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The Power of Peer Reviewing to Enhance Writing in Horticulture: Greenhouse Management

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Peer review is not included in undergraduate horticultural curricula. Our research objectives in an 8-year study, which ranged from 2000 to 2007 in two sections (2000-2002 non-peer reviewed and 2003-2007 peer-reviewed) of Greenhouse Management students at the University of Minnesota were to determine whether iterative peer reviews would result in improved learning, enhanced writing, refined revision processes, and higher written paper/course grades for undergraduate and professional horticulture students, as well as the effects of double blinding, whether years affected any parameter and the validity/reliability of peer reviews. Both sections were assigned a semester-long, 3-phase writing-intensive assignment. Principle findings that emerged were: (a) after engaging in iterative structured peer-reviews, student final grades in the peer review group exceeded those in 2/3 of non-peer reviewed years; (b) students quickly identified superior papers; (c) while students grasped the peer review process and matched their editing skills with the instructor and teaching assistants by Phase II, a lag time (Phase III) occurred before it significantly increased their grades; (d) graded paper scores were not different across years; (e) anonymity of peer reviews had no effect; and (f) students were initially able to recognize writing issues in peers' drafts and address them in their own writing. Inclusion of more than 2 peer reviews into horticulture courses is highly recommended.

Recent studies sponsored by the National Research Council (NRC, 1997, 1999, 2003) have referenced a growing body of empirical research that suggest student learning can be enhanced when college instructors in all disciplines incorporate teaching strategies that promote student-centered, interactive activity and work toward clearly measurable learning outcomes (McCray, DeHaan, & Schuck, 2003). The idea that what students learn is affected by how they learn is particularly pertinent in undergraduate science, technology, engineering, and mathematics (STEM) curricula, where lecture and lab course formats remain all but intractable (American Association for the Advancement of Science, 1990; Boyer Commission on Educating Undergraduates in the Research University, 1998; NRC, 1997, 1999). Specific recommendations include providing students in STEM disciplines more frequent opportunities to work in small interactive groups. A recent study presented at the annual meeting of the American Council on Higher Education found that forms of small-group learning resulted in increased academic achievement and retention of students in STEM programs (Springer, Donovan, & Stanne, 1999).

A desire to develop undergraduate students of horticulture into lifelong learners and professional writers—both during their degree programs and as graduates in their professions—has prompted many educators to incorporate active learning strategies into their coursework (MacKay, Emerson, MacKay, Funnell, & Welsh, 1999). For decades, faculty members in our department have relied on decision case studies as a method for engaging undergraduate horticulture students as hands-on stakeholders and critics of real or hypothetical situations (Davis 1992a, 1992b). However, as the University of Minnesota, a large-enrollment public research university, became increasingly invested in writing initiatives, the Department of Horticultural Science followed suit by successfully integrating both high- and low-stakes writing activities in lower- and upper-division courses (Anderson, 2001a, 2001b; 2002; Anderson & Walker, 2003; Foulk & Hoover, 1997; Hoover, 1993; Kuehny & McMahon, 1998; Meyer & Allen, 1994).

Shifts from curricula emphasizing content delivery (i.e., lecture-lab course format) to curricula that integrate iterative writing activity is evidenced by national and, increasingly, international writing initiatives. Throughout the 1980s and into the 1990s many post-secondary institutions across the country created Writing Across the Curriculum (WAC) programs and implemented writing-intensive (WI) course requirements to ensure that writing would be taught in all undergraduate majors (Bridwell-Bowles, 1993; Firman, 1992; Russell, 2002). A national survey of colleges and universities conducted between 2006 and 2008 identified more than 500 WAC programs. Of these, 330 have instituted WI course requirements (Thaiss & Porter, 2010). Our own university implemented an ambitious four-course WI requirement in 1999 and has, since 2007, piloted an innovative curricular approach to writing called the Writing-Enriched Curriculum Project (WEC). WEC supports departments and colleges—including Horticultural Science—in the intentional integration of developmentally sequenced writing instruction throughout all undergraduate curricula. As a result of these and other initiatives, scientific writing and writing instruction has become more widely accepted in the

horticulture curriculum by faculty and students alike (Zambreno, Hoover, Anderson, & Gillman, 2004).

Peer Review

Although scholarly applications of peer reviewing have been in place since the 1600s (Kronick, 1990), it did not become an accepted and mandatory scientific practice until post-World War II (Burnham, 1990) when scientific knowledge became common property (Carlsen, Cunningham, & Trautmann, 2001). Over the past few decades, much of the attention devoted to peer review has been focused on refining the procedure itself. More studies have, for example, been conducted into the effects of anonymity using blind editorial reviews (McNutt, Evans, Fletcher, & Fletcher, 1990) than into its efficacy as a learning tool in the undergraduate science classroom. While structured peer response activity has served as a successful and almost requisite component of written composition and creative writing courses at both secondary and post-secondary educational levels since the 1970s when Peter Elbow wrote his influential monograph *Writing Without Teachers* (Elbow, 1973; Gere, 1987; Lindemann, 1995), the first science educators to provide instructional guidelines for classroom peer review were Gratz (1990), Pechenik and Tashiro (1991), and Mangelsdorf (1992). Peer reviews in the classroom consist of a revision phase or phases based on their peer's/instructor's edits (Cho & MacArthur, 2010) and differ from peer assessments, wherein the latter assesses performance for a group task (Loddington, Wilkinson, Bates, Crawford, & Willmot, 2008). Billington (1997) proposed that peer reviewing can provide a motivational impetus for enhancing scientific writing—both for the reviewer and the authors whose papers are being reviewed—although the quality of the reviews can vary significantly between students (Bos, Krajcik, & Soloway, 1997; Moreira & Silva, 2003).

Theoretical Components of Classroom Peer Reviewing

The use of peer reviewing in the classroom has several purposes, namely to increase students' domain-specific knowledge levels (Papadopoulos, Lagkas, & Demetriadis, 2012), engage students in active learning that increases their reviewer skills (McConnell, 2001), foster higher-level learning/skill-building (Anderson & Krathwohl, 2001) by incorporating and emphasizing concepts and improve writing through reflecting and revising (Papadopoulos et al., 2012). Likewise, peer review reiterates and enforces the instructor's or teaching assistant's (TA) editing and comments with meaning and understanding, often complimentarily reducing the lengthy instructor/TA editing time (Yang, 2011).

Common research designs for peer review testing in classroom learning involve: (a) two students who exclusively review each other's work (assigned-pair, dyad, or reciprocal; Cho & Schunn, 2007; Papadopoulos et al., 2012; Yang, 2011), (b) multiple reviewers for each student (more than 2; Reily, Finnerty, & Terveen, 2009; Tsai & Liang, 2009; Tseng & Tsai, 2007), or (c) variable (i.e., free-selection protocol) where students select the writing to be reviewed (Papadopoulos et al., 2012). These designs may influence the written product and peer review effects, particularly if students do not work well together in a dyad, too many reviewers dilute the feedback and its impact or shorter, less difficult papers are chosen.

The key components of peer reviewing have been summarized by Papadopoulos et al. (2012) into four phases: (1) producing initial student work, (2) assigning reviewers, (3) review/feedback production, and (4) revisions. These phases are categorically subdivided into a description, expected benefits, key research questions and research evidence. While many courses across multiple domains and disciplines have used peer reviewing in higher education, fewer pedagogical studies have tested mechanisms, function, reliability, and validity of peer reviews (Reynolds & Thompson, 2011; Topping, 1998). Of those courses that have used peer reviewing, students had demonstrably enhanced learner outcomes and increased reviewer skills (Papadopoulos et al., 2012), particularly in their ability to identify substandard writing (Yankulov & Couto, 2012). Many important research questions remain regarding the effectiveness of peer reviewing in the classroom (Yankulov & Couto, 2012).

Peer Reviewer-Based Learning in Horticultural Science

Peer reviewing in horticulture is commonly conducted outside of classroom learning. It is restricted primarily to: (a) manuscripts submitted for publication as primary literature in peer-reviewed journals, serials, or monographs; (b) competitive grant proposals; (c) faculty promotion and tenure documents; (d) intellectual property applications; and less rarely for (e) trade journal articles or those destined for the popular press (Pollock, 1990; Ware, 2009). Such reviews may be quantitative (competitive grant proposals) or qualitative in nature (Ware, 2009). Further, their effectiveness has been scrutinized (Pollock, 1990). Undergraduates would rarely be exposed to peer reviewing while graduate students may encounter it in limited graduate courses with grant-writing assignments. Otherwise, graduate students and those

who become academic faculty are submitted to *de rigueur* of peer reviewing with formal training by their graduate advisor(s). Thus, using peer review as an educational tool for horticulture students to enhance their writing and gain feedback from peers is an unprecedented educational opportunity for the discipline of horticultural science.

A Key Peer Review Research Issue

While instructors in almost every discipline or domain have developed tools to enhance undergraduate/graduate student critical thinking skills and writing (Papadopoulos et al., 2012), most scientific studies testing their implementation and effectiveness are short-term, often for a single semester, quarter, or academic year (Anderson & Walker, 2003; Bos et al., 1997; Foulk & Hoover, 1997; Kuehny & McMahon, 1998; Likkel, 2012; Yang, 2011). Two exceptions involve 5-year peer review studies in computer networking (Papadopoulos, Lagkas & Demetriadis, 2012) and molecular genetics (Yankulov & Couto, 2012) courses. However, in both studies analyses of yearly variation in either the reviewers' or student performance were not performed. Thus, the issue of year-to-year variation in peer reviewing is unknown.

Purpose of the Current Study

A general lack of long-term educational pedagogical studies in higher education, as well as complete omission of peer review in curricula such as horticultural science, led to the formulation of this long-term study. The objectives of our 8-year study were to determine whether including iterative peer reviews in a semester-long writing intensive upper-division required horticulture course would result in improved learning, enhanced writing, refined revision processes, and higher written paper/course grades for undergraduate and professional horticulture students. Additional objectives of interest were the effects of double blinding, whether years affected any parameter, and the validity and reliability of peer reviews at the undergraduate level (Carlsen et al., 2001). These research objectives correspond to Phases 2 to 4 of the peer review process identified by Papadopoulos et al. (2012), as outlined above.

Methodology

Course Context

This research was conducted during eight spring semesters (2000-2007) with 257 primarily undergraduate students (Environmental Horticulture or other majors) enrolled in the Greenhouse Management class (Hort 3002W). Participants were predominantly undergraduates or professional (non-dissertation Master of Agriculture) students from the Department of Horticultural Science (~95%); the remainder (~5%) were landscape architecture and landscape design students. The prerequisite for this course was Plant Propagation, a science with laboratory course that teaches horticultural fundamentals. Hort 3002W was designed to enhance students' understanding of crop production in controlled environments. This course focused on building a technical knowledge base and providing opportunities for students to apply this foundational knowledge to practical situations (Nelson, 2003).

Target Assignment

Since 2000, the course expanded its writing component to reach well beyond the typical laboratory report. The course's primary assignment, a written project called the Greenhouse Design Project (GDP), required students to parlay classroom/laboratory education into a formal writing venue. For the GDP, students designed a greenhouse and described the proposed greenhouse operation as part of a hypothetical bank loan application to the fictional Floratech National Bank. This assignment was written in three phases (GDP I, GDP II, and GDP III) and resulted in a 15- to 35-page document that constituted 65% of the students' course grades.

The GDPs three phase components consisted of the following information. For the GDP I (4 weeks to write and submit this phase), students selected horticultural crop(s) to produce, product markets (e.g., mass market/wholesale, retail outlets, florists, grocery stores), and type of 50,000 ft^2 greenhouse facility (propagator or rooting station; pre-finisher or finisher grower). The GDP II (5 weeks to write and submit) included revision of GDP I with a memorandum that highlighted responses to peer reviewer or instructor/TA edits, plus a finalized construction budget estimate, the complete layout of the facility, and all heating/cooling calculations. For the GDP III (6 weeks to write and submit), students revised their GDP II and included a memorandum highlighting responses to instructor/TA or peer reviewer edits, a detailed schematic of the first year's production schedule to ensure economic feasibility and a mean of more than 100% space use efficiency, and an average turn-over rate of 10%/week for all crops. Students enhanced their loan applications with introductory letters to bank loan officers with descriptions of their business and marketing plans, as well as other innovative selling points.

At its inception in 2000, the GDP was designed as a tool for modeling and enhancing writing by undergraduates within the horticultural curriculum and

as a means for elevating and reinforcing students' experiential learning (Huang, 2002), active-collaborative participation in course activity (Orr, 1996), and development of such higher cognitive skills as application, analysis, synthesis, and evaluation (Bloom, 1956). The assignment was also designed to integrate course content within an associated framework of practical and integrative learning for student advancement in their careers (MacKay et al., 1999).

Participants

To determine whether student writing would benefit more from instructor/teaching assistant assessment at each GDP phase or if the incorporation of peer reviews would enhance student writing and learning processes, we studied groups of students who completed the assignment with and without engaging in reciprocal peer reviews. From 2000 to 2007, 257 students participated in this writing assignment in non-peer reviewed (NPR; from 2000-2002) or peer-reviewed (PR; from 2003-2007) groups. Since the course only had one section per year, NPR vs. PR groups could not be assessed concurrently each year as students would have had ample opportunity to share peer review information between groups; this would have reduced or eliminated testing the effectiveness of the peer review treatment.

From 2000 to 2002, students completed the GDP Phases I through III but did not engage in peer reviews. These NPR years' data constitute the control group for this experiment. In contrast, from 2003 to 2007, students completed the same assignment with the addition of two peer review sessions conducted within lecture periods. While less than an ideal setup for the control group, we could not institute a control group each year as the course had only one section with 26-38 students. As the students were in a cohort and predominantly in the same major, it was not possible to prevent information flow between the NPR and PR groups. We found at least one previous peer review study did not have a control group (Yankulov & Couto, 2012). The number of participating, enrolled students in this experiment was: 30 students in 2000, 35 students in 2001, 33 students in 2002, 35 students in 2003, 26 students in 2004, 31 students in 2005, 38 students in 2006, and 29 students in 2007. Thus, there were 98 students participating in the 3-year NPR control group (2000-2002) and 159 in the 5-year PR group (2003-2007).

Peer Review Design

During the 2003 to 2007 academic years, GDP Phases I and II work done by students in the peer review treatment group underwent review by two student colleagues in each assigned laboratory group of three to five students. Thus, this study uses the multiple reviewer method (Tsai & Liang, 2009; Tseng & Tsai, 2007). The peer review design, format and approach for use in this course were created in consultation with our institution's writing center (Flash, 2002). Implementation details are important for student satisfaction and outcomes (Likkel, 2012; Walvoord, Hoefnagels, Gaffin, Chemchal, & Long, 2008). The peer review forms were designed to scaffold—or sequence incrementally—constructive criticism and minimize risky classmate alienation due to negative feedback (Bos et al., 1997; Cho & Schunn, 2007). As effective peer review prompts start with identification of tasks and then move to tasks involving analytic, diagnostic, and evaluative responses (Flash, 2002) and, in both cases, require that students write directly on the GDP drafts, we designed peer review activities that were completed by students both in and out of class (Appendices A and B) and designed a sequence of appropriate modeling procedures. Useful peer review critiques were modeled in an explanatory lecture period to ensure that writers received feedback that was directed to enhance and change each writer's position (Timmerman & Strickland, 2006). Peer reviewing occurred throughout the writing process rather than at the project's completion (Bos et al., 1997). Timelines for completing each peer review were clearly specified each semester for GDP Phases I and II (Appendices A and B).

During the first 3 years (2003-2005), peer review treatments of GDP Phase I were conducted as double-blind reviews (i.e., each reviewer did not know whose application he or she was reviewing and vice versa; see Appendix A; McNutt et al., 1990) while peer review on GDP Phase II was not blinded (each reviewer reviewed the same authors' GDPs as in Phase I and could recognize the earlier papers they reviewed; Appendix B). During 2006-2007, none of the GDP Phase I peer reviews were double-blinded due to the findings of the 2003-2005 peer reviews (see results). In all instances, the peers being reviewed were in the same laboratory group that worked together on lecture/lab projects for the duration of each semester. Students had been randomly chosen for each laboratory group. Thus, the multiple reviewer choice was completely randomized within each year's student population.

Students were instructed that the purpose of each peer review was to improve the quality of all projects, as well as to engage them in critical review and thoughtful discussion by role-playing as the Floratech Bank Loan Officer. The professor and teaching assistants provided background information on how bank loan officers operate. Additionally, to determine financial viability and a proposal's merit, students

determined (1) whether the proposed business operation was adequately conceptualized and developed; (2) if the plan was strategic, unique, or creative; and (3) whether adequate contingency plans were incorporated in case of failure. Specific instructions for completing the peer review critiques and the questions posed for Phase I proposal were created to ensure that all students used uniform procedures to complete their critiques (Appendix A). Phase II peer review critiques followed a similar procedure, but several questions were modified or inserted to reflect the guidelines for this phase (Appendix B). Students were informed that peer review activity was not going to be graded (although students received credit for participation). Instead, these activities were intended to improve their ability to revise their work and would then, ultimately, result in improved project grades.

Peer Review Process

The time involved in introducing students to the peer review process, conducting the peer review sessions and providing follow-up activity occurred in lecture periods, although the topics and content covered by NPR control and PR treatment groups remained the same. Peer review groups who missed content due to spending lecture time on peer reviews had the missed lectures rescheduled for laboratory times during the same weeks to ensure equal content delivery as NPRs. In addition, the PR groups received one lecture devoted to introducing the students to the peer review process for GDP Phase I (peer review critique background/instructions) with examples of acceptable and unacceptable writing and editing modeled by the professor (Flash, 2002; Appendix A). Acceptable ($\geq$ 70% score) and unacceptable ($<$ 70%) writing was delineated using the three grading rubrics (provided to the students in week 1), which were designed for each of the GDP Phases (Appendix C).

On days when peer reviews were conducted, participating students received two pre-selected students' work (the other students in their lab group), along with instructions and forms, at the start of lecture. For the double-blind reviews, the names and other identifiers were blacked out prior to photocopying to make then non-discernable. Each student had exactly one week to complete their two peer reviews using the peer review critique forms (Appendices A and B, respectively). At the end of each in-class peer review panel, graded papers were returned to each student.

During the in-class peer review panels, the professor and teaching assistants would walk through the rooms and listen briefly to each panel review to ensure students were staying on task. To encourage student participation in the peer review treatment, failure to conduct each review meant exclusion from class on the day of the in-class peer review panels as well as no credit for participation and a 50% point reduction in their respective graded score for the missed peer review phase. To receive credit, students turned in GDP Phases II and III along with their colleague's peer reviews from the previous phase. They also submitted a Revision Memorandum (Flash, 2003) on which they indicated changes that had been made and the ways they thought their writing had improved. These scaffolded peer reviews were designed to (a) test their effectiveness in writing improvement; (b) promote experiential editing, reviewing, and proofing of peers' writing; (c) role-play the Floratech National Bank Loan Officer to enhance learning; (d) enhance student's benefit from their peer's ideas (cross-training); and (e) improve the overall quality and professional appearance (Appendices A and B).

Measures

The following measures were employed to test the validity of the peer review process throughout the duration of each year. Multiple peer reviewer choice was completely randomized within each year's student population of the PR groups to prevent bias between student colleagues. We used unbalanced, general linear model ANOVAs to test student final grades between NPR (2000-2002) and PR (2003-2007) years. Unbalanced repeated measures ANOVAs of professor/TA graded phase scores between NPR and PR groups were used to determine if/or when peer review was effective in improving student performance in GDP Phases I through III. Tukey's HSD tests were used to delineate mean response differences between treatments. Responses to and chi-square statistical tests (1:1, 1:1:1, χ^2) for nonparametric questions GDP peer review Phases I and II critiques tested the responses for greenhouse operations matching the specifications or project greenhouse fundability. Correlations of mean GDP Phases I and II peer review scores and fundability with the instructor's grades determined if these were influential.

Data Analyses

Similar to that of Yankulov and Couto (2012), both NPR and PR group papers were edited and graded by the professor and TAs, all of whom were highly skilled writers and reviewers. Grading was independent of the non-peer review/peer review process and all graded scores were final, regardless of peer reviewer scores. The same instructor conducted the course for all years, while the TAs changed each year. Since the instructor had taught Greenhouse Management previously, any changes in potential responses gauged are most likely not attributable to maturation of instructor delivery or

content refinement. Each PR treatment group also had their papers peer reviewed twice by multiple students. To assess the peer review process, we analyzed project and final grades received by students in each group. In addition, peer review students' evaluations of the process at the end of each semester were analyzed. In these evaluations, students answered five to six questions pertaining to the GDP I and II peer reviews and enrollment in a WI class. During the years of double blind peer reviews (2003-2005), question 4 (below) was included.

1. What did you learn from peer reviewing (blind reviews) other student's Phase I Greenhouse Design Project?
2. What types of things did you learn in your peer review session as your colleagues discussed your Phase I proposal?
3. How did role-playing the loan officer for Floratech National Bank aid you in the review/revision process?
4. Rate whether you think the peer review process in Phase I (blind reviews) versus Phase II (not blind) differed. (Ratings: no difference/the same or big difference)
5. Name one effective thing about the editing/revision process (Phases I, II, III) for the Greenhouse Design Project.
6. Describe how your writing has changed as a result of enrolling in a Writing Intensive class.

All students in both the NPR and PR treatment groups received professor/TA comments and grades at the same time (i.e., 1 week after they were due). The same level of detail was provided for both NPR and PR group student papers. Additionally, identical grading rubrics were used for each GDP phase (rubrics not shown). Professor and teaching assistant graded scores for all GDP I through III projects were used to compare performance between the NPR and PR groups to test whether the peer reviews had an effect and, if so, during which phase(s) of the GDP. GDP Phase I was worth 50 points, while GDP II and III were each worth 100 and 175 points respectively. Grading rubrics for each phase were supplied to the students at the beginning of each semester to clarify the essential components. Data was collected for each participating student from each peer review critique for Phase I and II projects.

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS Version 19). To answer the question whether peer review had an effect on student's final grades, an unbalanced, general linear model (GLM), univariate ANOVA was performed with mean separations using Tukey's HSD test at $\alpha = .05$. Tests for normality, independent observations, and equal variances were performed prior to analysis. GDP Phases I, II, and III graded scores as fractional values (score/total possible points for each phase) for the control and treatment groups were analyzed using an unbalanced, repeated measures ANOVA (mixed effects model). ANOVAs were performed on numeric scores for student's answers to all quantitative peer review questions (*i-viii,* question 4, Phase I, Appendix A and question 7, Phase II, Appendix B) with years (Yr), phases (Ph), and students (S) being the main effects and interactions of Yr x Ph, Yr x S, Ph x S, and Yr x Ph x S. Since students were asked different questions during each peer review, these data were not repeated measures. Data were pooled based on significance of the main effects. Student categorical (non-parametric, non-repeated measures) responses to questions regarding whether the greenhouse operation matches the Floratech National Bank Loan specifications and fundability (questions 2 and 8, respectively; Appendix B) across 5 years (2003-2007) posed in the Phase II peer reviews were tabulated and tested for goodness of fit using a 1:1 Pearson's chi-square test (χ^2) for yes/no answers to question 2 and a 1:1:1 χ^2 for question 8. The χ^2 test ratios assume that, by chance, the data follow a specified distribution (i.e., there is an equal probability of each answer for each respective question; Snedecor & Cochran, 1989). A $\chi^2 = 3.841$ is the critical value for rejecting the null hypothesis at $\alpha = .05$ for the 1:1 χ^2 ($df = 1$) whereas the critical value for the 1:1:1 $\chi^2 = 5.99$ ($df = 2$). On a per student basis for each peer review test year (2003-2007), grand mean Phase I reviewer scores/student (pooling all scores from all reviewers/student for *i-viii,* question 4, Phase I, Appendix A and question 7, Phase II, Appendix B) were correlated with professor's/teaching assistant grades for Phase I for each particular student; the same was done for mean Phase II reviewer scores, while the numeric funding score (1-3 scale; Question No. 8, Phase II PR; Appendix B) was correlated with the student's final grade for GDP Phase III.

Results

Student final course grades for all main effects in the ANOVA (years, PR/NPR, and Yr x PR/NPR) were significantly different (Tables 1 and 2). Interestingly, final grades for the NPR years were significantly lower than all other years of PR (Table 1). However, in NPR year 2002, the final grade score (81.7%), while still lower than all other PR years, overlapped with PR years 2003 to 2005 and 2007 using Tukey's mean separation test (Table 1). Mean separations of peer reviewing in 2003 through 2006 overlapped with NPR 2002; only final course grades for PR in 2006 (Table 1) were significantly higher than all NPR years. Overall, NPR final grades were significantly lower than PR years.

Table 1
Students' Final Grade Comparisons and ANOVA for Non-Peer-Reviewed and Peer-Reviewed Years

Year	Non-peer-reviewed	Peer-reviewed	Final grades *M* (*SD*)
2000	x		$0.633\ (0.019)_{a}$
2001	x		$0.590\ (0.020)_{a}$
2002	x		$0.817\ (0.019)_{b}$
2003		x	$0.875\ (0.020)_{bc}$
2004		x	$0.891\ (0.020)_{bc}$
2005		x	$0.850\ (0.018)_{bc}$
2006		x	$0.922\ (0.017)_{c}$
2007		x	$0.827\ (0.019)_{b}$

Note. Mean separations within columns are based on Tukey's Honestly Significant Difference (HSD) test, $\alpha = .05$.

Table 2
ANOVA for Student Final Grades in Non-Peer-Reviewed (2000-2002) and Peer-Reviewed (2003-2007) Years

Source	*df*	*F*	*η*	*p*
Year	6	15.47	.11	< .001
PR/NPR	1	146.29	1.54	< .001
Year x PR/NPR	5	26.65	.28	< .001

Note. An unbalanced, general linear model (GLM) ANOVA was used for the analysis.

Graded GDP Phases I through III were not significantly different between years and were, thus, pooled (Table 3). This lack of significance indicates similarities among enrolled student groups. Other main effects were significant (i.e., phase grade and NPR/PR treatment groups; Table 3). These differences were attributable to the significant increase in peer review scores for GDP Phase III over all other GDP Phases (Table 4). The NPR and PR group graded scores for Phases I and II were not significantly different. However, Phase III PR group scores were significantly different from Phase III NPR group scores (Table 3). Thus, the significant effect of peer reviewing was not evident until Phase III, after two peer reviews had been completed. It would not necessarily be expected that earlier peer reviews (particularly GDP Phase I) would have as much effect on student performance, as student writing had not yet benefited from the peer review process. Apparently the peer review GDP I effect on Phase II grades was minimal and, thus, not significant (Tables 3 and 4).

Quantitative scores of peer review critiques for proposal ratings to guide authors in their revision (Appendices A and B) were significantly different between years (2003-2007) for part *i* ("The writing style is appropriate for a bank loan"), *iii* ("Proposal is coherent within/between paragraphs"), *iv* ("The writing style is appropriate for a bank loan"), and *v* ("The proposal is written in a smooth, narrative fashion"; Table 5). The remaining questions (i.e., *ii*: "A clear picture of the site for the greenhouse is provided" or "A clear, to-scale drawing of the operation is provided"; *vi*: "The proposal is well organized"; *viii*: "The supporting documentation is concise and easy to read") were not significantly different between years (Table 5). Other main effects (phase, student) differed significantly for all parts except for parts *vi* and *vii* ("The supporting documentation is concise and easy to read") for students (Table 4). All Yr x S interactions were significant (Table 5), whereas the remaining interactions were non-significant with the notable exception of part *ii* for the three-way interaction Yr x Ph x St. Thus, the most significant effect on two- and three-way interactions to these peer review questions was the differing student populations taking the course.

Mean scores for peer review critiques for question 4 in Phase I and question 7 in Phase II were in the score range of 3 (*adequate*) to 5 (*outstanding!*; Table 6). For part *i*, only 2004 Phase I and II mean scores differed significantly (Tukey's mean separation). As answers to part *ii* were not significantly different between years, values were pooled whereupon Phase I and II scores were significantly different (Table 6). Scores for the other parts varied along these score ranges. Exceptional differences from these trends were for *vi* (The proposal is well-organized) where both years and phases were not significant and *viii* (The overall description of the market and crops is thorough vs. The proposal has improved in quality after Phase I revision) where scores for years were not significantly different while the phases were. Writing significantly improved from Phase I to II for *viii* (The overall description of the

Table 3

Unbalanced Repeated Measures ANOVA Between NPR and PR Groups Professor/TA Graded Phase Fractional Scores (Scores/Total Points) Over Years and to Determine if/or When PR Was Effective in Improving Student Performance for the Greenhouse Design Project Over Phases I-III

Source	*df*	*F*	*η*	*p*
Year	1	1.37	.02	.24
Phase grade	2	624.08	10.65	< .001
NPR/PR	1	21.71	.37	< .001

Note. NPR = non-peer-reviewed (years 2000-2002); PR = peer-reviewed (years 2003-2007).

Table 4

Fractional Mean (± SD*) Professor/TA Graded Phase Fractional Scores (Scores/Total Points) Over Years and Unbalanced Repeated Measures ANOVA Between NPR and PR Groups to Determine if/or When PR Was Effective in Improving Student Performance for the Greenhouse Design Project Over Phases I-III*

Phase	2000-2002 NPR fractional scores *M* (*SD*)	2003-2007 PR fractional scores *M* (*SD*)
I	$0.835\ (0.189)_a$	$0.858\ (0.136)_a$
II	$0.786\ (0.234)_a$	$0.826\ (0.179)_a$
III	$0.665\ (0.177)_a$	$0.869\ (0.169)_b$

Note. NPR = non-peer-reviewed (years 2000-2002); PR = peer-reviewed (years 2003-2007). Mean separations for NPR/PR scores are based on Tukey's HSD test at $\alpha = .05$.

Table 5

ANOVA for Peer Reviews (I, II) Proposal Rating Questions to Guide Authors in Their Revisions with Quantitative Scores of Peer Review Critiques[a] *("Rate this Proposal Below by Circling the Appropriate Score to Guide the Author in His/Her Revision") for Intensive Writing Exercises in Greenhouse Management, Pooled Across Five Years (2003-2007)*

Question(s)	Year (Yr)	Phase (Ph)	Student (S)	Yr x Ph	Yr x S	Ph x S	Yr x Ph x S
i. The writing is concise and to the point	**	***	***	ns	***	ns	ns
ii. A clear picture of the site for the greenhouse is provided[b] / A clear, to-scale drawing of the operation is provided[c]	ns	*	**	ns	***	ns	***
iii. Proposal is coherent within/between paragraphs	**	**	***	ns	**	ns	ns
iv. The writing style is appropriate for a bank loan	***	****	**	ns	***	ns	ns
v. The proposal is written in a smooth, narrative fashion	**	***	*	ns	***	ns	ns
vi. The proposal is well-organized	ns	ns	***	ns	****	ns	ns
vii. The supporting documentation is concise and easy to read	ns	*	ns	ns	***	ns	ns
viii. The overall description of the market and crops is thorough[b] / The proposal has improved in quality after Phase I revision[c]	ns	***			***	ns	***

Note. N = 159 students. ns = not significant.

[a] Numerical scores: 1 = *not working*; 2 = *needs extensive revision*; 3 = *adequate*; 4 = *strong*; 5 = *outstanding!*

[b] Question asked for Phase I peer review critiques (Appendix 1).

[c] Question asked for Phase II peer review critiques (Appendix 2).

*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

Table 6

Mean, Pooled Scores and Their Significance (ANOVAs) of Phases I, II Ratings to Questions with Quantitative Scores[a] of Peer Review Critiques (Appendix 1, Question No. 4, Phase I; Appendix 2, No. 7, Phase II) for Intensive Writing Exercises in Greenhouse Management, Pooled Within and/or Among Five Years (2003-2007)

		2003		2004		2005		2006		2007		Pooled	
Question posed	Phase	Score	*p*	Score	*p*	Score	*p*	Score	*p*	Score	*p*	Score	I/II *p*
i. The writing is concise and to the point	I	3.9		3.8		4.0		3.7		3.8			
	II	4.0	ns	4.3	***	5.0	ns	3.9	ns	4.0	ns		
ii. A clear picture of the site for the greenhouse is provided	I	3.6		3.5		3.8		3.8		3.8		**3.7**	
	II	3.7	ns	3.4	ns	3.7	ns	3.8	ns	3.6	ns	**3.6**	*
iii. Proposal is coherent within/between paragraphs	I	3.8		3.8		4.1		3.7		3.8			
	II	4.0	**	4.0	ns	4.1	ns	4.0	*	4.2	ns		
iv. The writing style is appropriate for a bank loan	I	3.6		3.6		4.0		3.5		3.8			
	II	3.9	**	4.0	ns	4.1	ns	3.9	*	4.2	ns		
v. The proposal is written in a smooth, narrative fashion	I	3.6		3.8		4.0		3.8		3.9			
	II	3.9	**	4.3	**	4.2	ns	3.9	ns	4.2	ns		
vi. The proposal is well-organized	I	3.8		3.8		4.0		4.0		4.1			
	II	4.1	*	4.0	ns	4.1	ns	4.1	ns	4.1	ns	**4.0**	**ns**
vii. The supporting documentation is concise and easy to read	I	3.6		3.5		5.0		3.7		3.5		**3.6**	
	II	3.8	ns	3.9	ns	4.0	ns	3.9	ns	3.7	ns	**3.8**	*
viii. The overall description of the market and crops is thorough; The proposal has improved in quality after Phase I revision	I	3.7		3.5		3.7		3.7		3.8		**3.7**	
	II	4.1	**	4.2	***	4.1	**	4.1	**	4.1	ns	**4.1**	***

Note. $N = 159$. Pooling within each question and among years for Phases I, II or both (I/II) were performed if main effects were non-significant (Phase I, II or Yrs; Table 2, ANOVAs) and are highlighted in **bold**. [a] Numerical scores: 1 = not working; 2 = needs extensive revision; 3 = adequate; 4 = strong; 5 = outstanding! ns = Not significant. *$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

market and crops is thorough . . .) in all years except 2007 (Table 6). The year 2003 had the highest proportion of significantly different scores between Phases I and II for *iii* through *vi* (Table 6).

Nonparametric responses to questions posed in the Phase II peer review critiques, regarding whether or not the greenhouse operations matched the Floratech National Bank Loan specifications (question 2) across peer review years (2003-2007), were predominantly positive. In no year for any question was there a 100% affirmative response (Table 7). Answers to the question "Are the pad/fan and bench layouts correct?" ranged

from 54.0% to 83.9% (Table 7) and, in one year (2003), the 1:1 chi-square test was not significant (Table 7).

Rating the proposals in Phase II peer reviews for funding potential did not fit the 1:1:1 chi-square test (Table 8). The majority of proposals were rated a score of 2. With the exception of one question in 2003 ("Are the pad/fan and bench layouts correct?"), there were no differences between years for student responses to these yes/no or rank scoring questions, as all were significantly different (Table 7). However, in all subsequent years (2004-2007), responses matched the trend for all other questions and years by being significantly different.

Correlations of peer reviewed student reviewer scores with professor/TA grades for GDP Phase I papers were low but significant (Table 9). This clearly demonstrates that in Phase I, there was no impact of peer review on student grades. As this was the first peer review session, students were learning about the process and the graded papers did not reflect this first peer review session. This trend changed dramatically for Phase II and the funding score correlations with grades; none were significantly different with the exception of 2006 (Table 9). Thus, overall there was a positive effect of the peer review process on student reviews for the majority of years, aligning closely with that of the professor/TAs. Correlations of funding (1-3 scale) with final project grades (Phase III) were significant for only 2 years (Table 9). The majority of non-significant reviewer score and GDP Phase II grades or Phase III funding correlations demonstrate that peer reviewing allowed students to comprehend the GDP requirements and tailor their writing to improve their grades on the Phase II paper.

Peer reviewer course evaluations generated a variety of student responses. For question 1, "What did you learn from peer reviewing . . . other student's Phase I Greenhouse Design Projects?," a typical response was, "It was nice to compare and contrast various ideas and approaches to designing the first and most overwhelming stage of the project." Also common was that they "learned how to observe things objectively and think critically about the presentation of information and how it affects" the Bank Loan Officer. Others commented on the advantages of seeing their colleagues' work which gave them new ideas to develop "more in-depth and comprehensive projects," helping them to "reflect on their own writing," forcing them "to be more complete" with their own projects (particularly when they were "unprepared"), helping them to see "other people's mistakes [which] made them see their own more easily," generally "learning how critical a reviewer can be," and perceiving the peer review panels as "fun."

The opportunity for outside opinions and the "rationale for the greenhouse location, market, and crop choices gave in-depth reasoning" were typical responses given to question. 2 ("What types of things did you learn in your peer review session as your colleagues discussed your Phase I proposal?"). Others learned that they were "too wordy" and/or "wrote in incomplete sentences," and their peers "were able to catch flaws" or had "ambiguous language" the writer was unaware of. They also "learned how to make criticism and discuss the papers in such a way that doesn't attack the author or hurt someone's feelings," and that they "needed more in-depth writing" to write in the discipline.

For the majority of students, role-playing the bank loan officer (question 3) allowed the students to "better understand how imperative it [was] . . . to have things clear, concise, and interesting," provided a "real-life perspective" or "constructive criticism," and promoted critical thinking and "objectively viewing [their own] writing." A small portion of students (i.e., one to three students per year) saw no value in this role-playing exercise at all.

Interestingly, a majority of the students (91% in 2003, 87% in 2004, and 84% in 2005) felt that there was no difference between the anonymous (Phase I) and non-anonymous (Phase II) peer reviews (question No. 4). Thus, we dropped the blind reviewer aspect of Phase I peer reviews during 2006 and 2007. When we designed the peer review process for Phase I, it was patterned after similar formats of author anonymity in peer review grant panels or many scientific journal manuscripts during the review process. Our undergraduates did not perceive any added benefit from anonymity. Many commented that they were relieved to finally learn who the authors were in the peer review sessions to enhance constructive criticism and foster idea exchange. It is unclear whether the inclusion of peer review panels, wherein the reviewers met and talked with the authors (after completing their reviews), may have affected their perceptions.

Typical comments regarding one effective thing about the editing/revision process (question 5) included: "Each time we revised each other's papers, we were more knowledgeable and could help more"; "It forces decision-making" without having to "keep rewriting the entire paper"; and "Different views and angles on business from other students, along with the combined knowledge of all, gave everyone a more coherent plan." Verbalizing comments—particularly positive ones—during the peer review panel sessions were more effective for some students. Guiding the students to read the papers first before making comments was also a useful tip in editing. Several commented on how the challenge of incorporating other reviewers' comments into their rewritten proposals, while keeping it in the author's voice, aided them later when summarizing scientific literature—without plagiarizing—in this and other class papers.

Table 7

*Responses (% of Student Responses) to and Chi-Square Statistical Test (1:1 χ^2) for Yes/No Questions Posed in Phase II Peer Review Critiques Regarding the Greenhouse Operation Matching the Floratech National Bank Loan Specifications (Question No. 2: "*Does the Phase II Drawing of the Greenhouse Operation Match the Specifications?"*) Across Five Years (2003-2007) for Greenhouse Management*

Questions posed	Response; 1:1 χ^2	2003	2004	2005	2006	2007
Is it to scale, with the scale indicated?	Yes	79.4	73.9	89.8	93.1	80.5
	No	20.6	26.1	10.2	10.9	19.5
	χ^2	12.6***	10.5***	31.0***	39.1***	15.2***
Is there at least 50,000 ft^2 of greenhouse growing area?	Yes	88.7	86.9	88.2	93.8	90.5
	No	11.3	13.1	11.8	8.2	9.5
	χ^2	20.8***	25.1***	29.8***	49.9***	27.5***
Is the N/S direction indicated?	Yes	83.9	83.3	86.3	89.5	87.8
	No	16.1	16.7	13.7	10.5	12.2
	χ^2	15.1***	21.3***	26.8***	41.9***	23.4***
Are the pad/fan and bench layouts correct?	Yes	54.0	82.6	78.3	83.9	71.4
	No	46.0	17.4	21.7	16.1	28.6
	χ^2	0.3ns	19.6***	14.7***	28.4***	6.4***
Are the heating/cooling calculations correct for this range?	Yes	83.6	74.4	86.4	82.2	67.5
	No	16.4	25.6	13.6	17.8	32.5
	χ^2	15.1***	10.3***	23.3***	25.8***	4.6**

Note. ns = not significant.
***$p \leq .001$.

Table 8

Student Responses (%) to and Chi-square Statistical Test (1:1:1 χ^2) for Question Posed in Phase II Peer Review Critiques Regarding the Greenhouse Fundability (Question No. 8: "Lastly, Rate this Proposal for Funding at this Phase") Across Five Years (2003-2007) in Greenhouse Management Class

Score, questions posed	2003	2004	2005	2006	2007
1, Not fundable—needs significant revision & more thought	4.8%	12.2%	7.3%	9.0%	5.5%
2, Good proposal, needs more work to make this competitive	69.8	59.2	69.0	59.1	75.0
3, Funded. An excellent loan application	25.4	28.6	23.7	31.9	19.5
1:1:1 χ^2 test	20.7***	16.7***	31.7***	24.8***	29.2***

Note. ***$p \leq .001$.

Table 9

Correlations and Significance of Mean Phases I, II Reviewer Scores and Fundability (Pooled Within Years for All Students' Scores) with Professor's Grades for Phases I, II, and III, Respectively

		2003		2004		2005		2006		2007	
	Phase	*r*	Final Grade	*r*	Final Grade	*r*	Final Grade	*r*	Final Grade	*r*	Final Grade
Reviewer scores	I	0.28*		0.44*		0.45*		0.37*		0.43*	
	II	0.21ns		0.14ns		0.29ns		0.52**		0.1ns	
Funding score	--		0.16ns		0.56*		0.2 ns		0.6**		0.4 ns

Note. ns = not significant.
*$p \leq .05$. **$p \leq .01$.

A majority (62% in 2003, 52% in 2004, 74% in 2005, 80% in 2006, and 91% in 2007) of the students attributed their change (i.e., improvement) in writing to be the result of enrollment in a Writing Intensive class such as Hort 3002W (question 6). In the present study, typical student comments in this category included that they were "more deliberate," "more confident," understood "the necessity of proof-reading," became a "better writer because of [the experience]," and that they "never had to be more professional in [their] writing." Many commented that understanding writing to be a process, rather than a singular one-time effort would be a lifelong gift of the peer review process. Several reported that "critical thinking of professional writing" moved "to the front of their thoughts when thinking about [their] profession." The minority who felt their writing had not changed commented that they were already "good" writers, that they had already enrolled in several WI courses, or that more writing assignments should be required.

Discussion

Complete student involvement (100% for all peer reviews, reviewer panels) was most likely attributable to the institution of peer review deadlines with clearly stated consequences for not participating, as reported in previous studies (e.g., Sims, 1989), as well as the realization after the first peer review session that it enhanced critical thinking to develop "more in-depth and comprehensive projects." Only a small portion of students (one to two per semester) found the peer review to have no inherent value; such students were often highly skilled writers from previous writing courses or were adult learners. The lack of students' perceived differences between the Phases I (double-blinded) and II (non-double-blinded) reviews from 2003 to 2005, where a majority (84%-91%) felt they were no different, demonstrated that anonymity was not critical to engage in the peer reviews effectively.

Tangible and Intangible Benefits of Peer Reviewing

Many tangible benefits were in evidence from the multiple opportunities of reading colleagues' writing and participating in panel review sessions. After the second peer reviews, student writing was significantly enhanced (Tables 1-4); students quickly identified superior papers when they read or discussed them. Likewise, peer reviewing enabled students to "compare and contrast various ideas and approaches to designing," "think critically," and understand their own mistakes by reading and critiquing better proposals. Objective opinions from their peers, while often identical to those provided by the professor/TAs by Phase II, had increased validity to evoke an enhancement to student writing. Students also gained confidence as they became experienced reviewers, noting in their evaluations that: "Each time we revised each other's papers, we were more knowledgeable and could help more." Students ascribed their improved writing to being actively involved in this Writing Intensive course where they "had to be more professional in [their] . . . writing," exuding confidence and with a more deliberate approach to writing. Of significance was the student attribution of understanding writing to be a process as a lifelong gift of the peer review process.

Similar to Sims (1989), intangible benefits occurred such as insight into how their colleagues interpreted the nature of the GDP assignment and the meaning that Bank Loan officers might derive. Transfer of new ideas or non-required items to make their bank loan applications stand out to the bank loan officers included creative business names, introductory letters, or more extensive preambles about the greenhouse operation, the crops being grown, and unique marketing strategies. Such idea transference between students is similar to that reported for chemistry students (e.g., Alaimo, Langenhan & Loertscher, 2007) and reinforces the perspective that learning is a social, participatory science (Wenger, 1998). This informational transfer significantly reduced the frequency of students questioning what the bank loan officers (i.e., professor/TAs) wanted in each proposal. Likewise, as reported previously by Hsvitfeldt (1986) and Sims (1989), the thoroughness of student reviews allowed for the identification of weak logic structure. The realized time savings for the professor/TA were redirected to writing improvement and the integration of higher scientific quality in the proposals.

Lag Time Before Student Grades Reflect Peer Review Effects

Almost without exception, by Phase II the students had grasped the peer review process and had matched their editing skills and critiques of quality writing in the discipline with that of the instructor/TAs. Eventually this resulted in higher graded scores for the peer review Phase III papers. This infers that students learn the reviewer function and quality writing recognition before it translates directly into improving their own. Thus, multiple peer review opportunities must be provided throughout a course to have an effect.

A lag time occurred before the effects of peer review translated into higher GDP grades, since only in Phase III scores did the peer review scores significantly exceed the non-peer reviews (Tables 3 and 4). It would not be expected that Phase I grades would differ, as neither section of students (NPR, PR) had been exposed to peer reviewing prior to this course. The speed at

which student reviewer scores matched those of the professor/TA grades occurred by Phase II in the majority of peer review years (Table 9). Thus, students quickly learned the peer review process and scored their colleagues in a similar manner as the professor/TA. The lack of a significant year effect for any of the phases (including Phase I) further supports this. We would have expected Phase II grades for the peer review years to be significantly higher than non-peer review years, but this did not occur. The demonstrable effect of peer review did not appear until Phase III. Even though all peer review scores were higher than corresponding non-peer review values, apparently students needed to experience two peer reviews for this GDP assignment to manifest significant change in writing and improved performance. This further emphasizes the continued use of peer reviews during the entire semester to reinforce and improve writing skills. One peer review session per course is insufficient for students to learn the editing/reviewer process and become better writers.

Content and Syntactical Function

Content is still an important component of WI courses, and Greenhouse Management is no exception. Emphasis of content and syntactical function during these Hort 3002W peer reviews is a new focus for the peer review process because, in most studies, content may represent as little as 20% of the peer review evaluation (Billington, 1997). In our original design of the peer review component in this course, we intentionally reassigned critical lecture content to laboratory sessions such that both NPR and PR groups received identical course content. Embedding the importance of content as well as enhancement of writing skills into the peer review process provided constant focus on both attributes. In addition to providing equal content between years, this balanced approach demonstrated that an increase in syntactical function in peer review does not have to sacrifice content. Both aspects complementarily made peer review the most powerful learning tool in this course.

Differences in student writing over years continued to have a significant effect during the peer review process where quantitative scores of peer review critiques for question 4 in Phase I and question 7 in Phase II, which referred to writing quality (parts *i, iii, iv, v*) differed significantly between years (2003-2007; Table 5). Such questions, related to writing style or overall quality, were significantly different between phases, indicating improvement in the coherence of the proposals, writing styles, narrative fashions, organization, and thoroughness. Similar results have been reported previously (Hsvitfeldt, 1986; Sims, 1989). Those parts relating to the incorporation of supportive documentation (parts *ii, vi*) were not significantly different between years (Table 5), which confirm that the student populations remained consistently able to follow instructions for the GDP and supply requested information. In most instances, Phase II scores for questions *i, ii, iii, iv, v, vii,* and *viii* significantly increased over Phase I (Tables 5 and 6), which reflects an increased syntactical function of peer reviews (Carlsen et al., 2001) and provides pertinent reviewer feedback (Timmerman & Strickland, 2006). As our student populations consisted of younger and older generation enrollees, this age difference may have been a significant effect on two- and three-way interactions (Table 5) because the older generation students were predominantly skilled writers. Additionally, significant yearly differences in the overall student enrollees' writing ability indicate that the student population's skill level in writing varies widely each year.

The Power of Peer Reviewing

A majority of the students attributed their change (i.e., improvement) in writing to be the result of enrollment in a Writing Intensive class. These results are consistent with the findings of Brumback, Squires, and Parrish (1985) where 70% of the students responded affirmatively when asked if the writing assignments improved their writing. In the present study, student comments regarding the power of peer reviewing in enhancing their learning trajectories were similar to those reported by Blair, Cline, and Bowen, (2007), for example, that they were "more deliberate" writers, that they were "more confident," that they understood "the necessity of proof-reading" and were "better writer[s] because of it." Many commented that understanding writing to be a process, rather than a singular one-time effort, would be a lifelong gift of peer reviewing.

Limitations

The need for a control group each year the peer review was performed, while not possible to institute in this course, would be an important component in future horticulture courses with multiple sections. While controls have not always been included in previous studies either (Yankulov & Couto, 2012), they may have accounted for inherent biases that may have occurred due to professor familiarity with the GDP assignment (e.g., the increased score in the 2002 NPR group). Lower grades in the control group herein were not due to the instructor's unfamiliarity with the subject matter, since the instructor was a veteran in the subject area (as noted earlier), but they may be attributed to the enrolled students' populations.

Only in some years did the effect of peer review on students' final course grades exceed those for the NPR group (Tables 1 and 2). The overlap of mean

separations in final grades for students in the 2002 NPR group (only 1/3 of the NPR group years) with the PR group years 2003 to 2005 and 2007 may be attributable to their increased performance in other assignments to elevate their final grade. Elevated student performance in the 2002 NPR group, or later PR group years, may have been partially due to increased student or professor familiarity with the GDP assignment, although this was not tested. Teaching assistant effects were minimal as each TA only taught one year.

Similar to Yang (2011), knowledge transfer between peers was not measured, and its effects on writing improvement versus that of the professor/TAs are unknown. This would be an important factor for future studies.

Results of this study cannot be generalized beyond the populations sampled to all horticulture student populations. Since this was a required course in the undergraduate horticulture major the student populations represented the spectrum of students in nursery, floriculture, turf, fruit science, and landscape design/architecture. However, the 8-year sampling, while long-term in nature, may or may not be indicative of other populations.

Recent innovations (e.g., online *calibrated peer review*: see http://cpr.molsci.ucla.edu) that were not available during the period of the present study may enable faster accomplishment of peer reviewing within the contextual framework of this course (Likkel, 2011). Future studies in online horticulture courses could test the effectiveness of peer review within this context.

Conclusions and Implications

Peer reviewing is a time investment for both the professor/TA and students, but the rewards far outweigh time constraints. Promotion of improved writing skills, lateral thinking and lifelong learning that encourage the development of Bloom's (1956) higher cognitive skills exceeds the results of strictly content- or memorization-based education (Aaron, 1996; Anderson, 1995; MacKay et al., 1999; Moss & McMillen, 1980). Student writers applied and synthesized concepts, and they discovered conceptual relationships in this GDP writing assignment, which occurred at higher levels of cognition (Parrish, Brumback, & Squires, 1985). As Sims (1989) pointed out, conducting peer reviews required extreme organizational skills as well as inflexibility of deadlines and clearly defined consequences. Adherence to these parameters allowed for 100% student participation in the peer review process. The sociological role of peer reviews is a powerful means of enhancing student's abilities to make evaluative assessments of their colleagues' writing which enhances their own learning and expands scientific/professional writing into a social function (Carlsen et al., 2001). We highly recommend incorporation of peer reviews into horticulture curricula. Likewise, integration of peer reviews in courses of other disciplines is highly recommended as this is highly likely to elicit equally useful and effective knowledge transference, writing enhancement and lifelong communicative learning.

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NEIL O. ANDERSON is a professor who teaches a wide range of undergraduate and graduate Horticultural Science courses at the University of Minnesota. Throughout his teaching career, Neil has sought to integrate cutting edge teaching methods to enhance student learning. The concept of incorporating peer reviewing student writing—the first formalized endeavor of its kind in the field of undergraduate horticulture courses—was created to provide alternative means of cross-learning for writing enhancement.

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Appendix A
Peer Review Critique Form for Student Reviews of Phase I (Greenhouse Design Project)
Conducted in Hort 3002W Class

Hort 3002W—Peer Reviews, Phase I
Greenhouse Design Project

PURPOSE.

The peer review process fulfills an important component of the Writing Intensive class requirement. You will serve on a panel to review your peer's projects. This peer review will be performed within each laboratory group serving as the panel for the respective group.

Overall, the purpose of this peer review is to improve the quality of all projects and engage in critical review and thoughtful discussion by role-playing as the Floratech Bank Loan Officer.

This exercise will not determine anyone's actual grades for Phase I—it is meant to improve your own writing skills, critique your peers, gain new ideas, and provide meaningful critiques. The professor and teaching assistant will assign the scores for your grade. You will receive credit for your participation in the peer review process.

When this exercise is completed, you will take the reviews for your proposal from your panel members and revise your Phase I draft. This revision, along with the additional components required for Phase II, and your original Phase I will be handed in together when the Phase II project is due.

THE PROCESS.

1. Each student will review two proposals from your lab group (that are not yours).
2. Pick up the two copies of proposals from your lab group that you will review. These have the names of your peers blocked out, so this phase of the review process is anonymous.
3. Review these two proposals on your own time, outside of class, during the next week, using the accompanying guidelines in your critique. YOUR REVIEWS MUST BE COMPLETED BEFORE CLASS (LECTURE) ON MONDAY, xxxxx (date). No exceptions! If you fail to do this, you will not be allowed to come to class and your Phase I score will be penalized with a 50% point reduction and you will not receive credit for the panel review.
4. FOR CLASS LECTURE ON xxxx (date), BRING THE PROPOSALS AND YOUR CRITIQUES FOR DISCUSSION. WE WILL DISCUSS EACH PROPOSAL IN PANEL REVIEWS DURING CLASS.

THE REVIEWS.

Note: We will go through an example in class today to clarify how to perform each review. As a reviewer, you will be role-playing as the Floratech National Bank Loan Officer. This will give you the opportunity to understand how the Bank Loan Officer thinks and reacts to each proposal as they cross his/her desk.

Some things to keep in mind about the Floratech National Bank Loan Officers:

- They're busy people and want all bank loan application to have all of the necessary requirements and be "to the point". Loan officers do not have the time to sift through printouts that could have been summarized in a table.
- Each proposal must be professional in appearance and delivery of information.
- The Loan Officers will be looking at each proposal for ideas that make it "stand out" as a superior loan application. For instance, ask yourself whether each proposal is well thought-out, whether the plan is strategic, unique, creative, or whether contingency plans have been incorporated in case of failure.
- These viewpoints will reflect on the anticipated potential success of the business, i.e. whether it is financially sound, competitive, etc.

Fill out the Peer Review Critique sheets and write a brief commentary (bullet points, if necessary) on each proposal and fill in the requested information before you bring it to your panel review in one week. There are sheets attached to use. Fill them out completely, honestly, and accurately.

Hort 3002W—Peer Reviews, Phase I
Greenhouse Design Project

Peer Review Critique Instructions

Now you have two Phase I proposals to review. Give yourself enough time to really focus on this—figure 30 minutes per proposal minimum. Remember to make your comments legible—you might want to use a pencil—and to focus on the BIG PICTURE issues rather than grammar or spelling.

The first thing to keep in mind as you read each proposal is that you will be reading and critiquing these proposals from the vantage point of the loan applicant's target audience—the Floratech National Bank Loan Officer, i.e. you are the Bank Loan Officer!! Take a couple of minutes BEFORE you read to figure out how you, as the Loan Officer, already feel about the necessary components of the Phase I Proposal. What might be your concerns, questions, or specific things that would make a proposal outstanding? Jot these things down on a piece of paper—to keep them fresh in your mind—for referral as you begin to review the proposals.

1. Begin by writing your name on the top right-hand corner of each proposal that you are reviewing. Do the same thing on the two sets of Peer Review Critiques that follow this handout. That way, if there's any confusion after the panel review session is over, your peer can contact you to clear up any unclear comment or notation.
2. Proceed with this exercise by critiquing one proposal at a time.
3. Read or scan through the entire proposal quickly. Resist the temptation to jump in with specific comments until you've read through the whole proposal once. Mark passages you think you might like to return to later—either because they are of interest or seem confusing.
4. Now go back to the beginning of the proposal and draw out/elaborate on your comments a bit further. You may write notes in the margins. As you re-read the text:
    - Underline the text that speaks to the type of business being proposed, as well as the crops to be grown.
    - Draw a wavy line underneath any sentences or paragraphs that are confusing to you. Such sentences may cause you to ask yourself "says who?" or "based on what?" as you're reading it. These are problematic areas that will need to be revised by the author.
    - Draw a box around a paragraph, sentence, or drawing that contains the most persuasive piece of the entire proposal. In other words, What would make you approve this loan? This area will be the best selling point(s)!
    - Place a star near the paragraph or section that has the most interesting information or is unique (something memorable). Possibly the author created a descriptive, yet interesting name for the business that caught your interest or attention.
5. Take a look at the evidence by re-reading the supporting documentation, i.e. the site's weather data and preliminary budget proposal. Write your comments in the margins of any page(s) to clarify any misunderstandings or areas that need more work. Again, you may draw wavy lines underneath or around such confusing or unclear sections.
6. Then answer the questions on the Peer Review Critique Sheet and rate the proposal.
7. You're done!

Appendix B
Peer Review Critique Form for Non-Anonymous Student Reviews of Phase II (Greenhouse Design Project)
Conducted in Hort 3002W Class (Appropriately Modified from Phase I)

PURPOSE.

The peer review process fulfills an important component of the Writing Intensive class requirement. You will serve on a panel to review your peer's projects. This peer review will be performed within each laboratory group serving as the panel for the respective group.

Overall, the purpose of this peer review is to improve the quality of all projects and engage in critical review and thoughtful discussion by role-playing as the Floratech Bank Loan Officer.

This exercise will not determine anyone's actual grades for Phase II—it is meant to improve your own writing skills, critique your peers, gain new ideas, and provide meaningful critiques. The professor and teaching assistant will assign the scores for your grade. You will receive credit for your participation in the peer review process.

When this exercise is completed, you will take the reviews for your proposal from your panel members and revise your Phase II draft. This revision, along with the additional components required for Phase III, and your original Phase I, II will be handed in together when the Phase III project is due.

THE PROCESS.

1. Each student will review two proposals from your lab group (that are not yours).
2. Pick up the two copies of proposals from your lab group that you will review. These reviews will not be anonymous.
3. Review these two proposals on your own time, outside of class, during the next week, using the accompanying guidelines in your critique. YOUR REVIEWS MUST BE COMPLETED BEFORE CLASS (LAB) ON MONDAY, xxx (date). No exceptions! If you fail to do this, you will not be allowed to come to class and your Phase II score will be penalized with a 50% point reduction and you will not receive credit for the panel review.
4. FOR CLASS LAB ON xxxx (date), BRING THE PROPOSALS AND YOUR CRITIQUES FOR DISCUSSION. WE WILL DISCUSS EACH PROPOSAL IN PANEL REVIEWS DURING CLASS.

THE REVIEWS.

This review will be conducted similarly to the Phase I reviews. Remember, as a reviewer, you will be role-playing as the Floratech National Bank Loan Officer. This will continue your opportunity to understand how the Bank Loan Officer thinks and reacts to each proposal as they cross his/her desk.

Some things to keep in mind about the Floratech National Bank Loan Officers:

- They're busy people and want all bank loan application to have all of the necessary requirements and be "to the point". Loan officers do not have the time to sift through printouts that could have been summarized in a table.
- Each proposal must be professional in appearance and delivery of information.
- The Loan Officers will be looking at each proposal for ideas that make it "stand out" as a superior loan application. For instance, ask yourself whether each proposal is well thought-out, whether the plan is strategic, unique, creative, or whether contingency plans have been incorporated in case of failure.
- These viewpoints will reflect on the anticipated potential success of the business, i.e. whether it is financially sound, competitive, etc.

Fill out the Peer Review Critique sheets and write a brief commentary (bullet points, if necessary) on each proposal and fill in the requested information before you bring it to your panel review in one week. There are sheets attached to use. Fill them out completely, honestly, and accurately.

Hort 3002—Peer Reviews, Phase II
Greenhouse Design Project

Peer Review Critique Instructions

Now you have two Phase II proposals to review. Give yourself enough time to really focus on this—figure 30 minutes per proposal minimum. Remember to make your comments legible—you might want to use a pencil—and to focus on the BIG PICTURE issues rather than grammar or spelling.

The first thing to keep in mind as you read each proposal is that you will be reading and critiquing these proposals from the vantage point of the loan applicant's target audience—the Floratech National Bank Loan Officer, i.e. you are the Bank Loan Officer!! Take a couple of minutes BEFORE you read to figure out how you, as the Loan Officer, already feel about the necessary components of the Phase II Proposal. What points are you looking for in the Phase I proposal revision? What might you expect in their memorandum explaining Phase I revisions versus what is in the text that demonstrates the applicant has incorporated ideas and suggestions? Jot these things down on a piece of paper—to keep them fresh in your mind—for referral as you begin to review the proposals.

Much of the review process remains the same as it was for Phase I reviews:

1. Begin by writing your name on the top right-hand corner of each proposal that you are reviewing. Do the same thing on the two sets of Peer Review Critiques that follow this handout. That way, if there's any confusion after the panel review session is over, your peer can contact you to clear up any unclear comment or notation.
2. Proceed with this exercise by critiquing one proposal at a time.
3. Read or scan through the entire proposal quickly. Resist the temptation to jump in with specific comments until you've read through the whole proposal once. Mark passages you think you might like to return to later—either because they are of interest or seem confusing.

Now go back to the beginning of the proposal and draw out/elaborate on your comments a bit further. You may write notes in the margins. As you re-read the text:

1. Draw a wavy line underneath any sentences, paragraphs, or parts of their drawings that are confusing to you. Unclear areas may cause you to ask yourself "says who?" or "based on what?" as you're reading it. These are problematic areas that will need to be revised by the author.
2. Draw a box around a paragraph, sentence, or drawing that contains the most persuasive piece of the entire proposal. In other words, What would make you approve this loan? This area will be the best selling point(s)!
3. Take a look at the evidence by re-reading the supporting documentation, i.e. the to-scale drawing of the greenhouse operation, the headhouse, parking lot. Look for the important components that are necessary in the drawings. Are the drawings easy to read and understand? Is a key supplied to aid in this process? Write your comments in the margins of any page(s) to clarify any misunderstandings or areas that need more work. Again, you may draw wavy lines underneath or around such confusing or unclear sections.
4. Then answer the questions on the Peer Review Critique Sheet and rate the proposal.
5. You're done!

Hort 3002W—Peer Reviews, Phase II
Peer Review Critique

Reviewer's Name (yours): _____

Proposal you are reviewing: _____

Answer the following questions:

1. What is the best selling point of this proposal (the area that you boxed in)?

2. Does the Phase II drawing of the greenhouse operation match the specifications? Circle your answer below for each item. You may also add comments, if you feel that is necessary.
   - Is it to scale, with the scale indicated? YES or NO
   - Is there at least 50,000 ft2 of greenhouse growing area? YES or NO
   - Is the N/S direction indicated? YES or NO
   - Are the pad/fan and bench layouts correct? YES or NO
   - Are the heating/cooling calculations correct for this range? YES or NO

3. In what way(s) does (or could) the bench system reflect space use efficiency to maximize production for this greenhouse range?

4. How did the author successfully prevent or minimize any traffic flow problems with the current bench/ground bed setup? Think about how a greenhouse worker would maneuver throughout the entire range while performing a variety of production tasks.
   a. In what way(s) does (or could) this greenhouse operation integrate modern technology to enhance overall crop production efficiency?
   b. What questions might you have for this bank loan applicant that will enable them to obtain a bank loan at Phase III? Look at the sentences that are underlined with a wavy line.

5. Rate this proposal below by circling the appropriate score to guide the author in his/her revision.
   Scores:
   1 = *not working*, 2 = *needs extensive revision*, 3 = *adequate*, 4 = *strong*, 5 = *outstanding!*

a.	The writing is concise and to the point	1	2	3	4	5
b.	A clear, to-scale drawing of the operation is provided	1	2	3	4	5
c.	Proposal is coherent within/between paragraphs	1	2	3	4	5
d.	The writing style is appropriate for a bank loan	1	2	3	4	5
e.	The proposal is written in a smooth, narrative fashion	1	2	3	4	5
f.	The proposal is well-organized	1	2	3	4	5
g.	The supporting documentation is concise and easy to read	1	2	3	4	5
h.	The proposal has improved in quality after Phase I revision	1	2	3	4	5

6. Lastly, rate this proposal for funding at this phase (check one):
   a. Not fundable—needs significant revision & more thought.
   b. Good proposal, but needs more work to make this competitive.
   c. Funded. An excellent loan application.
   What is your rationale for this rating?

Appendix C
Grading Rubrics for Phases I to III of the Greenhouse Design Project

Loan Application
to
Floratech National Bank

Applicant: _____

Phase I Scoring

Item	Points Possible	Your Score
Writing Proficiency		
Clear, concise writing	**5**	
Grammar, spelling	**5**	
Scientific accuracy, professionalism	**10**	
Market		
Market identification, type of growing facility	**5**	
Site selection:		
Correct location, accurate weather conditions	**4**	
Summation of weather parameters for ease of reading	**5**	
Economic feasibility	**4**	
Preparatory work required	**2**	
Photograph	**1**	
Crop(s)		
Number, scientific nomenclature	**5**	
Appropriateness to operation and market	**4**	
TOTAL	**50**	

Comments:

Loan Application
to
Floratech National Bank

Applicant: _____

Phase II Scoring
(Includes Revised Phase I + Phase II, as well as revision memorandum or letter assembled into a single loan application)

Item	Points Possible	Your Score
Writing Proficiency		
Revision of previous writing assignment, Phase I	**10**	
Revision memorandum or letter	**7**	
Scientific accuracy	**5**	
Layout, Construction Considerations for a Sustainable Greenhouse Operation		
Drawings (to scale), Proper ft^2 area of greenhouses and headhouse, Future expansion direction	**9**	
Buildings (structure types, orientation)	**7**	
Glazing material(s), Irrigation system, Lighting	**10**	

Bench arrangements and type, Designation of crop production in greenhouses	**5**	
Traffic flow patterns	**5**	
≥ 100% Space efficiency and appropriateness for crop(s)	**5**	
Additional required equipment	**1**	
Work areas (offices, headhouse, etc.)	**1**	
Heating/cooling calculations, fan/pad locations (if used)	**10**	
Explanatory write-up of all layout and construction considerations	**15**	
Budget (may exceed loan amount)		
Inclusiveness (all required supplies and equipment)	**5**	
Accuracy of line items	**5**	
TOTAL	**100**	

Comments:

Loan Application
to
Floratech National Bank

Applicant: _____

Phase III Scoring

(Containing Phase II revisions with revision memorandum or letter which are integrated into the Phase III proposal, making one complete bank loan application.)

Item	Points Possible	Your Score
Writing Proficiency		
Revision of previous writing assignment (Phase II), revision memorandum or letter	**30**	
Introduction to the facility	**10**	
Scientific accuracy	**10**	
Budget		
Budget modifications; explain why you changed components, advantages/disadvantages of these changes, ID how these can increase/decrease profitability	**40**	
Budget within the loan amount of US$ 1 million **(see note below)****		
Layout, Construction Modifications		
Revised, detailed listing of components	**10**	
Revision to drawing, layout, if required	**10**	
1-yr. Production schedule		
Accuracy (crop production requirements, timing, harvesting)	**20**	
10% crop turnover (average) / year	**10**	
# plants/crop	**5**	
crop spacing, ≥ 100% space use	**10**	
FBI/FBD treatments and production timing to make target harvest or finishing dates	**5**	
# hours (labor) required for each crop at each production stage	**10**	

Appropriate environmental parameters necessary to grow each crop	**10**	
Employees		
# of employees required (FT or PT) to run this business	**5**	
employee job titles/duties	**5**	
estimated # employee hrs/crop	**5**	
TOTAL	**175**	

****If the budget is not within the US$1 million loan amount, your Phase III score is automatically a zero.**
Comments (on verso):