

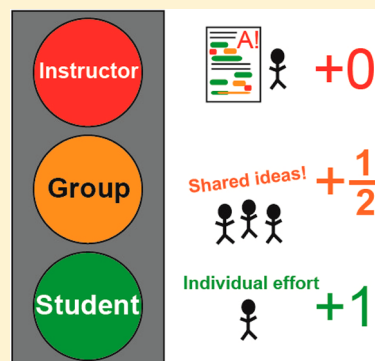
# Stoplight Quizzes: A Multilevel Assessment Strategy for Lecture and Laboratory Courses

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**S** Supporting Information

**ABSTRACT:** A multilevel assessment strategy, called the stoplight quiz, has been developed and implemented in analytical chemistry courses. Stoplight quizzes are given in three phases, individual, group, and instructor, with three different ink colors that mimic a traffic light. In the individual phase, students record answers in green ink. This is followed by group work during which students can modify their answers with orange ink. The instructor later marks the work in red ink. Correct work in green receives full credit, correct work in orange earns half credit, and red marks receive no credit. This assessment technique has many positive outcomes including increasing student motivation and student understanding of material. Stoplight quizzes can be used in any chemistry course and applied in other disciplines as well.



**KEYWORDS:** Upper-Division Undergraduate, Second-Year Undergraduate, First-Year Undergraduate/General, Analytical Chemistry, Laboratory Instruction, Testing/Assessment, Instrumental Methods, Quantitative Analysis

There are many reports in this *Journal* on creative strategies for providing feedback to students about course progress.<sup>1–9</sup> Here a three-phase quiz, called a stoplight quiz, has been developed that provides students with multiple modes of feedback on progress and understanding via a three-stage, color-coded process:

1. Individual phase (green ink): Students take the quiz on their own, without any notes or outside assistance. Students record answers in green ink, and correct work in green earns full credit from the instructor.
2. Group phase (orange ink): Students discuss the quiz in small groups without any notes or additional outside assistance. They can choose to modify answers with orange ink, and correct work in orange is awarded half credit.
3. Instructor phase (red ink): Students turn in the quiz. The instructor writes correct answers in red, which receive no credit.

Stoplight quizzes were inspired by Fluckiger's three-color quiz for graduate students, which allowed knowledge-building in the following manner: students took an ungraded quiz individually, then with a group, and finally by consulting outside resources.<sup>10</sup> Use of three different ink colors (black, green, and blue) let students see where correct information was acquired.

Stoplight quizzes are distinct from the three-color quiz. Stoplight quizzes are graded and involve direct, instructor feedback as part of the process, which is important at the undergraduate level. Awarding credit for work produced from the group phase inspires thorough and thoughtful discussion, while the half-credit value discourages students from only

relying on the group portion. The instructor observes the group discussions but does not indicate if answers are correct or incorrect during the discussion phase. The instructor can provide verbal feedback about the quiz before the class period is over if it was apparent during the group discussions that there was a classwide misconception about a quiz concept. Stoplight quizzes are graded by the instructor in red ink but do not take more time to grade than a traditional quiz; thus, the grading workload does not increase.

In this way stoplight quizzes provide students with multiple modes of assessment and opportunities for peer learning without increasing instructor workload. Stoplight quizzes can be used for a variety of courses and laboratory classes, and it is appropriate for all styles of quiz or test questions, including multiple choice, short answer, and calculation-based questions.

## ■ STOPLIGHT QUIZZES

### Implementation

Stoplight quizzes were first implemented in Instrumental Analysis (CHM 341), which is a lecture-only course intended for juniors (description in the Supporting Information). Green pens were distributed by the instructor at the start of the assessment and collected from each student at the end of the individual phase. Students then were placed into small groups (typically three to four students) by the instructor. Orange pens usually were given out a few minutes into the group phase to promote discussion rather than copying. The group phase provided opportunities for students to learn from one another,

Table 1. Course Survey Results on Stoplight Quizzes (SQ) Used in CHM 341<sup>a</sup>

Statement	Mean Scores (SD)		
	Fall 2011	Fall 2012	Fall 2013
1. Compared with traditional quizzes, I felt more satisfied with my learning after taking SQ.	3.4 (1.3)	4.1 (0.8)	4.0 (0.9)
2. I prefer SQ over traditional quizzes.	3.5 (1.1)	4.0 (0.7)	4.0 (0.8)
3. I understand the material better after taking a SQ than I do after taking a traditional quiz.	3.3 (1.1)	3.9 (0.7)	3.9 (0.8)
4. The feedback/discussion with my peers helped me understand the material better.	3.5 (1.2)	4.2 (0.8)	4.2 (0.7)
5. The feedback from my instructor helped me understand the material better.	3.9 (1.0)	4.2 (0.6)	4.1 (0.9)
6. The SQ encouraged me to keep up with the course material.	4.1 (0.8)	4.3 (0.5)	4.2 (0.8)
7. The SQ encouraged me to keep up with the course material more than a traditional quiz would have.	2.8 (1.0)	3.8 (1.0)	3.7 (0.9)
8. The SQ helped me assess potential problem areas before exams/final.	4.2 (0.8)	4.1 (0.5)	3.9 (0.7)
9. I felt a responsibility to my peers to come well-prepared to the SQ.	3.9 (0.8)	4.0 (0.7)	3.8 (1.2)

<sup>a</sup>Likert scale: 5, strongly agree; 4, agree; 3, neutral; 2, disagree; 1, strongly disagree. Student response: 14/16, 2011; 12/13, 2012; 14/14, 2013.

which helps reinforce material by both hearing it from a peer and explaining it to others. The group orange phase gave individuals a sense of their progress and understanding, and the instructor, who would listen in on group discussions, could observe how students talked through concepts. After the end of the group component, the orange pens and stoplight quizzes were collected by the instructor. The instructor graded each stoplight quiz by providing correct answers in red ink and generally returned the quizzes within the week. The distribution of green, orange, and red ink provides students with a visual indication of how well they understood the material at each quiz phase.

Stoplight quizzes replaced longer, less frequent exams in CHM 341, but stoplight quizzes could readily be used as a shorter assessment, as described below for prelaboratory assessment. Here, the individual phase took 15–30 min, and generally the group phase was half of that time (but not shorter than 5 min).

### Use as Prelaboratory Assessment

After the initial success of stoplight quizzes in CHM 341, they were also implemented as part of prelaboratory assessment for Quantitative Analysis (CHM 241), a sophomore-level course (description in the Supporting Information). Prior to the introduction of stoplight prelab quizzes, most students had not taken any prelaboratory quizzes in a science course. In their previous chemistry laboratory courses, students were required to write the full procedure in their notebooks prior to the lab period—a practice intended to require students to think about lab steps ahead of time—so when the author first taught CHM 241 in 2011, similar preparation was asked of students. The author observed that many students demonstrated minimal lab preparation and low engagement. Therefore, stoplight quizzes were used in 2012 in addition to requiring students to write the procedure in their laboratory notebooks to encourage more thoughtful laboratory preparation.

Prelaboratory stoplight quizzes required students to identify the main goal of the laboratory and the purpose of several provided procedural steps. Students first wrote individually in green ink and then completed the group phase with their assigned laboratory partner (Supporting Information). Both the individual and group phases were performed without consulting the prewritten lab procedure. The instructor collected the quizzes and then discussed the answers during a brief prelab lecture. The instructor later graded the stoplight quizzes in red ink, and the result was included as part of the laboratory report grade. Orange ink additions on prelaboratory quizzes occurred most often because the individual was not familiar enough with

the laboratory procedure. This is in contrast to lecture-based stoplight quizzes where students most often add material in the orange phase to correct misconceptions. The green and orange phases for the prelaboratory stoplight quizzes typically were 10 min total. Interestingly, without any prompting, students generally used any remaining orange phase time to start planning out their lab tasks with their partner.

### STUDENT PERCEPTION AND PERFORMANCE

Stoplight quizzes were first implemented in 2011 in CHM 341 and have since been used as assessment for over 200 students in three semesters each of CHM 341 and CHM 241. At the end of each semester, students were given an anonymous survey regarding the stoplight quizzes (Tables 1 and 2). Most students

Table 2. Course Survey Results on Prelab Stoplight Quizzes (SQ) Used in CHM 241<sup>a</sup>

Statement	Mean Scores (SD)		
	Spring 2012	Spring 2013	Spring 2014
10. I understand the lab material better after taking a prelab SQ.	3.9 (0.9)	4.1 (0.8)	3.7 (0.9)
11. The feedback/discussion with my peers helped me understand the lab material better.	3.9 (0.7)	4.0 (0.7)	4.3 (0.8)
12. The feedback from my instructor helped me understand the lab material better.	4.2 (0.6)	4.1 (0.7)	4.5 (0.7)
13. The SQ encouraged me to prepare for laboratory.	4.2 (0.8)	4.4 (0.8)	4.2 (0.9)
14. The SQ encouraged me to prepare for lab more than if there were no prelab assessment at all.	4.2 (0.7)	4.2 (0.9)	4.1 (1.1)
15. The SQ helped me assess potential problem areas before going into lab.	3.9 (0.8)	3.8 (1.0)	4.0 (0.9)
16. I felt a responsibility to my peers to come well-prepared to the prelab SQ.	3.8 (1.0)	4.1 (0.9)	4.3 (0.8)
17. I was more confident in lab after taking a prelab SQ.	3.7 (1.0)	4.0 (0.9)	3.8 (0.9)

<sup>a</sup>Likert scale: 5, strongly agree; 4, agree; 3, neutral; 2, disagree; 1, strongly disagree. Student response: 38/44, 2012; 52/52, 2013; 56/68, 2014.

enrolled in CHM 341 in 2012 and all students in 2013 previously experienced prelab stoplight quizzes in CHM 241; therefore, these students were already familiar with the assessment style.

Overall student response to stoplight quizzes was positive, particularly in the years after the first implementation. Students generally agreed that they preferred the stoplight quiz

assessment strategy over traditional quizzes, and they felt more satisfied with their learning after taking a stoplight quiz. Students self-reported that stoplight quizzes helped them understand the material better than a traditional quiz, and they found the peer and instructor feedback helpful. Most students agreed or strongly agreed that stoplight quizzes helped with preparation, encouraged course progress, and allowed self-assessment of problem areas. A majority of students indicated feeling responsible to their peers to come prepared, and laboratory students agreed that prelab stoplight quizzes improved their lab confidence.

This student feedback was supported by observations by the instructor of student performance on written work and contributions in the classroom and laboratory. The most dramatic change in student behavior as a result of stoplight quizzes was observed in CHM 241 laboratory. Students were noticeably more prepared and more confident in the laboratory after the incorporation of prelab stoplight quizzes. Students also worked better with their partners during lab tasks, likely because each knew the other's preparation strengths and weaknesses as a result of the discussion phase of the quiz. Overall, stoplight quizzes promoted a positive and productive student learning environment.

Surprisingly, student grades did not dramatically increase as a result of the half-credit group orange phase. Although in theory a student who does not know any material could, after correcting all answers in the group phase, increase from a 0% to a 50%, the actual increases in grades are not as dramatic. For a longer stoplight quiz such as those given in CHM 341, the grades increase on average between 5 and 10% as a result of the group phase. Shorter quizzes, like the three to five point prelaboratory quizzes used in CHM 241, have resulted in average increases up to 15% on the prelaboratory quiz. This difference is likely due to the lower amount of preparation that students self-report doing for laboratory quizzes in comparison to lecture assessment. Average course GPAs and performance on final exams have remained approximately the same as compared with years when stoplight quizzes were not used as part of student assessment.

Students also were asked to list what other courses should utilize stoplight quizzes. The most common courses recommended were Organic Chemistry and General Chemistry. Many students also suggested that stoplight quizzes should be used in "any lab class" and "all classes". The full list of student-recommended courses is included in the Supporting Information.

## CONCLUSION

The stoplight quiz is an assessment strategy that provides students with several types of feedback. Students benefit from learning from one another during the group phase, and the inclusion of partial credit for group work is an additional incentive for productive discussion. Stoplight quizzes do not require any additional work from the instructor, but they do take additional class time due to the group portion.

Stoptlight quizzes are an appropriate mode of assessment for any chemistry course, including material that is more calculation-based. There are many other disciplines that could implement stoplight quizzes, a recommendation that is supported by student feedback. Here pens were loaned to students during class, but if purchase of a departmental set of green and orange pens is cost-prohibitive, students could be required to bring their own. Additional advice for implementa-

tion of stoplight quizzes in other disciplines and class sizes is provided in the Supporting Information. Future plans include implementing stoplight quizzes in large lecture courses and additional science lab courses.

## ASSOCIATED CONTENT

### Supporting Information

Sample stoplight quiz instructions, course descriptions, recommendations for group formation, a summary of student-recommended courses that could benefit from stoplight quizzes, and additional recommendations for implementation. This material is available via the Internet at <http://pubs.acs.org>.

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### Notes

The authors declare no competing financial interest.

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