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## Student preferences for multiple attempts and feedback on online quantitative assessments

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**Abstract:** Research on multi-attempt online assessments is sparse and inconclusive and lacks the voice of students. To help bridge the gap, this paper analyzes student survey data across multiple supply chain management classes. The results show that students prefer three attempts on quantitative assessments. The preferences do not depend on age, gender or GPA. Other findings indicate that students favor concrete feedback over abstract. Rather than have the correct answer given away, students prefer the type of feedback that allows them to solve the problem on their own. This study helps pave the way to better understanding of effectiveness of and student satisfaction with different assessment settings of online assessments of quantitative assignments.

**Keywords:** *quantitative assignments, online assessments, formative assessments, multiple attempts, automated feedback, supply chain management education*

## Introduction

The rapid transition of higher education to entirely online learning at the start of the COVID-19 pandemic was stressful for both students and faculty. However, not all effects of the move were negative. One consequence was increased attention to the effective use of online learning assisted by learning management systems (LMSs).

LMS like Blackboard, Canvas, etc. were already extensively used prior to the pandemic, including in face-to-face classes for tasks like grade keeping because of the advantages LMS offered (Walker et al., 2016; Jaggars et al., 2020). However, *all* elements of a class had to be moved online during the COVID-19 outbreak.

One key element of any course is an assessment of learning outcomes. LMS can accommodate a variety of assessment formats offered in face-to-face classes: multiple choice, fill-in-the-blanks, essays, etc. Additionally, LMSs offer two distinct advantages. The first advantage is that they enable the use of multiple attempts outside the classroom time, giving students and teachers more flexibility. It is very easy to choose a certain number of attempts as part of setting up an assessment in an LMS. Second, they offer the option of customizable pre-programmed and instantaneous feedback for students when

the instructor is not available. This is also a time and effort-saving advantage for the instructor (Stratling, 2017).

Thus, when compared to in-class assessments, online assessments in LMS require the instructor to set up these two additional parameters (number of attempts and pre-programmed feedback). Of the two, the number of attempts has received some coverage in academic literature for decision science disciplines such as supply chain management. However, the research on the matter is sparse and inconclusive (Orchard, 2016), and does not completely address student preferences. A faculty poll at an online research colloquium at the author's school also showed widespread opinions about the best way to administer multiple attempts online (November 4, 2022).

Assessments are usually classified as formative or summative (Nicol & Macfarlane-Dick, 2006). A summative assessment is a cumulative assessment given at the end of the instructional period, e.g., a final exam, whereas a formative assessment is an evaluation of a student's progress during the instructional period, e.g., a homework quiz. Additionally, the precise definition of a formative assessment has been expressed in many ways. However, in all its variations, the definition of a formative assessment captures the ideas that it occurs during learning and is helpful in informing both students' and teachers' corrective actions in the learning process (William, 2011). Another term used to describe this type of assessment is assessment for learning. Assessment for learning is also an evolving term and is meant to leave less room for definitional interpretation than formative assessment. However, the basic concept remains the same: assessment for learning is meant to serve the purpose of helping students learn rather than to rank them (William, 2011). The effectiveness of formative assessments has long been recognized (Sullivan et al., 2021; Carney et al., 2023) and is supported by numerous empirical studies such as Pishchukhina and Allen (2021) and Strakos and Brazhkin (2022).

Recent literature suggests strategies for the use of formative assessment to improve student learning over time (Carney et al, 2023). For the purposes of this study, we refer to our quizzes as formative assessments. Even though the quizzes are ultimately evaluative, their administration and structure intend to help students and instructors make corrections that aid in the learning of the material.

The aim of this study is to fill a gap in the existing literature by presenting student preferences about the number of attempts and type of feedback in online formative assessments. This study is based on quizzes that use an answer format where a student needs to enter a numerical value into a blank field for each question.

The remainder of the paper is structured as follows. The next section provides a review of relevant literature. It is followed by the Research Design section. The subsequent section, Findings and Discussion, presents formal results and our comments on them. The concluding section summarizes the key findings and intended contributions of the paper and also addresses limitations and opportunities for future research.

## Literature Review

We have divided the literature review into two sections related to the two areas we are focusing on. The first section summarizes the literature on use of multiple attempts and the second section summarizes the literature on using LMS to provide feedback to students.

*Multiple attempts.* While numerical answer quizzes are not uncommon in decision-sciences courses, academic research has largely ignored the format. However, there are a few recent studies that provide insights into the effectiveness of multiple attempts on qualitative and quantitative LMS quizzes in college courses. These studies are grouped into two categories: those which seem not to support the effectiveness of multiple attempts and those which do.

The first group of studies tests the effectiveness of multiple attempts as measured by student scores on the attempts and in some cases, on a subsequent exam. Yourstone et al. (2010) studied the effectiveness of multiple attempts (two versus four) on quantitative homework assignments in introductory operations management classes using Homework Manager as the online grading system and found that students who were allowed two attempts outperformed those who were allowed four. Rhodes and Sarbaum (2015) experimented with offering one versus two attempts on homework assignments in introductory macroeconomic classes in the MyEconoLab and Blackboard online environment. The researchers found that a second attempt increased the home assignment scores but there was no difference in the final exam scores. Orchard (2016) used a mix of quantitative and qualitative questions in primarily multiple-choice format quizzes based on homework problems in introductory operations management courses. The quizzes were set up in the Blackboard LMS and allowed two attempts. Contrary to the study by Rhodes and Sarbaum (2015), the average second-attempt scores were lower than single-attempt scores.

Although the reasons for poorer performance with multiple attempts are not clear, some insights were presented. Yourstone et al. (2010) observed that some students, when given three or more attempts, were trying to find a shortcut to the correct answer by “burning” their first attempt (submitting blank or random answers) to see the solutions. Rhodes and Sarbaum (2015) reveal a similar insight in that the students in the two-attempt condition were more likely to guess and appeared to spend less time on the homework. Orchard (2016) also observed the kind of optimizing behavior by students reported by Rhodes and Sarbaum (2015) to use an extra attempt in search of a shortcut to the correct answers. The propensity to use the second attempt did not depend on the academic ability of the student in the Orchard (2016) study but the study found that the single-attempt students outperformed the multiple-attempt students. All these studies seem to point to a “less is more” approach. It seems that the multiple attempts in these cases were discouraging, rather than encouraging student engagement in learning.

An opposing set of conclusions can be found in other studies. In a study by Stratling (2017), MBA students in a business economics course were advised to review the material and retake online multiple-choice tests if they scored below 70% on their first attempt. The questions on the second attempt did not differ from the first but were randomized in the sequence and order of the answer options. The study found repeat testing was useful, particularly for students with a deep approach to

learning. The approach was also welcomed by the students. In another study that seems to support the use of multiple attempts (Robbins, 2021), unlimited attempts were allowed on quizzes in an MBA-level statistics course. However, the quiz scores that counted towards the grade were averaged over all attempts to discourage the experimentation described in the prior studies. Here, the average number of attempts taken was 2.56 and the study concluded that repeated attempts improved the scores and completion times and encouraged the students to learn through repetition.

Although research on multi-attempt online assessments is generally sparse and inconclusive (Orchad, 2016), these studies do show that some approaches seem to encourage student learning and engagement. This is further evidence for the value of studies seeking to find the best way to use multiple attempts in LMS assessments. Empirical studies of this topic have many limitations because they are carried out as the courses are delivered rather than as predesigned experiments (Robbins, 2021). In this situation, Orchard (2016) recommends surveying the students to better understand their behavior and preferences about multi-attempt assessments. This study helps to fill this gap by providing student perspectives and insights into their multi-attempt behavior.

*Feedback.* When using multiple attempts, feedback is included after each attempt to give students direction and instruction outside the classroom. In general, feedback that can be programmed into quizzes is found to be useful and appreciated by students (Mendoza & Lapinid, 2022). Most empirical studies of automated feedback in online quizzes found that it had a positive effect on performance, e.g., Butler et al. (2008) and Enders et al. (2021). However, there are also exceptions. Wieling and Hofman (2010) did not find a significant effect of automated feedback on student performance. The differences may lie in the diversity of the quiz formats, content, settings, and other attributes of the research design.

The scope of this study is numerical answer format quizzes given in college. Academic literature studying multiple attempts on college-level computational problems does not focus on feedback and conventionally assumes that minimum performance feedback is given by indicating whether each question was answered correctly without giving away the correct answer (Butler et al 2008). We also follow this convention in our approach. However, in this study, we provide value to researchers and practitioners by considering student preferences for *additional* types of feedback that can potentially be incorporated into a numerical answer format quiz. In the absence of studies on feedback in quantitative quizzes, we used academic literature on qualitative quizzes in college, mathematical problems in high school, and our own teaching experience to generate feedback types for student evaluation in our survey.

The first major type of additional feedback is providing the correct answer to the students immediately after a quiz attempt. All LMS have this option. Based on informal faculty polls, faculty believe that students would prefer it over other types (online research colloquium at the author's school, November 4, 2022; Northeastern Decision Sciences Institute annual conference, April 1, 2023). This assumes that in subsequent attempts the data are replaced or manipulated in some way to prevent the students from simply plugging in the answers that were already given. Alternatively, when the

correct answers were given away on the initial attempt as in the study by Mendoza and Lapinid (2022), the students were also required to submit detailed computations for manual grading.

Several types of feedback were extensively studied in psychology literature, even though many empirical conclusions were obtained from laboratory experiments with human subjects rather than from studies conducted in actual classroom settings. In these studies, feedback is typically viewed in a more formative way and defined as any “information about the gap between actual and desired performance” (Butler & Woodward, 2018, p. 2). In addition to identifying whether the answer was right or wrong (*right/wrong feedback*) and providing correct answers (*corrective feedback*), this stream studied *elaborate feedback*, which is any information beyond the first two types (Butler & Woodward, 2018). Specific examples of elaborate feedback include providing an explanation of a correct answer and an explanation of a misconception or a mistake (Petrović et al., 2017; Prinz et al., 2019). For our study, any preprogrammed verbal feedback automatically released to students falls into this category.

There are mixed results on the effects of elaborate feedback in the psychology literature stream. Some studies, e.g., Butler et al. (2013), Petrović et al. (2017), and Corall and Carpenter (2020), found a positive effect of elaborate feedback on learning, while others, e.g., Thijssen et al. (2019), did not. Enders et al. (2021) found that students benefited more from elaborate feedback on incorrect answers than on correct answers.

Finally, a motivational type of feedback, such as “Good job!”, given for a correct answer, is occasionally described in literature, e.g., Mendoza and Lapinid (2022). Motivational feedback is outside the scope of this study, which focused on feedback for wrong answers.

In summary, there is a lack of research on the types of feedback and their effectiveness on student learning (Enders et al., 2021) and there are calls for more studies in the area (Lindner et al., 2015). The students’ perspective on feedback has been particularly underrepresented (Weaver, 2006; Poulos & Mahony, 2008). Our study helps bridge this gap and specifically builds knowledge of student preferences about online feedback.

## Research Design

### Research Questions

This empirical study aims to contribute to this research topic by offering the students’ perspective on the number of attempts and feedback. This research is centered around using formative assessment as a tool for evaluating student progress, as mentioned in the introduction. The two primary research questions are:

1. How many attempts do students prefer on online assessments?
2. What kind of feedback do students prefer on online assessments?

Additionally, student demographic data are analyzed in search of more nuanced relationships with the primary questions. Wieling & Hofman (2010), Yourstone et al. (2010), Rhodes & Sarbaum (2015), and

other prior studies on multi-attempt assessments and feedback collected students' age, gender, and/or GPA data to use as control or variables of interest. In this study, we explore if these demographic characteristics influence the students' preferences on the number of attempts and automated feedback on online quizzes. It is the authors' hope that the knowledge of student expectations will aid instructors in making informed decisions about online assessment settings.

### Study Participants

The study data were collected from a survey of undergraduate supply chain and operations management classes where students were given computational analysis assignments as homework. The assignments were of a complex nature typically involving multiple steps or model building rather than merely plugging values into a given formula. The quiz questions required that the students enter the computed key figures into the blank fields. Once submitted, the quiz compared the entered values to the correct answers programmed by the instructor. The students were able to access the submitted quiz immediately to see if each question was answered correctly or not. However, the correct answers were not released until after the final deadline. Manipulating the number of attempts or types of feedback was not part of the research design. The details about the classes are provided to explain the context of the survey.

The research project was approved by the IRB and the administration of the survey fell within the guidelines of the authors' universities. The feedback survey was made available to all students of the classes with this type of assignment via the LMS. A nominal course credit was given for submitting the feedback survey. A total of 232 students were offered the survey. 198 responses were received, which corresponds to an 85.3% response rate.

### Data Cleaning and the Final Sample

Using applicable recommendations of the Brazhkin (2020) methodological paper, the raw data were reviewed for evidence of respondents failing to properly engage with the survey. The survey had built-in data quality checks, such as reverse-coded, attention check, and open-answer questions.

Additionally, individual survey completion times were available and were reviewed for unusually short completion times. Clear signs of "straightlining" (selecting the same choice, such as "strongly agree," for a block of questions) were also identified. All these checks were treated as "soft" checks (Brazhkin, 2020). A single violation was not an automatic cause for response removal. However, data from respondents failing multiple checks were removed.

After data cleaning, the final dataset included 160 responses (159 to answer the first research question). Out of 160 respondents, 114 (71%) were male and 46 (29%) were female. 128 (80%) of the students were under 25 years old, 22 (14%) were between 25 and 34, 8 (5%) were between 35 and 44, and 2 (1%) were 45 or older. The average self-reported GPA was 3.27 ( $SD = 0.47$ ). This generally reflects the demographics of the student population in the program, including a substantial male dominance in the supply chain and operations management classes.

## Variables and the Survey Instrument

The two primary variables of interest were the preferred number of attempts and the preferred type of feedback. In the questionnaire, the choices for the preferred number of attempts were based on prior studies reviewed above that typically allowed one, two, three, or more (four to ten) attempts. An additional choice was “unlimited” attempts since it is available in LMS and is well-known to students. The types of preferred feedback consisted of seven choices included in the right/wrong, corrective, and elaborate feedback categories explained in the “Feedback” section of the literature review. Since the quizzes always provided students with the right/wrong feedback, this option was identified as “no additional verbal feedback.” Brief definitions were also given to several elaborate feedback types to avoid any confusion. The respondents were asked to rank the seven feedback types in order of their preference.

The questionnaire was also designed to collect demographic information for the independent variables of age, gender, and GPA for regression analysis. As is common for demographic surveys, respondents were to choose an age bracket, rather than report their exact age. Based on the IRB recommendation, we used the self-reported GPAs of respondents rather than the GPA data available in the school database. The questionnaire was also used to collect data for other research questions not covered by this study. Questions applicable to this study and a sample attention check question are listed in the Appendix.

## Methods

The two primary research questions can be answered through descriptive statistics. Additionally, an analysis of variance (ANOVA) with posttests was conducted for the second research question to test for statistically significant differences between the categories and between the types of feedback. The additional exploratory research questions about demographic characteristics involved analysis of correlations and hypothesis testing using regression analysis.

Van den Berg and Hofman (2005) showed that women and younger learners have higher study success than men and older learners, respectively. Rhodes and Sarbaum (2015) found that higher GPA students used fewer attempts. Following these studies, we test hypotheses that women, younger learners, and higher GPA students will prefer fewer attempts.

While some variables were interval (e.g., self-reported GPA), others (e.g., age bracket) were ordinal based on data collected from Likert or similar scales. Such data do not typically follow a normal distribution and violate several assumptions of parametric statistical tests (Mircioiu & Atkinson, 2017), as was in our case. However, specific comparative studies of Likert-type data showed the robustness of parametric tests for larger sample sizes of over 15-30 (Boneau, 1960, Mircioiu & Atkinson, 2017) leading to the conclusion that the use of parametric tests in such cases is “perfectly appropriate” (Norman, 2010). Therefore, we conducted parametric tests for all data analyses using the SPSS statistical package. The results are reported in the next section.

## Findings and Discussion

To answer the first main research question about the number of attempts students prefer on the quizzes, usable data were available for 159 respondents. The results are reported in Table 1.

**Table 1**

*Preferred Number of Attempts*

| <b>Attempts</b> | <b>Responses</b> | <b>Percent</b> |
|-----------------|------------------|----------------|
| 1               | 3                | 2%             |
| 2               | 39               | 25%            |
| 3               | 69               | 43%            |
| 4-10            | 15               | 9%             |
| unlimited       | 33               | 21%            |

Almost half of the students (43%) prefer to be given three attempts. While other studies have not specifically looked at how many attempts students prefer, this is in line with the findings of Robbins (2021) where the students were not limited in their attempts and used an average of 2.56 attempts. Additional analysis of the demographic data revealed no significant differences in the desired number of attempts based on age, gender, or GPA. Contrary to our expectations, none of the three hypotheses were supported. In our study, student preferences do not directly translate to demographics-based performance characteristics previously reported in the literature.

The second main research question dealt with students' preferences concerning automated verbal feedback in the quizzes. After data cleaning, 160 survey responses were deemed acceptable for this part of the study. The students ranked different types of feedback on a scale from 1 (most desired) to 7 (least desired). The results are given in Table 2. For ease of understanding the results are reverse-coded, i.e., the most desired option has the highest value.

A one-way ANOVA with the Bonferroni posttests between the three main feedback categories (right/wrong ("no additional feedback"), corrective, and combined (averaged) elaborate feedback) showed statistically significant differences between them ( $F(2, 477) = 29.375, p < .001$ ). The results are reported in Table 3.

The results show that the least preferred option for students is having no additional feedback beyond the right/wrong information for each answer. This echoes the "better than nothing" students' preference for any feedback in the qualitative study of Poulos and Mahony (2008). Stated differently, students would like to receive help with incorrect answers before they attempt the assessment again. The value of timely feedback for learning has long been established (Wiggings, 2012). Our findings confirm this in the context of college-level online computational assessments.



**Table 2***Student Preferences for Feedback Types*

| <b>Feedback Category</b>    | <b>Feedback Type</b>            | <b>Score</b> |
|-----------------------------|---------------------------------|--------------|
| Elaborate (verbal) feedback | Specific hint                   | 4.8          |
|                             | Reference to sample problem     | 4.5          |
|                             | Explanation of common mistakes  | 4.3          |
|                             | General hint                    | 4.2          |
|                             | Reference to theoretical source | 4.1          |
| Corrective feedback         | Correct answer                  | 3.6          |
| Right/wrong feedback        | No additional feedback          | 2.7          |

**Table 3***Comparison of the Feedback Categories*

| <b>Feedback Category</b> | <b>Mean</b> | <b>SD</b> | <b>Difference of Means and Significance</b> |                   |                    |
|--------------------------|-------------|-----------|---|-------------------|--------------------|
|                          |             |           | <b>Elaborate</b>                            | <b>Corrective</b> | <b>Right/Wrong</b> |
| Elaborate                | 3.63        | 0.77      |   | .001              | <.001              |
| Corrective               | 4.40        | 2.43      | 0.775                                       |                   | <.001              |
| Right/Wrong              | 5.30        | 2.23      | 1.675                                       | 0.900             |                    |

Informal faculty polls that the authors conducted at research conference presentations show that faculty overwhelmingly believe that seeing the correct answer is students' most desired feedback type (online research colloquium at the author's school, November 4, 2022; Northeastern Decision Sciences Institute annual conference, April 1, 2023). However, in our study, any type of elaborate feedback was ranked higher by the students. Students recognize that in complex computational problems seeing a certain numerical value as an answer often does little to aid their learning. Rather than have the correct answer given away, students prefer the type of feedback that allows them to solve the problem on their own. While our findings cannot be generalized outside the context of the study, they can help dispel some of the common misconceptions about student preferences for online quizzes. The category of elaborate feedback consisted of several items (feedback types) that were further analyzed. An ANOVA showed a statistically significant difference between the groups ( $F(4, 795) = 4.675, p < .001$ ). Bonferroni posttest multiple comparisons identified differences between the elaborate feedback types. The results are reported in Table 4.

*Specific hint* was significantly different from all types, except for the reference problem. There were no significant differences between the other verbal feedback types. Combined with the results of the tests between feedback categories, the findings allow us to conclude that a specific hint is the type of feedback students prefer most. This correlates with Weaver (2006) who showed that students find general or vague feedback unhelpful.

**Table 4**

*Comparison of the Elaborate Feedback Types*

| Feedback Type                 | Mean | SD   | Abs. Diff. of Means and Significance |       |        |         |
|-------------------------------|------|------|--------------------------------------|-------|--------|---------|
|                               |      |      | RTS                                  | RTP   | EOM    | GH      |
| Reference to Source (RTS)     | 3.89 | 1.83 |                                      |       |        |         |
| Reference to Problem (RTP)    | 3.53 | 1.78 | 0.362                                |       |        |         |
| Explanation of Mistakes (EOM) | 3.74 | 1.41 | 0.156                                | 0.206 |        |         |
| General Hint (GH)             | 3.81 | 1.64 | 0.081                                | 0.281 | 0.075  |         |
| Specific Hint                 | 3.15 | 1.99 | 0.744***                             | 0.381 | 0.587* | 0.663** |

Note: \* sig. at  $p < .05$ , \*\* sig. at  $p < .01$ , \*\*\* sig. at  $p < .001$

Given our findings and that of Weaver (2006), we performed a post-hoc analysis contrasting abstract and concrete feedback. Within elaborate feedback, it is easy to see that the students ranked more concrete types of feedback higher than abstract types of feedback. Following the analysis logic of Mircioiu and Atkinson (2017), we consolidated the five elaborate feedback types into two groups for binary analysis. The concrete feedback group, which operated more with numerical values, included *specific hint* and *reference to a sample problem*. The abstract feedback group, which focused more on conceptual understanding and approaches to problem-solving, was comprised of the three remaining verbal feedback types: *explanation of common mistakes*, *general hint*, and *reference to theoretical source*.

The independent samples *t*-test of means produced significant results ( $t(318) = -3.636, p < .001$ ) confirming differences between the two groups. Concrete forms of elaborate feedback, more direct and time-saving, are preferred by students to abstract feedback that requires more effort to be processed and applied to the problem at hand. Thus, our empirical research provided support to the prior qualitative research conclusions.

As with the first research question and in line with other studies of assessments, we analyzed the significance of relationships between the GPA and the focus variables. The analysis was performed in an exploratory way and was limited to a review of Pearson correlations for significance. The data are reported in Table 5.

Given the coding of the variables, the results can be interpreted as follows. The higher the students' GPA, the *higher* their preference for a specific hint. On the other hand, the higher the students' GPA,

the *lower* their preference for the types of feedback that would send the student to another source (reference to a sample problem and reference to a theoretical source). No significant results were obtained to establish a link between other feedback types and GPA for this data sample.

**Table 5.**

*Pearson Correlations of GPA and the Elaborate Feedback Types*

|     | Ref. to Source | Ref. to Prob. | Expl. of Mist. | Gen. Hint | Spec. Hint |
|-----|----------------|---------------|----------------|-----------|------------|
| GPA | .277**         | .164*         | -.068          | -.117     | -.163*     |

Note: \* sig. at  $p < .05$ , \*\* sig. at  $p < .01$

It follows that higher GPA students prefer less time-consuming and more practical, focused feedback that allows them to stay within the context of the problem rather than seeking help from an external source. This may be related to their very pragmatic orientation focused on solving the problem at hand.

## Conclusion

### Key Findings

Although previous research has generally led to the conclusion that some form of multiple attempts along with elaborate feedback is helpful in formative assessments, this study provides details on student preference for these two online LMS assessment settings. Extending the findings of Robbins (2021), our study shows that students prefer multiple attempts and concludes that students specifically want at least three attempts. In the area of feedback type preference, we found that students would like to receive elaborate feedback rather than simply have the correct answer revealed. This makes sense in that formative assessments are supposed to aid learning. Elaborate feedback in the form of a specific hint may be construed as instruction more so than simply giving a correct answer and expecting students to reverse engineer the path to the answer. This is in line with the Enders et al. study (2021), which showed more benefit from elaborate feedback on incorrect answers than on correct answers. The finding that students prefer elaborate feedback also helps to dispel the misconception that students just want to see the correct answer. This finding can help instructors to design more effective online assessments where learning rather than ranking is the goal. Specific to this point, we found that students prefer three attempts on assessments and would like to receive automated verbal feedback upon an attempt completion in the form of a practical, specific hint for any assessment question answered incorrectly.

One study (Orchard, 2016) admitted to increasing the number of attempts on assessments in part due to pressure and complaints from the students. While we do not suggest that instructors should match student preferences, we believe it is helpful to know those from the start. Although instructors should not design courses strictly to meet student preferences, we can benefit from student satisfaction. For example, if a student is satisfied with substantive automated feedback from an online assessment in

which multiple attempts are allowed, he or she may be able to continue learning the material outside the classroom at any time of the day. This is an efficient use of time and effort for both the student and instructor. Knowing more about the specific student preferences presented here can help instructors with this design for efficiency.

### Limitations and Opportunities for Future Research

The study was limited to complex computational problems given as homework to supply chain and operations management undergraduate students in junior- and senior-level classes in college. Because of the narrow scope of the study, the findings may not be applicable to a wide variety of other settings, therefore further studies are encouraged.

Although this study explored how demographics like GPA affect student preferences for multiple attempts and feedback type, we did not incorporate this into our original research design. Higher or lower GPA did not seem to affect the preference for the number of attempts. We did, however, find a correlation between higher GPA and a preference for more specific elaborate feedback, which may point to higher performing students' being more focused on learning in an efficient way. However, since this question was outside the original scope of the study, these findings are tentative at best. This would be a valuable addition to future research in this area.

### Summary

A major shift to online learning in higher education due to the COVID-19 pandemic caused an increased interest in online assessment settings and their commonly available additional choices: multiple attempts and preprogrammed (automated) feedback. This study contributes to the research and practice of teaching by presenting the students' preferences regarding these features. Knowledge of students' preferences may help instructors with building online assessments, with overall course design, and with communicating about assessments to the students.

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## Appendix

### Survey Questions Used for this Study

What is your age bracket?

- a. Under 25.
- b. 25 – 34
- c. 35 – 44
- d. Over 45

What is your gender?

- a. Male
- b. Female

What is your current GPA? Round to two decimals, e.g., 3.27:

This is an attention check question. Please select “strongly disagree.” Thank you for reading carefully.

- a. Strongly agree
- b. Agree
- c. Neutral/neither agree nor disagree
- d. Disagree
- e. Strongly disagree

In addition to showing whether the answer you have entered is correct or incorrect, the Quiz can provide optional feedback. Please rank the feedback text options from the most useful (1) to the least useful (7) for your learning.

- a. General hint (description of strategy and direction of thinking to solve the problem)
- b. Specific hint (description of steps to arrive at the correct final answer)
- c. Reference to a specific source to consult for more information
- d. Reference to a similar problem solved
- e. Correct answer immediately given
- f. No additional verbal feedback
- g. Cautionary statement (explanation of typical mistakes)

How many attempts should be given for the Final Quiz for Excel-based assignments?

- a. 1
- b. 2
- c. 3
- d. 4 – 10
- e. unlimited

Please provide any additional feedback on the Excel-based assignments and quizzes. Thank you!