY 496 (Senior Seminar) two credits, senior level

The Department has recognized the need for both substantive coursework and an undergraduate research experience in its biology curriculum. The JSU URE is the outcome of curricular revision over the past 14 years. BY 370 and BY 496 are required courses, whereas independent research involves optional courses intended to interest students in research. BY 327 and BY 427 had been in the curriculum for some time, available for student research projects under the tutelage of a faculty mentor. BY 370 was initiated in 1991 to introduce majors to the science and art of biological research and grant-writing in an effort to strengthen the outcome of BY 327 and BY 427. This course is now offered with multiple sections and instructors both semesters every year. Today, BY 327 and BY 427 enable students to conduct original field and/or laboratory research, educational research in biology, or substantive library-based research of an approved biological topic. BY 496, a required course since 2002, involves both a senior thesis and an oral presentation, the latter given in a department-wide symposium format. BY 496 is the Biology Department's capstone course for all matriculating biology majors. The overall URE Experience has enabled the Department to integrate "communication across its curriculum" in a way that was never possible before.

This paper concerns a modification to BY 370. In this course, students now actively participate in an NSF-style peer review of their own undergraduate research proposals in biology.

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Teaching Grant-Writing to Undergraduate Biology Majors

Why? Incoming JSU students generally lacked a coherent understanding and appreciation of what was required to actively engage in scientific inquiry. Hence, they were unable to construct meaningful hypotheses or to design appropriate experimentation. Many lacked the verbal and oral skills to effectively communicate scientific activities to their peers and the rest of the world. None had written a grant proposal and few, if any, had engaged in substantive biological research. Most were not aware that the JSU faculty who teach biology also engage in research.

The majority of incoming students, as well as those matriculating in the past, rarely perceived the postgraduate benefits that accrued from doing undergraduate research. Undergraduates frequently received little or no formal training in grant-writing and/or research until they were doing postgraduate research. While some undergraduates did not always aspire to continue their education in biology or seek professional education, such activities did benefit those seeking teaching, technical, or other positions simply because their resumes now stood out from other applicants!

In the early years of BY 370, biology faculty and their research interests were introduced early in the course, thereby enabling students to identify a potential research project mentor. An exposure to biological literature followed, from searching and accessing literature through library journals and databases, including the use of applicable and appropriate Internet search engines. Students then made a critical analysis of selected research articles, including the good and the bad (for examples of both, contact one of the authors). The concept of scientific process and inquiry (both experimental and descriptive approaches) were developed with an emphasis on: the role of observation, asking questions, developing an appropriate hypothesis, and materials and methods. Experimental design included a basic introduction to statistical analysis, construction of appropriate tables and graphs, and the use of other tools (Ambrose & Ambrose, 1995). The continuing importance of professionalism and ethics in scientific research and the need to avoid plagiarism were noted. The value of a meaningful and competitive portfolio at matriculation was emphasized. The course culminated with a student-generated limited research proposal with budget (in consultation with a faculty mentor) whose format was patterned after Sigma Xi's application form for Grant-in-Aid of Research (Sigma Xi, 2004).

The Initial BY 370 Format: A Qualified Success

The number and quality of student research projects in BY 327 and BY 437 did increase. A few students gave oral presentations at an on-campus undergraduate symposium and later at state and regional meetings. Several students submitted their research proposals to the Sigma Xi Grants-in-Aid of Research program and received funding. An occasional research article was published and more majors were inclined to continue postgraduate study.

But the faculty soon realized that the project description in the Sigma Xi application format was limited and did little more than develop an abstract. It was flawed in that it failed to expose a student's potential weakness in effective communication skills, i.e., grammar, spelling, technical writing, etc. More importantly, interactive student participation was limited to individual contacts with a faculty mentor.

As a result, the student-generated research proposal became more in-depth with a more extensive analysis of pertinent literature leading to an appropriate hypothesis. The Materials and Methods section, especially the experimental design, was now expected to be well-developed. However, it was not until 2002 that the participation issue resolved itself when the lead author was invited to an NSF CCLI panel review. The idea emerged that an NSF-style student peer review of student-generated research proposals could involve student interaction to a degree never before possible. This concept was immediately incorporated into the format of BY 370.

The Student Research Proposal

Format and style of student-generated research proposals for BY 370 must adhere to departmental guidelines for format (font size, etc), literature citation, overall page limits, etc. Each research proposal now has seven or eight components:

1. A Title Page with author (proposed student investigator), a brief abstract or summary of the proposed research project (not more than 12 lines), course and section, and a line for approval by the faculty mentor.
2. A second and incomplete Title Page, with title of proposal, abstract, and an identification number provided by the instructor (for use by the student peer review panel (student author is not identified).
3. An Introduction section with literature review and hypothesis.
4. A Materials and Methods section with sufficient detail to support the proposed research. Instrumentation not currently available in the Department must have approval for use.
5. A Timetable for completion of proposed research.
6. A Literature Cited section that includes those journal articles, popular articles, books, and Web sites that were cited in the Introduction and Materials and Methods sections.
7. A Bibliography section that includes those publications read but not cited.
8. A Budget page whose total estimated costs should not exceed the maximum funding level set by all instructors participating in BY370 for that term. Estimated costs for chemicals and other supplies are based on prices available in current biological and chemical supply catalogs maintained in the departmental office. Estimated travel costs for field work are based on current university mileage allowances. Expenditures exceeding $100 and for travel must be justified. Budget pages are printed on colored paper.

Why budget pages for a student-generated research proposal? Students during routine laboratory exercises in courses were never confronted with the costs involved. But students gain an appreciation and respect for the "cost" of doing research when confronted with assessing equipment needs and operating costs, the costs associated with routine chemical and other supplies, and the costs and logistics associated with travel.

Evaluation of Student-Generated Research Proposals

Each student-generated research proposal submitted for BY 370 is subjected to two concurrent and independent evaluations by the student peer review panelist and the course instructor. The overall criteria for both student and instructor evaluations are the same, emphasizing the quality and science of the proposal and its budget, the overall presentation (such as the review and critical analysis of applicable literature), the hypothesis, and justification of the funding request. Attention to spelling and grammar is also expected.

Student Peer Review Evaluation

Student evaluation involves an NSF-style peer review panel whose purpose is to constructively critique each proposal. A student is arbitrarily assigned as a panelist on one or more peer review panels, each with four to six members. The instructor convenes each panel, distributes evaluation forms, and discusses the criteria for evaluation. Anonymous copies of the proposals (either electronic or paper versions) submitted by another section of BY 370 are distributed to each panelist. Directions and advice (similar to that given to NSF review panels) are given to each panel for conducting its evaluations. The amount of imaginary funding allotted to each panel is announced. The funding level is determined by the instructor, usually about 25% of the total funding request for all proposals assigned to that panel. When possible, a second student peer review panel is convened to review proposals, thereby generating a second opinion.

The student panel determines the order in which proposals are to be reviewed. Each panelist independently conducts an evaluation of all proposals assigned to that panel, using the evaluation forms shown in Figures 1-2. Panelists are required to make written comments for each type of evaluation. They are encouraged to be constructive in their commentary, providing specific examples of areas within each proposal that could be improved. The student panelist then rates each proposal as:

1 = Excellent • 2 = Very good • 3 = Good • 4 = Below average

The panel as a whole reconvenes to critically discuss each proposal and to establish an overall panel rating and ranking. During this process, a panelist may abstain from the review process if either a panelist or the panel as a whole has determined a conflict of interest. Proposals are recommended for funding (at or below the level requested) or rejection. A previously-selected panelist, serving as an NSF-style scribe, writes a composite summary justifying the panel's overall ranking and recommendation. The scribe's report must be approved by all panelists. Where there is a differing opinion, a signed minority report also may be submitted. The evaluations by each panelist and the scribe's summary, and any minority reports, are submitted to the instructor. Funding recommendations along with anonymous copies of the evaluations by each panelist and the scribe (and minority reports) are distributed to the student grant applicants.

Figure 1. Peer Panel Composite Evaluation Form.

Peer Panel Composite Evaluation

BY 370 Section _____ Date _____ Proposal Number _____

Proposal Title _____

Panel Evaluation

	Numerical
Part I	_____
Part II	_____
Part III	_____
Proposal Rating	_____

Funding Recommendation

Recommended? _____ Amount Funded? _____

Not recommended? _____

Scribe's Commentary

Scribe _____

Other Panelists _____ _____

_____ _____

_____ _____

Faculty Evaluation

The grade for this part of BY 370 (the research proposal and peer review) is determined solely by the instructor to avoid student bias. In so doing, the instructor not only independently evaluates each proposal, but also considers the written comments by panelists and the composite panel (i.e., the scribe). The instructor looks for the thoroughness of an evaluation, grammatical and spelling assessment, constructive critiques, innovative ideas, and overall participation in the evaluation process by each panelist. The number of such evaluations can vary depending on the number of proposals submitted from the other section. Therefore, the total number of proposals to be evaluated is assigned a 100% and evaluation of all the documents could earn a student full marks. It is essential that a student peer panel's rating of a proposal never be a factor in the final outcome, i.e., the course grade.

Undergraduate Student Peer Review: A Success

Since student peer evaluations do not impact directly on a student's grade in BY 370, we believe the outcome of student peer review has proven to

Figure 2. Peer Panelists Evaluation.

Peer Panelist Evaluation

Proposal number _____

Proposal title _____

RATING SCALE: 1- Excellent; 2 - Very Good; 3 - Good; 4 - Fair; 5 – Poor

PART I - QUALITY OF SCIENCE

	RATING		
Introduction	_____	Review/hypothesis adequate?	_____
Literature Cited	_____	Literature search adequate?	_____
	_____		
Materials/Methods	_____	Techniques appropriate?	_____
Budget	_____	Estimated costs appropriate?	_____
Part I Rating	_____		

PART II – QUALITY OF PROPOSAL

	RATING		
Introduction	_____	Literature review adequate?	_____
Materials/Methods	_____	Methods understandable?	_____
Budget	_____	Costs justified?	_____
Literature Cited	_____	Literature current?	_____
Part II Rating	_____		

PART III – GUIDELINES

	RATING
Cover page format met?	_____
Deadlines met?	_____
Page limits met?	_____
Budget format met?	_____
Grammar?	_____
Spelling?	_____
Part III Rating	_____

Comments/Recommendations

be an invaluable learning experience. This was evident from some of the written comments by panelists and scribes:

Quality of proposal

This proposal is great. • Excellent, a great idea. • Even I would fund it. • There is no justification for funding this proposal.

Presentation

This proposal is easy to follow. • Proposal confusing. • Does not flow. Does not appear to have been read before submission. • Needs to be reworked. • Abstract does not explain project.

Grammatical concerns

Technical skills lacking. • Sentences repeated or contradictory statements. Too many mistakes. • Needs reworking. • Mentor's name misspelled or not identified. • There is "Spell Check."

Quality of the science

Proposal not well-developed. • No hypothesis. • Literature review insufficient and/or lacking. • It is not clear how research can be accomplished with existing facilities.

Guidelines

No timeline was given. • No double spacing. • Etc.

These comments reflect the serious and critical nature of student peer review. Their expectations were high; in fact, they were far more demanding of themselves than were the faculty. In general, they thoroughly scrutinized proposals. Their reviews, especially those of the panels as a whole, often provided insight that otherwise might have been overlooked. Student conflict of interest surprisingly was infrequent.

Students were assessed as to their perception of scientific inquiry before and after BY 370. Only those results pertinent to grant-writing and peer review were considered in this paper and these were not statistically significant due to small sample size. The survey did suggest that student perception of grant-writing (i.e., development of a research proposal and budget) improved as students became aware of the competitive edge that such activities provide for postgraduate employment and education as well as professional advancement. Awareness and understanding of the scientific process in acquiring scientific knowledge as well as appreciation of the faculty's research activities has certainly increased. This course has made students more cognizant of the need for basic courses in genetics, cell biology, and even ecology. Finally, it has promoted the need for biology majors to take computer science and scientific writing.

Student peer review not only provides valuable input into a project's experimental design but also ensures meritorious dispersal of the available research funds (Gift & Krasny, 2003). Carlsen, Cunningham, and Trautmann (2001) concluded that peer review separates science from non-science and therefore is an essential component of scientific inquiry.

Conclusions

There is little doubt that NSF-style peer review in combination with grant-writing as an integral component of a required undergraduate research experience has had a positive impact on the JSU biology major. The latter certainly provides BY 370 students with a unique learning experience through the peer review panel process. Now, the JSU major is better prepared to experience scientific inquiry through BY 327 and BY 427, culminating in the capstone BY 496, the Senior Seminar. Verbal and oral communicative skills also have improved considerably, a fact that has been noted by other JSU departments. It also means that our matriculating majors now have a substantive and meaningful resume; hence, they have established a competitive edge over students from other institutions when seeking either postgraduate education (including professional schools such as medical and pharmacy schools), or employment in teaching or technical positions. Even those majors entering the K-12 teaching field no longer fear the daunting task of writing grant proposals in order to acquire external funding.

This approach to undergraduate scientific inquiry has been a highly successful endeavor at JSU, a regional public institution of higher education, and is very applicable to any science program. It also has greatly enhanced the academic reputation of the Biology Department throughout the Southeast region.

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