**Title: Think before (and after) you speak:** Practice and self-reflection build student confidence and bolster performance in oral communication skills in ecology and conservation biology classes

**Manuscript type:**  Research and Teaching Article

**Short running title:** Practice and self-reflection for oral communication skills

**Keywords**

**Oral communication, self-assessment, self-reflection, video, undergraduate biology, process skills, formative assessment, rubrics**

**Abstract**

With limited funding and increased job competition, STEM professionals face a growing need to communicate their science. In this study, conservation biology faculty and practitioners from across the US designed classroom exercises and teaching interventions intended to bolster oral communication skills. Through repeated oral presentation assignments integrated into course requirements, we examined individual student learning gains via quantitative assessments. We used two teaching modes: in an “intense” version of a teaching intervention, students watched their presentations on video and reflected on their performance using a rubric; the “light” version included delivery of the rubric only. Students completed pre- and post-course surveys of student confidence, and pre- and post-exercise content knowledge questions. Faculty scored student performance based on a detailed rubric made up of components of effective oral presentations. We saw content gains accompany enhanced skill performance between the first and second presentations with greater gains occurring during intensive teaching intervention. Our results indicate that practice of a skill coupled with reflection on the process bolsters student learning. Oral communication skills can be improved in the context of undergraduate conservation classes, preparing students for skills they will need in future science and conservation careers.

**Introduction**

Educating the next generation of students to address complex societal and environmental issues involves more than delivering scientific content. Undergraduate students need to develop effective process skills in leadership, communication, working in groups, critical thinking, data analysis, and project management to adequately prepare for careers in conservation science, policy, and practice (NRC, 2003; Rhodes, 2010; AAAS, 2011; Blickley *et al.*, 2013).

Experts recognize that training conservation scientists and practitioners must emphasize effective oral communication (OC) skills, particularly across disciplines and to general audiences (Cannon *et al.*, 1996; Noblitt *et al.* 2010; Chan 2011; Schmidt *et al.*, 2012; Blickley *et al.*, 2013). Yet, if student practice in OC in conservation-related courses takes place at all, it generally involves a one-time, end-of-semester capstone presentation that may not provide adequately scaffolded skill development or otherwise meaningful training in and expectations for effective communication and feedback (Muir and Schwartz, 2009; Blickley *et al.*, 2013). Assessment of OC in undergraduate education typically includes instructor comments rather than student self-reflections or students’ peer-reviews (De Grez *et al.*, 2012). However, recent work concludes that self-reflection, such as student review of video recordings of their own presentations, plays a key role in boosting student learning (Hammoud *et al.*, 2012).

To improve our understanding of the investment needed for science students to learn process skills and for faculty to develop efficient teaching tools, the Network for Conservation Educators and Practitioners (NCEP) from the Center for Biodiversity and Conservation (CBC) at the American Museum of Natural History (AMNH), partnered with faculty teaching undergraduate conservation-related courses. We designed a large-scale multi-institutional study on three fundamental process skills: critical thinking, data analysis, and oral communication (OC). This paper reports the results on OC skills, defined as the ability to make a prepared, purposeful presentation designed to increase knowledge, to foster understanding, or to promote change in the listeners' attitudes, values, beliefs, or behaviors (following Rhodes 2010). We asked three key questions: 1) Does student repetition of an OC task improve performance? 2) Does instructor emphasis on communication skills affect the magnitude of individualized skill gains? and 3) Can students gain concept knowledge while practicing OC skills? To address these questions, we created and validated instructional materials designed to develop and assess OC skills and piloted these materials in diverse classroom settings across four institutions.

**Methods**

We conducted this study between April 2011 and August 2013. The project received an exemption from Institutional Review Boards (IRB) at all relevant institutions: AMNH, Clarkson University, Princeton University, James Madison University, Southwestern University, University of Maryland Eastern Shore, and University of Puerto Rico.

***Developing, validating, and implementing assessment tools***

Between April and July 2011, we developed and validated a set of instructional materials (Instructional Unit - IU) for OC skills. The IU consisted of 1) a rubric for OC skills, 2) two exercises (with solutions) designed to develop OC skills, 3) a pre/post content knowledge assessment for each exercise, 4) a student’s pre/post self-assessment of their OC skills, and 5) a light and an intensive oral communication teaching intervention (Figure 1). The IU can be downloaded by registering as an educator on the NCEP website (<http://ncep.amnh.org>).

Between August 2011 and August 2013, we implemented the IU following the experimental design shown in Figure 1. By using the IU in a single semester, we evaluated whether students gained OC skills, content knowledge, and self-confidence in their OC skills in courses that used the IU with one of the teaching interventions. By using both interventions (light and intensive) in the same course, albeit different semesters, we compared whether the degree to which oral communication is emphasized in a course influences students’ overall OC gains. We implemented the IU in four higher education institutions from the US and Puerto Rico, in a variety of undergraduate courses (Biodiversity, Ecology, General Ecology, and Primate Conservation Biology), using a suite of different course styles (e.g. seminar, lecture) (Table 1).

We based the OC rubric on elements found in other available reputable rubrics, including the Oral Communication Value Rubric (Rhodes, 2010). The resulting rubric included four performance levels (from 1 to 4) for six dimensions related to organization, content, comprehension, delivery, visual aids, and time. By using a collaborative and participatory approach to rubric development, we sought to validate rubric content, ensure familiarity of faculty participants with the rubric, and minimize scoring differences among project participants.

Exercise 1 asked students to assess the value or importance of a particular species, and exercise 2 to research and present convincing evidence for an area to be considered a high priority for conservation. Each exercise consisted of two parts: 1) an introduction to the main concepts of the exercise’s topic, and 2) detailed instructions to prepare a 5-minute oral presentation.

To measure OC gains at the individual student level, each student delivered an oral presentation for each exercise. Students had at least two weeks to prepare presentations. Scores from both exercises contributed towards students’ grades.

We measured reliability of the OC exercises 1 and 2 by assessing their internal structure or consistency. The Cronbach’s alpha coefficients (Cortina, 1993; Bunce *et al.*, 2010) obtained in a pilot study conducted at Princeton University in the Spring 2011 (N=21 students; 0.6 and 0.7 for exercises 1 and 2, respectively) and this study (N=238 students; 0.6 for both exercises) indicate an acceptable internal structure of these assessments following the criterion of Bowling (2002; alpha ≥0.5).

To assess students’ content knowledge on the topics of the exercises, we developed a short pre/post content assessment questionnaire for each exercise (Figure 1). We validated the content by interviewing six volunteers using a one-on-one interview format. We evaluated the interviewee’s rationale used to construct answers (Beatty and Willis, 2007), and thus eliminated questions with limited ability to measure content knowledge. The final questionnaire contained a comparable total number of points for both exercises (18 and 15, respectively). We developed an instructors’ scoring guide with the correct answers, a solution rubric, and criteria for assigning points to each answer.

We administered the questionnaires before and after students completed an exercise in a pre/post fashion (Figure 1). The pre-assessments took place before students received either a lecture on the exercise topic or the exercise itself as an assignment. Each questionnaire required about 10 minutes for students to complete. The scores of the pre/post assessments were not graded, but students did receive some fixed credit for participation.

After data collection, we post-validated the questionnaires for exercises 1 and 2. We excluded questions that had ≥70% perfect score on the pre-assessment (following Smith *et al.*, 2008), and those for which faculty users reported a poor match with the exercise content or the solution rubric. Final analyses included three multiple choice, one fill in the blank and two open-ended questions for exercise 1 and four multiple choice and one open-ended question for exercise 2.

To assess changes in student self-assessment, we developed a Likert-scale (1-5) survey that included three questions on students’ self-confidence with their OC skills. We validated this tool by requesting feedback from faculty participants during its development. Instructors used the same tool at the beginning and end of the semester as a pre and post-assessment, respectively (Figure 1). Self-assessments did not count towards students’ grades.

To assess the effect of instructor emphasis on individual OC skill gains over a semester, we developed instructions and materials for a light and an intensive teaching intervention. We implemented the teaching interventions between exercises 1 and 2 (Figure 1), during lecture or lab time. All students, under both interventions, received the rubric at the outset of the semester. In the light intervention, students received their scored rubric from exercise 1. If questions occurred, professors answered them during class but limited the total discussion to no more than 10 minutes. At the end of the discussion, professors reminded students that the same rubric would be used to evaluate their performance for exercise 2 later in the semester.

For the intensive teaching intervention, after students completed exercise 1, professors introduced students to the importance of OC skills and the use of rubrics. Then, students watched a 4-minute oral presentation on video, graded it with the OC rubric and discussed possible scores for it in small groups. Once students increased their familiarity with the rubric, each of them individually reviewed her/his own performance of exercise 1, and reflected on how to improve her/his OC skills. For this, each individual student received the rubric scores for her/his presentation as well as a video of it to watch at home. Students then turned in an answer to the following questions: *which of the presentation criteria/elements in the rubric do you think is the most challenging for you, and what could you do to overcome that difficulty?* The intensive intervention activity required 45-50 minutes of class. The activities for the teaching interventions were not graded, but students did receive some fixed credit for participation.

***Statistical analysis***

To evaluate gains in OC skills, we determined the normalized change (*c*) for each student who completed both exercises. A *c* value ranges from -1 to 1 and represents the ratio of the observed change to the total possible change (Marx and Cummings, 2007). We first converted the total points obtained from the rubric scores for each exercise (maximum of 24 points) to a percentage (up to 100) and calculated a *c* value for each student as follows:

(1)

(2)

(3)

(4)

We then calculated the average normalized change ± standard error of the mean for all students grouped by teaching intervention.

To determine which students improved the most, for each teaching intervention, we compare *c* values of students whose scores for exercise 1 fell below the median of exercise 1 with those above or equal to the median. In addition, we compared total points obtained in exercise 1 with points of exercise 2. To determine changes at rubric dimensions, we compared the points from each dimension (4 points maximum) for exercises 1 and 2. Alpha values received Bonferroni corrections (Gotelli and Allison, 2004). For all comparisons we used a paired Wilcoxon signed-rank test (Crawley, 2007).

To assess student self-confidence, for each individual student, we averaged the scores for the three Likert-scale (1-5) self-assessment questions of pre and post self-assessments. With each paired average score, we calculated the normalized change for each individual student. In addition, we compared the average scores of each pre- versus post-assessments question using a paired Wilcoxon signed-rank test (Crawley, 2007). Alpha values received Bonferroni corrections (Gotelli and Ellison, 2004).

We analyzed the content gains for each exercise. For each pre/post paired content assessment, we calculated the normalized change using the percentage scores. With these values, we then calculated the average normalized change and the standard error for the whole class. We also compared the total percentage score of the pre- versus the post-content assessments using a paired Wilcoxon signed-rank test (Crawley, 2007) with a Bonferroni adjustment for the alpha values. We conducted these analyses for the light and intensive teaching interventions.

We explored the correlation between the normalized change values of skill and self-confidence, as well as the correlation between the normalized change values of skill and the average gain in content knowledge for exercises 1 and 2, using Spearman correlation analysis. We explored correlations in the whole dataset as well as segregated by teaching intervention.

We tested for the effect of instructor emphasis on individual OC skill gains using the light versus intensive teaching interventions with a linear mixed-effects model (LMM). We used the percentage score difference between exercises 2 and 1 as a response variable and institution as a random factor (Faraway, 2006). We tested for normality and homogeneity of variances of the response variable previous to conducting the analysis. We used the difference between percentage scores of exercise 2 and 1 because normalized change values do not meet a normal distribution requirement and do not have a known distribution.

All calculations and statistical analyses were performed in R (R Development Core Team, 2012) with code developed by A. Bravo.

**Results**

Students gained in OC skills within a single semester. On average, students improved their performance by 24% with the light teaching intervention and by 40% with the intensive teaching intervention (Table 2). Paired comparison of total points obtained in exercises 1 and 2 for the light and intensive teaching interventions support these results (Figure 2).

With the light teaching intervention, students with exercise 1 scores below the median showed higher gains than students with scores equal or above the median (Table 2). In average, they improved their scores of 71% to 79% (Figure 3a). Furthermore, 70% of these students reported positive gains (Table 2). On the other hand, students above or equal to the median did not change their average score. Some of these students gained in skill (Table 2).

We found similar results for students in courses with an intensive teaching intervention (Table 2). Students below the median significantly improved the average score of 72% to 86% (Figure 3b) with 93% of these students gaining skills. In agreement with results from the light teaching intervention, students above or equal to the median did not show significant change in their average scores (Table 2, Figure 3b). On average, they gained 30% in OC skill, with 51% of the students reporting positive gains

In a detailed analysis for each OC dimension, we found that the level of students’ improvement on these dimensions varied between the light and intensive teaching interventions (Table 3; Figure 4). Under the light teaching intervention, students significantly improved in only two of six dimensions: *Delivery and language* and *Visual aids and text* (Table 3). On the other hand, in courses that used the intensive teaching intervention, students significantly improved in five out of six dimensions measured by the rubric (Table 3). When we examined the distributions of students across levels of performance for exercises 1 and 2, we found that most students already exhibited high levels of achievement for *Organization* and *Student comprehension* (Figure 4a and c, respectively). For the other four dimensions each showed slightly different patterns (Figures 4b, d, e and f, respectively) under the different teaching interventions.

We found a gain in students’ content knowledge for exercises 1 and 2 with the light and intensive teaching intervention (see Table 4). We observed significant gains between the pre- and post-content assessment scores for exercise 1, but no significant changes occurred for exercise 2 (Table 4).

We found a significant increase in students’ self-confidence on their abilities to distinguish, prepare, and deliver an effective oral presentation over the course of a semester when using the IU with the light and the intensive teaching interventions (Table 5). In addition, most students went from being somewhat confident to highly confident for all three tasks under both teaching interventions (Figure 5).

We did not find a correlation between gains in OC skills and self-confidence or between gains in OC skill and content knowledge (Figure 1S).

We found a significant effect of the intensity of teaching intervention on skill gains (N=229 students; F (1,224) = 6.437; P = 0.01). With the light teaching intervention 50% of students gained skills (N=96) compared to 70% with the intensive teaching intervention (N=133; Figure 6).

**Discussion**

Our results clearly show that instructors using the Instructional Units developed as part of this study observed a gain in student OC skills within a single semester, and that the intensity of teaching method positively influenced the gains observed. Professors who implemented the intensive intervention, wherein they explained the importance of communication skills and fostered practice and self-reflection in students, noted almost a doubling in improvement over the light intervention where students received more passive feedback.

This supports other studies showing the benefits of case study-based exercises and student independent data analysis and research in association with OC assignments (Noblitt *et al*., 2010). Other studies affirm that assessment, both self- and peer-based, engages students actively in their own learning process (Ozogul and Sullivan, 2009), and video documentation enhances this process. The use of video for self-assessment and reflection has a long history in teaching for some fields (Hammoud *et al.*, 2012) with evidence of effective teaching from across disciplines spanning from foreign language training to medicine (Silliker, 1994; Castañeda, 2011). Tatar *et al.* (2010) even noted the efficacy of video and self-reflection in learning other process skills such as team building and management. Video use has the potential to increase in classrooms as technological advancements simplify the logistics.

However, Hammoud *et al.* (2012) discussed several studies where video review with self-assessment showed limited effectiveness without standards (such as the use of rubrics and models of effective communication) and feedback from faculty and peers. We believe self-reflection after review of individual video presentations and feedback from professors together provided the critical components to student success in our study. We advocate for more research in this area to discover the ideal combination of efforts.

Practice, including watching effective communication, as well as designing and implementing a presentation, provides students with a baseline for comparison and improvement and likely promotes increased self-efficacy (Trujillo and Tanner, 2014). In our study, we witnessed a boost in students’ perceptions of their confidence in OC, and their ability to recognize, prepare, and execute a quality oral presentation. Although students worked diligently and received quality grades for the first species-level talk, this presentation ultimately served as a “first go” at mastering such skills and laid the groundwork for improvement.

The assessment of repeated assignments parallels a scaffolding approach used to improve scholarly writing in students, widely adopted through programs such as Writing Across the Curriculum (Bazerman *et al.* 2005; Thaiss and Porter 2010; Gazza *et al.*, 2012). Repeating an oral assignment within a semester gave students opportunities to “revise and resubmit” as they may do with papers. Kolber (2011) found a similar increase in student OC performance in senior biology students for both individual and group presentations repeated over the course of one semester. Consequently, we recommend that future efforts try to incorporate more opportunities to reflect and revise.

The improvement in OC performance with more intensive intervention affected more dimensions of the skill (five out of six), whereas the (lower) improvement in skills for the light intervention only noticeably surfaced in the *Delivery and language* and *Visual aids and text* skills. In the light intervention, we speculate that students only fixed the ‘surface-level’ problems of poor quality slides or simple delivery errors (i.e. no eye contact, excessive use of pet words, speaking too quickly, or simply not practicing at all). These two dimensions of *Delivery* and *Visual aids* also contain elements that students can likely self-assess better than dimensions like *Student comprehension* or quality of *Supporting evidence* that rely partially on the experience of the instructors. With the intensive intervention, faculty sought to engage students at a deeper level that touched on all parts of the rubric. This included answering questions about how best to integrate supportive evidence and what presentation strategies help showcase student comprehension. In the intensive intervention, these more sophisticated dimensions likely boosted self-efficacy (Trujillo and Tanner, 2014) as students gradually got more comfortable with a topic. Using the rubric in a “formative” manner – repeating its use across the two exercises – probably helped students to focus and partially explains the skill increase within the semester.

For students who read the directions, the substantially structured assignment also probably facilitated organization from the beginning of the exercise. Instructors felt that students might not have examined the rubric closely before the first presentation. However, after reflection and faculty feedback, students intentionally reviewed the rubric criteria, accounting in part for higher scores later in the semester. In addition, we noted that students who scored below the median, in comparison with those who scored at or above the median, exhibited greater gains in student skill improvement. Consequently, the overall approach of aligning exercise rubrics and teaching interventions may be fundamental to bringing up lower performing students in a classroom.

Panadero and Jonsson (2013) found that formative use of rubrics facilitated assessment transparency, which may reduce student anxiety. Formative rubric use also appeared to aid the process of providing feedback, improved student self-efficacy, and supported student self-regulation, all potentially resulting in enhanced student performance (Dunbar *et al.*, 2006; Panadero and Jonsson, 2013; though see Reddy and Andrade 2010 for challenges in rubric use).

Our study design did not focus on the mechanism of the intensive intervention and we did not examine the relative impact of these activities versus using rubrics or watching a good presentation by other students. The management of videos and sharing with individual students proved cumbersome so most instructors opted to provide only one video experience for assessment purposes (Exercise 1). Ideally students would have been able to compare both of their presentations in video format, and pre- and post-videos would have allowed instructors to randomize and independently score presentations to decrease the potential for bias in instructor scoring. Nevertheless, we reduced scoring bias by separating data from exercises 1 and 2 into discrete data collection sheets so instructors could not see the student’s first score when entering the second. Instructors received specific instruction not to refresh their memories regarding exercise 1 prior to scoring exercise 2. Future efforts need to streamline handling of large video files while still maintaining student privacy.

In terms of confidence, we found significant gains at the end of the semester in several elements including the students’ confidence in their ability to distinguish effective from ineffective presentations and to prepare and deliver effective oral presentations. Although our study design only allows for a preliminary assessment of the correlation between confidence and skills, the lack of evidence for a correlation is important to note, as self-assessed confidence is often used as a proxy for skill development.

We observed statistically significant gains in content knowledge for exercise 1, and slight, but non-significant gains for exercise 2. The other IUs designed and applied in the course of our study that focused on data analysis and critical thinking produced different results. We observed significant gains in content in relation to all exercises in those units (Bravo *et al.*, submitted; Porzecanski *et al.*, in prep). We hypothesize that the results obtained in OC could be related to students’ familiarity with the idea of habitat value (the subject of exercise 2), compared to the value of a specific species (the subject of exercise 1), which could have contributed to higher pre-test results.

Overall, we interpret these results as evidence that attention to skills development appears compatible with the development of content gains and that process skill practice can benefit students in many different kinds of courses. Students can improve certain elements of their OC skills in a short time period with the added benefit of knowledge gains. An emphasis on process skills by instructors, through more intensive practice, or through more opportunities to practice during a full program of study, could result in even more substantial gains.

Two oral presentations per student, even short presentations, plus the instructor interventions proved time intensive. Instructors are often hard-pressed to adequately treat all of the essential topics of a course in a semester, and our courses certainly faced this challenge. However, from the instructors’ standpoint, the learning and practice of authentic process skills was worthwhile; students improved in skill and confidence in presenting professional talks on conservation science. Moreover, students seemed to appreciate learning the material presented by their peer students, and were engaged and motivated to do good presentations themselves. We believe that the assignment of the talks and associated exercises helped students better see the relevancy of the course content. It would be worthwhile to further investigate this potential benefit of oral exercises in conservation science coursework.

From our experience, practice alone without an accompanying analysis of performance proves less effective and we recommend that students be given the opportunity to reflect in a structured way before and after they speak. As with scaffolding writing, the process of drafting and revision takes time. Some professors in our study thought that the second round of talks met their expectation for quality improvements, whether or not the students critically reflected on their actions. Others felt that students who took the reflection element seriously experienced intangible learning gains that will serve them well into the future.

While the design of this project across multiple institutions magnified organizational challenges, we feel the results are more robust than work carried out within one classroom or one institution. We recommend further work be undertaken at this scale to broaden existing cross-institutional work (Hagenbuch *et al.* 2009; Gormally *et al.* 2012, Gottesman and Hoskins 2013) and to better understand development of process skills for biodiversity conservation.

In sum, oral communication is a key component of successful scientific engagement in societal issues such as conservation. Training in process skills and content are equally important for understanding and “doing” conservation. This study shows that we can engage skills training without compromising content.

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**Figures**



Figure 1. Experimental design and main questions within and across semesters. The discontinuous arrow between Light and Intensive Teaching Interventions indicates an interchangeable order. Abbreviations are as follows: SSA = Student-self assessment; CA = content assessment; ex 1 = exercise 1; ex 2 = exercise 2; and TI = teaching intervention.



Figure 2. Total points obtained in exercises 1 and 2 in courses that used the instructional unit with the light (V = 865.5; \*\**p* < 0.01) and intensive (V = 1054; \*\*P < 0.01) teaching intervention (TI). Box plots show the median, upper and lower quartiles, highest and lowest data values.



Figure 3. Average scores for exercises 1 and 2 of students that scored above or equal and below the median in courses that used the IU with a light teaching intervention (a) and an intensive teaching intervention (b). Asterisk indicates significant differences (\*\*P<0.01) and n.s. indicates no significant differences (P>0.05). Error bars are SE of the mean. (a) N= 50 and 46 respectively for students below and above the median; (b) N= 59 and 74 respectively for students below and above the median.



Figure 4. Frequency distribution of students’ performance within the four levels of proficiency for oral communication skills (1=lowest, 4=highest) when using the instructional unit with the light (N= 96 students) and intensive (N=133 students) teaching interventions. Asterisks indicate significant differences (\*\*P<0.001 and \*P<0.008) and n.s. indicates no significant differences (P>0.008) between the pre and post-assessment rubric scores Bonferroni corrected.



Figure 5. Frequency distribution of students’ self-assessed confidence levels with their oral communication skills when using the instructional unit with the light (N=76 students) and intensive (N=129 students) teaching interventions. One and two asterisks indicate significant differences between pre and post-assessments scores with P<0.016 and P<0.003, respectively, and n.s. indicates no significant differences (P>0.016) Bonferroni corrected.



Figure 6. Comparison of the effect of the intensity of teaching intervention on skill gains (N=229 students; F (1,224) = 6.437; P = 0.01). Light teaching intervention, N=96; intensive teaching intervention, N=133.



Figure 1S. Correlation plots between gains in OC skills and self-confidence (N = 203 students; rho = 0.006; P = 0.9) and between gains in OC skill and content knowledge (N=186 students; rho=0.19; P = 0.8).

Table 1. Institution type, student level, class size and implementation schedule of the courses that used the oral communication instructional unit with the light (light gray box) and intensive (dark gray box) teaching intervention.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Institution type** | **Course** | **Student level** | **Class size** | **Fall**  **11** | **Spring 12** | **Fall**  **12** | **Spring 13** |
|  |  |  |  |  |  |  |  |
| Baccalaureate College - Arts & Sciences | Biodiversity | Freshman | 25 students\* |  |  |  |  |
| Research University | Ecology | Sophomore | 30 students |  |  |  |  |
| Baccalaureate College - Diverse Fields | General Ecology | Sophomore | 15-20 students |  |  |  |  |
| Master's College and University | Primate Conservation Biology | Sophomore - Senior | 15 students |  |  |  |  |
|  |  |  |  |  |  |  |  |

(\*) Multiple sections of this course used the IU with light and intensive teaching interventions.

Table 2. Overall average gains for science courses that used the instructional unit for data analysis with the light and intensive teaching interventions (TI).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Light TI** | | | **Intensive TI** | | |
|  | N (%)a | Skill gains (*c*ave ± SE)b | *P* | N (%)a | Skill gains (*c*ave ± SE)b | *P* |
| Courses | 96 (52) | 0.24 ± 0.04 |  | 133 (70) | 0.40 ± 0.03 |  |
| Median score (%) | 79 |  |  | 83 |  |  |
| Below median | 50 (70) | 0.30 ± 0.05 | \*\* | 59 (93) | 0.52 ± 0.03 | \*\* |
| Equal to or above median | 46 (33) | 0.17 ± 0.05 | n.s. | 74 (51) | 0.29 ± 0.04 | n.s. |

(a) Percentage of students that gained skills in parenthesis; (b) average normalized gains ± mean standard error; \*\* P < 0.01; and (n.s.) no significant gains between exercises 1 and 2 using a paired Wilcoxon signed-rank test.

Table 3. Changes observed between the pre and post-assessment scores for the six dimensions of oral communication skills when using the instructional unit with a light and an intensive teaching intervention.

|  |  |  |
| --- | --- | --- |
|  | **Light Teaching Intervention (N = 96 paired tests)** | **Intensive Teaching Intervention**  **(N = 133 paired tests)** |
| ***Skill dimensions*** |  |  |
| Organization | V = 273 | V = 60\*\*\* |
| Content and supporting evidence | V = 570 | V = 334.5\*\*\* |
| Student comprehension | V = 414.5 | V = 161\*\*\* |
| Delivery and language | V = 222\* | V = 420\*\*\* |
| Visual aids and text | V = 380\*\*\* | V = 862\*\*\* |
| Timing | V = 852 | V = 1115.5 |

\*P < 0.05; \*\*P < 0.01; \*\*\*P < 0.001; V = values for the paired Wilcoxon signed-ranked test.

Table 4. Gains in students’ content knowledge measured as the average normalized change (*c*ave) and changes in scores (%) between the pre and post-content assessments of exercises 1 and 2 when using the instructional unit with the light and intensive teaching interventions (TI)

|  |  |  |  |
| --- | --- | --- | --- |
|  | | **Light TI** | **Intensive TI** |
| ***Content assessment*** |  | |  |
| *Exercise 1* |  | |  |
| N (paired assessments) | 76 | | 120 |
| Gains *(c)* | 0.24 ± 0.04 (SE) | | 0.21 ± 0.03 (SE) |
| Pre- vs. post-scores (%) | V= 392\*\*\* | | V=788\*\*\* |
| *Exercise 2* |  | |  |
| N (paired assessments) | 67 | | 118 |
| Gains *(c)* | 0.12 ± 0.05 (SE) | | 0.1 ± 0.03 (SE) |
| Pre- vs. post-scores (%) | V=402 | | V=1152 |

\*\*\*P < 0.001

Table 5. Total normalized change and changes in students’ self-confidence with their oral communication skills before and after using the instructional unit with the light and intensive teaching interventions.

|  |  |  |
| --- | --- | --- |
|  | **Light Teaching Intervention** | **Intensive Teaching Intervention** |
| ***Student-self assessment*** |  |  |
| N (paired assessment) | 76 | 129 |
| Gains *(c)* | 0.3 ± 0.04 | 0.31 ± 0.03 |
| Confidence to distinguish an effective from an ineffective oral presentation | V = 209 | V = 207\*\* |
| Confidence to prepare an effective oral presentation | V = 93\*\* | V = 310.5\*\* |
| Confidence to deliver an effective oral presentation | V = 240\*\* | V = 598\*\* |
|  |  |  |

\*P < 0.016; \*\*P < 0.003; V = values for the paired Wilcoxon signed-ranked test.

Extra figures



Normalized change in courses the used the IU with LTI (no significant differences among them)



Gains in courses that used the ITI (no significant differences among them)