

Feedback Effectiveness: Is It What You Say or How Much You Say It?

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The purpose of this study is to examine the effect of feedback amount and type on classroom performance. Varying the number of assessment instruments on which students receive feedback, as well as whether the feedback is directed at the student's brainstorming process (process feedback) or at the student's final answer (outcome feedback), we find improved performance across multiple measures for students who received more feedback compared to those who received less. The effects of process feedback are more complex and depend on both the specific measure or assessment instrument used and the ability/motivation of the student.

INTRODUCTION

Feedback is information provided about someone's performance on a task that is meant to facilitate learning. In an educational context, feedback is a means of assisting and guiding students into a deeper understanding of the material such that it becomes useful beyond the classroom (Archer, 2010). Feedback can be viewed from either a cognitive perspective or a socio-constructivist perspective (Evans, 2013). In the cognitive perspective, feedback is primarily corrective and involves an expert (e.g. the instructor) telling the student what was done incorrectly and how to fix the problem; the recipient of the feedback is largely passive in this process. In contrast, in the socio-constructivist view, the feedback recipient plays an active role in the feedback process. The feedback comments, instead of being directive, are more open and offered as suggestions which the recipient interprets and then uses to make whatever changes he/she decides are likely to improve performance.

There is an abundance of evidence from the research conducted on feedback over the years to support the conclusion that it is a significant factor in student learning (c.f. reviews by Black & William, 1998; Evans, 2013; Hattie & Timperley, 2007; Kluger & DeNisi, 1996; Parboteeah & Anwar 2009). Nevertheless, despite the overall positive impact of feedback, it is not uncommon for studies to report feedback interventions that either had no impact or even a negative impact on student learning. Furthermore, a meta-analytic review conducted by Kluger and DeNisi (1996) finds a significant amount of variability in effect sizes across studies. Although this variability is partially explained by differences

across studies in terms of feedback characteristics or by a variety of situational factors, it is clear there is still much that is unknown regarding how to most effectively use feedback to enhance student learning.

Models of the feedback process frequently utilize a control-theory perspective in which feedback is used to reduce the gap between desired performance (the standard) and actual performance (e.g., Hattie & Timperley, 2007; Kluger & DeNisi, 1996). In an educational context, this suggests that feedback is a means of spanning the gap between what students know now and what they need to know in the future (Lizzio & Wilson, 2008). According to the Feedback Intervention Theory (FIT) proposed by Kluger and DeNisi (1996), when a performance gap exists, there are several possible responses to this gap. The feedback recipient can increase effort in response to the feedback, can change or abandon the standard, or can reject the feedback. Only a response that involves increasing effort is likely to result in improved performance and/or learning.

From an educational perspective, therefore, what is important is understanding the conditions that will produce the desired response of increasing effort, so that student learning is enhanced, and knowing how to avoid the less desirable, performance-hindering responses. The study reported here was undertaken with this goal in mind. Varying the number of assessment instruments on which students receive feedback, as well as whether the feedback is directed at the student's brainstorming process (process feedback) or at the student's final answer (outcome feedback), we examine the effect of both feedback volume and type on classroom performance. In short, we pose the following question: is it what you say or how much you say it that matters most when providing feedback to students?

THE FEEDBACK MESSAGE

In conceptualizing the feedback process as a special case of the more general communication process, Ilgen, Fisher and Taylor (1979) have suggested that the effectiveness of feedback is influenced by characteristics of the feedback source, the feedback recipient and the feedback message. The focus of our research is primarily on the feedback message itself. The feedback message can vary in terms of its sign (whether the feedback is positive or negative), in terms of the content of the information provided, or in terms of its frequency (or amount of feedback provided). The latter two aspects of the message are of particular relevance to this study.

Content of the Feedback Message

Research on the content of the feedback message has examined a variety of content-related factors, including whether the feedback provides information about the correctness of the response, whether comments and/or a grade are provided, and whether the feedback includes praise or criticism. This research generally suggests that providing information about why a response is incorrect is superior to just indicating that the response is incorrect (Chase & Houmanfar, 2009) and that providing a grade has a negative impact on performance (e.g., Butler, 1987; 1988; Butler & Nissan, 1986). Praise has typically been found to have a positive impact on motivation (Deci, Koestner & Ryan, 1999), but its effect on performance is less clear, as both positive and negative effects have been found (e.g., Baumeister, Hutton & Cairns, 1990). Lipnevich and Smith (2009) have examined the combined effect of providing praise and/or a grade along with either no feedback or detailed feedback and find results consistent with previous research. Specifically, they have reported that detailed feedback provided without either praise or a grade results in the best performance. Feedback that includes praise does not, by itself, affect performance. However, providing a grade along with comments results in lower performance than just providing comments, an effect that is lessened when praise is also provided.

Another way of characterizing differences in the content of the feedback message has been suggested by Hattie and Timperley (2007), who note that the feedback message can be directed at several different "levels." Task-level feedback provides information about how well tasks are understood and/or performed. Process-level feedback addresses the learning processes necessary for successful completion of the task. Feedback can also be more directly aimed at the student, with self-regulation-level feedback helping students monitor their own performance and self-level feedback simply offering a personal

evaluation of the student. In the context of this framework, it is argued that both process-level and self-regulation feedback are effective tools for increasing the student's mastery of material, with task-level feedback also being appropriate under the right conditions.

Regardless of the content of the message, in most studies, feedback is directed at the student's answer or final product and, thus, involves looking back at what the student has accomplished. It is also typically focused on content outcomes. This parallels what is referred to as summative assessment (Black & William, 1998; Eberly Center for Teaching Excellence & Educational Innovation, Carnegie Mellon University, 2015), which is given at the conclusion of a performance task and provides information about whether a benchmark or desired performance level has been achieved. While learning can, and does, occur by looking back at past performance, equally important is the student's ability to use information about past performance to look forward so that performance on future tasks is improved. This is commonly referred to as formative assessment (Black & William, 1988). Feedback used for formative assessment is provided during the process of completing a task and is, therefore, intended to be used to improve performance on either that task (e.g., when students are able to revise an assignment) or a different task. In a similar vein, Carless (2006) has used the term "feedforward," to refer to feedback information that is applied on future assignments. Feedforward information can be contrasted with feedback information that comes at the conclusion of a final submission and that primarily looks back at past performance.

In this study we provide a direct comparison of the relative effectiveness of feedback information and feedforward information. We refer to feedback information as outcome feedback because it is directed at the student's final answer (the outcome of the student's work). We refer to feedforward information as process feedback because it is focused on the student's thinking process as they are formulating their answer. Process feedback is intended to show students how they need to think differently in order to improve their subsequent performance. Outcome and process feedback are similar to what Hattie and Timperley (2007) have referred to as task-level feedback and process-level feedback, respectively.

Consistent with recommendations from educational practitioners (e.g., Halvorson, 2015; Orlando, 2015), some have examined how feedback provided during the process of working on an assignment affects performance on the final product (e.g., Lipnivich & Smith, 2009). However, our application of process feedback is different because we focus the process feedback not at the student's final answer (or an interim "final" answer, such as the first draft of an assignment), but rather at the thinking process the student uses in preparing the final product. Previous research by Paulson Gjerde, Padgett and Skinner (2017) has suggested that feedback on the student's thinking process (process feedback) may result in higher quiz scores and greater improvement in quiz scores over the semester than feedback provided on the final answer (outcome feedback). The superiority of process feedback may occur because process feedback addresses more basic or fundamental thinking activities that are directly relevant to a variety of different performance tasks, making it more easily transferable to future assignments than outcome feedback. Consistent with this possibility, Kluger and DeNisi (1996) and Sadler (1983) have both concluded that feedback which comments on the way students arrive at an answer is more effective than feedback provided on the content outcome. In this study, we extend the research conducted by Paulson Gjerde et al. (2017) by examining the impact of receiving process feedback on several different types of assessments rather than on only one type of assessment.

Frequency/Amount of the Feedback Message

Providing feedback on multiple assessments means that students are receiving not just more frequent feedback but also a greater amount or volume of feedback. Consequently, in this study we also examine how the amount of feedback students receive affects their performance. We define amount of feedback both in terms of the total number of assessments on which students receive feedback and the number of *different types* of assessments on which they receive feedback. Using the characterization of Nelson and Schunn (2009) of feedback as being a source of motivation, reinforcement or information, the amount of feedback received should primarily influence the information value of the feedback. One could argue that receiving a greater amount of feedback provides students with more information to use in improving their

performance and, thus, should result in higher performance than when less feedback is received. Alternatively, receiving more feedback could have either no impact on performance or possibly even a negative impact because the student is receiving more information that is potentially threatening to their self-esteem and consequently, more likely to be denied and/or not used (Butler, 1988; Carless, 2006; Kluger & DeNisi, 1996). Although denial of feedback would be more likely to occur when students receive critical or negative feedback, even feedback intended to be helpful and constructive is often viewed by students as harsh and critical (Ackerman & Gross, 2010; Ackerman, Dommeyer & Gross, 2017) and thus, might be ignored.

Research explicitly examining feedback amount is surprisingly sparse. An early meta-analysis finds limited evidence that providing more feedback results in better performance than providing less feedback (Harris & Rosenthal, 1985), while a more recent meta-analysis conducted by Kluger and DeNisi (1996) has found that feedback effect sizes are actually somewhat more positive in studies providing less feedback than in studies providing more feedback (0.39 vs. 0.32), suggesting that more feedback is not necessarily better than less. The meta-analysis results, however, are not based on a direct comparison of differing amounts of feedback. More recent direct comparisons related to how amount of feedback affects performance (e.g., Wallace, Heine, Garmen, Bartos & Richards, 1999) are limited but generally consistent with the conclusion from Kluger and DeNisi (1996).

A few recent studies have examined how the amount of feedback received affects student responses to the feedback rather than how it affects performance (Ackerman & Gross, 2010; Ackerman et al., 2017). Both studies report similar results. Specifically, they find that students respond more favorably to a lower amount feedback than to either no feedback or a high amount of feedback. More specifically, students receiving less feedback report greater liking for the instructor and greater satisfaction with their performance than those receiving more feedback or no feedback. Conversely, students receiving more feedback indicate that they think the instructor has a more negative perception of them as a student than students receiving less feedback. There is also some evidence that more feedback is perceived as less fair (Ackerman & Gross, 2010) but more helpful (Ackerman et al., 2017) and that receiving more feedback elicits greater anger and less happiness than receiving less feedback (Ackerman et al., 2017).

The Present Study

Building on previous models in the literature, the focus of this study is threefold. First, we examine how the type of feedback message students receive (either feedback on their thinking process or feedback on their answer) affects their classroom performance. Second, we examine how the amount of feedback they receive affects performance. Finally, we explore the possibility of synergy between type and amount of feedback to see if different combinations of feedback type and amount differentially affect student classroom performance. Given the exploratory nature of our research comparing process and outcome feedback and the equivocal findings from previous research related to amount of feedback, we pose the following three research questions:

R1: Is there a difference in student learning, as measured by classroom performance, between students who receive feedback directed at their thinking process (process feedback) and those who receive feedback directed at their final answer (outcome feedback)?

R2: Does the amount of feedback students receive affect their learning as measured by classroom performance?

R3: Do some combinations of type and amount of feedback result in better classroom performance than other combinations?

METHODOLOGY

Sample Description

The subjects for this study are 134 students in six sections of a 300-level economics elective across multiple semesters. All students have completed an introductory principles of microeconomics course as well as an introductory principles of macroeconomics course. Class activities, texts, materials, pace, etc.,

as well as the instructor, are the same for all the classes. All classes meet two times a week for 75 minutes in the afternoon.

In terms of content and structure, this course utilizes a set of tools and basic framework of analysis to understand various aspects of the employee-employer relationship. The aim is to help students apply basic economic analysis to a wide range of strategic personnel problems encountered in the workplace. Thus, the focus is on developing students' critical-thinking skills instead of memorization of certain facts and figures. As such there is often not a correct answer or conclusion given the ambiguity in the questions posed to the students. Instead, they are simply graded on their ability to look at the issue from multiple perspectives. Since this course is also designated as a writing-intensive course, a second objective of the course is to improve students' written communication skills.

Although some variation across sections in terms of GPA (both cumulative and in the semester in which study was conducted), credits completed (both cumulative and in the semester in which the study was conducted), major, and college exist, these differences are not statistically significant (see Table 1).

**TABLE 1
DESCRIPTIVE STATISTICS**

	Single Assessment Instrument		Multiple Assessment Instruments	
	Section 1 N=48	Section 2 N=45	Section 1 N=22	Section 2 N=19
Academic Experience				
Cumulative GPA – Prior Semesters (4.0 scale)	3.314	3.160	3.313	3.410
GPA - Semester of Study (4.0 scale)	3.194	3.016	3.292	3.355
Cumulative Number of Credits - Prior Semesters	112.500	107.392	104.773	100.513
Number of Credits – Semester Of Study	16.723	15.133	18.182	15.474
Major				
Accounting	0.014	0.031	0.000	0.053
Economics	0.171	0.219	0.182	0.211
Entrepreneurship & Innovation	0.014	0.016	0.045	0.053
Finance	0.286	0.172	0.182	0.263
International Business	0.029	0.031	0.000	0.000
Marketing	0.329	0.328	0.318	0.263
MIS	0.014	0.031	0.045	0.000
Risk Management	0.014	0.063	0.045	0.000
Engineering	0.071	0.063	0.045	0.053
Political Science	0.014	0.000	0.045	0.000
Actuarial Science	0.000	0.031	0.000	0.053
Undecided	0.014	0.016	0.000	0.053
College				
College of Business	0.843	0.797	0.773	0.737
College of Liberal Arts and Science	0.157	0.203	0.227	0.263

Intervention Description

A significant component of the course is a series of nine assigned cases. Combining grades received on case quizzes, participation in case discussions, and case reports, these cases represent 50% of a student's course grade. Thus, students have a strong incentive to carefully review and analyze these readings. Prior to each case discussion, students are given a one-question, essay-based quiz in class. Students in both sections are given similar questions, although not identical in order to prevent the later section from having an advantage over the earlier section. In both sections, students are instructed to spend five minutes brainstorming and organizing their thoughts in the box located at the top of the quiz. During this time, students are not allowed to write in the answer box located at the bottom of the quiz. After five minutes of brainstorming, students are directed by the instructor to write their answer. They are reminded that their score will be based not only on the content and organization of their answer but also on grammar and punctuation. Students are given five minutes to write their answer. Before the quiz is turned in, students are required to proofread it for accuracy and completeness.

All quiz answers are graded on the same 5-point scale. However, to assess whether the type of feedback affects performance, the written comments on the students' quizzes vary. In particular, some students receive feedback solely on their answer, while other students receive feedback solely on their brainstorming process.

In addition to the type of feedback received, the number of assessment instruments on which the feedback is received varies across students groups. In particular, students in the single-assessment-instrument-treatment group receive formal process- or outcome-related feedback on quizzes only. Students in the multiple-assessment-instrument-treatment group receive formal process- or outcome-related feedback on quizzes, case reports, and the mid-term exam. This framework allowed us to examine both the impact of process vs. outcome-related feedback (with amount held constant) and the impact of single vs. multiple assessment instruments (with type of feedback held constant). At the end of all semesters, students are asked to assess the effectiveness of the feedback received during the semester as well as the degree to which their critical-thinking and writing skills have improved.

Measures

Student Performance

Student performance is measured by scores received on the following graded components in the course: (1) average score across the 9 quizzes administered over the semester; (2) score on the original submission of the second case report completed in the second half of the semester (students are allowed to revise case reports, so the original case report score is a more appropriate measure of students' ability than their final case report score); (3) score on the midterm exam; (4) score on the final exam; and (5) overall course grade.

Student Perceptions of Feedback Usefulness

Students are asked to assess the usefulness of the feedback received during the semester in terms of its contribution to their performance in the course. They assess the usefulness of the feedback on the quizzes and, for students in the more feedback condition, the usefulness of the feedback they receive on the case report and the midterm exam. All items are measured using a 5-point rating scale, with the "1" being "strongly disagree" and "5" being "strongly agree."

Student Perceptions of Learning

Students also indicate the extent to which the course has improved their ability to analyze what they read. This is measured using a 5-point rating scale, with "1" being "strongly disagree" and "5" being "strongly agree."

RESULTS

Tests of Mean Differences

To examine the role of feedback type on both academic performance and students' perceptions of learning, we perform a simple test of means, comparing students receiving outcome-oriented feedback and students receiving process-oriented feedback (see Table 2). Results indicate that students receiving process feedback perform significantly better than those receiving outcome feedback on the overall quiz average but perform less well on the final exam. However, these differences are only observed for those students who receive process feedback on multiple assessments (i.e., more feedback). There are no statistically significant differences between process and outcome feedback for the other performance assessment instruments.

When comparing students' perception of feedback usefulness and learning across feedback types, we find that students receiving process-oriented feedback are more likely to report that quiz-related feedback has a positive impact on course performance and that their reading analysis skills have improved compared to their counterparts receiving outcome-oriented feedback. However, this result only occurs for students who receive less feedback.

TABLE 2
TEST OF MEANS: OUTCOME VS. PROCESS FEEDBACK

	Single Assessment Instrument			Multiple Assessment Instruments		
	Outcome-oriented Feedback	Process-oriented Feedback	Difference in Means (p-value)	Outcome-oriented Feedback	Process-oriented Feedback	Difference in Means (p-value)
Academic Performance						
Quiz Average	4.333	4.380	0.047 (0.602)	4.487	4.609	0.122* (0.067)
Original Score Case Report 2	80.458	80.378	-0.081 (0.964)	82.773	85.789	3.017 (0.148)
Midterm Exam	74.792	74.511	-0.281 (0.865)	75.500	76.789	1.289 (0.594)
Final Exam	69.563	67.667	-1.896 (0.375)	80.364	76.368	-3.995* (0.102)
Overall Course Average	81.014	80.166	-0.848 (0.520)	84.578	85.330	0.752 (0.635)
Student Assessment						
Perception of Feedback Usefulness						
The feedback I received on my in-class quizzes positively impacted my performance in this class.	3.636	4.146	0.510*** (0.008)	3.950	3.833	-0.117 (0.672)
The feedback I received on my case reports positively impacted my performance on this class.	4.136	3.976	-0.161 (0.334)	4.200	4.389	0.189 (0.510)
The feedback I received on my mid-term exam positively impacted my performance in this class.	3.523	3.683	0.160 (0.403)	4.000	4.167	0.167 (0.554)

Perception of Learning						
After taking this course, I am better at analyzing or processing what I read.	4.136	4.439	0.303** (0.021)	4.300	4.111	-0.189 (0.462)
After taking this course, I am better at explaining my thoughts in a written format.	4.091	4.175	0.084 (0.507)	3.950	4.000	0.050 (0.860)
After taking this course, I am more aware of how I use feedback to improve my answers to questions.	3.977	4.100	0.123 (0.403)	3.900	4.056	0.156 (0.487)

*** Significant at 1%

** Significant at 5%

* Significant at 10%

To examine the role of feedback amount on both academic performance and students' perceptions of learning, we again perform a simple test of means, comparing students receiving either process or outcome feedback on one assessment instrument and those receiving the same type of feedback on multiple assessment instruments (see Table 3). In terms of academic performance students receiving more feedback outperform students receiving less feedback on quizzes, the final exam, as well as overall course average, and this difference is statistically significant. Moreover, this result is true whether students receive outcome-oriented feedback or process-oriented feedback. Students receiving more feedback on the case report also outperform those receiving less feedback, but this result only occurs for those receiving process-oriented feedback.

TABLE 3
TEST OF MEANS: SINGLE VS. MULTIPLE ASSESSMENT INSTRUMENTS

	Outcome-oriented Feedback			Process-oriented Feedback		
	Single Assessment Instrument	Multiple Assessment Instruments	Difference in Means (p-value)	Single Assessment Instrument	Multiple Assessment Instruments	Difference in Means (p-value)
Academic Performance						
Quiz Average	4.333	4.487	0.154* (0.072)	4.380	4.609	0.229* (0.056)
Original Score Case Report 2	80.458	82.773	2.314 (0.300)	80.378	85.789	5.412*** (0.009)
Midterm Exam	74.792	75.500	0.708 (0.703)	74.511	76.789	2.278 (0.333)
Final Exam	69.563	80.364	10.801*** (0.001)	67.667	76.368	8.702*** (0.005)
Overall Course Average	81.014	84.578	3.564*** (0.010)	80.166	85.330	5.164*** (0.007)
Student Assessment						
Perception of Feedback Usefulness						
The feedback I received on my in-class quizzes positively impacted my performance in this class.	3.636	3.950	0.314 (0.222)	4.146	3.833	-0.313 (0.143)
The feedback I received on my case reports positively impacted my performance on this class.	4.136	4.200	0.064 (0.786)	3.976	4.389	0.413** (0.046)
The feedback I received on my mid-term exam positively impacted my performance in this class.	3.523	4.000	0.477 (0.094)	3.683	4.167	0.484*** (0.010)

Perception of Learning						
After taking this course, I am better at analyzing or processing what I read.	4.136	4.300	0.164 (0.382)	4.439	4.111	-0.328* (0.066)
After taking this course, I am better at explaining my thoughts in a written format.	4.091	3.950	-0.141 (0.460)	4.175	4.000	-0.175 (0.348)
After taking this course, I am more aware of how I use feedback to improve my answers to questions.	3.977	3.900	-0.077 (0.664)	4.100	4.056	-0.044 (0.821)

*** Significant at 1%

** Significant at 5%

* Significant at 10%

Turning to differences in students' perceptions based on the amount of feedback received, we find no statistically significant differences for students who receive outcome-oriented feedback. For students who receive process-oriented feedback, however, those receiving more feedback have more positive perceptions of both feedback usefulness and learning than those receiving less feedback.

Overall, while we find limited evidence that process feedback is superior to outcome feedback, a slightly stronger case can be made for the superiority of more feedback over less feedback. The lack of robustness, however, may simply be due to failing to control for multiple factors that could affect performance. In particular, performance may be impacted by the combination of type and amount of feedback received, the innate ability of the student, the level of the student's familiarity with the instructor, and the degree to which the student is interested in the course or its perceived relevance to major. We control for these factors in the next set of analyses.

Regression Analysis

In order to more clearly illuminate the relationship between feedback and academic performance, we estimate a series of regression models. In particular, we regress each of the academic performance measures examined in the previous section (i.e. quiz average, case report score, mid-term exam score, final exam score, and overall course average) against the following independent variables.

- FEEDBACK TYPE: Dummy variable with value of 1 if student receives process-oriented feedback and value of 0 otherwise.
- FEEDBACK AMOUNT: Dummy variable with value of 1 if student receives feedback on multiple assessment instruments and value of 0 otherwise.
- CUMULATIVE GPA: Cumulative GPA at the end of the semester in which enrolled, based on 4.0 scale.
- REPEAT: Dummy variable with value of 1 if student has previously taken a course with the same instructor and value of 0 otherwise.
- ECONOMICS MAJOR: Dummy variable with value of 1 if student is economics major and value of 0 otherwise.

In addition, to explore the interaction between type of feedback and amount of feedback, we also estimate models which include the following terms, both individually and collectively.

- FEEDBACK TYPE * FEEDBACK AMOUNT: Dummy variable with value of 1 if student receives process-oriented feedback on multiple assessment instruments and value of 0 otherwise.
- FEEDBACK TYPE * CUMULATIVE GPA: Term which captures potential interaction between feedback type and student's academic ability.
- FEEDBACK AMOUNT * CUMULATIVE GPA: Term which captures potential interaction between feedback amount and student's academic ability.

In the absence of interaction terms, both feedback type and feedback amount have a positive impact on quiz performance (column 1 of Table 4). In particular, the average quiz score for students receiving process-oriented feedback is approximately 2% greater than that of students receiving outcome-oriented

feedback. Similarly, receiving feedback on multiple assessment instruments increases students' average quiz score by approximately 2%. This result, however, is sensitive to the inclusion of interaction terms in the model. With the inclusion of these terms, the main effect of both type of feedback and amount of feedback on quiz performance is no longer significant (column 2 of Table 4). Instead, the results suggest that process-oriented feedback is more effective than outcome-oriented feedback but only for students with a higher cumulative GPA.

In the context of case reports and the mid-term exam, we find no evidence that type of feedback impacts performance and only limited evidence that amount of feedback has a positive impact on performance (columns 3 and 5 of Table 4). Moreover, this positive relationship disappears with the inclusion of the interaction terms. As in the case of quiz performance, we find that cumulative GPA has a significant and positive impact on performance on both the case report and the midterm exam. In particular, a unit increase in the student's cumulative GPA (e.g. 3.00 to 4.00) is correlated with an approximately 8% increase in the student's case report score and mid-term exam score.

Turning to broader measures of performance (the final exam and course average), in the absence of interaction terms, students receiving feedback on multiple assessment instruments score approximately 8% higher on the final exam than those who do not (column 1 of Table 5), and their course average is approximately 3% higher (column 3 of Table 5). However, feedback type does not affect performance on either of these measures. These results are sensitive to the inclusion of interaction terms in the model. With the inclusion of these terms, the direct effect of feedback amount on final exam and overall course performance is no longer observed, and the direct effect of process-oriented feedback is negatively correlated with students' final exam score and course average (column 2 and column 4 of Table 5), indicating the process feedback actually has a negative impact on performance. High-ability students, however, are less negatively impacted by receiving process feedback, as shown by the significant interaction between feedback type and cumulative GPA. The significant interaction between feedback type and amount for the final exam indicates that the lowest performance occurs for students receiving process feedback on multiple assessments.

TABLE 4
REGRESSION MODEL – INTERMEDIATE ASSESSMENT INSTRUMENTS

	Quiz Average		Case Report		Mid-term Exam	
	(1)	(2)	(3)	(4)	(5)	(6)
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
Constant	2.680*** (0.001)	2.902*** (0.001)	51.568*** (0.001)	52.728*** (0.001)	42.076*** (0.001)	51.868*** (0.001)
Feedback Type (=1 if process-oriented; 0 otherwise)	0.103* (0.068)	-0.617 (0.178)	1.481 (0.246)	-2.597 (0.805)	0.885 (0.456)	-8.678 (0.367)
Feedback Amount (=1 if more feedback; 0 otherwise)	0.132** (0.032)	0.817 (0.164)	2.783** (0.046)	8.150 (0.547)	0.319 (0.805)	-26.299** (0.034)
Cumulative GPA	0.493*** (0.001)	0.426*** (0.001)	8.628*** (0.001)	8.327*** (0.001)	9.745*** (0.001)	6.745*** (0.003)
Repeat (=1 if student has taken course previously with instructor; 0 otherwise)	0.010 (0.886)	-0.015 (0.840)	-0.280 (0.866)	-0.393 (0.817)	0.365 (0.813)	0.678 (0.662)
Economics Major (=1 if student is economics major; 0 otherwise)	0.137** (0.0532)	0.123* (0.083)	1.141 (0.478)	1.077 (0.509)	2.499* (0.096)	2.369 (0.113)
Feedback Type * Feedback Amount		-0.071 (0.568)		0.842 (0.768)		-1.566 (0.548)
Feedback Type * Cumulative GPA		0.229* (0.102)		1.189 (0.712)		2.960 (0.315)
Feedback Amount * Cumulative GPA		-0.199 (0.254)		-1.745 (0.665)		8.140** (0.028)
Adjusted R²	0.318	0.325	0.205	0.189	0.249	0.266

*** Significant at 1%

** Significant at 5%

* Significant at 10%

Cumulative GPA and whether or not the student is an economics major also have a significant and positive impact on performance on both the final exam and course average, suggesting that student ability/motivation and course relevance are important factors influencing performance. In particular, a unit increase in the student's cumulative GPA (e.g. 3.00 to 4.00) is correlated with an approximately 11-14% increase in the student's final exam score and an approximately 7-10% increase in the student's course average. Economics majors score approximately 5% higher on the final exam and have a course average approximately 3% higher than their non-economics-major counterparts.

To examine the relationship between feedback and student perception of learning, we use as the dependent variables the average response for the feedback effectiveness questions and the average response for the perception of learning questions listed in Table 2. Results for both are reported in Table 6. In terms of feedback effectiveness, the receipt of process-oriented feedback and the number of assessment instruments on which this feedback is received are significantly and positively correlated with student perceptions of this feedback (column 1 of Table 6). The inclusion of interaction terms, however, changes this result, in that neither the estimated coefficients associated with the direct feedback-related measures nor those associated with the feedback-related interaction terms are statistically significant

(column 2 of Table 6). Additionally, cumulative GPA has a significant and positive impact on student perception of feedback effectiveness. However, we find no evidence of systematic differences in students' perception of learning based on either type or amount of feedback (column 3 and column 4 of Table 6).

TABLE 5
REGRESSION MODEL – FINAL ASSESSMENT INSTRUMENTS

	Final Exam		Course Average	
	(1)	(2)	(3)	(4)
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
Constant	21.389*** (0.001)	32.209*** (0.001)	47.091*** (0.001)	54.902*** (0.001)
Feedback Type (=1 if process-oriented; 0 otherwise)	-1.733 (0.171)	-27.464*** (0.007)	0.286 (0.697)	-12.967** (0.031)
Feedback Amount (=1 if more feedback; 0 otherwise)	8.071*** (0.001)	14.294 (0.265)	3.131*** (0.001)	-3.615 (0.636)
Cumulative GPA	14.499*** (0.001)	11.045*** (0.001)	10.112*** (0.001)	7.732*** (0.001)
Repeat (=1 if student has taken course previously with instructor; 0 otherwise)	0.122 (0.941)	-0.639 (0.692)	0.091 (0.925)	-0.019 (0.984)
Economics Major (=1 if student is economics major; 0 otherwise)	5.836*** (0.001)	5.303*** (0.001)	3.060*** (0.001)	2.833*** (0.003)
Feedback Type * Feedback Amount		-6.805*** (0.013)		-1.535 (0.342)
Feedback Type * Cumulative GPA		8.527*** (0.006)		4.166** (0.024)
Feedback Amount * Cumulative GPA		-1.063 (0.780)		2.163 (0.343)
Adjusted R²	0.536	0.569	0.549	0.561

*** Significant at 1%

** Significant at 5%

* Significant at 10%

DISCUSSION

The purpose of this study is to better understand how varying the type and amount of feedback influences students' learning through both their actual performance on assessment instruments and their self-reported perceptions of learning. With respect to type of feedback, some students are given feedback on the notes they write as they are “processing” the information to formulate their answers while others are given feedback on the “outcome” (i.e., their actual answers). We also vary the amount of feedback given to students. In the more-feedback condition, students receive either process or outcome feedback on multiple types of assessment instruments (quizzes, exam, case report), while in the less-feedback condition students only receive process or outcome feedback on one type of assessment instrument (quizzes). Not only are we interested in whether there are differences in the effectiveness of feedback based on its type or amount, we are also interested in the interaction between these two aspects of the feedback message. In particular, we assess whether feedback type and feedback amount have a

synergistic, or complementary, effect where particular combinations of type and amount are more effective than others or, alternatively, if they might serve as substitutes for each other.

TABLE 6
REGRESSION MODEL – STUDENT PERCEPTIONS

	Perception of Feedback Effectiveness		Perception of Learning	
	(1)	(2)	(3)	(4)
	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)	Coefficient (p-value)
Constant	2.573*** (0.001)	2.387*** (0.002)	4.303*** (0.001)	4.871*** (0.001)
Feedback Type (=1 if process-oriented; 0 otherwise)	0.194* (0.092)	0.732 (0.439)	0.134 (0.173)	-0.760 (0.345)
Feedback Amount (=1 if more feedback; 0 otherwise)	0.209* (0.094)	-0.416 (0.737)	-0.076 (0.471)	-0.682 (0.517)
Cumulative GPA	0.372*** (0.009)	0.418* (0.058)	-0.050 (0.675)	-0.230 (0.217)
Repeat (=1 if student has taken course previously with instructor; 0 otherwise)	-0.033 (0.825)	-0.017 (0.912)	-0.156 (0.219)	-0.166 (0.202)
Economics Major (=1 if student is economics major; 0 otherwise)	-0.145 (0.321)	-0.141 (0.340)	-0.144 (0.248)	-0.167 (0.185)
Feedback Type * Feedback Amount		-0.174 (0.490)		-0.254 (0.234)
Feedback Type * Cumulative GPA		-0.149 (0.606)		0.295 (0.230)
Feedback Amount * Cumulative GPA		0.212 (0.561)		0.214 (0.492)
Adjusted R²	0.070	0.056	0.006	0.005

*** Significant at 1%

** Significant at 5%

* Significant at 10%

Our first research question focuses on the impact of process vs. outcome feedback on performance. When looking at the means tests of differences between process and outcome feedback for each of the performance measures used, we only find evidence for the superiority of process feedback for average performance on quizzes and only for students receiving more feedback. On the other performance measures (except final exam score), we find no difference between process and outcome feedback. Interestingly, on the final exam we actually find that students who receive process feedback performed *less well* than those receiving outcome feedback but again, only for students who receive more feedback. With the exception of the final exam result, these findings are consistent with previous research (Paulson Gjerde et al., 2017).

Our second research question addresses the impact of feedback amount on classroom performance. Mean difference tests present a clearer picture for the effect of feedback amount. Results show that receiving more feedback results in better performance than receiving less feedback. The fact that this occurs across multiple performance measures and occurs regardless of the type of feedback received suggests that it is a fairly robust finding. The only exception to this pattern is the case report, where more

feedback is only beneficial for those receiving process feedback. This suggests that repeated exposure to the same type of feedback consistently over a period of time may be more beneficial in terms of performance than receiving a specific type of feedback. Our findings regarding the positive impact of more feedback differ from prior research, which has found limited evidence that receiving more feedback results in greater learning than less feedback (Harris & Rosenthal, 1985; Kluger & DeNisi, 1996). It is possible that this difference occurs because the feedback in this study is provided in a way that is less threatening to the self-esteem of our participants, making them less inclined to deny or ignore the feedback. It is also possible that our participants are less prone to the negativity effect, where even constructive feedback is viewed as critical and threatening to self-esteem (Ackerman & Gross, 2010).

Although our primary focus is on the impact of feedback on student learning and classroom performance, we also report data on student perceptions of how useful the feedback is in terms of positively impacting their performance in the class as well as their perceptions of learning in the class. Our results show that students receiving process feedback perceive the quiz feedback to be more useful than do students receiving outcome feedback, but this only occurs for students in the less-feedback condition, who only receive feedback on the quizzes; students who receive feedback on multiple assessments do not perceive any difference in the usefulness of process and outcome feedback for any of the assessments on which they receive feedback. Amount of feedback received also has an impact on student perceptions of feedback usefulness. Students who receive more feedback perceive the feedback to be more useful than those who receive less feedback but only for those who also receive process feedback. This finding contrasts with research by Ackerman and Gross (2010) and Ackerman et al. (2017), who have found that students react more favorably when they receive less feedback rather than more. It is possible that this difference occurs because of the different nature of the student responses measured in the two Ackerman studies compared to those that we measure. Specifically, both Ackerman studies have focused on student affective reactions (e.g. perceptions of fairness, liking for the instructor and satisfaction with their performance) while we focused on perceptions of the actual value of the feedback. This contrast suggests that even though students may respond negatively on an emotional level to more feedback, they do recognize its value.

Surprisingly, however, students who receive less feedback perceived greater learning in the course than did students who receive more feedback. This presents an interesting contradiction because our results suggest that actual performance and learning is greater with more feedback even though students *perceive* less learning. This may suggest that it would be beneficial for instructors to take class time to review the feedback that is provided to the students, at least when initial assessments are returned. In particular, demonstrating, by example, the application of the feedback to future assignments and/or reinforcing the benefits of getting detailed feedback might be helpful to students interested in improving/learning. Additionally, it might be helpful to remind students that feedback is not intended as a personal attack or as a means to discredit their abilities. Instead, it is provided to help them “practice” and make corrections and, therefore, improve their skills. Finally, showing them how academic feedback is similar to the practice and instructional feedback they might receive on other types of endeavors (e.g., athletic or artistic pursuits) that they are familiar with may make academic feedback seem less threatening and more helpful.

The regression analyses provide results related to our third research question about the combined impact of type and amount of feedback. The regression analysis also allows us to determine if there are interactions between feedback type or amount and student characteristics. We examine three student characteristics, but cumulative GPA, which we consider to be a proxy for student ability/motivation, is the only one that we interact with either feedback type or amount. When there are no interaction terms included in the regression model, our results for feedback type and amount are very similar to those from the simple test of means. Noteworthy are the additional, although not surprising, findings of a significant positive effect of cumulative GPA on all of the performance measures and the positive, but smaller, effect of being an economics major on most performance measures. These observations suggest that academic ability/motivation and relevance of the course have a non-trivial impact on performance in the course. Contrary to what we expected given the finding that the impact of feedback type or amount is sometimes

contingent on the level of the other feedback variable, we do not find much evidence for an interaction between the two feedback variables, with the exception of performance on the final exam.

Interestingly, but consistent with the test of means results, we find lower performance on the final exam for students receiving process feedback, an effect that is magnified by receiving process feedback on multiple assessments (i.e. more feedback). Although inconsistent with the positive impact of process feedback on quiz performance found in this study, it is possible that this difference occurs because, contrary to what we initially thought, process feedback may be more complex, and thus, actually *harder* for students to apply to a different type of assessment instrument. Specifically, because students actually receive process feedback on the quizzes themselves, it may be easier for them to use this feedback to improve their performance on subsequent quizzes even though they are not able to take their learning from the quiz context and use it to improve their performance on other assessment instruments, such as the final exam. The fact that receiving process feedback on their first case report does not improve performance on the second case report, even though it is a very similar type of assessment, may be due to the fact that students know they can revise the case report and thus, do not put as much effort into preparing their initial submission.

Additional, although indirect, support for the greater difficulty involved in applying process feedback can be found in our finding that feedback type interacts with cumulative GPA for the final exam and overall course average. The direction of the effect suggests that the performance of higher ability/motivation students is less negatively impacted by receiving process feedback than is the performance of lower ability/motivation students. If process feedback is more complex and/or harder to apply in a different context, it would be expected that higher ability/motivation students would be more able to apply it (even though not effectively enough for it to improve their performance on the assessment). We do not find much evidence that feedback amount interacts with cumulative GPA except on the midterm exam, where we find that regardless of the type of feedback received, higher ability/motivation students who receive more feedback performed better than others. This suggests that students, regardless of their ability/motivation, can benefit from receiving more feedback.

Our results are suggestive of several conclusions. First, the amount of feedback provided to students seems more important in terms of enhancing their performance than the type of feedback – at least when comparing feedback on the answer provided with feedback on the student's thinking process. In particular, our results suggest that receiving either process or outcome feedback across multiple different assessments is likely to lead to higher performance than receiving either type of feedback on just one type of assessment.

Second, despite our results, we think there is value in pursuing the use of process feedback. Providing feedback to students on their thinking process may teach them important meta-cognitive skills, including self-assessment and self-regulation. Additionally, Hattie and Timperley (2007) have suggested that process feedback may be a more efficient strategy for shaping behavior than outcome feedback that is focused on surface-level task performance. However, given the difficulty students seem to have in applying this type of feedback (or any type of feedback), it may first be necessary to show students *how* to use feedback, instead of assuming, as we often do, that they understand this.

Third, our results suggest that examining the impact of feedback characteristics by themselves and without regard for characteristics of the recipient may not be an effective strategy for understanding and improving the effectiveness of feedback. In particular, it appears that different students may benefit from different types and/or amounts of feedback. This lack of attention to student characteristics has been noted by others (e.g., Burke, 2009; Shute, 2008; Evans, 2013). As educators, we may need to consider the possibility of individualizing our feedback further so that students receive the type of feedback that will benefit them the most.

Finally, the sometimes disparate results we found across assessment instruments suggests that the nature of the feedback provided might also need to vary from one type of assessment to another. This indicates a need for more attention being given to understanding the impact of task characteristics on feedback effectiveness, a conclusion that has been reached by others (e.g., Hattie & Timperley, 2007; Kluger & DeNisi, 1996). For example, the more complex process feedback seems to result in better

performance on the quizzes than did outcome feedback, a result consistent with our previous study (Paulson Gjerde et al., 2017). Quizzes by their nature, are more specific and narrowly focused; they are also smaller-scale assignments. In this simpler context, students may be able to make use of the more complex process feedback. However, on broader, more complex assignments, with a wider number of factors to consider, such as the case reports and the final exam, they seem less able to do so. The fact that students are equally unable to apply outcome feedback to improve their performance on these other assessments may be indicative of a general inability to apply learning from one context to another, suggesting, as noted earlier, a need for instructors to help students learn how to use academic feedback to improve future performance. A related possibility is that students may not see the performance contexts as being similar enough to warrant applying their learning. If this is the case, explicit statements from the instructor that alert students to the similarity between different assignments may help to trigger application of feedback from one context to another.

CONCLUSION AND FUTURE RESEARCH

Although our results suggest that both type and amount of feedback play a role in student performance, the lack of robustness may be partially attributed to several shortcomings of our model. First, the sample size on which our results are based is relatively small, and, thus, the results may not reflect the true underlying relationships inherent in the student population. In addition, the variation in the amount of feedback received between treatment groups may not have been sufficiently different to produce a large and consistent difference in learning and performance across all assessment instruments. In particular, students in both treatment groups receive feedback on nine quizzes, with students in the multiple-assessment-instrument group receiving feedback on only three additional items. Although it can be argued that these three additional items represent more substantial components of the course, thereby magnifying their importance, it is unclear as to whether the increased weight sufficiently compensates for the relatively modest increase in the number of instances in which feedback is received. In the future, it would be helpful to more carefully examine and control for the multiple dimensions of feedback amount, including the weight associated with the assessment instrument on which feedback is received, the extent of feedback provided on a specific assessment instrument, and the number of instances in which feedback is received.

Similarly, our model uses cumulative GPA as a proxy for student ability. Although cumulative GPA and student ability are positively correlated, grades are also impacted by a host of other student-specific factors, including motivation, work ethic, and learning mindset. Given the critical role the recipient plays in determining feedback effectiveness, it would be helpful to use more precise or narrowly defined student-specific independent variables in the model. Such a framework would provide additional guidance on how to more appropriately tailor feedback to specific types of students. Regardless of the specific student attribute and feedback metrics used in future models, it is critical to not simply consider each of these factors in isolation. Instead, the key to understanding feedback effectiveness likely lies in the interaction between feedback message, feedback recipient, and feedback source. Viewed from this perspective, the issue is not whether process-oriented feedback is superior to outcome-oriented feedback, nor is it whether more feedback is superior to less feedback. These narrow questions, although relevant, do not capture the complex nature of the feedback process. Based on our results, a more careful examination of how to best match the feedback message to the appropriate student population is needed.

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