USE OF COURSE-EMBEDDED PROJECTS FOR PROGRAM ASSESSMENT

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There is increasing demand on science faculty to develop authentic assessment measures for both individual courses and undergraduate programs. We report here on a quarter-long group project used in a neurophysiology course that can be used for either purpose. Small groups of four to five students critically analyze at least 10 articles from the primary scientific literature. The end result of this process is the equivalent of a scientific review article that is presented in two formats, a 10-min oral presentation and a scientific poster presentation. Students perform better on application tasks than on analysis, synthesis, or evaluation tasks associated with the project (P < 0.025) and generally respond positively to process questions (59–82%) but less positively to task questions (36–76%) about group dynamics. The cognitive skills and basic content knowledge required to complete this project are developed throughout the undergraduate program. Thus the project is a type of culminating program experience. However, the project also assesses basic course proficiency, because students cannot analyze primary neuroscience research without an understanding of neurophysiological principles.


Key words: authentic assessment; embedded assessment; undergraduate science education; cognitive tasks associated with science projects; student self-report of group process

There is increasing demand on science faculty to develop authentic assessment measures for both individual courses and undergraduate programs, i.e., to develop measures of student performance in "real-life situations" (1–3, 7–10). The culmination of most practicing scientists' work is its communication to colleagues and the lay public. In general, original scientific research is first communicated as a professional conference presentation. Posters are an increasingly popular venue for these presentations, whereas 10-min oral "platform" presentations are the traditional communication format. Consequently, senior natural sciences students are thought to benefit significantly from an exposure to the culture of professional scientific communication by participation in a mock scientific conference before graduation from undergraduate programs and entry into the workforce. In addition, this requirement provides an ideal opportunity for assessment of student performance in an authentic setting.

Graduates with majors in the natural sciences are increasingly exposed to group work environments, either in the traditional laboratory setting or in more modern health care settings (1, 8, 10). Consequently, experiences that encourage the development of group interaction skills will benefit these students as they move into the workforce. Evaluation of these skills as part of an organized program assessment plan provides feedback regarding the extent to which a
program is aiding students in development of these critical career-related skills.

We report here on a quarter-long small group project in use since 1992 in a senior-level neurophysiology course that provides an opportunity for authentic assessment of learning in both the course and the undergraduate program. The assessment data are generated within the framework of the course and are used for overall program assessment but are also used to help assign final course grades. The cognitive skills and basic biological content knowledge required to complete the course project are developed throughout the undergraduate program. Thus the project is a type of culminating or capstone program experience that can be used for program assessment. However, the project also assesses basic course proficiency, because students cannot complete the project without an understanding of basic neurophysiological principles.

PROCEDURE

Student Project Protocol

Assignment of students to groups. Students are assigned to groups (n = 4-5 students) by the course instructor. Factors such as class standing, academic major, and grades in prerequisite courses are used to produce balanced groups with no prior history. Group assignments are announced at the beginning of the second week of the quarter, once the final class enrollment has been established.

Project description and assessment criteria. Students receive a detailed description of the project requirements on the first day of class. This material is supplied as a part of the course syllabus. Briefly, groups critically analyze 10 or more research publications from the primary neuroscience literature, synthesize these papers into a scientific review article, and then communicate their findings in two media, a scientific poster presentation and a 10-min oral presentation. Students are also supplied by the ninth week of the quarter with the detailed grading criteria used to assess the project (APPENDIXES A and B).

Introduction to team learning and establishment of peer evaluation criteria. One lecture period is used to acquaint students with basic principles of small group communication and team learning (4). The groups are then given time in class to establish task and process criteria for peer evaluations. The class instructor provides input on these criteria, and students modify their drafts before submission of the final evaluation forms. This is the first task that the students perform as a group, and it begins the establishment of a group identity. The final evaluations of group members are due at the end of the quarter and constitute 10% of the final course grade. Task and process criteria used by the groups are summarized in Tables 1 and 2.

Library exercise. The second task that the groups perform is a library exercise designed to 1) ensure that all students understand the use of on-line scientific bibliographic databases and 2) continue the process of group building. Students are prepared for the exercise by library personnel, who provide hands-on

**TABLE 1**

<table>
<thead>
<tr>
<th>Task criteria used for peer evaluations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion</td>
</tr>
<tr>
<td>Attend group meetings (8)</td>
</tr>
<tr>
<td>Complete tasks in timely manner (7)</td>
</tr>
<tr>
<td>Research articles (7)</td>
</tr>
<tr>
<td>Involved in discussion at group meetings (6)</td>
</tr>
<tr>
<td>Help in assembly of poster (6)</td>
</tr>
<tr>
<td>Help to write, edit, type poster (5)</td>
</tr>
<tr>
<td>Attend final class meeting (4)</td>
</tr>
<tr>
<td>Summarize articles (4)</td>
</tr>
<tr>
<td>Teach other group members (1)</td>
</tr>
<tr>
<td>Help in choosing poster topic (1)</td>
</tr>
</tbody>
</table>

Number of groups out of total of 9 groups that used each criterion is indicated in parentheses.

**TABLE 2**

<table>
<thead>
<tr>
<th>Process criteria used for peer evaluations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion</td>
</tr>
<tr>
<td>Cooperative attitude (3)</td>
</tr>
<tr>
<td>Equal participation (3)</td>
</tr>
<tr>
<td>Willing to compromise and respect opinions of others (3)</td>
</tr>
<tr>
<td>Punctual (2)</td>
</tr>
<tr>
<td>Keep group members informed of progress (1)</td>
</tr>
<tr>
<td>Contribute ideas to discussion versus just agreeing with others (1)</td>
</tr>
<tr>
<td>Positive interactions with others in group (1)</td>
</tr>
<tr>
<td>Supportive of others in group (1)</td>
</tr>
<tr>
<td>Commitment to group (1)</td>
</tr>
<tr>
<td>Good communication skills (1)</td>
</tr>
</tbody>
</table>

Number of groups out of total of 9 groups that used each criterion is indicated in parentheses.
**TABLE 3**
Grading criteria

<table>
<thead>
<tr>
<th>Grading Criteria</th>
<th>Total Points Possible</th>
<th>X (SE)</th>
<th>Percentage of Points Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Title: appropriate length/descriptive</td>
<td>50</td>
<td>43.7</td>
<td>87.4</td>
</tr>
<tr>
<td>Introduction: 2–3 paragraphs</td>
<td>3</td>
<td>3 (0)</td>
<td>100</td>
</tr>
<tr>
<td>Introduction: uses references</td>
<td>3</td>
<td>2 (0.3)</td>
<td>66.7</td>
</tr>
<tr>
<td>Research description: figures/tables from 6–10 papers</td>
<td>8</td>
<td>5 (0.9)</td>
<td>62.5</td>
</tr>
<tr>
<td>Research description: references articles</td>
<td>4</td>
<td>3.6 (0.3)</td>
<td>90</td>
</tr>
<tr>
<td>Research description: majority of poster</td>
<td>4</td>
<td>4 (0)</td>
<td>100</td>
</tr>
<tr>
<td>Summary: ~1 page</td>
<td>4</td>
<td>3 (0)</td>
<td>100</td>
</tr>
<tr>
<td>References: lists at least 10 primary articles</td>
<td>6</td>
<td>5.4 (0.3)</td>
<td>90</td>
</tr>
<tr>
<td>References: citations in approved format</td>
<td>2</td>
<td>1.9 (0.1)</td>
<td>95</td>
</tr>
<tr>
<td>References: alphabetical/numbered</td>
<td>2</td>
<td>1.8 (0.1)</td>
<td>90</td>
</tr>
<tr>
<td>General: approved organization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General: readability</td>
<td>2.5</td>
<td>2.3 (0.1)</td>
<td>92</td>
</tr>
<tr>
<td>General: mechanics</td>
<td>2.5</td>
<td>2.2 (0.2)</td>
<td>88</td>
</tr>
<tr>
<td>General: no larger than 3 × 4 ft</td>
<td>2.5</td>
<td>2.3 (0.2)</td>
<td>92</td>
</tr>
<tr>
<td>Analysis and synthesis tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction: gives general background</td>
<td>3</td>
<td>2.9 (0.1)</td>
<td>96.7</td>
</tr>
<tr>
<td>Research description: describes methods</td>
<td>8</td>
<td>5.8 (0.7)</td>
<td>72.5</td>
</tr>
<tr>
<td>Research description: interpretation of figures</td>
<td>8</td>
<td>6.4 (0.6)</td>
<td>80</td>
</tr>
<tr>
<td>Research description: groups similar results</td>
<td>4</td>
<td>3.4 (0.3)</td>
<td>85</td>
</tr>
<tr>
<td>General: paraphrases/no direct quotes</td>
<td>2.5</td>
<td>2.4 (0.1)</td>
<td>96</td>
</tr>
<tr>
<td>Evaluation tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction: how fits into neuroscience?</td>
<td>3</td>
<td>2.9 (0.1)</td>
<td>96.7</td>
</tr>
<tr>
<td>Introduction: states hypothesis</td>
<td>3</td>
<td>2.3 (0.4)</td>
<td>76.7</td>
</tr>
<tr>
<td>Research description: subsection conclusions</td>
<td>4</td>
<td>2 (0.6)</td>
<td>50</td>
</tr>
<tr>
<td>Summary: draws general conclusions</td>
<td>6</td>
<td>5.4 (0.4)</td>
<td>90</td>
</tr>
<tr>
<td>Summary: do results support hypothesis?</td>
<td>6</td>
<td>4.1 (0.8)</td>
<td>68.3</td>
</tr>
<tr>
<td>Other tasks: aesthetics</td>
<td>2.5</td>
<td>2.5 (0)</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total score</strong></td>
<td>100</td>
<td>84.1 (3.6)</td>
<td>84.1</td>
</tr>
</tbody>
</table>

Grading criteria are arranged according to cognitive skill level for poster presentations, total points possible for each criterion, and mean (X), standard error (SE), and percentage possible points achieved for each criterion (n=9 groups).

**TABLE 4**
Grading criteria

<table>
<thead>
<tr>
<th>Grading Criteria</th>
<th>Total Points Possible</th>
<th>X (SE)</th>
<th>Percentage of Points Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction: ~1⁄4 of presentation</td>
<td>2</td>
<td>2 (0)</td>
<td>100</td>
</tr>
<tr>
<td>Introduction: references prior research</td>
<td>2</td>
<td>1.6 (0.2)</td>
<td>80</td>
</tr>
<tr>
<td>Research description: refers to figures/tables</td>
<td>6.5</td>
<td>5.7 (0.4)</td>
<td>87.7</td>
</tr>
<tr>
<td>Research description: references sources</td>
<td>3</td>
<td>2.7 (0.1)</td>
<td>90</td>
</tr>
<tr>
<td>Research description: ~1⁄4 of presentation</td>
<td>3</td>
<td>2.7 (0.2)</td>
<td>90</td>
</tr>
<tr>
<td>Conclusions: ~1⁄4 of presentation</td>
<td>2</td>
<td>1.5 (0.3)</td>
<td>75</td>
</tr>
<tr>
<td>General: approved organization</td>
<td>2</td>
<td>1.5 (0.2)</td>
<td>75</td>
</tr>
<tr>
<td>General: ~10 min total length</td>
<td>2</td>
<td>1.7 (0.2)</td>
<td>85</td>
</tr>
<tr>
<td>General: descriptive title</td>
<td>2</td>
<td>2 (0)</td>
<td>100</td>
</tr>
<tr>
<td>Analysis and synthesis tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction: gives general background</td>
<td>2</td>
<td>1.7 (0.1)</td>
<td>85</td>
</tr>
<tr>
<td>Introduction: gives overview of presentation</td>
<td>2</td>
<td>0.9 (0.2)</td>
<td>45</td>
</tr>
<tr>
<td>Research description: interprets figures</td>
<td>6.5</td>
<td>6.3 (0.2)</td>
<td>96.9</td>
</tr>
<tr>
<td>Research description: describes methods</td>
<td>6</td>
<td>5.1 (0.6)</td>
<td>85</td>
</tr>
<tr>
<td>Conclusions: synthesizes/draws general conclusions</td>
<td>4</td>
<td>3.2 (0.4)</td>
<td>80</td>
</tr>
<tr>
<td>General: paraphrases/no quotes</td>
<td>2</td>
<td>2 (0)</td>
<td>100</td>
</tr>
<tr>
<td>General: effective use of transitions</td>
<td>2</td>
<td>1.2 (0.1)</td>
<td>60</td>
</tr>
<tr>
<td>Evaluation tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction: states hypothesis</td>
<td>2</td>
<td>1.7 (0.2)</td>
<td>85</td>
</tr>
<tr>
<td>Conclusions: do results support hypothesis?</td>
<td>4</td>
<td>2.3 (0.4)</td>
<td>57.5</td>
</tr>
<tr>
<td>Other tasks:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General: effective/engaging style</td>
<td>3</td>
<td>2.7 (0.2)</td>
<td>90</td>
</tr>
<tr>
<td>General: extemporaneous/makes eye contact</td>
<td>2</td>
<td>1.9 (0.1)</td>
<td>95</td>
</tr>
<tr>
<td><strong>Total Score</strong></td>
<td>60</td>
<td>50.4 (1.7)</td>
<td>84.1</td>
</tr>
</tbody>
</table>

Grading criteria are arranged according to cognitive skill level for oral presentations, total points possible for each criterion, and mean (X), standard error (SE), and percentage possible points achieved for each criterion (n=9 groups).
training in the library's electronic classroom. The training session occurs during a regularly scheduled class period, and the group assignment is due 1 wk later.

Selection of poster topic. The third task that groups perform is the selection of a poster topic. The instructor supplies a list of potential topics, but students are encouraged to suggest others. Topic choices and one supporting article are due the fourth week of the quarter. The next class period is used for meetings between the instructor and the groups to approve or modify the topics.

Project outlines. A detailed outline of the project is due at the beginning of the eighth week of the quarter. Primary literature used to develop the outline is submitted at the same time. The remaining class periods for that week are used for meetings between the instructor and the groups. The meetings are used to discuss the appropriateness of the literature references submitted by the group and the organization and content of the proposed outlines. Suggestions for improvement of the project outline are made by the instructor at this meeting. In addition, the students have an opportunity, as a group, to ask questions of or engage in discussion with the instructor.

Final project presentations. The final examination period is used for the presentation of the final class projects. The first 1.5 h are used for oral presentations. Each group has 10 min to present its project to the class. Usually, one or two people are chosen by the group to make this presentation. The presentations are assessed by the instructor according to previously distributed criteria (APPENDIX B). The final hour of class is used for a "scientific conference poster session," where guests from the university community are invited to browse through the posters and ask questions of all group members or engage the authors in discussion. The posters are submitted to the instructor at the end of the scientific conference poster session and are assessed according to previously distributed criteria (APPENDIX A).
Faculty Assessment Protocol

Program and course assessment based on student surveys. Indirect assessment of student accomplishment was achieved in spring 1997 with student surveys. Students were surveyed three times during the quarter, at the beginning of week 2 before the “team learning” lecture was given and work in groups had begun (early quarter survey), about midway through the quarter after the detailed outlines for their projects were due (midquarter survey), and at the final class meeting when the final projects were due (end of quarter survey). The early quarter survey contained five questions that assessed prior preparation in the undergraduate program for carrying out complex projects and provided a type of overall assessment of the undergraduate program (APPENDIX C, questions 1–5). Answers to these questions were tabulated and are presented in graphic form (see Figs. 1–5).

All surveys contained questions that assessed the students’ attitudes toward the group process and provided assessment of the effectiveness of the course interventions at improving group work skills (APPENDIX C, questions 6–10). The questions from the early quarter survey were phrased slightly differently for the midquarter and end of quarter surveys. The rephrasing of questions was designed to allow determination of the effect of this course, versus previous experiences, on the students’ attitudes toward group work. For example, the question “I enjoy working on graded projects in small groups,” which appeared on the early quarter survey, was changed on the midquarter survey to “I am enjoying working on this graded small group project,” and to “I enjoyed working on the neurophysiology small group project” for the end of quarter survey. Answers to these questions were tabulated and presented in graphic form (see Figs. 6–10). The response distributions obtained from the three surveys were then compared using the Kruskal-Wallis one-way ANOVA followed by Ryan’s procedure (6). Differences were considered statistically significant at $P < 0.05$. 

Student responses (n = 44) to survey question requesting information about prior experience with primary scientific literature.

FIG. 2.

![Graph showing student responses to survey questions](image-url)
Program and course assessment based on direct assessment of student learning. The direct assessment of student learning was accomplished in spring 1997 by creating specific grading criteria for both the oral and poster presentations (APPENDIXES A and B). Each criterion was then assigned to a cognitive skill domain according to Bloom’s taxonomy (Tables 3 and 4; Ref. 5). The grading criteria were sorted into three cognitive skill levels: application tasks, analysis and synthesis tasks, and evaluation tasks. Application tasks were defined as those that required use of abstractions in concrete situations (5). For example, the criterion for assessing the title was that it be “an appropriate length and descriptive of research results to be discussed.” Students were required to use this abstract statement and to produce a title that suited their project. Analysis and synthesis tasks were defined as those that broke a communication down into the constituent elements and arranged the elements to produce a new structure (5). For example, one assessment criterion for the Introduction was “gives a general background to the topic.” To accomplish this task, students needed to break scientific literature into its main points, an analysis task, and then arrange these points to form their Introduction, a synthesis task. Evaluation tasks were defined as those that required the student to make a judgment (5). For example, one criterion for assessment of the Conclusions section was “states whether results support or refute the original hypothesis/model,” which requires a judgment on the part of the student.

Overall program assessment was accomplished by use of combined class data to assess general performance by advanced students on specific tasks associated with scientific writing.
the projects. The mean, standard error, and percentage of possible points for each assessment criterion for \( n = 9 \) groups were calculated. The Kruskal-Wallis one-way ANOVA \( (6) \) was then used to compare performance, measured as the percentage of possible points attained, on application, analysis and synthesis, and evaluation tasks. Poster presentation data were analyzed separately from oral presentation data. These ANOVA did not reach statistical significance \( (P > 0.05) \). Consequently, the data from the oral and poster presentations were combined, as were the task categories. A Mann-Whitney \( U \)-test \( (6) \) was then used to compare performance on application tasks to performance on the higher-order analysis, synthesis, and evaluation tasks. Differences were considered statistically significant at \( P < 0.05 \).

In addition, the scores received by individual students on the projects were used to help assign final grades in the class \( (n = 44) \). That is, the group project grades were used for partial assessment of each individual student's performance in the course.

**RESULTS**

**Program Assessment Based on Student Surveys**

The students' responses to survey questions addressed prior program experiences indicated that they were well prepared to undertake this advanced project. The majority of students had some experience with scientific databases (Fig. 1; 40 of 44 students), knew what the primary scientific literature was (Fig. 2; 41 of 44 students) and had made use of it in a previous course (Fig. 2; 34 of 43 students), had completed an upper-division writing course that required them to write a scientific review article (Fig. 3; 25 of 44 students), and had some experience with oral presentation of scientific information (Fig. 4; 30 of 44 students) but little experience with the poster presen-
Course Assessment Based on Student Surveys

Students’ responses to survey questions about the group process were surprisingly positive. The majority of students answered “agree” or “strongly agree” to the question about their overall enjoyment of the group process (Fig. 6; 59–73%), their satisfaction with work outcomes (Fig. 7; 66–82%), and their perceptions about interactions in the group (Fig. 8; 75–81%). Their responses to group process questions were not influenced by their involvement in this course project ($P > 0.05$, Kruskal-Wallis one-way ANOVA).

More complex and interesting results were obtained with survey questions that addressed task issues dealing with workload. At midquarter the students’ responses to the question about even distribution of work assignments were significantly more positive than at the beginning of the quarter ($P < 0.02$, Kruskal-Wallis one-way ANOVA followed by Ryan’s procedure). Seventy-six percent of student responses were positive at the midquarter survey, whereas only forty-eight to fifty-seven percent of responses were positive at either the early or end of quarter surveys (Fig. 9). Similar results were obtained with the question about equal participation by all group members ($P < 0.03$, Kruskal-Wallis one-way ANOVA followed by Ryan's Procedure). Sixty percent of student responses were positive at the midquarter survey, whereas only thirty-six and forty-eight percent of responses were positive at the early and end of quarter surveys, respectively (Fig. 10).

Program and Course Assessment Based on Direct Assessment of Student Learning

Generally, students performed better on application tasks than on higher-order analysis and synthesis tasks (Tables 3 and 4). Students received 87.4 and 87.3% of the possible points on application tasks associated with the poster and oral presentations, respectively. In contrast, they received only 82 and 83.3% of the possible points on analysis and synthesis tasks and...
75.9 and 66.7% of the possible points on evaluation tasks associated with poster and oral presentations, respectively. However, we could not show a statistically significant difference without combining data from both projects and then comparing performance on the application tasks to that on the combined analysis, synthesis, and evaluation tasks (89% of available points on application tasks \( n=23 \) tasks) vs. 79% of available points on analysis, synthesis and evaluation tasks \( n=19 \) tasks); \( P<0.025 \), Mann-Whitney U-test).

**DISCUSSION**

Overall, the students' answers to the survey questions (Figs. 1–5) indicate that their undergraduate program prepared them well for performing the types of complex projects that will be required of them as professional scientists or health care providers (1–3, 7–10). Most students had received some training in the use of scientific databases, had prior exposure to the primary scientific literature, had completed their junior-level discipline-specific writing course in which they were required to write a scientific review article, and had some experience with oral presentation of scientific information. In contrast, during this course most students were exposed for the first time to communication of scientific information in the poster format. These survey results suggest that the early years of the undergraduate program are providing adequate opportunity for students to develop the skills needed to excel in the more complex, authentic assignments that are encountered in the senior year.

The students' performance on the poster (Table 3) and oral (Table 4) presentations reinforce the self-report survey data that students are well prepared for performance of career-level tasks. The overall goal of the neurophysiology project was to produce a review
of the primary literature on a topic of current interest in neuroscience that was presented in both poster and oral forms. Tables 3 and 4 indicate that even the simplest of tasks associated with these assignments were relatively complex application tasks, i.e., level 3 in Bloom’s taxonomy of cognitive skills, with 1 the lowest and 6 the highest (5). Consequently, the students' performance on the poster and oral presentations, receiving 84.1% of the possible points, indicates that advanced students are prepared to undertake and excel in the execution of extremely complex, cognitively demanding, authentic assignments.

The current study is the first in the higher education science literature to present data on student achievement on an authentic assessment task categorized as a function of cognitive skill level (Tables 3 and 4). Other researchers have described authentic, open-ended assignments (7, 8, 10), have reported student responses to the assignments (10), and have used final grades to document increased student learning in a course that used traditional examinations plus portfolios as course assessment tools instead of just examinations (3). However, none of these studies attempted to determine the cognitive skills required of students and their performance levels when engaged in the learning process.

The results of this study have implications for undergraduate program design. For example, students performed better on application tasks than on analysis, synthesis, and evaluation tasks associated with this assignment. If the program faculty determine that performance on the higher-order cognitive tasks should be better than reported here, they will need to think about the introduction of exercises requiring such skills at the introductory and sophomore/junior levels.

Overall, the students were remarkably positive about involvement in group projects (Figs. 6–10). Most
students answered in the affirmative to process questions about group work (59–82%). The response distributions did not change significantly during the quarter, suggesting that involvement in the current group project did not change students' positive attitudes toward the process of group work. In contrast, response distributions to task questions regarding group work were significantly influenced by involvement in the current project (Figs. 9 and 10). At the beginning of the quarter, about one-half of the students felt that work assignments had been evenly distributed and 36% felt that there had been equal participation by all group members in prior work groups. Their involvement in the neurophysiology group project had a positive effect on their perception of group task issues, with 76% responding that work assignments were evenly distributed and 60% believing that all members were participating equally at midquarter. However, by the last day of the quarter, responses to task questions had returned to the lower early quarter survey levels, with only about one-half of the students leaving the course believing that work assignments had been evenly distributed and 48% feeling that all members of the group had participated equally. What is not clear is whether this pattern is normal in the group process or whether there is something instructors can do to keep the positive responses at the higher midquarter survey level. It is possible that the 10-wk quarter was not a long enough period of time to allow students inexperienced in the group process to work through conflicts associated with complex decision making (4). Future experience with the group process may produce individuals who are more efficient at conflict resolution (4) and retain a more positive attitude about group task issues.

Prior science education research has addressed the importance of exposing undergraduate students to group projects in preparation for professional careers (8, 10). However, only Wright (10) reports on student
responses to a questionnaire regarding the group process. The mean scores on nine questions submitted to students at the end of a semester-long analytical chemistry course ranged from 4.5 to 3.2 on a scale of 1 to 5 with 1 = strongly disagree and 5 = strongly agree (10). This result agrees with that from the current study, suggesting that natural science students enjoy group projects.

The project reported here, currently in use in an upper-division neurophysiology course, is a type of culminating program experience that could easily be adapted to any subdiscipline within the biological sciences or to any of the other natural sciences. The cognitive skills and basic content knowledge required to complete this project are developed throughout the undergraduate program and, consequently, performance on the project can be used as an authentic program assessment tool. An improvement on the current assessment design would be to have professionals other than the course instructor assess the final projects.

Appendix A:
Grading Criteria Used for Poster Presentations

Title: (5 pts.)
1. Title is an appropriate length and descriptive of research results to be discussed.
   Incomplete or __ Below __ Average __ Good __ Excellent __ not included average

Introduction (15 pts.; all points given equal weight):
1. Gives a general background to the topic
   Incomplete or __ Below __ Average __ Good __ Excellent __ not included average

FIG. 9.
Student responses to early quarter (n = 44), midquarter (n = 42), and end of quarter (n = 40) survey questions asking students whether "work assignments in work groups have been evenly distributed among the group members." Midquarter distribution differed from early quarter and end of quarter distributions at P < 0.02 (Kruskal-Wallis one-way ANOVA followed by Ryan's procedure). For early and end of quarter surveys 48–57% of responses were positive, whereas 76% of responses were positive for midquarter survey. For early and end of quarter surveys 14–20% of responses were undecided, whereas 12% of responses were undecided for midquarter survey. For early and end of quarter surveys 29–32% of responses were negative, whereas 12% of responses were negative for midquarter survey.
Introduction: (continued)
2. Explains explicitly or implicitly how the topic fits into the broad context of neuroscience.
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average
3. Uses the last few sentences to state the hypothesis(es) or model to be explored in the poster.
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average
4. Appropriate length (2–3 paragraphs)
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average
5. Uses appropriate techniques to reference articles (authors' names, year of publication, or number, as in references section).
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average

Description of Research (40 pts.; #1-4 weighted – 2×; #5-6):
1. Includes figures or tables from or summary figures based on 6–10 of the primary articles.
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average

2. Includes a verbal description/interpretation of these tables/figure.
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average
3. There is a synthesis of information from the different papers instead of 10 separate article summaries:
   a) Groups together results that can be used to address the same hypothesis or same part of the model.
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average
   b) Draws conclusions at the end of each subsection, if appropriate.
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average
4. Describes methods in appropriate detail to understand the results.
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average
5. Uses appropriate techniques to reference primary articles (authors' names, year of publication, or number, as in references section).
   Incomplete or __ Below __ Average __ Good __ Excellent __
   not included average

FIG. 10.
Student responses to early quarter (n = 44), midquarter (n = 42), and end of quarter (n = 40) survey questions asking students whether “all members of the group participated equally while working on group projects.” Early quarter survey differed from midquarter survey at P < 0.03 (Kruskal-Wallis one-way ANOVA followed by Ryan’s procedure). Positive: 36% of early quarter responses, 60% of midquarter responses, and 48% of end of quarter responses. Undecided: 28% of early quarter responses, 19% of midquarter responses, and 20% of end of quarter responses. Negative: 36% of early quarter responses, 21% of midquarter responses, and 32% of end of quarter responses.
Grading Criteria Used for Oral Presentations

Introduction (10 pts.; all points given equal weight):
1. Gives a general background to the topic
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. States the hypothesis(es) or model to be discussed
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Provides a clear overview of the presentation to follow
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

Summary or Conclusions (15 pts.; #1-2 weighted twice #3):
1. Synthesizes and draws general conclusions based on results summarized above, i.e., identifies 1-3 "take-home messages" or global conclusions
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. States whether results support or refute the original hypothesis/model
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Appropriate length (~1 page)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

4. Overall organization follows the directions given in the syllabus
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

5. Readability: wording, sentence and paragraph structure
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

6. Mechanics: usage, punctuation, spelling
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

7. Adheres to the established size limit (3 ft × 4 ft)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

8. Aesthetics of presentation
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

References (10 pts.; #1 weighted 3× #2-3):
1. Lists at least 10 primary articles
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. Citations are in the following format:
   Complete author list with last name first followed by initials, article title with first word capitalized, journal title underlined or in italics, journal volume: pages (inclusive), year.
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. List is alphabetized and numbered
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

General (15 pts.; all points given equal weight):
1. Paraphrases instead of using direct quotes
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. Overall organization follows the directions given in the syllabus
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Readability: wording, sentence and paragraph structure
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

4. Mechanics: usage, punctuation, spelling
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

5. Adheres to the established size limit (3 ft × 4 ft)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

6. Aesthetics of presentation
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

Appendix B:
Grading Criteria Used for Oral Presentations

Introduction (10 pts.; all points given equal weight):
1. Gives a general background to the topic
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. States the hypothesis(es) or model to be discussed
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Provides a clear overview of the presentation to follow
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

Summary or Conclusions (15 pts.; #1-2 weighted twice #3):
1. Synthesizes and draws general conclusions based on results summarized above, i.e., identifies 1-3 "take-home messages" or global conclusions
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. States whether results support or refute the original hypothesis/model
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Appropriate length (~1 page)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

4. Overall organization follows the directions given in the syllabus
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

5. Readability: wording, sentence and paragraph structure
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

6. Mechanics: usage, punctuation, spelling
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

7. Adheres to the established size limit (3 ft × 4 ft)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

8. Aesthetics of presentation
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

References (10 pts.; #1 weighted 3× #2-3):
1. Lists at least 10 primary articles
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. Citations are in the following format:
   Complete author list with last name first followed by initials, article title with first word capitalized, journal title underlined or in italics, journal volume: pages (inclusive), year.
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. List is alphabetized and numbered
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

General (15 pts.; all points given equal weight):
1. Paraphrases instead of using direct quotes
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. Overall organization follows the directions given in the syllabus
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Readability: wording, sentence and paragraph structure
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

4. Mechanics: usage, punctuation, spelling
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

5. Adheres to the established size limit (3 ft × 4 ft)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

6. Aesthetics of presentation
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

Appendix B:
Grading Criteria Used for Oral Presentations

Introduction (10 pts.; all points given equal weight):
1. Gives a general background to the topic
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. States the hypothesis(es) or model to be discussed
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Provides a clear overview of the presentation to follow
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

Summary or Conclusions (15 pts.; #1-2 weighted twice #3):
1. Synthesizes and draws general conclusions based on results summarized above, i.e., identifies 1-3 "take-home messages" or global conclusions
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. States whether results support or refute the original hypothesis/model
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Appropriate length (~1 page)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

4. Overall organization follows the directions given in the syllabus
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

5. Readability: wording, sentence and paragraph structure
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

6. Mechanics: usage, punctuation, spelling
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

7. Adheres to the established size limit (3 ft × 4 ft)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

8. Aesthetics of presentation
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

References (10 pts.; #1 weighted 3× #2-3):
1. Lists at least 10 primary articles
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. Citations are in the following format:
   Complete author list with last name first followed by initials, article title with first word capitalized, journal title underlined or in italics, journal volume: pages (inclusive), year.
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. List is alphabetized and numbered
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

General (15 pts.; all points given equal weight):
1. Paraphrases instead of using direct quotes
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

2. Overall organization follows the directions given in the syllabus
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

3. Readability: wording, sentence and paragraph structure
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

4. Mechanics: usage, punctuation, spelling
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

5. Adheres to the established size limit (3 ft × 4 ft)
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average

6. Aesthetics of presentation
   Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___ not included average
3. Effective and engaging presentation style
Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___
not included average
4. Speaker is extemporaneous and makes eye contact with the
audience
Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___
not included average
5. There are good transitions between sections and between topics
within a section
Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___
not included average
6. Adheres to established time limit (10 min total for presentation
and audience questions)
Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___
not included average
7. Title is descriptive of research results that are discussed
Incomplete or ___ Below ___ Average ___ Good ___ Excellent ___
not included average

Appendix C:
Early Quarter Survey Used in Indirect Assessment of Student Accomplishment

DIRECTIONS: Please choose the best answer to the following questions.

1. Which of the following statements best describes your prior experience with computer databases to conduct library research?
   - I have never used computer databases to conduct library research.
   - I have limited experience and am self-taught in the use of computer databases to conduct library research.
   - I have experienced but received formal training in the use of computer databases to conduct library research.
   - I have extensive experience and am self-taught in the use of computer databases to conduct library research.
   - I have extensive experience and received formal training in the use of computer databases to conduct library research.

2. Which of the following statements best describes your prior experience with the primary scientific literature?
   - I do not know what the primary scientific literature is.
   - I know what the primary scientific literature is but have never been required to make use of it.
   - I have been required, in a previous course, to make use of the primary scientific literature.
   - I use the primary scientific literature regularly, on a monthly basis.
   - I use the primary scientific literature regularly, on a daily or weekly basis.

3. Which of the following statements best describes your standing and experience with scientific writing?
   - I am an undergraduate and have not taken my required upper-division writing course.
   - I am an undergraduate and am currently enrolled in my upper-division writing course.
   - I am an undergraduate and was required to write a scientific review article in my upper-division writing course.

   - I am an undergraduate and was not required to write a scientific review article in my upper-division writing course.
   - I am a graduate student and have not written a scientific review article.
   - I am a graduate student and have written a scientific review article.

4. Which of the following statements best describes your prior experience with oral presentations of scientific information that made use of slides or overheads?
   - I have never made an oral presentation of scientific information.
   - I have made an oral presentation in a class.
   - I have made an oral presentation at a campus or regional meeting.
   - I have made an oral presentation at a national or international meeting.

5. Which of the following statements best describes your prior experience with scientific poster presentations?
   - I have never attended a poster session.
   - I have attended a poster session as an observer.
   - I have attended a poster session as a presenter.

6. I enjoy working on graded projects in small groups.
   - ___ agree ___ undecided ___ disagree ___ strongly agree
   - ___ agree ___ undecided ___ disagree ___ strongly disagree

7. In the past, I was satisfied with the work outcomes for group projects.
   - ___ agree ___ undecided ___ disagree ___ strongly agree
   - ___ agree ___ undecided ___ disagree ___ strongly disagree

8. In the past, interactions in work groups I have been assigned to have been positive.
   - ___ agree ___ undecided ___ disagree ___ strongly agree
   - ___ agree ___ undecided ___ disagree ___ strongly disagree

9. The work assignments for previous group projects I have been assigned to have been evenly distributed among the group members.
   - ___ agree ___ undecided ___ disagree ___ strongly agree
   - ___ agree ___ undecided ___ disagree ___ strongly disagree

10. While working on previous group projects, I have felt that all members of the group participated equally.
    - ___ agree ___ undecided ___ disagree ___ strongly agree
    - ___ agree ___ undecided ___ disagree ___ strongly disagree

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