Using a Program-Wide Rubric to Assess Scientific Literacy Improvement of Students in the Integrated Plant Sciences Program at Washington State University

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Abstract

Like many Land-Grant institutions in the U.S., over the last decade, Washington State University (WSU) has consolidated several of its' former agricultural department-based, undergraduate degree programs and restructured them into multi-departmental, interdisciplinary programs. One such program is called Integrated Plant Sciences (IPS, ips.wsu.edu). The IPS program comprises six different majors: Agricultural Biotechnology, Field Crop Management, Fruit and Vegetable Management, Landscape, Nursery and Greenhouse Management, Turfgrass Management and Viticulture and Enology. This successful program currently has more than 250 undergraduate students enrolled. To assess the quality of student work in the IPS program, a rubric with seven student-learning outcomes (SLOs) was used. We focused on two of these SLOs in this study. They were scientific reasoning and the use of scholarly information (e.g., obtaining, evaluating, and applying). We used this program-wide rubric to compare the quality student work in both an introductory (HORT/CROP_SCI 202 "Crop Growth and Development") and senior-level course (SOIL_SCI 441 "Soil Fertility"). In particular, we focused on final projects submitted by student teams. In the former course, this was a final research poster summarizing a semester-long, greenhouse-based plant growth and development research project. In the latter course, this was a final nutrient management plan created for a "real-world" plant-soil system of interest (e.g., commercial orchard, vineyard, etc.). Course instructors provided samples of representative student work (e.g., "A", "B", and "C" grade-level) but did not disclose student grades. For each of the two courses, members of the IPS assessment committee received copies of representative student final projects, the student assignment prompts and the program-wide assessment rubric. Assessment committee members used the rubric to independently evaluate and rank the student projects on scale of 1 point (minimal) to 6 points (mastery). Following their independent evaluation, the assessment committee came together and participated in a facilitated discussion with a university teaching and assessment specialist. The purpose of this discussion was to compare and norm our project ratings and to determine a critical threshold score that was expected for student proficiency. Student team proficiency for these SLOs at both the freshman and senior level and the benefits and limitations of using a program-wide assessment rubric will be presented and discussed.

Background

Cerny-Koenig et al. (2007) reported early steps at WSU toward developing a program-level assessment plan for plant and soil science students that aligned with university learning goals. Since that time, the interdisciplinary IPS degree program was established that comprises six different undergraduate majors as noted above. IPS program graduates will achieve mastery in each of seven program-level student learning outcomes (SLOs): **1. Apply scientific and quantitative reasoning to address real world problems in plant production and management systems;** 2. Understand the growth and development of horticultural and agronomic crop plants, current management practices, and factors that influence yield, aesthetics, and end-use quality; 3. Integrate skills, facts, concepts, principles and research methods from plant and other sciences in order to actively participate in a wide variety of environmental and agricultural activities, including research, outreach, education and management; 4. Understand and appreciate the importance of horticultural and agronomic crop plants to global society, and use this knowledge to contribute to the welfare of global society; **5. Obtain, evaluate, and apply scholarly information to expand understanding and knowledge-base of the plant sciences;** 6. Communicate effectively to a broad range of audiences using appropriate traditional and emerging technological media; and 7. Appreciate the breadth and depth of professional opportunities in plant science.

The preparedness of college graduates for the working world involves a combination of academic coursework and training, research projects, internships, summer jobs, etc. Fabris (2015) noted that there is often a disconnect between the college graduates' perception of their job readiness versus the reality of their readiness as noted by employers. In particular, based on a survey of 400 executives and 613 college graduates, he noted that students had a much higher self-assessment than employers did for many job-necessary skills. Half a dozen skills were noted with particularly large gaps between student and employer evaluation. One of these was the skill of "locating, organizing, and evaluating information". Other skills included "critical/analytical thinking, analyzing/solving complex problems, and applying knowledge/skills to real world" (Fabris, 2015). As we have interacted with and interviewed industry partners who provide student internships, participate in our classes and often employ our graduates, we have been informed that some of our graduates have similar deficiencies. Further, it was emphasized to us that students needed more experience working on teams.

Approach

One attempt to enhance the job skill preparedness of our graduates has been the development of a senior-level capstone course that partners student teams with industry to solve real-world problems (Layne et al., 2017). Another approach, involves incorporating semester-long, student team-based research projects in courses ranging from the introductory to senior level. In order to determine how our students were progressing in skill scaffolding from introductory to senior level work, we chose two representative classes (HORT/CROP_SCI 202 "Crop Growth and Development" and SOIL_SCI 441 "Soil Fertility") that incorporated such projects. We utilized our program level rubric to assess student final projects and focused on IPS program SLOs 1 and 5 (above, in **bold**) emphasizing scientific reasoning and the use of scholarly information (Tables 1 and 2 respectively).

Data Collection

For both courses, we asked instructors to provide us with the following: i. assignment prompt; ii. assignment evaluation rubric; and iii. representative examples of student projects spanning the "A" to "C" grade levels. Student grades for the projects were not shared with evaluators. For the HORT/CROP_SCI 202 "Crop Growth and Development" course, the project evaluated was a traditional research poster from the Spring 2017 semester (Figure 1). For the SOIL_SCI 441 "Soil Fertility" course, the project evaluated was a final research report from the Spring 2016 semester. Project evaluation was conducted by members of our AFS/IPS program assessment team which includes representative teaching faculty from the interdisciplinary program (Figure 2) with help from specialists in the university office of Assessment of Teaching and Learning (ATL) at WSU. For each of the two courses noted there were five faculty evaluators of student work.

In 2016, the procedures for the SOIL_SCI 441 "Soil Fertility" project evaluation were: i. Team members were provided with the two program-level evaluation rubrics, assignment prompt, and four representative samples of student work to evaluate on their own using the supplied rubrics; and ii. An ATL specialist facilitated a meeting with team members to share their project ratings, critique and be "normed" to the two program rubrics, and discuss what an appropriate minimum "cut point" score (1-6) would be expected for a graduating senior for these SLOs.

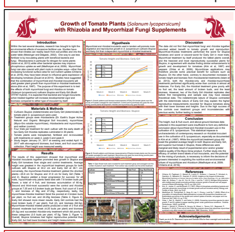

Figure 1: Representative student poster

Figure 2: AFS/IPS assessment team evaluating HORT/CROP_SCI 202 student posters and discussing the two program assessment rubrics in August, 2017

Table 1: Revised IPS program-wide developmental rubric for scientific reasoning.

Scientific Reasoning. Students apply scientific and quantitative reasoning to address real world problems in plant production and management systems. Students can use scientific and quantitative methods to identify research problems, explore associated issues and analyze problems. *Notes: Partially Successful* indicates that the student attempted to do something and may not have succeeded or may have applied this skill or knowledge inconsistently, inaccurately, or with minor errors or gaps. Some criteria may not apply to a given assignment or performance. **(Annotated after norming session 8.29.17).** *Rater#___ Poster#___*

SCORE	CRITERIA	Absent	Basic		Developing		Advanced	
		(0)	Partially Successful (1)	Successful (2)	Partially Successful (3)	Successful (4)	Meets Expectations for Graduating Seniors (5)	Exceeds Expectations (6)
	Generates a scientifically plausible hypothesis		• Describes a relevant issue in crop growth, development and production • Suggests hypothesis based in knowledge of crop growth, development and production issues • Identifies and classifies crops and production systems using scientific terms		• Identifies a gap and a hypothesis that can be investigated using scientific method • Proposes a manageable hypothesis grounded in knowledge of crop growth, development and production issues • Identifies crop and production issues relevant to hypothesis testing		• Proposes a focused, testable hypothesis • Identifies novel or understudied approach to critical issue in crop growth • Explains crop growth, development and production issues relevant to hypothesis testing • Describes limitations of hypothesis	
	Uses scientific knowledge to inform experimentation and analysis		• May utilize a combination of scientific and non-scientific information in experiment design and implementation • Relies on one scientific approach to frame experimentation and analysis • Describes elements of experiment		• Uses scientific literature to justify experiment and analysis techniques • Provides multiple, relevant scientific sources for particular study or experiment • Explains elements of crop production systems in experiemental design		• Situates study within relevant scientific literature • Synthesizes relevant scholarly information to improve research design, practices, and/or data analysis • Utilizes innovative experiment or analysis techniques	
	Employs scientific methods of inquiry		• Identifies scientific methods to be used to test hypothesis • Collects scientific data, though collection and documentation may be incomplete • Describes scientific dataset collected		• Describes scientific methods employed to test hypothesis • Applies established scientific methods relevant to topic under study • Collects and documents full scientific data • Describes scientific dataset accurately		• Explains reasons for employing specific methods and relationship to hypothesis • Utilizes solid scientific methods to test hypothesis, may use novel methods • Applies techniques from relevant scientific disciplines or subdisciplines • Organizes & describes scientific dataset accurately	
	Uses scientific evidence and data to investigate and evaluate crop production issues		• Describes research findings • Utilizes appropriate scientific terms to identify elements of research findings • Identifies relationship of research findings to issues in crop production		• Describes fully study's findings • Explains how scientific findings address crop production practices • Evaluates how scientific study creates knowledge • May incorporate relevant scientific literature into analysis		• Analyses research findings completely, including identifying limitations of research • Research study investigates relevant issues in crop production • Synthesizes research findings and scientific literature to examine critical issues in complex crop production systems	
	Provides a logical conclusion and/or recommendation based on findings		• States a general conclusion, based at least partly on scientific findings • Research findings are used to support conclusions, though may be superficial or inacccurate. • Conclusion identifies relevant crop production issues, though may also include personal bias or irrelevant discussion		• States a conclusion that addresses relevant crop production issues • Integrates research findings and scientific knowledge of food systems • Illustrates causal and correlationships in study, when relevant • Presents knowledge using appropriate scientific terminology and data formats		• Articulates a logical conclusion, based in synthesis of knowledge of crop production issues and research findings • Explores how research study contributes to scientific knowledge of crop production systems • Distinguishes causal and correlational relationships • Presents knowledge accurately, using academic language, appropriate to format/mode	

Table 2: Revised IPS program-wide developmental rubric for scholarly information.

Scholarly Information *Rater#_ Poster#_*

IPS Learning Outcome: Students appropriately identify all information needs, and evaluate and use a wide variety of high quality sources that are relevant, balanced and up to date (*IPS REVISED PROGRAM RUBRIC*: 8.14.17)

Notes: *Partially Successful* indicates that the student attempted to do something and may not have succeeded or may have applied this skill or knowledge inconsistently, inaccurately, or with minor errors or gaps. Different kinds of student work demonstrate some skills and not others; some criteria may not apply to a given assignment or performance. **(Annotated after norming session- 8.29.17)**

SCORE	Criteria	Absent	Basic		Developing		Advanced	
		(0)	Partially Successful (1)	Successful (2)	Partially Successful (3)	Successful (4)	Meets Expectations for Graduating Senior (5)	Exceeds Expectations (6)
	Determines the extent of information needed		• Presents a research question which may be explicit or implicit • Identifies basic information needs appropriate to the general research question or focus and finds some resources		• Formulates a focused and clear question • Identifies concepts related to the topic, and finds a sufficient number of information resources to meet the information need • Specifies what type of information will be useful		• Formulates a focused, clear, and complete question; may be complex or original • Identifies key concepts and terms related to the topic, and identifies extensive information resources • Redefines statement of need for information to direct future searches	
	Evaluates information and its sources critically		• Identifies sources which are scholarly, scientific and/or current		• Identifies sources which are **relevant** scholarly, scientific and/or current • Distinguishes between information which is objective and that which is biased		• Compares and evaluates multiple and diverse sources and viewpoints of information according to specific criteria, such as authority, credibility, relevance, timeliness, and accuracy appropriate for the discipline. • Matches criteria to a specific information need, and articulates how identified sources relate to the context of the discipline	
	Uses information effectively		• Uses appropriate information to describe, compare and contrast processes and systems		• Uses appropriate information to solve a problem, answer a question, or other intended purpose • Provides conclusions based on information		• Synthesizes, integrates and communicates information from a variety of sources, with clarity and depth • Draws appropriate conclusions based on information and builds upon them	
	Cites sources and provides bibliography		• Cites sources • Bibliography/references are provided		• Cites relevant sources in correct format • Bibliography/references are fairly complete and acceptably-formatted		• Cites multiple and diverse sources appropriately in correct format • Bibliography/references are complete and professionally-formatted	

Data Collection (continued)

Prior to the 2017 evaluation of HORT/CROP_SCI 202 "Crop Growth and Development" posters, ATL specialists and the Program Director reviewed the program-level rubrics used in 2016 for their suitability to assess work at the introductory/freshman level. We noted that the rubrics were suitable for assessing work at the senior level but they failed to adequately measure and allow us to see student skill development throughout the program. As a result, we made revisions to the rubrics to focus on developmental stages (basic, developing, advanced) and what "Partial" success looked like (Tables 1 and 2). Team members were provided with the two revised IPS program-wide developmental rubrics and the assignment prompt to review ahead of time. Student names were redacted from all posters and an ATL specialist facilitated a norming and poster scoring session. This session included familiarizing evaluators with the assignment and the revised rubrics. Evaluators were calibrated together by evaluation of two representative posters. Finally, a total of 10 student posters were evaluated by the team with each evaluator reviewing a total of 5 posters. At the end of the session, rubrics, rating process and next steps were discussed. Poster evaluations were submitted to ATL specialists who analyzed the results and provided a written report and recommendations.

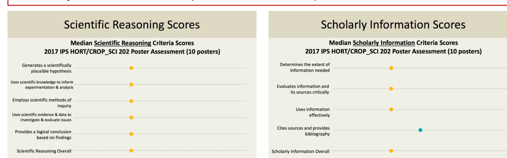

Figure 3: Median scores for 10 posters each for evaluation criteria related to scientific reasoning (left) and scholarly information (right) for HORT/CROP_SCI 202 student posters

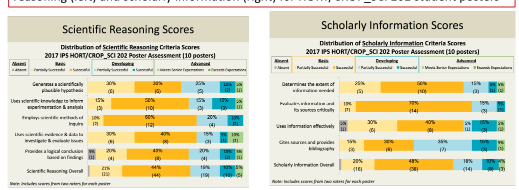

Figure 4: Score distribution for 10 posters each for evaluation criteria related to scientific reasoning (left) and scholarly information (right) for HORT/CROP_SCI 202 student posters

Results and Discussion

The original program level rubrics used in 2016 were suitable for measuring student success criteria for the two IPS program SLOs for graduating seniors. However, they failed to adequately capture skill development of students at different stages in the program. The revised rubrics provided both the ability to measure student performance at/near the end of the program while also serving as a developmental rubric, allowing us to measure skills throughout the program. Once reviewers were "normed" to the rubrics, their independent evaluations of student project posters were largely within one point of each other on the rubric scale. Norming faculty using "anchor" poster examples (representative of "A" grade level, for example) significantly enhanced the reviewer evaluation agreement, accuracy and speed with which samples of student work could be evaluated. In the case of the introductory HORT/CROP_SCI 202 "Crop Growth and Development" course, scores for both scientific reasoning and scholarly information had a majority of students at the basic successful level (our "cut point") or above (Figures 3 and 4, respectively). For the senior level SOIL_SCI 441 "Soil Fertility" course, scores for both scientific reasoning and the use of scholarly information were near or at the advanced, meets expectations for graduating seniors, "cut point" level (data not shown). The process of assessment faculty "test driving" the rubrics with real assignments, discussing wording and negotiating rubric revisions was powerful to develop buy-in for future use in enhancing other courses. As noted by Jonson et al. (2014), faculty participation in this process can be used to both improve the courses we teach and the student learning outcomes achieved. This may help to narrow the skill gap noted between employers and student graduates (Fabris, 2015).

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