



Analysis of Competency Assessments Used in an Upper-level Soil Fertility Course

V. Steven Green^{1,2}, Jerica J. J. Rich¹, Jacob L. Manlove¹, and GwanSeon Kim¹

¹College of Agriculture, Arkansas State University

²University of Arkansas System Division of Agriculture

Author Note

The authors declare there is no conflict of interest.

The authors would like to thank all students from Arkansas State University who participated in the study.

This study was evaluated by Arkansas State University's Institutional Review Board (IRB) and received an 'exempt' declaration. This study conforms to recognized standards when using student test scores and focus groups.

Correspondence regarding this article should be addressed to V. Steven Green, College of Agriculture, Arkansas State University, PO Box 1080, State University, AR 72467. Phone: 870-972-3463. Email: sgreen@astate.edu.

Abstract

Competency-based assessments are a common tool used to increase retention and understanding for students in university courses. This analysis of competency assessments in an upper-level soil science course focuses on both the measurable, quantitative impact of the use of competency assessments on student learning as well as the qualitative student perceptions of their use when a compulsory mastery of the assessment was required. This study utilizes data from two years of the course over which the competency assessments and mastery of the content on the assessment to a required 100% was introduced to examine the impact on student learning. Quantitatively, our results show that the proportions of students deemed fully competent for each competency area are not statistically different between 2008 and 2019. In addition, the impact of the number of attempts to achieve 100% mastery, on final exam performance across competencies, was not statistically significant. However, through focus groups, students expressed value and an appreciation of the competency assessments in learning and retaining course material. This analysis expresses the importance of not only the measurable impact of teaching practices, but also the perception of those practices by students.

Keywords: competency, assessment, mastery

Several methods have been employed to reinforce learning outside of the normal exam cycle. These include exam wrappers, regrade opportunities, and smaller tests aimed at core concepts, such as using competency assessments. These alternate testing and competency assessing methods facilitate learning and add value to course instruction.

In a previous report including students enrolled in this same Soil Fertility and Fertilizers course, students reported feeling less test anxiety contributing to a more positive learning experience when provided the opportunity to correct mistakes on their exam and have their exam regraded (Schroeter et al., 2010). More recent reports corroborate this finding, where students reported stress reduction as a result of second-chance test-taking opportunities (Emeka et al., 2021). Second-chance refers to providing the opportunity to retake an exam for some sort of grade replacement. The use of repeat attempts typically involves two exams, the first- and second-chance versions that are similar or the same; some instructors may choose to make use of new questions over the same material/concepts, or they may choose to simply adjust numbers and/or variable names. Prior to electing to take a second-chance exam students know their attempt one grade and have received feedback. Repeat attempts of assessments promote retention and allow students to identify weak areas in their content knowledge and provide an opportunity for students to focus their efforts to benefit their learning (Emeka et al., 2021). Test retakes also promoted increased student interactions and contributed to positive attitudes

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in two undergraduate-level agronomy courses (Bacon & Beyrouy, 1988). Several reports exist that provide evidence of improved performance in subsequent tests and in overall course grades among students taking the time and effort to retake exams. Furthermore, the amount of increase in assessment performance was related to the number of retake opportunities the students completed (Baral et al., 2021; Emeka et al., 2021; Juhler et al., 1998; Rozell et al., 2017).

Another strategy to ensure effective learning and study techniques includes the use of exam wrappers, a method of capturing feedback, in the form of a survey, from students regarding their perceptions of competence with the materials, their satisfaction with their performance, reports of hours spent studying, and their assessment of availability for accessing help with the material. Rosales et al. (2019) reported that the use of exam wrappers was an effective method for student reflection and intervention for improving study practices and test performance. In their study, four exam wrappers were used, each after a grading opportunity (quiz, exam, or midterm). The exam wrappers aimed to trigger reflection and encourage students to consider their study behaviors and commit to changes that would elicit success. Some specific examples of how these exam wrappers were used included questions that asked students how they felt about their competence in conceptual understanding and problem-solving, the exam wrappers also included an assessment of students' views on how accessible help was.

Competency-based assessments focus on the acquisition of competencies: they can redefine learning objectives, can benefit both instructors and learners, and can be effective at promoting student success (Harris et al., 2017; Combéfis et al., 2022). They also create flexibility and new educational opportunities allowing students to progress as they master academic content regardless of pace and focus on outcomes and skill sets (Evans et al., 2015; Ion et al., 2016). Competency-based assessments aim to determine whether competencies have been acquired (loosely defined as the ability to do something well) and how well. These competency assessments allow for the establishment of learning milestones in the classroom and enable students and instructors to determine barriers to progression for each student (Harris et al., 2017). Competency-based assessments shift from traditional instructional delivery to student performance emphasis (Voorhees, 2001).

According to Brumm et al. (2006) and Bradley, et al. (2022), students value competency-based assessments and believe they contribute positively to their understanding of requirements for success in their intended field. Competency-based assessments provide a clearer understanding of levels of achievement and improved accountability (Harris et al., 2017). As reported by Evans and co-workers (2015), it took several submissions for students to attain competency; this emphasizes the fact that competency-based assessments force students to spend more time on key topics and can help to improve success with key content in a course.

By approaching course learning objectives in a way that differs from the traditional exam cycle, providing

regrade opportunities, exam wrappers, and/or competency assessments, there is more opportunity for evaluation of work and for feedback in the learning process. Increased feedback combined with effective instruction contributes positively to effective learning when provided at the correct time and the correct level (Hattie & Timperley, 2007).

The specific objectives of the present study were to 1) evaluate the effectiveness of competency assessments in promoting a complete understanding of the material in an upper-level soil fertility course and 2) examine student attitudes and perceptions about competency assessments as a means of enhanced learning.

Methods

Study Development

Soil Fertility and Fertilizers is an upper-level, undergraduate course taught at a non-land grant college of agriculture with an R2 Carnegie designation. The majority of students taking this course are junior and senior-level students majoring in agronomy. There are key concepts in this course that a student must master in order to do well in their chosen career. Most of these students plan to return to the family farm or work as crop consultants or in agriculture input sales. Many of the students taking this course in previous semesters prior to 2010, struggled to master the fertilizer calculations and thus, a plan was put into place to encourage mastery of fertilizer calculations as well as other key concepts. A set of five 'competency assessments' was developed in 2010 to encourage mastery of these important concepts and skills (Table 1).

Beginning in 2010, students were required to complete each of the competency assessments at a 100% mastery level in order to qualify to pass the course. The five competency assessments were administered throughout the 16-week semester at the time in the semester corresponding to when the concept or skill was introduced and practiced via lecture, in-class exercises, and homework. Any student not demonstrating mastery (100% score) on the assessment at the time it was given in class, had the opportunity to re-take the assessment in subsequent weeks (after class), and as many times as needed, in order to master the competency. For competency assessments that were calculation-based, the questions changed slightly by changing the numbers in the problem, but the concept of the calculation problem remained the same. Beginning in 2015, points were allocated to the competency assessments with an added stipulation requiring students to re-take the assessment each week after class until it was mastered, with a 10% reduction in score each time it was re-taken. This caveat was put in place in order to avoid students waiting to re-take unpassed competency assessments until the last week or two of the semester. The competency assessments directly accounted for approximately 10% of the course grade. Additionally, students were required to pass all competency assessments at a 100% level prior to the end of the semester in order to qualify to pass the course. All students in the 2019 cohort successfully mastered (100% level) each of the 5 competency assessments prior to the end of the semester.

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Table 1

Competency assessments administered in Soil Fertility and Fertilizers course

Competency assessment	Competency assessment number	Week of semester first administered
List plant essential elements and chemical symbol in correct categories of structural, primary macro, secondary macro, micro (spelling counts)	1	3
Label nitrogen cycle with all transformations, gains and losses, and major microorganisms involved (13 components)	2	6
List chemical form(s) of each of the 14 soil nutrients taken up by the plant, including proper valence	3	8
Calculate fertilizer application rates based on nutrient recommendation	4	12
Calculate a) bulk blend fertilizer based on nutrient recommendations and b) the cost of that bulk blend	5	13

Retained mastery of the aforementioned competencies and skills was evaluated from student final exams from the 2008 and 2019 cohorts. The 2008 cohort represented the control group (compulsory competency assessments not used) and the 2019 cohort represented the experimental group (compulsory competency assessments used). In both the 2008 and 2019 groups, students were taught the concepts and skills in class through lectures, homework, and classwork and were evaluated by semester exams. The final exams were identical in 2008 and 2019. We used the final exam to determine achieved competency/retention in each of the five knowledge/skills areas by utilizing questions on the exam that directly corresponded to each of the five knowledge/skills areas. For some competency assessment knowledge/skills, there was more than one corresponding question on the exam. We evaluated those exam questions in each knowledge/skill category as either 'yes' they got the question correct or 'no' they did not. A correctly answered question was deemed as retained competency in that category. However, if more than one question was asked in a particular competency assessment category, a student was deemed competent in that category only if all questions in that category were answered correctly on the final exam. The competency assessments were designed to assess key knowledge and skills in soil fertility. As each student had successfully shown complete competence in each of the 5 knowledge/skills areas by passing all 5 competency assessments at 100% level at some point during the semester, it is reasonable to rate a student as competent in a specific category only if they show complete competence in that area on the final exam. Although there were questions on the final exam that were tangentially related to competency assessment 3, there were no questions that were directly related to that competency and therefore there was no evaluation of competency assessment 3 knowledge retained on the final exam for this study.

The number of times a student needed to take the competency assessment during the semester was documented in order to evaluate the impact of multiple re-takes on retained competency (for the 2019 experimental group).

The same professor has taught this course annually from 2006 to the present (2022).

Data Analysis

The main methodology used in this study was a two-sample proportion z-test to test the equality of proportions for each competency area between the two samples collected in 2008 and 2019. Simple linear regression was also used to evaluate the impact of the number of competency assessment attempts needed to achieve the compulsory 100% mastery for each competency assessment during the semester. This study considers each student as an individual in statistical analysis.

Focus Group Methods

In 2022, a focus group was used to gain a more in-depth understanding of students' perceptions and perceived value of the competency assessments used in Soil Fertility and Fertilizers. The focus group was conducted at the end of the semester outside of scheduled class times and was conducted by researchers not associated with the course. Students were randomly solicited to participate in the group and of the 10 students solicited, 7 (representing 28% of the class) chose to participate. Students were compensated with a gift card for their participation. The use of the focus group allowed students to clarify the researcher's questions and promote a dialogue not achievable in online surveys (Brandi et al., 2018).

The focus group dialogue consisted of three questions as well as time dedicated to open-response feedback from the students. The Soil Fertility and Fertilizers professor did not participate in the focus group session and information gained from the focus group was not shared with the professor until after course grades were submitted. This study was evaluated by the university's Institutional Review Board and received an 'exempt' declaration for the study, survey, and focus group participation.

During the focus group, students were introduced to the purpose of the focus group, were prompted to introduce themselves, and consent, confidentiality, and ground rules were established before proceeding with the recording of the focus group and progression through the 3 questions and open discussion. The focus group session lasted for one hour and took a dual moderator approach,

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where one of the moderators asked the questions and ensured the progression of the session, while the other moderator observed and took notes, sometimes adding to the discussion with various follow-up questions. The focus group recordings were analyzed and transcribed to evaluate and analyze the presence of specific themes that arose during the session. Students were asked 3 main questions and then given time for an open response and discussion forum. Students were asked to provide feedback about the competency assessments including their thoughts about them and what they would change about them. Additionally, the students were asked to respond regarding their performance on the competency assessments and how they believed it translated to their overall performance in the class.

Results

Competency Assessment Results

The results of the two-sample test of proportions are presented in Table 2. Although there were small proportional increases across competency performance for competencies 1, 5, and overall outcomes attributed to the compulsory competency assessments, the proportions are not statistically different between the two years (2008 and 2019). This result is contrary to the results of the qualitative study presented in the focus group results below, in which students expressed a positive relationship with the competency assessments and overall success in the course.

The results of the linear regression evaluating the impact of the number of attempts to achieve 100% mastery, on final exam performance across competencies, were not statistically significant (data not shown).

Focus Group Results

Students in the focus group readily shared their thoughts about the competency assessments and their perception of their usefulness (Table 3). Student responses to each of the 3 questions follow with 1) the question posed to the students, 2) a general summary of their responses, and 3) actual responses from the focus group students.

Table 2

Comparison of the proportion competency achievement (N=22 in 2008 and N=29 in 2019)

Competency no.	No. of questions on the final exam	2008	2019	Difference	z value
1	1	54.5%	65.5%	11.0%	0.786
2	3	27.3%	24.1%	-3.2%	-0.254
3	0	-	-	-	-
4	5	18.2%	13.8%	-4.4%	-0.427
5	2	27.3%	31.0%	3.7%	0.292
Overall	11	9.1%	10.3%	1.2%	0.149

What are your thoughts on the competency assessments?

The general theme from the focus group participants was that the competency assessments were helpful, not only for performance in the class, but also for career preparedness.

"I like them, they are tough, but they help me retain the information."

"They are scary because they are pass-fail."

"They help ensure that you know the material."

"They align well with the CCA exam, however, the soil portion of the CCA exam could be better represented in the competency assessments."

"The competency assessments are beneficial for applied knowledge for conversations pertinent to the career and to be able to have informed interactions with other professionals in the field."

"They are hard and make you study."

"Whether you pass or not, the repeated attempts help you learn the information."

"They weren't too hard."

What would you change about the competency assessments?

A majority (>70%) of the focus group participants stated that they would not change anything about the competency assessments. Further, when the focus group hosts asked if the competency assessments should be kept or discontinued for future students, four out of seven students said to keep them. Other students qualified their responses to suggest fine-tuning the competency assessments' delivery. Students also emphasized that intentional class time and discussion for competency assessment topics were helpful.

"Repetition is helpful, but it might be better to have the repeat attempt assessments be exactly the same."

"Keep the competency assessments the same, I wouldn't change anything."

"Keep up the advanced notice about when competency assessments will be given."

"Make time during lecture to introduce all concepts that will be covered in the competency assessments, versus only posting resources for students to read through independently."

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How well do you think your performance on the competency assessments translates to your overall performance in the class?

Overall, the students highlighted that the competency assessments did not fully translate to the material that would be included in the exam. In the focus group, the students were informed that, in 2019, statistical analysis showed that the competency assessments did not correlate well to overall final exam performance. About half of the students in the focus group were surprised by this because they believed the two would be strongly correlated. However, the other half of the focus group participants were not surprised by the findings.

“Some of the portions of the competency assessments that end up on the test are great and translate well, other material is easy to forget when it comes time to take the exam.”

“The competency assessments are not a clear-cut structured study guide for exam preparation.”

“More structured review sessions for the exam would be better.”

“The competency assessments are very structured and helpful; however, the tests are a mixed-bag and it is difficult to study effectively.”

Discussion

Incorporating competency assessments and requiring that students demonstrate mastery of the topic did not necessarily play a role in students' retention and understanding of course material. This research studied the impact of these competency assessments on student learning through both a qualitative and quantitative approach. While the results of the quantitative impact of the competency assessments on students' overall performance on specific final exam questions were not statistically significant, students' overall perception of the use of competency assessments was more positive. Overall, the students found the assessments to be relevant to the course and appreciated the repetition of learning the material and potential contribution to their success in their intended career (Bradley et al., 2022). This finding of students' positive perception of the competency assessments is consistent with previous literature (Seemiller et al., 2020; Park, 2003).

The qualitative component of this study, in the form of a focus group with the students, allowed us to evaluate their assessment and perception of the competency assessments. This revealed that some students had misconceptions about the purpose of the competency assessments. This was evident when several comments were made that compared the competency assessments and their functionality to the exams i.e. “The competency assessments are not a clear-cut structured study guide for exam preparation.” The competency

Table 3

Focus group questions and emerging themes

Questions asked in the focus group session	Descriptive analysis of data & themes	
	Favorable	Unfavorable
What are your thoughts on the competency assessments?	Helpful, beneficial, study aid, application of knowledge, help with retention of material, career preparedness	Scary, hard, tough
What would you change about the competency assessments?	Keep assessments the same, continue with advanced notice, repeat attempts are helpful	Make repeat attempts exactly the same, ensure all material on assessments is introduced in the course
How well do you think your performance on the competency assessments translates to your overall performance in the class?	Material from assessments translates well to grade	Assessments do not translate to exam material, formal review sessions for exams would be better
What additional comments do you have?	Keep the assessments, assessments are structured and helpful, assessments allow for informed interactions with other professionals	It is difficult to study effectively for exams using competency assessments as the guide

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assessments were not designed to be a study guide or to be the only concepts or skills evaluated on the exams. This information was extremely valuable to the instructor, as it can be used to better prepare students to understand the utility of the competency assessments and can be used to revise and/or refine both the competency assessments and the exams. While there were no significant relationships between the competency assessments and student performance on specific questions on the final exam, it is important to consider the role of competency assessments on overall student perception of effective learning, as well as the understanding of how the competency-based assessments serve the purpose of acquiring specific and seminal concepts versus being a template study guide for exams.

Summary

This study focused on competency of specific areas crucial to the understanding of soil fertility. The compulsory completion of competency assessments did not translate to full competency of students on the final exam any more than the students in the control cohort when compulsory completion of competency assessments was not required. However, students reported a positive perception of competency-based assessments, valuing their impact on course material retention and career preparedness.

References

- Bacon, R. K., & Beyrouy, C. A. (1988). Test retakes by groups of students as a technique to enhance learning. *Journal of Agronomic Education*, 17(2), 99-101.
- Baral, K., Offutt, J., Ammann, P., & Mohod, R. (2021). Practice makes better: quiz retake software to increase student learning. In *Proceedings of the 3rd International Workshop on Education through Advanced Software Engineering and Artificial Intelligence* (pp. 47-53).
- Bradley, E. J., Board, L., Archer, D., & Morgans, M. (2022). Evaluation of entrustable professional activities and competency assessment in sport and exercise sciences in higher education: Student perceptions of the impact on learning. *Journal of Hospitality, Leisure, Sport & Tourism Education*, 31, 100402.
- Brandi, K., Rabadia, S. V., Chang, A., & Mandel, J. (2018). Benefits of focus group discussions beyond online surveys in course evaluations by medical students in the United States: a qualitative study. *Journal of Educational Evaluation for Health Professions*, 15.
- Brumm, T., Hanneman, L. F., & Mickelson, S. K. (2006). Assessing and developing program outcomes through workplace competencies. *International Journal of Engineering Education*, 22(1), 123-129.
- Combéfis, S., & Van den Schrieck, V. (2022). Continuous competency-based assessment: Impact of regular student involvement on their performances and success. *Higher Education*, 4, 7.
- Emeka, C., Bretl, T., Herman, G., West, M., & Zilles, C. (2021). Students' perceptions and behavior related to second-chance testing. In *2021 IEEE Frontiers in Education Conference (FIE)* (pp. 1-8). IEEE.
- Evans, J. J., Garcia, E., Smith, M., Van Epps, A., Fosmire, M., & Matei, S. (2015). An assessment architecture for competency-based learning: Version 1.0. Paper presented at the Frontiers in Education Conference (FIE), El Paso, TX 2015. 32614 2015. IEEE.
- Harris, P., Bhanji, F., Topps, M., Ross, S., Lieberman, S., Frank, J. R., Snell, L., Sherbino, J. (2017). Evolving concepts of assessment in a competency-based world. *Medical Teacher*, 39:6, 603-608. DOI: 10.1080/0142159X.2017.1315071
- Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81-112.
- Ion, G., Cano, E. & Cabrera, N. (2016). Competency assessment tool (CAT). The evaluation of an innovative competency-based assessment experience in higher education. *Technology, Pedagogy and Education*, 25:5, 631-648. DOI: 10.1080/1475939X.2015.1134635
- Juhler, S. M., Rech, J. F., From, S. G., & Brogan, M. M. (1998). The effect of optional retesting on college students' achievement in an individualized algebra course. *The Journal of Experimental Education*, 66(2), 125-137.
- Park, C. (2003). Engaging students in the learning process: The learning journal. *Journal of Geography in Higher Education*, 27(2), 183-199.
- Rosales, E., Chavarga, A., Grandoit, E., Mayer, S., Hackman, N., Elbulok-Charcape, M., ... & Horowitz, G. (2019). An exam wrapper intervention in Organic Chemistry I. *Journal of College Science Teaching*, 49(2), 53-61.
- Rozell, T. G., Johnson, J., Sexten, A., & Rhodes, A. E. (2017). Correcting missed exam questions as a learning tool in a physiology course. *Journal of College Science Teaching*, 46(5).
- Schroeter, C., Green, V. S., & Bess, E. (2010). Second time is a charm: The impact of correcting missed exam questions on student learning. *NACTA Journal*, 54(2), 21-29.
- Seemiller, C., Grace, M., Dal Bo Campagnolo, P., Mara Da Rosa Alves, I., & Severo De Borba, G. (2021). What makes learning enjoyable? Perspectives of today's college students in the U.S. and Brazil. *Journal of Pedagogical Research*, 5(1), 1-17.
- Voorhees, A. (2001). Creating and implementing competency learning models. *New Directions for Institutional Research*, (110), 83-95.