

Relative Effectiveness of Computer-based and Human Feedback for Enhancing Student Learning

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Abstract

In an online learning environment, students are forced to rely on feedback to gauge the extent to which they have mastered course content and to enhance their knowledge of course material. There are two primary avenues for this type of feedback: interactions with online instructors and computer-based feedback automatically generated by online assessment programs.

The purpose of this study is to examine the educational impact of presenting various levels of computer-based, online feedback (no-feedback, knowledge-of-response, knowledge-of-correct-response, topic-contingent, and response-contingent) either alone or paired with human interaction in an independent, mastery learning environment. Results indicate that student learning is enhanced by human interaction but is not influenced by the various types of computer-based feedback. Although the type of computer-based feedback does not impact student learning, students report distinct preferences for knowledge-of-response and response-contingent computer-based feedback.

The results of this study reveal important implications for online instructors: 1) while the type of computer-based feedback may not significantly impact learning, students prefer feedback that is direct and clearly addresses the correctness of their response; and 2) instructors cannot rely on computer-based feedback alone to correct errors in student understanding as live interaction remains a critical element for student success in independent learning environments.

Introduction

The shift to online instruction has created an academic environment in which students in online courses complete a significant portion of their educational activities utilizing independent study and review of online course materials. Students then apply their knowledge and test their understanding through interactions and activities in the online classroom. In this environment, students are forced to rely on feedback to gauge the extent to which they have mastered course content and to enhance their knowledge of course material. There are two primary avenues for feedback: interactions with online instructors and computer-based feedback automatically generated by online assessment programs.

Feedback provided through online assessment programs offers several advantages over reliance on online instructors. Specifically, computer-based feedback can provide immediate feedback on individual responses regardless of class size or the time at which an assignment is completed and computers can tirelessly provide unbiased, accurate and nonjudgmental feedback that is irrespective of student characteristics or the nature of the student response. These practical advantages have lead many online instructors to rely extensively on computer-based assessment programs to provide students with feedback on their understanding of course concepts.

Effective feedback provides the learner with two types of information: verification and elaboration (Kulhavy and Stock, 1989). Verification is the simple judgment of whether an answer is correct or incorrect, while elaboration is the informational component providing relevant cues to guide the learner toward a correct answer. Feedback that facilitates the greatest gains in learning must include both verification and elaboration. This combination highlights response errors and provides information to strengthen correct responses.

Feedback can take on many forms depending on the levels of verification and elaboration incorporated into the item response. The literature focuses on five commonly used levels of feedback (see Gilman, 1969; Kulhavy & Stock 1989; Merrill, 1987; and Overbaugh, 1994):

- No-feedback. A no-feedback condition simply provides learners with a performance score but no reference to individual test items. This minimal level of feedback

contains neither verification nor elaboration, but simply states the learners' proportion of correct responses.

- Knowledge-of-response. Knowledge-of-response feedback tells learners whether their answers are correct or incorrect. While this type of feedback is essential for verification purposes, it does not provide any information that would further the learners' knowledge or provide additional insight into possible errors in understanding.
- Knowledge-of-correct-response. Knowledge-of-correct-response feedback provides individual item verification and supplies learners with the correct answer. Knowledge-of-correct-response provides no elaborative information beyond identification of the correct response option.
- Topic-contingent. Topic-contingent feedback provides item verification and general elaborative information concerning the target topic. After incorrect responses, learners are returned to passages or other learning material where the correct information is located or they are given additional information from which they may find the answer. While topic-contingent feedback makes extensive elaborative information available, it depends upon learners to locate the correct answer within the instructional material.
- Response-contingent. Response-contingent feedback provides both verification and item-specific elaboration. In addition to providing knowledge of the correct response, response-contingent feedback gives response-specific feedback that explains why the incorrect answer was wrong and why the correct answer is correct.

While several studies have found that providing elaborative computer-based feedback did not influence students' knowledge of the material (e.g., Hodes, 1984-85; Merrill, 1987; Mory, 1994; Park & Gittelman, 1992), a larger body of research shows enhanced learning in response to more elaborate feedback (e.g., Clariana, 1990, 1992; Gilman, 1969; Pridemore & Klein, 1991, 1995; Morrison, Ross, Gopalakrishnan, & Casey, 1995; Roper, 1977; Waldrop, Justen, & Adams, 1986; Whyte, Karolick, Neilsen, Elder & Hawley, 1995). The contradictory findings concerning the impact of feedback elaboration indicate that there is no clear-cut “best” type of feedback in

computer-based instruction for all learners and learning outcomes. The challenge therefore is to identify the type of feedback that is most effective in specific educational settings.

The purpose of the proposed study is to examine the educational impact of presenting various levels of computerized feedback (no-feedback, knowledge-of-response, knowledge-of-correct-response, topic-contingent, and response-contingent) either alone or paired with human interaction in an independent, mastery learning environment. In this type of environment, students work at their own pace and must demonstrate mastery of content material in order to progress through the course. While online assessment programs are able to provide specific, preprogrammed information relevant to each question, technology does not currently allow the computer to respond to individual student inquiries. Thus, while computer-based feedback may help to clarify simple, definition-based errors, it may be less effective in correcting more complex errors in understanding. In addition, research indicates that student understanding is enhanced more through the application of relevant examples than through repetition of basic information (Chi, DeLeeuw, Chiu, & LaVancher, 1994; Lee & Hutchison, 1998; and Ross & Kennedy, 1990). With these factors in mind, it was hypothesized that students who received more elaborative forms of feedback (topic-contingent or response-contingent) would show increased learning over students receiving less elaborate feedback (no-feedback, knowledge-of-response, or knowledge-of-correct-response) and students who received a combination of computer-based feedback and human interaction would demonstrate more learning than students receiving only computer-based feedback.

Methods

Participants:

Two hundred and ten students at a large Midwestern university participated in the study. Participation was voluntary and was available to all students enrolled in the Introductory Psychology mastery learning course; participants received four hours research credit and course credit on passed unit tests in exchange for their participation.

Females (n = 98) slightly outnumbered males (n = 73) and the majority of students were underclassmen (freshman, n = 51; sophomores, n = 76; juniors, n = 22; seniors, n = 22). The

majority of participants were Caucasian (n = 158) and were not psychology majors (n = 142). There were no between-group significant differences in gender, year in school, ethnic background, grade point average, hours of paid work per week, hours spent per week studying for this course, or experience with independent learning courses.

Procedure:

Participants were randomly assigned to one of the ten feedback-delivery by feedback-elaboration conditions (see Table 1 for a detailed listing of conditions with relevant sample size). Regardless of experimental group, all students were allowed unlimited time to test, unlimited time to review feedback, and unlimited testing attempts to reach mastery. Students who did not perform at a mastery level (above 80%) on the initial test were required to restudy the original chapter and retest. For each successive retest, questions were changed while test topics remain constant. This procedure was repeated until all participants demonstrated mastery (above 80%) of the material. All participants were instructed to carefully review any feedback provided. At the conclusion of each test, participants in the combined feedback-delivery mode (receiving both computer-based feedback and human interaction) were required to review and discuss their test with a teaching assistant. During these live test discussions, the teaching assistants expanded upon the computer-based feedback, provided examples, and answered individual student questions.

Materials and Measures:

Computer-Based Testing Program. The "eGrade On-Line Assessment System" (Orr, 2000) was utilized for all computer-based testing and feedback. At the first course meeting, students were given complete instructions for navigating the "eGrade" testing program. When a student finished the test, the appropriate computer-based feedback appeared on the screen.

Unit Tests. To measure student learning, unit tests were administered following each of three target chapters (Units 5, 6, and 7) of information. Each test consisted of 15 multiple-choice questions and 1 essay question designed to assess various levels of understanding.

Computer-Based Feedback. Five types of computer-based feedback-elaboration were utilized: no-feedback which provided the overall test percentage without addressing individual questions;

knowledge-of-response feedback informed students of the correct/incorrect status of each question, but did not inform students of the correct answer; knowledge-of-correct-response which addressed the correct/incorrect status of each question in addition to providing the correct answer; topic-contingent feedback provided the correct/incorrect status of each question along with paragraph of information from which the correct answer could be found; response-contingent feedback addressed the correct/incorrect status of each question along with an explanation of the selected response and the correct response.

Discussion Information. During initial training, teaching assistants were instructed to provide structured discussions to each student based on a set format in which the teaching assistant would review every missed question, ask the student to generate an example for each missed question, ask for additional student questions, and provide encouragement for future test attempts. When reviewing missed questions, teaching assistants were instructed to explain why the selected answer was incorrect, explain why the correct answer is correct, and provide an example to illustrate the correct answer. In order to examine individual variations in the discussions provided by the teaching assistants, a Discussion Information form was filled out following each discussion. This 7-item measure recorded the length of the discussion, activities included in the discussion (examples, definitions, questions, and etc.), and the perceived level of interest shown by the student. Summary data (including frequencies by percentage of discussion activities) can be found in Table 2.

Post-Test Satisfaction Survey. The Post-Test Satisfaction Survey is a 5-item measure that targets students' attitudes about the type of feedback that was administered.

Results

Separate analyses were conducted to examine significant differences in learning between the ten feedback-elaboration by feedback-delivery conditions as measured by retest performance and students' attitudes towards computer-based feedback. For all learning measures, data from participants who passed the unit test on the first testing attempt was eliminated from the analysis as this sub-sample of participants did not have any incentive to utilize the feedback nor was there a follow-up measure to test possible use. Table 1 provides the resulting group size.

Learning. A MANOVA revealed a significant main effect for feedback-delivery on Unit 5 [$F(1,33) = 5.247, p = .029$] but found no interactions or main effects for feedback-elaboration for any of the units. Specifically, for Unit 5, students who discussed their test with a teaching assistant scored significantly higher on their retest than students receiving only computer-based feedback. A complete list of means for all conditions is located in Table 3.

While the only significant difference in learning was detected in Unit 5, for all three units, students receiving a discussion showed increased retest performance compared to students receiving only computer-based feedback. Students receiving a discussion in combination with the computer-based feedback produced a mean increase in retest performance of approximately 1.44 points or 8%. As indicated in Figure 1, receiving a discussion in combination with the computer-based feedback produced a mean increase in retest performance of approximately 1.44 points or 8%. Thus, the lack of an overall significance for the feedback-delivery main effect may be the result of the small sample size of the current study rather than a lack of educational impact.

This effect is clearly depicted when examining changes in the frequency distribution of retest scores. Consistent across all units, students who received a discussion were more likely to receive a passing score (above 14 points) than students receiving no discussion. When all units are combined and scores are divided according to achievement level (low = less than 8 points; average = 9 to 13 points; high = 14 or more points) students receiving only computer-based feedback were more likely to show low to average retest performance. Conversely, students who discussed their test with a teaching assistant demonstrated high achievement on the initial retest.

Attitude. While the various types of computer-based feedback did not impact learning, students did report different attitudes in response to feedback-elaboration. A MANOVA revealed that participants receiving knowledge-of-results and topic-contingent feedback were more likely to disagree with the statements “the feedback was helpful in correcting errors in understanding” [$F(1,87) = 2.128, p = .084$], “the feedback was clear” [$F(1,87) = 3.224, p = .016$], and “the feedback was easy to understand” [$F(1,87) = 3.506, p = .011$], than students receiving the other

three types of feedback. In addition, students receiving knowledge-of-results, topic-contingent and no-feedback reported that the feedback was less effective in helping to understand concepts and correct errors in understanding than students receiving either knowledge-of-correct-results or response-contingent feedback. Table 4 provides the means for the attitude measures by condition.

Discussion

As hypothesized, a main effect was found for feedback-delivery. Specifically, participants who received a combination of computer and human feedback demonstrated more learning (scoring an average of 1.44 points or 8% higher on their first retest) than students receiving only computer-based feedback. In order to account for the increase in learning, it is important to examine the activities or interactions that occur during a live test discussion. A sizable portion of discussions addressed essay grading criteria (36%), explained definitions (34%), provided examples (29%), and addressed item-specific explanations (29%). It is possible that while the computer-based feedback provided basic feedback regarding definitions, it did not provide the necessary elaborative information to promote active learning. The computer-based feedback repeated basic information but did not provide relevant examples or promote application of the material, while the live discussions elaborated the information to make it more relevant to the students' lives and level of understanding.

While the current study does not provide insight into which discussion activities are responsible for the gains in student learning, it provides a starting point for follow-up research to identify influential aspects of an effective discussion. In addition, if it is possible to identify specific activities in a discussion that promote the greatest gains in understanding, research may want to examine whether the effectiveness of these activities is dependent upon the delivery method. Specifically, research may examine whether examples can be effectively incorporated into a computer-based feedback series or if the effectiveness is dependent upon a live, interactive presentation. In the current study 36% of the students initiated questions during their discussions, suggesting that the discussions were not simply one-way presentations of information but contained an interactive element. It is possible that the active learning component of the discussions was more educationally powerful than the content of the information presented.

Thus, while the current study provides support for the effectiveness of live discussions, further investigations are suggested to examine the specific factors contributing to these learning gains.

Contrary to the hypothesis, participants who received more elaborative forms of feedback (topic-contingent or response-contingent) did not show increased learning over participants receiving less elaborate feedback (no-feedback, knowledge-of-response, or knowledge-of-correct-response). As indicated previously, there were no significant learning differences in response to any of the forms of feedback-elaboration, including students who received no-feedback at all. In fact, for two of the units (Units 6 and 7), students receiving no-feedback slightly outperformed students receiving any of the more elaborate forms of computer-based feedback. These findings contradict the vast majority of feedback literature that provides support for the educational advantages of elaborative feedback, thus it becomes important to examine specific features of the current study that may have interfered with students' utilization of the feedback. Two factors that may have interfered with potential feedback effects are the timing of feedback-delivery and the availability of feedback review.

In the current study, students took the unit exam, received their score (indicating the pass/fail status of the exam), and were immediately given the computer-based feedback. In this situation, it is possible that students were unable to separate the assessment and instructional aspects of the activity. Immediately after completing the exam, students may have been more concerned about whether they passed the exam than they were about learning the information; thus, only using the feedback for item-verification purposes. In this case, providing the feedback in conjunction with the exam results may have reduced the potential educational benefits available through any of the forms of feedback-elaboration.

This explanation was supported in an examination of the amount of time students spent studying the feedback. Regardless of feedback-elaboration, students reported spending very little time examining the feedback (self-reported time spent reviewing and studying the computer-based feedback ranged from 2.82 minutes for students receiving knowledge-of-correct-results feedback to 6.25 minutes for students receiving knowledge-of-results feedback). In fact, a close examination of the reported feedback study times indicates that in several of the feedback-

elaboration conditions, participants did not report a sufficient amount of time to have even read the computer-based feedback. This evidence suggests that students may not have even read, let alone studied, the feedback following each exam. This failure of students to have utilized the computer-based feedback likely accounts for the lack of learning gains in response to the various forms of feedback-elaboration.

The availability of feedback review may have also limited the impact of feedback-elaboration. Due to the security features of the current testing program, students did not have an opportunity to return to the feedback at a later time. This may have prevented students from utilizing the feedback to its fullest potential as the feedback was not readily accessible during traditional study times. Allowing students the opportunity to repeatedly view the feedback and use it as a study tool may enhance the educational benefits. Future studies may want to examine the educational impact of the various forms of feedback-elaboration when the feedback is readily accessible for students to use at their own discretion.

As noted previously, data from participants that passed the unit test on the first attempt were not included in the analysis of learning (as these participants did not have an incentive to actively utilize the feedback since they were not required to retest over the same material). Thus the learning measures represented in this study do not reflect the overall impact of feedback (human or computer-based) on learning but rather the effects of feedback for a sub-sample of students. It is likely that higher achieving or highly motivated students were able to pass the unit tests on the first attempt, thus the current study provides no information as to the potential benefits of various forms of computer-based feedback for this population.

Differences in students' attitudes did appear in response to the various types of computer-based feedback. Participants receiving no feedback, knowledge-of-results or topic-contingent feedback believed the feedback was less helpful than students receiving knowledge-of-correct response or response-contingent feedback. These findings support similar research (Pridemore & Klein, 1991, 1995) showing that students receiving simple verification feedback desired additional, elaborative information. It is important to highlight while the current study found no attitude differences between knowledge-of-correct-results and response-contingent feedback, there was a

significant attitude difference between these two types of elaborative feedback and topic-contingent feedback (which is also considered an elaborative form of feedback). As noted by Pridemore and Klein (1995), students indicated a desire for information about the correct answer; thus, while topic-contingent feedback provides general information about the target question, it does not provide direct information about the correct answer. Failure to provide a clear, direct answer may account for the attitudinal differences between topic-contingent and other forms of elaborative feedback.

Consistent with research by Pridemore and Klein (1991, 1995), the current study found that students' attitudes toward the feedback-elaboration or feedback-delivery was not related to their learning outcome. While a student's attitude toward feedback may not bear directly on its measured educational impact, it may still be important to incorporate feedback that students perceive as beneficial. In independent learning environments, students have limited instructor contact time so it becomes especially important to find alternate means of motivation and encouragement. In this sense, students' perceptions that feedback is beneficial may encourage them to stay actively involved with the material. Thus, while the form of feedback-elaboration may not impact learning, it can serve as a valuable component of a course relying on independent learning.

The results of this study reveal important implications for online instructors: 1) while the type of computer-based feedback may not significantly impact learning, students prefer feedback that is direct and clearly addresses the correctness of their response; and 2) instructors cannot rely on computer-based feedback alone to correct errors in student understanding as live interaction remains a critical element for student success in independent learning environments.

While there is evidence for the effectiveness of utilizing live discussions in conjunction with computer-based feedback, the educational impact of the various forms of feedback-elaboration is not clear. The present results suggest that it may be counterproductive to eliminate the live interaction aspect of independent learning courses, even if elaborative feedback can be provided via computer. Further, there is a clear need for more research regarding students' attention to and use of elaborative computer-based feedback.

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Table 1: Final Number of Participants per Condition

Feedback Elaboration:	Knowledge-of-results	Knowledge-of-results	Knowledge-of-correct-results	Knowledge-of-correct-results	Topic-contingent	Topic-contingent	Response-contingent	Response-contingent	No-feedback	No-feedback
Feedback Delivery:	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone
Original	23	18	17	15	23	23	12	23	27	29
Unit 5	12	6	7	10	14	12	8	18	13	13
Unit 6	9	9	5	9	11	10	4	9	11	11
Unit 7	8	5	8	8	8	8	5	9	12	7

Table 2: Frequencies for Teaching Assistant Discussion Sessions

	Unit:	5	6	7	Average:
Duration	<1 min.	25%	49%	57%	44%
	1-5 min.	66%	46%	36%	49%
	>5 min.	9%	5%	7%	7%
Activities	examples	30%	35%	22%	29%
	definitions	41%	35%	26%	34%
	grading criteria	38%	28%	43%	36%
	question	30%	14%	14%	19%
	specific explanation	46%	23%	17%	29%
Interest	not very	14%	16%	28%	19%
	somewhat	46%	47%	40%	44%
	very	29%	32%	31%	31%
	don't know	4%			4%
Questions	yes	42%	34%	34%	37%
	no	58%	66%	66%	63%

Table 3: Learning Means by Feedback-Delivery and Feedback-Elaboration

	Feedback Elaboration:	Knowledge-of-results	Knowledge-of-results	Knowledge-of-correct-results	Knowledge-of-correct-results	Topic-contingent	Topic-contingent	Response-contingent	Response-contingent	No-feedback	No-feedback
Unit:	Attempt:	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone
5	1	11.96	12.29	12.97	10.14	11.98	12.20	11.25	10.76	12.35	12.10
	2	11.79	11.08	14.14	10.50	11.82	9.75	13.00	12.28	12.43	11.77
	3	13.33	8.33	13.00	10.50	13.19	11.63	13.50	12.50	10.75	12.00
	4	11.67	12.50	15.00	13.10	15.50	14.00	15.00	13.17	10.75	14.50
	5	9.50	15.50	-	15.13	-	16.00	-	14.33	9.00	-
6	1	13.13	12.35	14.06	11.50	12.09	12.57	13.42	12.50	13.32	12.90
	2	11.61	12.00	15.40	11.89	13.64	8.90	13.00	12.89	13.82	13.36
	3	8.80	11.50	15.50	12.40	10.00	13.71	15.00	14.50	14.75	11.67
	4	11.67	15.00	-	14.50	14.33	13.00	17.00	-	14.00	8.00
7	1	13.57	12.76	12.76	11.36	13.11	12.96	13.33	11.76	13.23	13.54
	2	12.25	13.80	13.75	11.19	13.38	11.81	13.30	10.83	13.67	12.14
	3	11.50	9.00	10.67	11.75	13.67	13.75	14.50	14.50	11.67	12.67
	4	12.00	15.00	13.50	14.00	7.00	12.50	-	14.00	15.50	-

Table 4: Computer Attitude Means by Feedback-Elaboration and Feedback-Delivery

Feedback Elaboration:	Knowledge-of-results	Knowledge-of-results	Knowledge-of-correct-results	Knowledge-of-correct-results	Topic-contingent	Topic-contingent	Response-contingent	Response-contingent	No-feedback	No-feedback
	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone	Computer and Human	Computer Alone
Feedback is helpful to correct errors in understanding.	3.31	3.57	3.86	4.63	3.29	3.92	4.14	4.08	4.00	4.20
Feedback is clear.	3.15	3.57	4.14	4.50	3.21	3.77	4.00	4.31	4.07	4.27
Feedback is easy to understand.	3.23	3.57	4.14	4.63	3.21	3.85	4.00	4.31	4.14	4.36
Computer feedback makes it possible for me to learn quickly.	3.38	3.86	3.57	4.38	3.36	3.92	4.00	4.00	3.93	3.55
In view of what I learned, computer feedback is superior to human feedback.	2.54	3.14	2.57	2.88	2.64	3.08	3.00	2.92	2.86	2.82

Figure 1: Main Effect of Feedback-Delivery on Learning

