

Learning to improve the quality peer feedback through experience with peer feedback

Zheng Zong , Christian D. Schunn & Yanqing Wang

To cite this article: Zheng Zong , Christian D. Schunn & Yanqing Wang (2020): Learning to improve the quality peer feedback through experience with peer feedback, Assessment & Evaluation in Higher Education, DOI: [10.1080/02602938.2020.1833179](https://doi.org/10.1080/02602938.2020.1833179)

To link to this article: <https://doi.org/10.1080/02602938.2020.1833179>



Published online: 18 Oct 2020.



Submit your article to this journal [↗](#)



Article views: 48





View related articles [↗](#)



View Crossmark data [↗](#)



Learning to improve the quality peer feedback through experience with peer feedback

Zheng Zong^a, Christian D. Schunn^b  and Yanqing Wang^a 

^aSchool of Management, Harbin Institute of Technology, Harbin, China; ^bLearning Research and Development Center, University of Pittsburgh, Pittsburgh, PA, USA

ABSTRACT

Peer review is regularly found to be a powerful and efficient technique for assessment and feedback, but many students are inexperienced and sometimes struggle to provide meaningful feedback. It is considered best practice to provide students with some training on how to be a good reviewer, but few classes can afford to devote much time to such training, and the assumption is that review quality will improve with experience. This study directly examines what kinds of experiences during peer feedback activities improve reviewing quality. In particular, organized by theories of norm-setting and practice-based learning, it examines the relationship of the amount of provided and received feedback on one assignment to improvements in the quality of feedback on the next assignment. Data on peer feedback experiences and behaviors across multiple assignments were taken from students across two introductory level undergraduate courses ($N = 360$). Multi-regression analyses reveal that the number and length of feedback provided predicted growth in helpfulness rates, and both improvements in domain performance and the reviewer's preference for length explains the effects on review helpfulness. Further, compared with high-performing students, low-performing students show more remarkable growth in helpfulness from providing feedback.

KEYWORDS

Peer assessment; peer feedback; students' performance; number of feedbacks; length of feedback

Introduction

Peer feedback involves qualitative comments from peers within a course to evaluate and improve performance. The use of peer feedback is argued to be an essential contributor to learning, whether the student work involves essays (Cho and Schunn 2007; Schunk and Zimmerman 2007; Applebee and Langer 2011), video presentations (Min 2016), design projects (Grabe and Kaplan 1996; Gatfield 1999) or computer code (Ballantyne, Hughes, and Mylonas 2002; Wang et al. 2012). Peer feedback is also considered to be a challenging learning method that requires development through extensive experience (Ruiz, Candler, and Teasdale 2007). As an interactive evaluation mode that can address a specific task/product, processes of learning or personal evaluation (Hattie and Timperley 2007), peer feedback attempts to expand the informational interaction between learners which can improve course performance (Ericsson and Charness 1994; van Gog et al. 2005).

Extensive prior research on peer feedback has revealed how its value can be influenced by various factors such as feedback content (Tseng and Tsai 2007; Nelson and Schunn 2009; Lu and

Law 2012), students' individual differences (Liu and Carless 2006; Weaver 2006; Winstone et al. 2017), and students' perceptions towards peer feedback (van der Pol et al. 2008; Strijbos, Narciss, and Dünnebier 2010). Extensive research has also demonstrated the effectiveness of peer feedback: students can increase knowledge and skills by receiving and providing feedback (Lundstrom and Baker 2009; Tsivitanidou, Zacharia, and Hovardas 2011; Huisman et al. 2018; Wichmann, Funk, and Rummel 2018; Wu and Schunn 2020a).

However, peer review has also encountered difficulties in practice. Since many students have not had much experience with and rarely received training on peer feedback, they still have much to learn about how to produce helpful feedback (Watson, Bishop & Ferdinand-James, 2017). Both students and teachers are concerned about whether assessment from their peers is reliable compared to assessment by teachers (Kaufman and Schunn 2011). Many scholars have studied the reliability of peer assessment and found that the evaluations from peers (at least when combining multiple peer assessments) are at least as reliable as teacher assessments (Yang, Badger, and Yu 2006; Paré and Joordens 2008; Bai 2012). There are also concerns about whether peers have sufficient professional knowledge to provide helpful qualitative feedback (Winstone et al. 2017), although peer feedback is quite helpful in practice (Cho, Schunn, and Charney 2006; Cho and Schunn 2007).

While it is clear that students can provide useful feedback to their peers, it does not mean that peer feedback is always useful (Nilson 2003; Zacharias 2007). There have been many studies examining the role of motivation in shaping the amount of feedback provided (Liu and Carless 2006; Kaufman and Schunn 2011; Zhao, Ha, and Widdows 2013; Zou et al. 2018). Correspondingly, some approaches have been used to hold peer reviewers accountable for the quality of their feedback in order to improve the overall quality (Patchan, Schunn, and Clark 2018). However, far fewer studies have examined how students learn to become better reviewers through experience with peer feedback (Price, Handley, and Millar 2011). It is considered best practice to provide some training on peer assessment (Nicol, Thomson, and Breslin 2014; Wichmann, Funk, and Rummel 2018). It is also the case that students learn from the experience of participating in peer feedback, just as learning in any domain. However, little is known about how peer feedback quality improves from the reviewer's or reviewee's experience of participating in peer feedback.

Theoretical background

What is helpful feedback in peer review?

There are many different approaches to conceptualizing and measuring the quality of peer feedback. Some researchers have focused on easily quantified aspects such as the number of comments or length of comments (e.g. Patchan, Schunn, and Clark 2018). Fewer comments or a shorter number of characters often lack sufficient persuasion to enable students to accept and recognize the reviewer's point of view (Gibbs and Simpson 2004; Price, Handley, and Millar 2011). Another approach focuses on the accuracy of the comments: are the critical problems in the document addressed by the feedback (Gao, Schunn, and Yu 2019)? Other researchers have examined the form of the comments in terms of whether they include features generally thought to be helpful, such as identifying the problem, explaining the problem, or including a suggestion for improvement (Nelson and Schunn 2009; Patchan, Charney, and Schunn 2009; Wichmann, Funk, and Rummel 2018; Wu and Schunn 2020a). Another approach is to look at the effect of feedback: did it result in revisions or revisions that improved the document (Cho and Cho 2011; Patchan, Schunn, and Correnti 2016). A related approach involves judging whether the feedback is likely to produce improvements (Wu and Schunn 2020c).

The more straightforward methods are easy to implement but likely provide poor approximations of feedback quality. The other approaches are very time intensive (e.g. hundreds of hours

to systematically evaluate all the comments in a class) and may present narrow perspectives (e.g. focus only on immediate effects such as document improvement or only on delayed effects such as learning as shown in future performance).

A straightforward alternative that is easily implemented and integrates multiple facets of feedback quality involves collecting helpfulness judgments by the feedback recipient. After receiving peer feedback comments, the assessee can give a rating of the quality of the review comments received. The process is sometimes called a back-evaluation (Cho and Schunn 2007; Minami and Ohura 2015) that can be used a part of an accountability mechanism (e.g. by contributing to grades for reviewing quality; Patchan, Schunn, and Clark 2018) and as a source of data to study reviewing quality (Nelson and Schunn 2009; Tillema, Leenknecht, and Segers 2011). Although subjective, it most directly captures the holistic component of the multi-dimensional aspects of the helpfulness of feedback in a recipient-centric way: is the feedback understandable, is it educative, and is it persuasive (Ballantyne, Hughes, and Mylonas 2002; Nelson and Schunn 2009)?

Studies of peer review and performance

What improves peer review performance? One general connection that is often made is between the reviewer's overall ability in the domain. Students are more willing to accept feedback from an expert (Tsui and Ng 2000; Yang, Badger, and Yu 2006; Kaufman and Schunn 2011), and lower ability students may provide less feedback (Nesbit and Burton 2006; Patchan and Schunn 2015). Feedback is less persuasive because it is tentative (Shashok 2008) or with missing components like possible solutions (Ross et al. 2014). Thus, when students have review experiences that improve their abilities in the domain (such as learning from received feedback or learning from providing feedback; Lundstrom and Baker 2009; Crinon 2012; Adachi, Tai, and Dawson 2018; Deiglmayr 2018; Wu and Schunn 2020b), these improvements may also translate into improved peer feedback quality. Nicol, Thomson, and Breslin (2014) found that receiving feedback can help students quickly recognize the advantages and disadvantages so that they can focus on areas that needed improvement and get helpful suggestions, whereas providing feedback exercises students' understanding and cultivates their own cognitive process. However, providing feedback appears to produce a more significant amount of domain learning than does receiving feedback (Lundstrom and Baker 2009; Wu and Schunn 2020b), so one might expect providing feedback should produce more improvements in the quality of provided feedback.

Another possible mechanism for learning to improve peer feedback quality comes from experiencing good and poor models of peer feedback. At the level of the domain, Cho and MacArthur (2011) found that the process of reviewing and providing feedback enables students to see models of what could be done as well as examples of errors that can be made. A similar process could also occur regarding the ways of providing feedback: students can see more and less effective ways of providing feedback from the feedback they receive. For example, they may notice that overly brief comments, containing no explanations or possible solutions, are just not helpful (Kaufman and Schunn 2011).

A third possible mechanism for improving peer feedback quality involves practice, and the more practice the better (Ericsson 2006). Thus, when peers provide more feedback, they will likely learn more about how to provide higher quality feedback. Providing feedback is a cognitively-demanding activity that extends students' understanding and abilities (Falchikov 2006; Roscoe and Chi 2007; Wooley et al. 2008). However, very brief feedback likely requires little reflection, and thus it may be that it is only the amount of in-depth feedback (rather than any kind of feedback) that is a good learning opportunity for improving feedback quality.

Finally, there is the role of norm-setting. Guidance on best practices for using peer feedback involves setting classroom norms (Chang 2004). One way of learning norms is through observation (Martin and Double 1998; Blackmore 2005). Students have been found to be influenced by

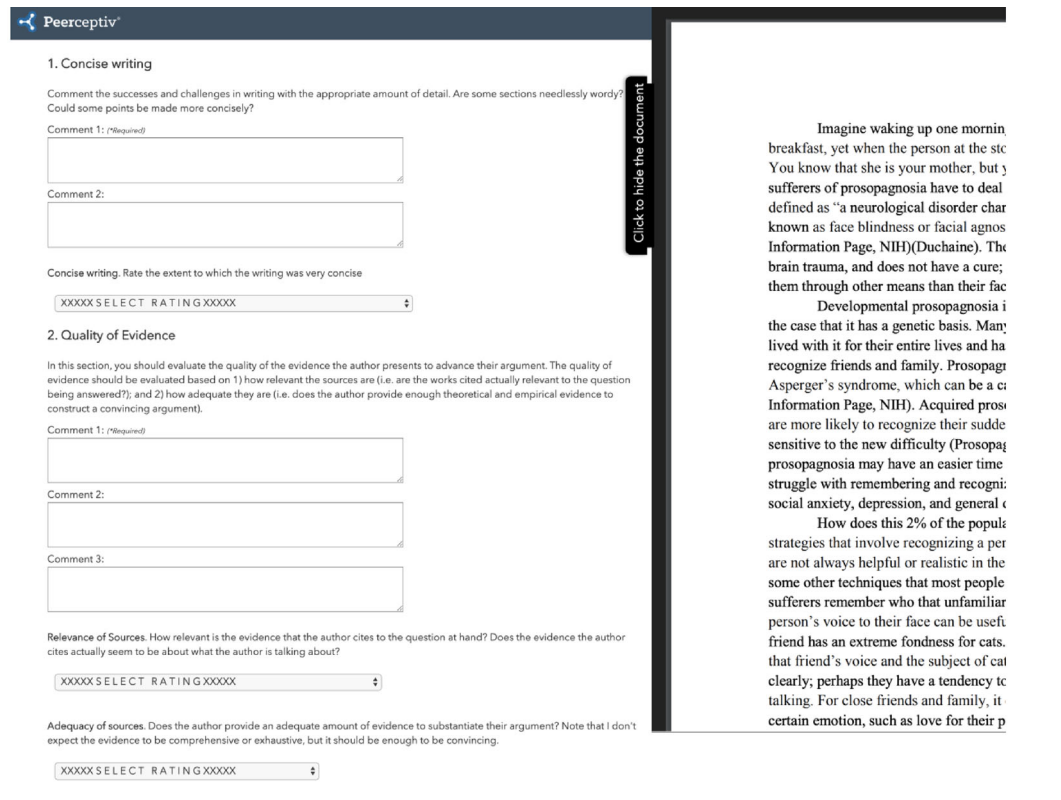


Figure 1. The main student reviewing interface within Peerceptiv.

how much help they provide their peers based on the amount of help they receive (Wasko and Faraj 2000). Thus, the amount of peer feedback that students receive and the quality of the peer feedback that students receive could shape the perceived norms for peer feedback in the given classroom, thereby shaping the quality of the feedback produced.

In sum, although not directly studied before, experiencing peer review across assignments in a course should shape the quality of provided feedback through a variety of possible mechanisms. The current study tests these possible mechanisms by testing the empirical relationship of five measures: amount, length and helpfulness of received feedback; amount and length of provided feedback. Three specific research questions are examined: (RQ1) what experiences are associated with improvements in review quality? (RQ2) through what mechanism do those effects appear to occur? (RQ3) are the experience effects more vital for weaker students? Two potential mechanisms are formally tested: improvements in feedback quality through improvements in the underlying domain (i.e. improved submitted documents) and improvements in feedback quality through changes in reviewing approach (i.e. tendency to provide longer or more in-depth feedback). Interactions with student ability are tested because review quality concerns are especially severe for lower ability students.

Methods

Course setting and participants

There were 360 (74% female) undergraduates across two different sections from different semesters ($n = 166$ and $n = 194$) of a writing-intensive, second-level introductory course call

Reviewer	Your Comment(s)	Reviewer #2	Reviewer #3	Reviewer #4
Concise writing	<p>I think the writing is great, just finish it</p> <hr/> <p><i>Backevaluation(2):</i> Obviously.</p>	<p>Well, considering you are not finished, it was pretty good. I have a few suggestions. "we have to look at the relationship between the brain and memories, as well as the relationship with strategies as the ones mentioned above. In our class, we discussed what exactly remembering and forgetting was. Is remembering just finding the copy of a memory or just rebuilding it? Is forgetting just losing a memory for good or one that hasn't been found yet? We theorize a lot about things like this and thus, we study how we can better ourselves in learning how to remember things through research. An important start for this is organization, context and the overall importance of structure. There was a study done on the impact of structure, one which we discussed in one of our lectures, that detailed how recollection was affected by organized or random lists." I would change the part above by: adding a transition between the two paragraphs "we have a lot of different theories regarding this topic so we can study how we can better ourselves in learning how to remember. The bases of this topic is organization, context, and the overall importance of the structure. Structure can be defined as _____. A study on this topic found that recollection was affected by organized or random lists.</p> <hr/> <p><i>Backevaluation(5):</i> This was very helpful! I know sometimes my sentence and paragraph structures can be out of sorts, but sometimes I don't know where to fix it. But this specific example and suggestion will help me a lot!</p>	<p>You do a good job keeping the essay concise. It never really seemed needlessly wordy to me.</p> <hr/> <p><i>Backevaluation(4):</i> Straight forward</p>	<p>Overall, the author uses an appropriate amount of detail. The introduction is heavily detailed, however, this may be a stylistic choice as the author is trying to form a narrative.</p> <hr/> <p><i>Backevaluation(5):</i> Introduction was heavy in detail, so I might try to make it more concise or make it shorter.</p>

Figure 2. The Peerceptiv interface showing received helpfulness ratings and optional comments for each completed review dimension. Only one review dimension is shown in the figure. The reviewer can see the ratings for their own review alongside what other reviewers for the same document said and the back-evaluations and accompanying comments those reviews received.

"Introduction to Cognitive Psychology" at a research-oriented university in the Midwestern region of the US. Students were predominantly second and third-year undergraduates and a roughly equal number of psychology majors and majors from other disciplines. These two sections had the same instructor and had similar course contents and requirements.

Materials

In each section, there were six writing tasks with peer review, and students had to complete all six tasks. In one section, it was two drafts each of three different writing assignments, and in the other section, it was one draft each of six different writing assignments. In all cases, the writing assignments were similar: choosing from a fixed set of writing prompts that apply concepts from the course to specific situations in approximately 1,000 to 2,000 words, using similar evaluation dimensions in each assignment. The writing prompts were overlapping across the two sections, with only minor changes.

All participants were required to submit assignments and complete review tasks through a widely-used, web-based, online peer assessment system call *Peerceptiv* (<https://peerceptiv.com>). For each document/draft, there was the same set of steps: submitting the document, reviewing peers' documents, and performing a back-evaluation of the helpfulness of the received comments (i.e. assessing feedback quality). Students were required to complete four reviews per assignment. The reviewing was randomly assigned for each assignment and anonymous: authors were identified by a pseudonym and reviewers by a number.

Table 1. Definitions of student and context level variables, along with indicators of whether the variable is defined in analysis in terms of the prior assignment, the current assignment, or both (if applicable).

Measure	Definition	Prior	Current
Student-level variables			
<i>Provided Helpful_j</i>	The mean helpfulness rating for the comments received by the student for their provided peer review comments on the J^{th} assignment.	✓	✓
<i>Received Helpful_j</i>	The mean helpfulness rating for the comments provided by the student for their received peer review comments on the J^{th} assignment.	✓	
<i>#Provided_j</i>	The number of peer feedback comments provided by a student on the J^{th} assignment.	✓	
<i>#Received_j</i>	The number of peer feedback comments received by a student on the J^{th} assignment.	✓	
<i>Length Provided_j</i>	The mean number of characters within peer feedback comments provided by the student on the J^{th} assignment.	✓	
<i>Length Received_j</i>	The mean number of characters within peer feedback comments received by the student on the J^{th} assignment.	✓	
<i>%Provided Long_j</i>	Percentage of total comments provided by the student that were long (> 50 words) for the J^{th} assignment.	✓	✓
<i>%Provided Short_j</i>	Percentage of total comments received by the student that were short (< 10 words) for the J^{th} assignment.	✓	✓
<i>Z-Score_j</i>	Standardized score of the student's document on the J^{th} assignment (i.e., score minus mean assignment grade / SD of assignment grade)		✓
<i>Low Score_j</i>	1 if the student's document score on the J^{th} assignment is lower than the median score, and 0 otherwise.	✓	
Context variables			
<i>J</i>	The assignment number (1–6)		✓
<i>Course</i>	Dummy indicator (0 for first course, 1 for second)	NA	

Figure 1 (top) shows the main student reviewing interface. The students can see the document (right) while they complete the review (left). The review is divided into five separate dimensions (concise writing, quality of evidence, explanations, word choice/language use, and conventions) that were selected based on student surveys for areas of importance for their expected future careers. For each dimension, students entered some open-response comments based on a brief prompt for that dimension (with a minimum of one comment per dimension). Students also made 1-to-2 Likert ratings per dimension based on rubrics that were specific to each dimension. These ratings were used by the system to produce document scores using an algorithm that weighted each reviewer's ratings by their overall accuracy as a reviewer.

After the reviewing deadline had passed, and all reviews for a given document were distributed, authors were required to rate the helpfulness the comments they received. This step consisted of a 5-point Likert rating per comment dimension per review, along with an optional comment that explained the rating. The scale was: 5 - much more helpful than average, 4 - slightly more helpful than average, 3 - average helpfulness, 2 - a little less helpful than average, 1 - very unhelpful. Once the back-evaluation period had finished, reviewers could see what other reviewers had said about the same documents they had reviewed and the detailed explanations (see Figure 2).

Measures

The overall analytic approach organizes the data as a time-series within each student (i.e. measures of experiences and behaviors of each student in each assignment) in order to be able to

Table 2. Mean and standard deviations for each predictor variable, along with maximum observed values on each variable for $J = [2,6]$.

Variable	Max	Mean	SD
Comment helpfulness			
<i>Provided Helpful_{J-1}</i>	5	4.4	0.5
<i>Received Helpful_{J-1}</i>	5	4.4	0.5
Document Quality			
<i>Z-Score_J</i>	2.5	0.0	1.0
<i>Low Score_{J-1}</i>	1	0.53	0.50
# of Comments			
<i>#Provided_{J-1}</i>	55	21.9	10.7
<i>#Received_{J-1}</i>	34	13.0	5.0
Comment Length			
<i>Length Provided_{J-1}</i>	1331	272	152
<i>Length Received_{J-1}</i>	716	265	84
<i>%Provided Long_{J-1}</i>	1	34%	28%
<i>%Provided Short_{J-1}</i>	1	9%	16%
<i>%Provided Long_J</i>	1	31%	28%
<i>%Provided Short_J</i>	1	11%	17%

examine the relationship of improvements in review quality on one draft (assignment J , varying from 1 to 6) to reviewing experiences (giving and receiving feedback) on the prior draft (i.e. assignment $J - 1$). Each of the measures summarizes an aspect of reviewing experiences for a given round, and often the analyses involve including a given measure defined for both one round and the prior round (e.g. the mean helpfulness rating in the current assignment and the mean helpfulness rating in the prior assignment). The measures, their definitions, and whether the analyses used the current assigned or lagged assignment measure (or both) are shown in Table 1. Since analyses based on lagged data cannot include the first round, this should produce roughly 1,800 data points (360 participants \times five assignments). However, students occasionally did not submit or review for a given assignment, and thus the maximum number of datapoints was 1,634. Table 2 lists the observed maximum, mean and standard deviation for each variable. Since current and lagged variables use a different set of assignments (i.e. 2–6, 1–5 respectively), separate descriptions are presented for both where appropriate.

Review helpfulness

Across all helpfulness ratings (one rating for each dimension in each review), a mean helpfulness rating was computed on the 1–5 scale (dropping missing values when the author did not complete the back-evaluation step). The mean helpfulness for all the reviews a student completed for assignment J was called *Provided Helpful_J*, and the mean helpfulness for all the reviews a student received for assignment J was called *Received Helpful_J*.

Number of feedback comments

Students were required to provide at least one comment for each dimension, but they had the option of providing additional comments. Further, students sometimes did not complete all of the required reviews. *Provided_J* and *Received_J* refer to the number of comments provided and received, respectively, across reviews on the J^{th} assignment. *Received_J* was set to missing when no document was submitted.

Length of feedback comments

In addition to varying in how many separate comments occurred, the open-ended comments could also widely vary in length (e.g. from one word to a long paragraph). Also, words could be less meaning-rich short words or more substantive long words. By combining these aspects, a

mean total comment length (in characters) was calculated per review, once for reviews provided by the student (*Length Provided_j*), and once for reviews received (*Length Received_j*) on assignment *J*.

Relative frequency of short and long comments

Since the effects of comment length may be non-linear, comment length was also analyzed by length categories. This analytic approach also allowed for orthogonal measures of the number of comments as well as examining the role of comment length within comment helpfulness. To this end, each comment was classified according to the number of characters in short, medium and long comment categories. Histograms of comment length were examined, and thresholds of 10 words for short comments and 50 words for long comments were used. The percentages of comments provided for assignment *J* that were long and short were calculated (*%Provided Long_j*, *%Provided Short_j*).

Document score

A document score for each assignment was generated from the mean peer ratings across review dimensions and reviews. Prior studies have shown that the ratings produced by multiple peer review are reliable and valid scores (Li et al. 2016), particularly when given strong rubrics and incentives to take the task seriously (Patchan, Schunn, and Clark 2018). In taking into account differences in assignment difficulty, scores were normalized (subtract assignment mean score and divide by assignment SD) to produce the variable *Z-Score_j* (the relative score for an individual compared to the class average score for that assignment). Further, a binary indicator (*Low Score_j*) was created to identify lower-performing students (i.e. all students whose document score was below the median for that assignment).

Assignment

In accounting for changes in reviewing behaviors across the assignments, an indicator variable *J* was created to represent the assignment number (1–6).

Course

Two different sections of the same courses were combined in the dataset. For controlling possible differences within the course or across the student cohorts, a *Course* indicator variable was created: the first course was set to 0, and the second was set to 1.

Analyses

The primary analyses correspond to three research questions. For research question 1, to identify the experiences that predict improvements in review helpfulness in a later round of peer review, the relative frequency of different provided and received reviewing experiences are tested through multiple regression. The dependent variable, mean helpfulness rating across all the reviews submitted in a given assignment (*Provided Helpful_j*), is a continuous variable with roughly normal distribution; thus, traditional linear regression was selected. The models predict *Provided Helpful_j* controlling for *Provided Helpful_{j-1}*. This approach is conceptually similar to predicting gain scores, but it is preferred over models predicting gain scores from one round to the next because of artificial regression-to-the-mean phenomena associated with gain scores (Barnett, van der Pols, and Dobson 2005). *J*, *Z-Score_j*, and *Course* are included as additional control variables for gradual changes across assignments, the different kinds of feedback documents of higher and lower quality receive, and context effects across courses. Note that separate models for each

course produced similar results; we present the analyses from the combined dataset because of the greater statistical power to allow for controlling more potential confounds at once.

This part includes three regression models (Models 1–3). Model one includes the helpfulness of received comments, the number of provided and received comments, and the length of the provided and received comments. Because predictors may be correlated with one another, Model two tests the stability of the regression coefficients after removing non-significant variables from Model 1. Model three then further explores length (focusing on the length variable that was significant in Models 1 and 2) to test the different negative effects of very short comments from the positive effects of very long comments.

In addressing the second research question regarding mediators of the effects, potential mediators are included in isolation and then together, and the changes in predictor strength are examined (comparing Models 5–7 to baseline Model 4). The mediators are: 1) improvements in understanding of the assignment (*Z-Score_j*), and 2) changes in the length of provided comments (increases in the tendency to give longer comments or decreases in the tendency to give shorter comments). A formal mediation test is also conducted using the process macro (Hayes 2013) to estimate the size of the indirect effect, focused on the predictors showing sensitivity to inclusions of mediating variables.

Finally, to address the third research question, for whom are these experiences especially crucial in predicting changes in reviewing helpfulness, moderation analyses were conducted. Three models were created (Models 8 through 10) that each tested the potential interaction of being a higher or lower scoring author in the prior round, with each of the main predictors found to be significant in Model 2.

Results

Predictors of change in comment helpfulness

Table 3 shows the Pearson correlations amongst the predictors. Given the large N, most correlations are statistically significant. However, most of the correlations are relatively small. The largest correlations involve variations of the length provided variables (e.g. *Length Provided_{j-1}* and *%Provided Long_{j-1}/%Provided Short_{j-1}*), and these variables do not appear in the same regression analysis. Thus, multicollinearity problems were not expected. Indeed, an examination of variance inflation factors (VIF) confirms there were no multicollinearity problems (i.e. all VIFs < 2). Most of the predictor variables were correlated with the outcome variable (see bottom row of Table 3). However, since most of the variables were also correlated with the baseline version of the outcome variable (i.e. *Provided Helpful_{j-1}*, see left column of Table 3), multiple regression controlling for the baseline is needed to identify the associates of growth in helpfulness.

Table 4 presents the results of the multiple regression models testing the relationship of the critical predictors to growth in helpfulness in various combinations. In all three models, the prior helpfulness baseline is a significant predictor of later helpfulness, but this relationship is only moderate in size, indicating that there is also substantial variation in helpfulness from one task to the next. Also consistent across all three models, students were more likely to provide helpful feedback after they received helpful feedback and after they had provided more feedback in the prior round.

In the first model focused on the total length of the feedback provided and received, only the total length of feedback provided predicted later helpfulness. Figure 3 presents this relationship graphically by grouping different amounts of feedback provided on the prior round in different frequency bins. Neither the number of comments received, nor the length of comments received, predicted later helpfulness. Thus, receiving some helpful comments appeared productive, but the amount received did not matter. In models 2 and 3, the amount received variables were therefore dropped, and the estimates for the remaining variables were stable.

Table 3. Pearson intercorrelations amongst the predictors (upper rows) and between each predictor and the outcome variable (bottom).

	Provided Helpful _{J-1}	Received Helpful _{J-1}	#Provided _{J-1}	#Received _{J-1}	Length Provided _{J-1}	Length Received _{J-1}	%Provided Long _{J-1}	%Provided Short _{J-1}	Z-Score _J
Provided Helpful _{J-1}	.17***								
Received Helpful _{J-1}	.10***	.03							
#Provided _{J-1}	-.04	.00	.04*						
#Received _{J-1}	.26***	-.08**	-.15***	-.05*					
Length Provided _{J-1}	-.05*	-.01	-.06**	-.28***	.06**				
Length Received _{J-1}	.29***	-.06*	-.10***	-.07**	.87***	.06*			
%Provided Long _{J-1}	-.09***	.07**	.25***	.03	-.41***	-.06**	-.36***		
%Provided Short _{J-1}	.10***	.00	.16***	-.04	.16***	-.07**	.17***	-.10***	
Z-Score _J	.37***	.18***	.10***	-.01	.20***	-.05*	.24***	-.05*	.15***

*** $p < .001$,

** $p < .01$,

* $p < .05$.

Table 4. Standardized Beta coefficients for each predictor of Provided Helpful, along with N and fit statistics from the multiple regression models testing key predictors.

Predictor	Model 1 (length, full)	Model 2 (length, reduced)	Model 3 (% long)
Baseline			
<i>Provided Helpful</i> _{J-1}	0.17***	0.17***	0.14***
Core predictors			
<i>Received Helpful</i> _{J-1}	0.05*	0.05*	0.05*
# <i>Provided</i> _{J-1}	0.07**	0.07**	0.10***
# <i>Received</i> _{J-1}	-0.003		
<i>Provided length</i> _{J-1}	0.17***	0.17***	
<i>Received length</i> _{J-1}	0.01		
% <i>Provided Long</i> _{J-1}			0.18***
% <i>Provided Short</i> _{J-1}			-0.08**
Control variables			
<i>Z-Score</i> _J	0.10***	0.10***	0.09**
<i>Course</i>	0.34***	0.34***	0.38***
<i>J</i>	0.10***	0.10***	0.12**
N	1,397	1,397	1,395
R ²	0.26	0.26	0.27

****p*<.001,***p*<.01,**p*<.05.

In model 3, the length provided variable was replaced with percent short and percent long predictors. Notably, the predictiveness of the number provided increased once the character of the comments was included in the model, and both %long and %short variables predicted growth in helpfulness (with %short having the expected negative relationship to growth). Thus, giving short comments appeared to be harmful to growth in helpfulness, but, even more so, giving long comments appeared to be helpful to growth in helpfulness. Combining the effects of comment frequency and length, Figure 3 presents the relationship between the number of long comments in the prior round and estimated helpfulness in the next round (controlling for prior helpfulness and other predictors).

Note that the three control variables included in Models 1, 2, and three were consistent predictors. In particular, students provided more helpful feedback when they did well in that same round on the assignment, in later rounds (likely reflecting larger patterns of learning to review), and in one of the two courses (perhaps reflecting the difficulty of providing helpful comments on the 2nd draft of an assignment).

Mediators of change in comment helpfulness

Table 5 presents the results of mediation analyses, focused on the tested key predictors found to be significant in the prior set of analyses, with Model four serving as the baseline model (i.e. no included mediators). As revealed by the results of Model 5, the introduction of the mediator of *Z-Score*_J slightly weakened the effect of the prior provided feedback variables. Thus, some of the benefits of providing more feedback may come from better mastery of the underlying task. As revealed in the results of Model 6, adding in the typical length of the current round significantly reduced the predictiveness of providing longer feedback in the prior round. Thus, it appears more likely that feedback quality later improves when students give longer feedback because they are more likely to keep providing more feedback in the next round.

To more directly estimate the size of the mediation effects of each pathway controlling for the other effects, mediation analyses were conducted considering the effects of both providing long comments and short comments in the prior round on later comment quality via the possible mediators of better task mastery (as indicated by *Z-Score*_J) and similarly sized comments in the current round (%*Provided Long*_J for %*Provided Long*_{J-1} and %*Provided Short*_J for %*Provided Short*_{J-1}). All four indirect effects were statistically significant (see Table 6). However, the benefit

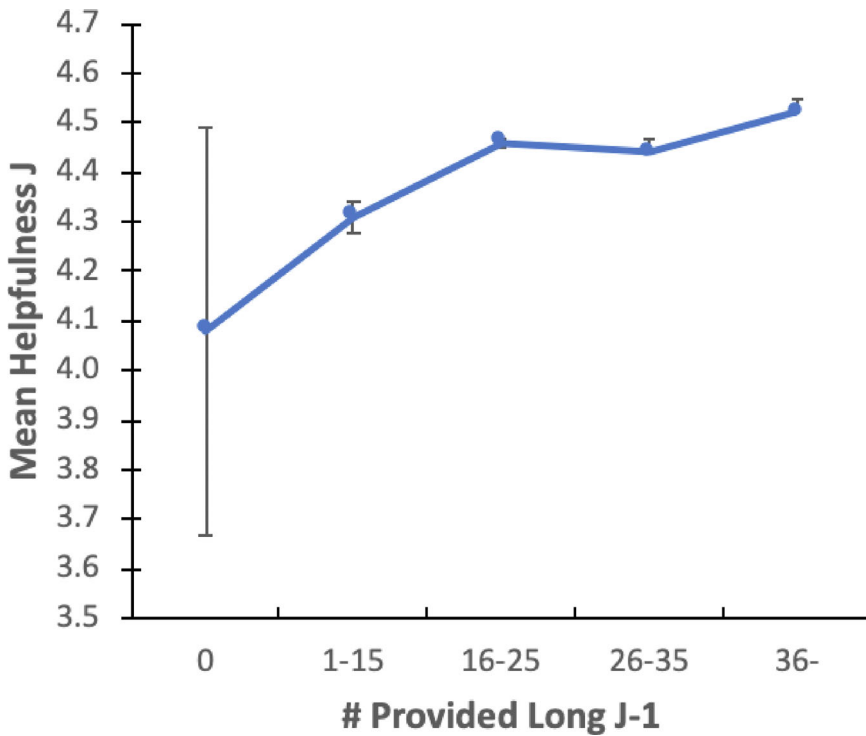


Figure 3. The estimated mean helpfulness rates on the J^{th} assignment (with SE bars) as a function of the number of long comments provided by student on the $(J-1)^{\text{th}}$ assignment, controlling for other predictors.

of long comments or the harm of short comments via task mastery were both small effects, and the effect of providing short comments via mastery is just on the edge of statistical significance. By contrast, the indirect effects via the tendency to give similarly sized comments in the next round were much larger. Further, the negative impact of short comments was twice as large as the positive impact of long comments. Figure 4 shows the mediation relationships, showing the relatively large stability of comment length tendencies from one round to the next, the moderate relationship of comment length to comment helpfulness, and the much smaller relationships of comment length to task mastery or task mastery to comment helpfulness.

Moderators of change in helpfulness

Three moderation models were conducted to see whether the benefit of prior reviewing experiences depended upon whether the student was relatively strong or relatively weak. These models involved the interaction with an indicator variable for having a below-average document score in the prior round ($Low-Score_{J-1}$). The three models respectively focused on the three main predictors that were overall statistically significant: $\%Provided Long_{J-1}$, $Receiving Helpful_{J-1}$, and $\#Provided_{J-1}$. Only the interaction with the relative length was statistically significant (see Table 7). As shown in Figure 5, there was an effect of $\%Provided Long_{J-1}$ for both stronger and weaker students, but the effect of $\%Provided Long_{J-1}$ was larger for weaker students. The bins for different levels of $\%Provided Long_{J-1}$ were defined based on inspection of the frequency histogram: zero (no long comments provided), rare (some long comments were provided, but not more than the mean value, 34%) and common (more than the mean value, 34%, of provided comments were long).

Table 5. Standardized Beta coefficients for each predictor of Provided Helpful, along with N and fit statistics from the multiple-regression models testing possible mediators, alone and in combination.

Predictor	Model 4 (Base)	Model 5 (Score)	Model 6 (Length)	Model 7 (Both)
Baseline				
<i>Provided Helpful</i> _{<i>J</i>-1}	0.14***	0.14***	0.14***	0.13***
Core predictors				
# <i>Provided</i> _{<i>J</i>-1}	0.12***	0.11***	0.12***	0.11***
% <i>Provided Long</i> _{<i>J</i>-1}	0.19***	0.17***	0.05	0.04
% <i>Provided Short</i> _{<i>J</i>-1}	-0.10***	-0.09***	0.04	0.04
Mediators				
% <i>Provided Long</i> _{<i>J</i>}			0.17***	0.17***
% <i>Provided Short</i> _{<i>J</i>}			-0.20***	-0.20***
<i>Z-Score</i> _{<i>J</i>}		0.09**		0.08***
Control variables				
<i>Course</i> _{<i>J</i>}	0.39***	0.39***	0.39***	0.39***
<i>J</i>	0.11***	0.11***	0.13***	0.14***
N	1,503	1,494	1,499	1,490
R ²	0.27	0.28	0.31	0.31

****p*<.001,***p*<.01,**p*<.05.

General discussion

The primary purpose of this study was to uncover information about how students improve the quality of the feedback they provide to their peers through experiences with providing and receiving peer feedback. This topic is of central importance to formative assessment in higher education because educators struggle to provide formative feedback on complex tasks in a timely fashion (Hattie and Timperley 2007; Shute 2008; Topping 2009; Gielen and De Wever 2015). Also, peer assessment is widely applicable, being an approach to formative assessment problems (Hattie and Timperley 2007; Topping 2009; Applebee and Langer 2011).

The study took a 'micro' lens, examining how performance in one assignment was related to performance in the next assignment. We examined seven specific measures that capture different aspects of three kinds of experiences: quality of received feedback, quantity of received feedback, and quantity of provided feedback. Two of the three were consistently found to predict growth in feedback quality across all of the specific experience measures that were explored: quality of received feedback (one measure) and quantity of provided feedback (four measures). The strongest relationship was with providing long comments, and this relationship was strongest for students showing weaker performance on the assignments. No measure of the quantity of received feedback received any support.

Why might providing long comments be helpful for reviewing quality in later assignments? Conceptually, providing longer feedback could provide an opportunity to learn the underlying domain content (Crinon 2012; Adachi, Tai, and Dawson 2018; Deiglmayr 2018), and having a better understanding of the underlying domain content might enable students to provide more helpful comments (Patchan and Schunn 2015). Providing feedback is more consistently associated with learning outcomes than is receiving peer feedback (Lundstrom and Baker 2009; Wu and Schunn 2020b), which would then explain why the amount of provided rather than the amount of received feedback was predictive of reviewing quality. The results of the mediation analyses provided some support for this underlying mechanism. However, that pathway was relatively weak because the performance on an assignment did not have a strong relationship to review quality, similar to what some other researchers have found (Leckey and Neill 2001; Lin, Liu, and Yuan 2001).

Another possible mechanism involved establishing behavioral patterns. In general, longer comments will tend to contain more helpful components (Wu and Schunn 2020a), and developing the pattern of having longer comments in one assignment could then continue in later

Table 6. Estimated indirect effects (and 95% CI of the effect) from the mediation analysis predicting *Provided Helpful_t*.

Predictor	Mediator	Indirect effect	Indirect CI
%Provided Long _{<i>t-1</i>}	Z-Score _{<i>t</i>}	0.02	[0.01, 0.04]
%Provided Long _{<i>t-1</i>}	%Provided Long _{<i>t</i>}	0.21	[0.13, 0.29]
%Provided Short _{<i>t-1</i>}	Z-Score _{<i>t</i>}	-0.02	[-0.05, -0.003]
%Provided Short _{<i>t-1</i>}	%Provided Short _{<i>t</i>}	-0.39	[-0.56, -0.24]

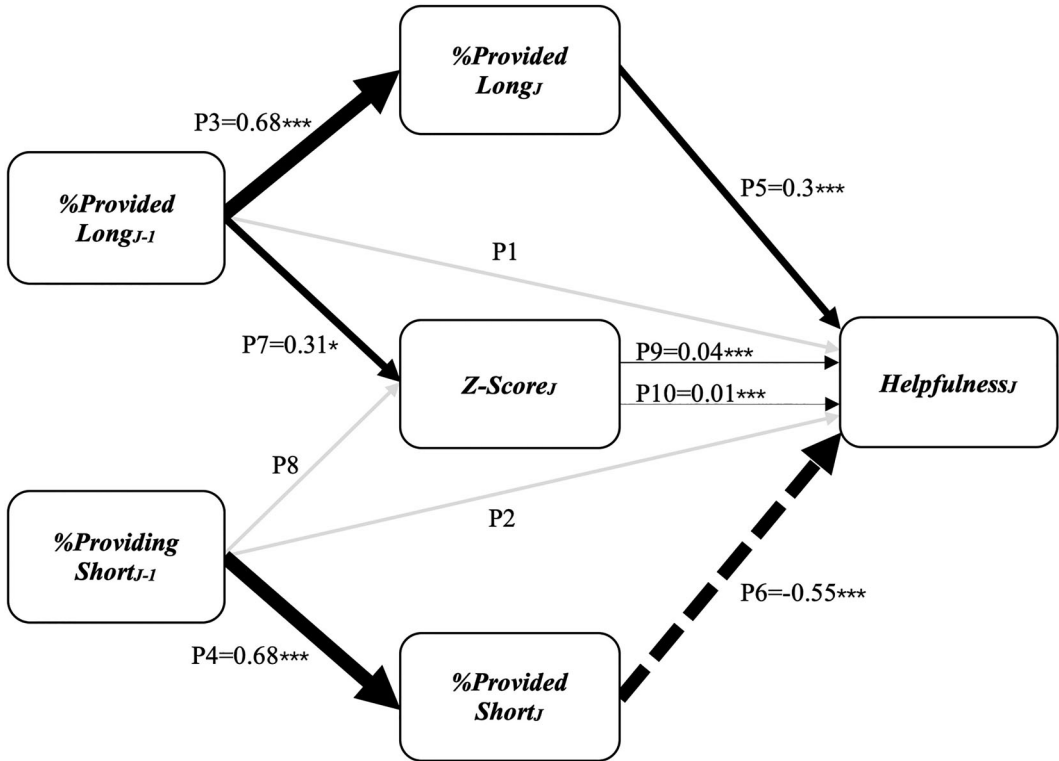


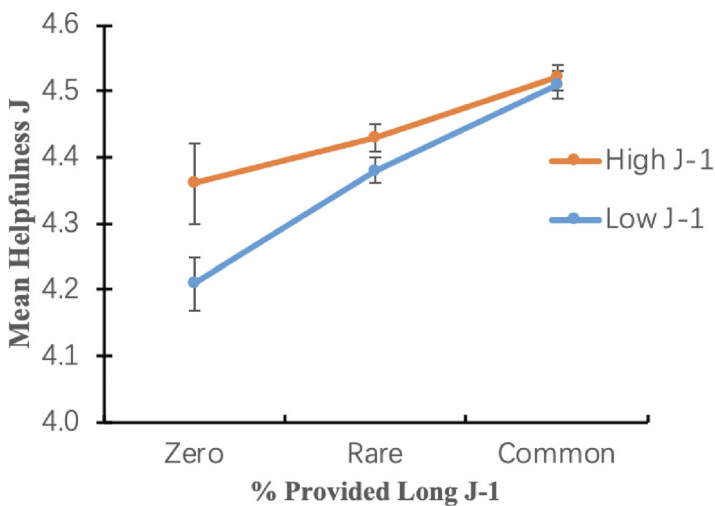
Figure 4. The mediation pathways for the positive relationship of long comments and negative relationship of short comments on later helpfulness improvements via changes in assignment performance and comment length. Grey lines indicate a non-significant relationship and dotted lines indicate a negative relationship.

assignments. The results of the mediation analyses provided strong support for this mechanism, and indeed there was a robust relationship between tending to provide long comments in one assignment with tending to provide long comments in the next assignment. Note that there was also a similar pattern for the tendency to provide especially short comments, which was very unhelpful to the recipients of the feedback.

The lack of any relationship of growth in helpfulness to the amount of feedback received, along with a relatively weak relationship to helpfulness in quality of feedback received, suggests that norm-setting is not an essential aspect of learning to provide helpful comments. The norms of feedback might be established in the initial training sessions or conveyed by the peer review rubrics such that there was no additional norm-setting effect from later experiences with peer feedback. Alternatively, it could be that norm-setting is important in determining the amount of peer feedback each student provides or stylistic components of peer feedback rather than the quality of each piece of peer feedback. Thus, the current results do not rule out the role of norm-setting in peer feedback more generally, but instead argue against a strong role in the narrower relationship between experience within a class and growth in peer feedback quality.

Table 7. Standardized Beta coefficients for each predictor of Provided Helpful_J along with N and fit statistics from the multiple-regression models testing interactions with low document performance.

Predictor	Model 8 (Score * %Long)	Model 9 (Score * RHelpful)	Model 10 (Score * #Provided)
Baseline			
<i>Provided Helpful</i> _{J-1}	0.16***	0.23***	0.23***
Core predictors			
# <i>Provided</i> _{J-1}	0.09***	0.05***	0.05**
% <i>Provided Long</i> _{J-1}	0.16***		
<i>Received Helpful</i> _{J-1}		0.03	
<i>Low-Score</i> _{J-1}	-0.11**	-0.06	-0.08
Interactions			
<i>Low-Score</i> _{J-1} * % <i>Provided Long</i> _{J-1}	0.09**		
<i>Low-Score</i> _{J-1} * <i>Received Helpful</i> _{J-1}		0.00	
<i>Low-Score</i> _{J-1} * # <i>Provided</i> _{J-1}			-0.02
Control variables			
<i>Course</i> _J	0.36***	0.31***	0.32***
<i>J</i>	0.11***	0.07***	0.07***
N	1,503	1,404	1,507
R ²	0.27	0.22	0.23

*** $p < .001$,** $p < .01$,* $p < .05$; RHelpful means Received Helpful.**Figure 5.** Separately for authors with high and low document scores on the prior assignment, the estimated mean helpfulness scores on the Jth assignment (with SE bars) as a function of the percentage of long comments provided by student on the prior assignment, controlling for other predictors. Zero, rare, and common levels were created by inspecting the frequency histograms.

Practical implications

Uncovering the predictors of growth in reviewing helpfulness and their underlying mechanisms can help develop or improve training conditions to guide students to provide helpful feedback better, and thereby become an excellent reviewer. Educators can encourage students to actively provide more and longer comments because longer comments not only contain more opinions or ideas but also enable students to improve their own performance in the process of providing comments. There will be reciprocal effects, as the higher helpfulness produced by some students appears to result in higher helpfulness in the comments produced by the recipients in the next assignment. Thus, comment length is an ideal target from multiple perspectives.

In terms of how to improve comment length, there are multiple possible strategies to pursue. As both Carlson et al. (2000) and Ballantyne, Hughes, and Mylonas (2002) pointed out, the attitude of educators towards peer feedback plays a vital role in improving the quality of student feedback. Giving students clear guidance in training and reviewing rubrics on the components each comment should contain (e.g. clearly identifying the problem, explaining the problem, making constructive suggestions) will encourage longer comments (Cho, Schunn, and Charney 2006; Ekşi 2012). Similarly, providing grading incentives to reviewers for providing longer comments (e.g. via helpfulness ratings that turn into reviewing grades; Patchan, Schunn, and Clark 2018) may be effective. Some online systems allow instructors to set minimum word counts on review length (ex. *Calibrated Peer Review*TM by Robinson (2001), <http://cpr.molsci.ucla.edu>; and *Turnitin*, <https://turnitin.com>), although this might produce extra superficial verbiage in the comments.

It is also important to note that this study found that low-performing students were especially affected by peer review experiences. Lower-performing students gave less helpful comments, but in general the effect size of this relationship was small. That is, low-performing students are capable of being good reviewers, and it appears they are simply choosing not to submit longer comments rather than not being able to submit longer comments. Further, not providing enough comments or providing shorter comments are core reasons why low-performance students do not produce very helpful or constructive comments. For these students, providing comments is not just a process to help peers, but also a process to improve their own understanding of domain content. Such students may be especially reticent to provide much feedback to their peers (Miller and Geraci 2011). Thus, educators need to encourage low-performing students to participate actively and reap more benefits from the peer review process.

Limitations and future research

This study suggests that when students provide long comments, they tend to continue to do so and also produce more helpful feedback and do better in later assignments. Such relationships are likely mediated by the contents of the feedback (the specific ideas, the inclusion of constructive suggestions or explanations for problems, and the inclusion of mitigating praise) rather than the length *per se*. However, this study did not directly examine the contents contained in comments of different lengths. Future research should examine the contents of comments in greater depth to see whether students learn different contents through different mechanisms. For example, the style of mitigating praise (i.e. positive statements added to balance critical comments; Nicol, Thomson, and Breslin, 2014) might be learned through receiving feedback with mitigating praise.

The current study used a regression approach to building statistical models of the relationships between past experiences and changes in behaviors. The advantage of such an approach is that authentic learning environments can be studied in a way that does not add artificial elements for experimental reasons that could systematically change the behaviors in question (e.g. forcing students to make longer comments in artificial ways could produce ineffective long comments). Another advantage is that many possibly relevant experience dimensions can be studied at once, whereas an experimental approach necessarily needs to focus on a smaller set of dimensions to manipulate. Statistical confounds are partially addressed through the inclusion of control variables and then further reduced by looking at the relations between past experiences and future behaviors rather than concurrent variables. However, causality is best confirmed through an experimental approach, and future research will need to verify the causal role of longer comments. However, before investing in such an experiment, additional correlational studies should be conducted to tease apart the difference between the effects of length *per se* versus including particular components in the comments.

The current study also focused exclusively on helpfulness ratings obtained within the online peer feedback tool as a measure of peer feedback quality in an attempt to capture author-centric dimensions of helpfulness holistically. The use of this measure is easily adopted by other researchers to efficiently replicate the current study in other contexts and explore the effects of various training and support tools or interventions aimed at improving comment quality. However, subject ratings are potentially biased, and thus future work should complement the current study with objective measures (e.g. minimum amounts of feedback known to be helpful, components of feedback known to be helpful, impact on later reviewee performance).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was partially supported by the National Natural Science Foundation of China [71573065].

Notes on contributors

Zheng Zong, a doctor candidate in the School of Management, Harbin Institute of Technology, China. His research interests included peer assessment, text mining, education management and natural language processing.

Dr. Christian D. Schunn, a professor and senior cognitive scientist working with Learning Research & Development Center (LRDC) at the University of Pittsburgh. His research interest extends to a wide range of cognitive studies involving STEM reasoning and learning, web-based peer interaction and instruction, neuroscience of complex learning, and engagement and learning. He is the founder of an online peer review system (SWoRD), which is widely used in USA, China, and some European countries.

Dr. Yanqing Wang, an associate professor working with the School of Management, Harbin Institute of Technology, China. He is the founder of an information system (EduPCR), which is dedicated to peer code review in educational contexts. His recent research interests include peer assessment, peer code review, reviewer assignment problem, gamification of peer learning, and integer linear programming.

ORCID

Christian D. Schunn  <http://orcid.org/0000-0003-3589-297X>
Yanqing Wang  <http://orcid.org/0000-0002-5961-0482>

References

- Adachi, C., J. H. M. Tai, and P. Dawson. 2018. "Academics' Perceptions of the Benefits and Challenges of Self and Peer Assessment in Higher Education." *Assessment & Evaluation in Higher Education* 43 (2): 294–306.
- Applebee, A., and J. Langer. 2011. *The National Study of Writing Instruction: Methods and Procedures*. Albany, NY: Center on English Learning & Achievement.
- Bai, L. 2012. "Developing the Assessment Tests for Peer Revision in College English Academic Writing." *Modern Foreign Languages* 35 (2): 184–192.
- Ballantyne, R., K. Hughes, and A. Mylonas. 2002. "Developing Procedures for Implementing Peer Assessment in Large Classes Using an Action Research Process." *Assessment & Evaluation in Higher Education* 27 (5): 427–441.
- Barnett, A. G., J. C. van der Pols, and A. J. Dobson. 2005. "Regression to the Mean: What It is and How to Deal with It." *International Journal of Epidemiology* 34 (1): 215–220. doi:10.1093/ije/dyh299.
- Blackmore, J. A. 2005. "A Critical Evaluation of Peer Review via Teaching Observation within Higher Education." *International Journal of Educational Management* 19 (3): 218–232. doi:10.1108/09513540510591002.
- Carlson, T., D. Macdonald, T. Gorely, S. Hanrahan, and R. Burgess-Limerick. 2000. "Implementing Criterion-Referenced Assessment within a Multi-Disciplinary University Department." *Higher Education Research & Development* 19 (1): 103–116.

- Chang, L. 2004. "The Role of Classroom Norms in Contextualizing the Relations of children's social behaviors to peer acceptance." *Developmental Psychology* 40 (5): 691–702. doi:10.1037/0012-1649.40.5.691.
- Cho, K., C. D. Schunn, and D. Charney. 2006. "Commenting on Writing: Typology and Perceived Helpfulness of Comments from Novice Peer Reviewers and Subject Matter Experts." *Written Communication* 23 (3): 260–294. doi:10.1177/0741088306289261.
- Cho, K., and C. MacArthur. 2011. "Learning by Reviewing." *Journal of Educational Psychology* 103 (1): 73–84. doi:10.1037/a0021950.
- Cho, K., and C. D. Schunn. 2007. "Scaffolded Writing and Rewriting in the Discipline: A Web-Based Reciprocal Peer Review System." *Computers & Education* 48 (3): 409–426.
- Cho, Y. H., and K. Cho. 2011. "Peer Reviewers Learn from Giving Comments." *Instructional Science* 39 (5): 629–643. doi:10.1007/s11251-010-9146-1.
- Crinon, J. 2012. "The Dynamics of Writing and Peer Review at Primary School." *Journal of Writing Research* 4 (2): 121–154. doi:10.17239/jowr-2012.04.02.2.
- Deiglmayr, A. 2018. "Instructional Scaffolds for Learning from Formative Peer Assessment: Effects of Core Task, Peer Feedback, and Dialogue." *European Journal of Psychology of Education* 33 (1): 185–198. doi:10.1007/s10212-017-0355-8.
- Ekşi, G. Y. 2012. "Peer Review versus Teacher Feedback in Process Writing: How Effective." *International Journal of Applied Educational Studies* 13 (1): 33–48.
- Ericsson, K. A. 2006. "The Influence of Experience and Deliberate Practice on the Development of Superior Expert Performance." *The Cambridge Handbook of Expertise and Expert Performance* 38: 685–705.
- Ericsson, K. A., and N. Charness. 1994. "Expert Performance: Its Structure and Acquisition." *American Psychologist* 49 (8): 725–747. doi:10.1037/0003-066X.49.8.725.
- Falchikov, N. 2006. "Product Comparisons and Process Benefits of Collaborative Peer Group and Self-Assessments." *Assessment & Evaluation in Higher Education* 11 (2): 146–166.
- Gao, Y., C. D. Schunn, and Q. Yu. 2019. "The Alignment of Written Peer Feedback with Draft Problems and Its Impact on Revision in Peer Assessment." *Assessment & Evaluation in Higher Education* 44 (2): 294–308. doi:10.1080/02602938.2018.1499075.
- Gatfield, T. 1999. "Examining Student Satisfaction with Group Projects and Peer Assessment." *Assessment & Evaluation in Higher Education* 24 (4): 365–377.
- Gibbs, G., and C. Simpson. 2004. "Does Your Assessment Support Your Students' Learning?" *Journal of Teaching and Learning in Higher Education* 1 (1): 1–30.
- Gielen, M., and B. De Wever. 2015. "Structuring the Peer Assessment Process: A Multilevel Approach for the Impact on Product Improvement and Peer Feedback Quality." *Journal of Computer Assisted Learning* 31 (5): 435–449. doi:10.1111/jcal.12096.
- Grabe, W., and R. B. Kaplan. 1996. *Theory and Practice of Writing: An Applied Linguistic Perspective*. New York; London: Longman.
- Hayes, A. F. 2013. *An Introduction to Mediation, Moderation, and Conditional Process Analysis*. New York: The Guilford Press.
- Hattie, J., and H. Timperley. 2007. "The Power of Feedback." *Review of Educational Research* 77 (1): 81–112. [Database] doi:10.3102/003465430298487.
- Huisman, B., N. Saab, J. van Driel, and P. van den Broek. 2018. "Peer Feedback on Academic Writing: Undergraduate Students' Peer Feedback Role, Peer Feedback Perceptions and Essay Performance." *Assessment & Evaluation in Higher Education* 43 (6): 955–968.
- Kaufman, J. H., and C. D. Schunn. 2011. "Students' Perceptions about Peer Assessment for Writing: Their Origin and Impact on Revision Work." *Instructional Science* 39 (3): 387–406. doi:10.1007/s11251-010-9133-6.
- Leckey, J., and N. Neill. 2001. "Quantifying Quality: The Importance of Student Feedback." *Quality in Higher Education* 7 (1): 19–32. doi:10.1080/13538320120045058.
- Li, H., Y. Xiong, X. Zang, M. Kornhaber, Y. Lyu, K. S. Chung, and H. Suen. 2016. "Peer Assessment in the Digital Age: A Meta-Analysis Comparing Peer and Teacher Ratings." *Assessment & Evaluation in Higher Education* 41 (2): 245–264.
- Lin, S. S. J., E. Z. F. Liu, and S. M. Yuan. 2001. "Web-Based Peer Assessment: Feedback for Students with Various Thinking-Styles." *Journal of Computer Assisted Learning* 17 (4): 420–432. doi:10.1046/j.0266-4909.2001.00198.x.
- Liu, N. F., and D. Carless. 2006. "Peer Feedback: The Learning Element of Peer Assessment." *Teaching in Higher Education* 11 (3): 279–290. doi:10.1080/13562510600680582.
- Lu, J. Y., and N. Law. 2012. "Online Peer Assessment: Effects of Cognitive and Affective Feedback." *Instructional Science* 40 (2): 257–275. doi:10.1007/s11251-011-9177-2.
- Lundstrom, K., and W. Baker. 2009. "To Give is Better than to Receive: The Benefits of Peer Review to the Reviewer's Own Writing." *Journal of Second Language Writing* 18 (1): 30–43. doi:10.1016/j.jslw.2008.06.002.
- Martin, G. A., and J. M. Double. 1998. "Developing Higher Education Teaching Skills through Peer Observation and Collaborative Reflection." *Innovations in Education & Training International* 35 (2): 161–170. doi:10.1080/1355800980350210.

- Miller, T. M., and L. Geraci. 2011. "Training Metacognition in the Classroom: The Influence of Incentives and Feedback on Exam Predictions." *Metacognition and Learning* 6 (3): 303–314. doi:10.1007/s11409-011-9083-7.
- Min, H. 2016. "Effect of Teacher Modeling and Feedback on EFL Students' Peer Review Skills in Peer Review Training." *Journal of Second Language Writing* 31: 43–57. doi:10.1016/j.jslw.2016.01.004.
- Minami, T., and Y. Ohura. 2015. "How Student's Attitude Influences on Learning Achievement? An Analysis of Attitude Representing Words Appearing in Looking-Back Evaluation Texts." *International Journal of Database Theory and Application* 8 (2): 129–144. doi:10.14257/ijdta.2015.8.2.13.
- Nelson, M. M., and C. D. Schunn. 2009. "The Nature of Feedback: How Different Types of Peer Feedback Affect Writing Performance." *Instructional Science* 37 (4): 375–401. doi:10.1007/s11251-008-9053-x.
- Nesbit, P. L., and S. Burton. 2006. "Student Justice Perceptions following Assignment Feedback." *Assessment & Evaluation in Higher Education* 31 (6): 655–670.
- Nicol, D., A. Thomson, and C. Breslin. 2014. "Rethinking Feedback Practices in Higher Education: A Peer Review Perspective." *Assessment & Evaluation in Higher Education* 39 (1): 102–122.
- Nilson, L. B. 2003. "Improving Student Peer Feedback." *College Teaching* 51 (1): 34–38. doi:10.1080/87567550309596408.
- Paré, D. E., and S. Joordens. 2008. "Peering into Large Lectures: Examining Peer and Expert Mark Agreement Using peerScholar, an Online Peer Assessment Tool." *Journal of Computer Assisted Learning* 24 (6): 526–540. doi:10.1111/j.1365-2729.2008.00290.x.
- Patchan, M. M., and C. D. Schunn. 2015. "Understanding the Benefits of Providing Peer Feedback: How Students Respond to Peers' Texts of Varying Quality." *Instructional Science* 43 (5): 591–614. doi:10.1007/s11251-015-9353-x.
- Patchan, M. M., D. Charney, and C. D. Schunn. 2009. "A Validation Study of Students' End Comments: Comparing Comments by Students, a Writing Instructor, and a Content Instructor." *Journal of Writing Research* 1 (2): 124–152. doi:10.17239/jowr-2009.01.02.2.
- Patchan, M. M., C. D. Schunn, and R. J. Clark. 2018. "Accountability in Peer Assessment: Examining the Effects of Reviewing Grades on Peer Ratings and Peer Feedback." *Studies in Higher Education* 43 (12): 2263–2278. doi:10.1080/03075079.2017.1320374.
- Patchan, M. M., C. D. Schunn, and R. J. Correnti. 2016. "The Nature of Feedback: How Peer Feedback Features Affect Students' Implementation Rate and Quality of Revisions." *Journal of Educational Psychology* 108 (8): 1098–1120. doi:10.1037/edu0000103.
- Price, M., K. Handley, and J. Millar. 2011. "Feedback: Focusing Attention on Engagement." *Studies in Higher Education* 36 (8): 879–896. doi:10.1080/03075079.2010.483513.
- Robinson, R. 2001. "Calibrated Peer Review™ an Application to Increase Student Reading & Writing Skills." *The American Biology Teacher* 63 (7): 474–480.
- Roscoe, R. D., and M. T. H. Chi. 2007. "Understanding Tutor Learning: Knowledge-Building and Knowledge-Telling in Peer Tutors' Explanations and Questions." *Review of Educational Research* 77 (4): 534–574. doi:10.3102/0034654307309920.
- Ross, J., C. Sinclair, J. Knox, S. Bayne, and H. Macleod. 2014. "Teacher Experiences and Academic Identity: The Missing Components of MOOC Pedagogy." *Journal of Online Learning and Teaching* 10 (1): 57–69.
- Ruiz, J. G., C. Candler, and T. A. Teasdale. 2007. "Peer Reviewing e-Learning: Opportunities, Challenges, and Solutions." *Academic Medicine: Journal of the Association of American Medical Colleges* 82 (5): 503–507. doi:10.1097/ACM.0b013e31803ead94.
- Schunk, D. H., and B. J. Zimmerman. 2007. "Influencing Children's Self-Efficacy and Self-Regulation of Reading and Writing through Modeling." *Reading & Writing Quarterly* 23 (1): 7–25.
- Shashok, K. 2008. "Content and Communication: How Can Peer Review Provide Helpful Feedback about the Writing?" *BMC Medical Research Methodology* 8 (1): 3–9. doi:10.1186/1471-2288-8-3.
- Shute, V. J. 2008. "Focus on Formative Feedback." *Review of Educational Research* 78 (1): 153–189. doi:10.3102/0034654307313795.
- Srijbos, J.-W., S. Narciss, and K. Dünnebie. 2010. "Peer Feedback Content and Sender's Competence Level in Academic Writing Revision Tasks: Are They Critical for Feedback Perceptions and Efficiency?" *Learning and Instruction* 20 (4): 291–303. doi:10.1016/j.learninstruc.2009.08.008.
- Tillema, H., M. Leenknecht, and M. Segers. 2011. "Assessing Assessment Quality: Criteria for Quality Assurance in Design of (Peer) Assessment for Learning—a Review of Research Studies." *Studies in Educational Evaluation* 37 (1): 25–34. doi:10.1016/j.stueduc.2011.03.004.
- Topping, K. J. 2009. "Peer Assessment." *Theory into Practice* 48 (1): 20–27. doi:10.1080/00405840802577569.
- Tseng, S. C., and C. C. Tsai. 2007. "Online Peer Assessment and the Role of the Peer Feedback: A Study of High School Computer Course." *Computers & Education* 49 (4): 1161–1174.
- Tsvitanidou, O. E., Z. C. Zacharia, and T. Hovardas. 2011. "Investigating Secondary School Students' Unmediated Peer Assessment Skills." *Learning and Instruction* 21 (4): 506–519. doi:10.1016/j.learninstruc.2010.08.002.
- Tsui, A. B., and M. Ng. 2000. "Do Secondary L2 Writers Benefit from Peer Comments?" *Journal of Second Language Writing* 9 (2): 147–170. doi:10.1016/S1060-3743(00)00022-9.

- van der Pol, J., B. A. M. van den Berg, W. F. Admiraal, and P. R. J. Simons. 2008. "The Nature, Reception, and Use of Online Peer Feedback in Higher Education." *Computers & Education* 51 (4): 1804–1817. doi:10.1016/j.compedu.2008.06.001.
- van Gog, T., K. A. Ericsson, R. M. J. P. Rikers, and F. Paas. 2005. "Instructional Design for Advanced Learners; Establishing Connections between the Theoretical Frameworks of Cognitive Load and Deliberate Practice." *Educational Technology Research and Development* 53 (3): 73–81. doi:10.1007/BF02504799.
- Wang, Y., H. Li, Y. Feng, Y. Jiang, and Y. Liu. 2012. "Assessment of Programming Language Learning Based on Peer Code Review Model: Implementation and Experience Report." *Computers & Education* 59 (2): 412–422. doi:10.1016/j.compedu.2012.01.007
- Wasko, M. M., and S. Faraj. 2000. "It is What One Does": Why People Participate and Help Others in Electronic Communities of Practice." *Journal of Strategic Information Systems* 9 (2–3): 155–173.
- Watson, F. F., M. C. Bishop, and D. Ferdinand-James. 2017. "Instructional Strategies to Help Online Students Learn: Feedback from Online Students." *TechTrends* 61 (5): 420–427. doi:10.1007/s11528-017-0216-y.
- Weaver, M. R. 2006. "Do Students Value Feedback? Student Perceptions of Tutors' Written Responses." *Assessment & Evaluation in Higher Education* 31 (3): 379–394.
- Wichmann, A., A. Funk, and N. Rummel. 2018. "Leveraging the Potential of Peer Feedback in an Academic Writing Activity through Sense-Making Support." *European Journal of Psychology of Education* 33 (1): 165–184. doi:10.1007/s10212-017-0348-7.
- Winstone, N. E., R. A. Nash, J. Rowntree, and M. Parker. 2017. "It'd Be Useful, but I Wouldn't Use It': Barriers to University Students' Feedback Seeking and Recipience." *Studies in Higher Education* 42 (11): 2026–2041. doi:10.1080/03075079.2015.1130032.
- Wooley, R., C. Was, C. D. Schunn, and D. Dalton. 2008, July. "The Effects of Feedback Elaboration on the Giver of Feedback." In *30th Annual Meeting of the Cognitive Science Society* (Vol. 5).
- Wu, Y., and C. D. Schunn. 2020a. "From Feedback to Revisions: Effects of Feedback Features and Perceptions." *Contemporary Educational Psychology* 60: 101826. doi:10.1016/j.cedpsych.2019.101826.
- Wu, Y., and C. D. Schunn. 2020b. "The Effects of Providing and Receiving Peer Feedback on Writing Performance and Learning of Secondary School Students." *American Educational Research Journal*. doi:10.3102/0002831220945266.
- Wu, Y., and C. D. Schunn. 2020c. "When Peers Agree, Do Students Listen? The Central Role of Feedback Quality and Feedback Frequency in Determining Uptake of Feedback." *Contemporary Educational Psychology* 62: 101897. doi:10.1016/j.cedpsych.2020.101897.
- Yang, M., R. Badger, and Z. Yu. 2006. "A Comparative Study of Peer and Teacher Feedback in a Chinese EFL Writing Class." *Journal of Second Language Writing* 15 (3): 179–200. doi:10.1016/j.jslw.2006.09.004.
- Zacharias, N. T. 2007. "Teacher and Student Attitudes toward Teacher Feedback." *RELC Journal* 38 (1): 38–52. doi:10.1177/0033688206076157.
- Zhao, J., S. Ha, and R. Widdows. 2013. "Building Trusting Relationships in Online Health Communities." *Cyberpsychology, Behavior, and Social Networking* 16 (9): 650–657. doi:10.1089/cyber.2012.0348.
- Zou, M., C. D. Schunn, Y. Wang, and F. Zhang. 2018. "Student Attitudes That Predict Participation in Peer Assessment." *Assessment & Evaluation in Higher Education* 43 (5): 800–811. doi:10.1080/02602938.2017.1409872.