JOURNAL OF CONTEMPORARY MEDICAL EDUCATION, 2018
VOL 8, NO. 1, PAGE 1–9
10.5455/jcme.20180311124334

ORIGINAL RESEARCH

Open Access

Computer-supported collaborative learning by medical students

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ABSTRACT

Objective: In higher education, it is common practice that expert teachers provide feedback on students' learning tasks. Regardless of the quality of the provided feedback, students are more likely to accept feedback from experts than from peers. Still, peer feedback could be an interesting alternative or a valuable addition to expert feedback. Research suggests that peer feedback on the work of fellow students facilitates critical thinking and reflection. The benefits of peer feedback can be even greater when feedback on a task is provided by more than one peer. An asynchronous discussion forum of a computer-supported collaborative learning (CSCL) environment offers an opportunity to conveniently exchange peer feedback when students are dispersed. The aim of the present study is to explore whether peer feedback by a CSCL environment could lead to task revision of such good quality that it obviates, at least in part, the need for expert feedback.

Methods: Fifty-two medical students were invited to participate in the review process. Students had to write a research protocol and they were invited by a review process consisting of three phases: (1) to discuss their protocol with peers, (2) to revise their protocol according to peer feedback, and (3) to submit their protocol to an expert for feedback. The nature and type of peer and expert feedback were analyzed. Descriptive statistics were calculated and differences between revised and unrevised tasks were statistically tested on the data of the three phases.

Results: Forty-six students participated in the review process. Peers provided significantly more feedback during a discussion of a task when compared with expert feedback after discussion. Eighteen (39%) written tasks received feedback from peers, one-third of which were revised accordingly. Of the 14 tasks that did receive expert feedback, 71% had remained unrevised. Overall, 32 tasks (70%) were of such good quality that expert feedback remained absent.

Conclusion: This study shows that in a process in which a complex task is reviewed, students make significant contributions. Feedback by peers is an effective instrument to help students revise a written task. Experts mostly provide feedback on tasks already revised by peers. Trivial comments in peer feedback do not obstruct medical students´ discussions and task revision ensuing from them.

ARTICLE HISTORY

Received March 11, 2018
Accepted October 28, 2018
Published November 08, 2018

KEYWORDS

Computer-mediated communication; cooperative/collaborative learning; interactive learning environments; learning communities

Introduction

In higher education, it is common practice that expert teachers provide feedback on students' learning tasks. Regardless of the quality of the provided feedback, students are more likely to accept feedback from experts than from peers [1,2]. Students regard expert teachers as a more credible source purely based on their status [3]. Still, peer feedback could be an interesting alternative or a valuable addition to expert feedback. Research suggests that peer feedback on the work of fellow students facilitates critical thinking and reflection and helps them to improve the quality of their task [4,5]. Peer feedback has the advantage

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that both provider and receiver might understand it better because peers live and work in comparable circumstances, share the same language and knowledge, and are more familiar with the difficulties that their fellow students may struggle with [4,6–8]. Peer feedback also fits very well within a social-constructivist educational perspective that considers learning as an interactive, dynamic, and self-directed process during which students collaboratively acquire new construct ideas and concepts that builds on existing knowledge [9–11]. The benefits of peer feedback can be even more when feedback on a task is provided by more than one peer [6]. Such feedback is considered as more reliable and founded because more problems, omissions, and blind spots are detected, and feedback from various sources promotes error reduction because the collective consensus tends to be accepted as valid or true [6]. Research on classroom education has demonstrated that paper revision ensuing from peer feedback can improve the task's quality without the provision of expert feedback [12,13]. When students are not able to be present in a classroom at the same time, the advent of online learning environments has made it easier for students to still effectively exchange feedback. An asynchronous discussion forum of a computer-supported collaborative learning (CSCL) environment offers such an opportunity to conveniently exchange peer feedback when students are dispersed [14–19]. Although there is a lot of research on the effects of a forum discussion in a CSCL environment on students' task, it is still unclear whether the expert feedback is still needed on a revised task after a peer discussion on a forum in a CSCL environment [20-29]. The question that arises is whether peer feedback by an asynchronous discussion on a CSCL environment could lead to task revision of such good quality that it obviates, at least in part, the need for expert feedback. The present study, therefore, seeks to explore three various phases of a task review process: (1) feedback on the task by peers on a forum of a CSCL environment, (2) task revision ensuing from feedback by peers, and (3) expert feedback on the task afterward.

Research questions

The following research questions will be addressed accordingly:

1. Does the nature and type of peer and expert feedback vary in accordance with their pertinence to revised and unrevised tasks?
2. What is the volume of feedback provided by peers on students' tasks during a discussion in a CSCL environment? (phase 1 review process)
3. What is the effect of feedback by peers on task revision ensuing from the discussion? (phase 2 review process)
4. What is the effect of task revision on the volume of expert feedback? (phase 3 review process)

Materials and Methods

Participants

Fifty-two medical students of the Faculty of Health, Medicine and Life Sciences at the Maastricht University, The Netherlands participated in this study that was conducted in the period spanning from August 2010 to December 2010 and from July 2012 to September 2012.

Task

In preparation for a clinical research elective in the final year of their 6-year training program, each individual master student had to autonomously write a fully-detailed research protocol. In the earlier years of this program, students had practiced their skills in either writing parts of a research protocol individually or in preparing a whole research protocol in cooperation with peers. For the present task, students were free to formulate their ideas as long as they adhered to the protocol structure existing of four topics, each of which addresses a number of specific subtopics: (1) Introduction and background;—problem definition,—literature references,—previous study results, and—relevance of the present study, (2) Hypothesis and research question(s);—hypothesis and—research question(s), (3) Research population;—inclusion criteria,—patient selection,—power and sample size, and—exclusion criteria, and (4) Research design;—methods,—design,—data analysis,—statistics,—selection procedure, and—intervention(s). After this process of writing, all students were invited to participate in a review process consisting of three consecutive phases. The first phase engaged students in a peer discussion on a CSCL forum in which they addressed the strong and weak points of the topics and subtopics of each other's written protocols. It was not mandatory to comment on each subtopic. The second phase conceded all students time to revise their protocol following the discussion.

Protocol revision was not obligatory. In the third phase, students submitted their final written protocol to an expert (teacher) for feedback.

From a group of 10 experts, one was randomly selected and invited to provide feedback on the topics and subtopics of a particular protocol when deemed necessary. Experts did not know if a protocol had been revised or not. All students gave informed consent before the start of the study.

Study design

Students were randomly assigned to 17 discussion groups, 16 of which consisted of three students each and one discussion group counting four students. To effectively partake in the review process, all students received an e-mail that contained the names of the other students in their group, an instruction manual, the description of the peer review task, and a time schedule with set deadlines. The instruction manual provided information on the design and use of the CSCL environment. Group members were free to decide on the time schedule of the discussions conjointly but had to inform the principal investigator of the time the discussion would start and end, the order in which the individual research protocols would be discussed, and the sequence of topics to be discussed. All students had to comply with two deadlines. The first one specified the date by which their individual protocols were to be uploaded, that is, 1 week before the start of the discussion so as to allow for an adequate preparation. The second concerned the date by which their final research protocols had to be submitted for expert feedback. All students were given the opportunity to familiarize themselves with the learning environment (Blackboard©) and its asynchronous CSCL discussion forum before starting the discussion. Discussion threads were only visible to the members of the discussion group and to the principal investigator. After the submission of the final protocol, each student was asked to indicate which subtopics of the protocol had been revised in response to peer feedback. Each final protocol was evaluated by an expert who provided feedback if considered necessary. Expert feedback was sent to the student and to the principal investigator of this study.

Measurement instruments and statistical analysis

Nature and type of peer and expert feedback

First, peer and expert feedback were explored by categorizing them according to the nature of feedback: (1) "Editorial," (2) "Explication," or (3) "Content." Second, the "Content" of peer and expert feedback was categorized into six types according to Cho et al. [5], as shown in Table 1.

For the classification of the nature and type of both peer and expert feedback, a descriptive statistical analysis was performed. For the data that was ordinal, a Mann–Whitney *U* test for two independent samples was used to compare the nature between peer feedback and expert feedback.

The review process

As described earlier, the review process consisted of three consecutive phases. In phase 1, students provided their fellow group members with feedback on some or all of their protocols' subtopics.

Table 1. Feedback categorized by nature and type with their definition [5].

Nature of feedback	Definition
Editorial	Feedback regarding the justification of the text
Explication	Feedback regarding the request for an explanation of the text.
Content	Feedback regarding the discussion of the text
Type of feedback	**Definition**
1. Directive comments	Suggests a specific change particular to the writer's paper.
2. Nondirective comments	Suggests a nonspecific change that would apply to any paper. Comment on a detail without suggesting a change.
3. Criticism comments	Gives a critical or negative evaluation of the paper or a portion of the paper; points out an underdeveloped area. No suggestions for improvement are offered.
4. Praise comments	Describes the paper or a portion of the paper positively, including encouraging remarks.
5. Summary comments	Recapitulation of the main points of the paper or a portion of the paper.
6. Off-task comments	Comments do not fit any of the code categories; the comments are ambiguous, or a rating was given without written comment.

Next, in phase 2, students could choose whether or not to revise their individual protocol according to peer feedback. Finally, in phase 3, the expert provided feedback according to the protocol structure when deemed appropriate. The different scenarios possible for each phase led to a theoretical classification of eight different review processes a students' protocol could potentially proceed through (see Table 2).

In review processes 2, 4, and 6, expert feedback was absent. Students received feedback by peers in review process 2 and revised their protocol accordingly, no further expert feedback ensued after this revision. In review process 4, although peer feedback was present, protocols were not revised and neither did they receive expert feedback. Finally, review process 6 reflects the congruence of opinion between peers and experts, as neither peers nor experts provided feedback nor did any revision ensue. In each of the review processes 1, 3, or 5, experts still had comments regardless of whether or not any prior discussion of subtopics had taken place among peers and whether or not protocols had been revised accordingly.

As to the final two review processes (7 and 8), these were not considered further since it never happened that a protocol would be revised without prior peer feedback. It follows that six different review processes remain that merit consideration. Therefore, all final protocols were classified into one of these six review processes. Consequently, the number of protocols was counted in each of these review processes and descriptive statistics were calculated.

Phase 1: Volume of feedback by peers during discussion: All feedback postings were counted and a descriptive statistical analysis at subtopic level was performed, classified by protocols with and without feedback. Consequently, all subtopic-related data were grouped and presented per topic. For the data that was ordinal, a Mann–Whitney *U* test for two independent samples was used to compare protocols with and without feedback by peers.

Phase 2: Effect of peer feedback on protocol revision: All postings of peer feedback on the protocols were counted and a descriptive statistical analysis at subtopic level was performed, classified by revised or unrevised protocols. Subsequently, all subtopic-related data were grouped and presented per topic. For the data that was ordinal, a Mann–Whitney *U* test for two independent samples was used to compare the number of feedback postings on topics between the revised and unrevised protocols after peer feedback.

Phase 3: Effect of task revision on expert feedback: Postings of expert feedback on the research protocols were counted and a descriptive statistical analysis at subtopic level was performed, classified by revised or unrevised protocols. Consequently, all subtopic-related data were grouped and presented this per topic. For the data that were ordinal, a Mann–Whitney *U* test for two independent samples was used to compare the number of expert feedback between the revised and unrevised protocols.

Results

Out of the 52 invited students, 46 (89%) actively participated in the online discussions and provided peer feedback. Fourteen discussion groups had only active participants; two discussion groups had one inactive student; and one group of three students showed no activity at all. It was unclear why these students did not participate.

Nature and type of peer and expert feedback

Table 3 depicts the results on the nature of peer and expert feedback, i.e., "Editorial," "Explication," and "Content," as well as on the type of "Content" postings of peer and expert feedback. In total, peers exchanged 345 discussion postings where experts provided 158 feedback postings on the final protocol. On every category of the nature of feedback,

Table 2. Classification of possible review processes.

Review process	Phase 1: feedback by multiple peers?	Phase 2: protocol revision?	Phase 3: expert feedback?
1	Yes	Yes	Yes
2	Yes	Yes	No
3	Yes	No	Yes
4	Yes	No	No
5	No	No	Yes
6	No	No	No
7	No	Yes	Yes
8	No	Yes	No

Table 3. Nature and type of peer and expert feedback.

Nature of feedback	Peer feedback	Expert feedback	*p*-value
	No. (%)	No. (%)	
Content	178 (75%)	58 (25%)	$p < 0.034$
Editorial	50 (57%)	38 (43%)	$p < 0.334$
Explication	117 (65%)	62 (35%)	$p < 0.049$
Type of feedback	**Peer feedback**	**Expert feedback**	
	No.	**No.**	
Directive comments	17	15	
Non-directive comments	47	20	
Criticism comments	–	18	
Praise comments	103	1	
Summary comments	–	–	
Off-task comments	11	4	

students send more postings than experts. On "Editorial," peers provided 57% more postings than experts, as well as on an "Explication" and "Content," 65% and 75%, respectively.

On the "Content," peers exchanged 178 discussion postings where experts provided 58 postings on the final protocol. On four of the six types of the "Content" postings, peers provided more postings than experts: i.e., directive comments; nondirective comments; praise comments, and off-task comments. A Mann–Whitney test indicated that the "Content" postings were significantly greater for peer feedback (mean rank = 20) than for expert feedback (mean rank = 13), $U = 72$, $p < 0.034$.

The following example of peer feedback was categorized as "Editorial": "I think it is better to change the title of your research protocol." An example of on "Explication" was: "In the summary, you describe that some angiogenic factors will be determined. Maybe you can describe these factors already?" A sentence as the following was categorized as "Content": "The action to obtain a skin biopsy is still invasive; however, significantly less than a kidney biopsy. You write that this is not invasive. However, I think this is still invasive; however, probably less invasive. What´s your opinion about this?"An example of expert feedback that was categorized as "Editorial" was: "Your learning goals are not described by the SMART-method (Specific; Measurable; Attainable; Relevant; Timely). Please adjust." "Explication" was exemplified as follows: "I think the question here is which models to predict are of good quality, I think you have to describe more specifically about your own prediction." "Content" was typed as: "Your research question describes TREC's (T-cell receptor excisions circles). However, within the method, section I do not recognize TREC's at all. Could you please explain to me why this occurs?"

The review process

As described in the Methods section, there were six review processes a protocol could possibly go through. Table 4 details the number of protocols, overall and per topic, in each of the profitable and unprofitable processes. A total number of 32 protocols were classified into the review processes 2, 4, and 6. All of these protocols did not receive expert feedback. Within this group, 4% of the protocols could be linked to process 2, whilst 18% pertained to process 4, and 48% could be associated with process 6.

The review processes 1, 3, and 5 were allocated a total of 14 protocols. All of these protocols received expert feedback. Among these protocols, 9% were classified into process 1, i.e., where peer feedback and revision occurred; 12% underwent process 3, in which the protocol remained unrevised after peer feedback was provided; and 9% were grouped into process 5, in which peer feedback and revision were absent.

Phase 1: volume of feedback by peers during discussion: The number of research protocols that received feedback by multiple peers on protocols' content is shown in the upper section of Table 5. Overall, 18 of the 46 protocols received feedback by multiple peers. More specifically, 21 protocols received feedback on topic 1 and 32 protocols were provided with feedback on topic 2, whereas 18 and 12 protocols received feedback on topics 3 and 4, respectively. A Mann–Whitney test indicated that the overall number of protocols that received peer feedback (mean rank = 35.22) was significantly smaller than the number of protocols that received peer feedback (mean rank = 57.78), $U = 539$, $p < 0.001$. More specifically, on topic 3; protocols with feedback (mean rank = 37.73) and protocols without feedback (mean rank = 55.27), $U = 654.5$, $p < 0.001$, and on topic 4; protocols with feedback (mean rank = 27.38) and protocols without feedback (mean rank = 65.62), $U = 178.5$, $p < 0.001$. On topic 2, the number of protocols that received peer feedback (mean rank = 56.29) was significantly greater than protocols that were not provided with peer feedback (mean rank = 36.71), $U = 607.5$, $p < 0.001$.

Phase 2: Effect of peer feedback on protocol revision: The respective numbers of protocols that received peer feedback are presented on the center section of Table 5. These protocols were classified into revised and unrevised protocols. Overall, six protocols were revised in response to peer feedback. More precisely, nine protocols saw a revision on topic 1 and 12 protocols on topic 2. On topics 3 and 4, five and four revised protocols received peer feedback, respectively. A Mann–Whitney test indicated that the overall number of protocols that were revised (mean rank = 36.79) was significantly smaller than the protocols that were not revised (mean rank = 56.21), $U = 611.5$, $p < 0.001$.

On topics 2, 3, and 4, specifically, the number of revised protocols was significantly smaller than unrevised protocols: on topic 2; revised protocols (mean rank = 41.41) and unrevised protocols (mean rank = 51.59), $U = 824$, $p < 0.038$, on topic 3; revised protocols (mean rank = 36.82) and unrevised protocols (mean rank = 56.18), $U = 612.5$, $p < 0.001$, and on topic 4; revised protocols (mean rank = 40.30) and unrevised protocols (mean rank = 52.70), $U = 773$.

Phase 3: Effect of task revision on expert feedback: The lower section of Table 5 presents the number of expert feedback provided on the revised and unrevised protocols. Overall, 14 protocols received expert feedback, four of which had been revised before. On the protocols that had seen a previous revision, seven protocols received expert feedback both on topic 1 and on topic 2. Whilst three protocols required expert feedback on topic 3 and one of the protocols was provided with expert feedback on topic 4. A Mann–Whitney test showed no differences on provided expert feedback between revised protocols and unrevised protocols.

Discussion

The results of the present study showed that feedback by peers can be easily wielded by means of an asynchronous discussion forum in a CSCL environment. Regarding the nature of peer feedback, peers provided more feedback during discussion than experts afterward. Peers exchanged significantly more feedback on the "Content" of a protocol than experts did. Considering the type of feedback, students received significantly more "Nondirective comments" and "Praise comments" from their peers than from experts. Overall, 46 (89%) of the students participated in the review process. One-third of students' protocols received peer feedback and was revised after discussion. After peer feedback was exchanged and, when applicable, protocols were revised, the quality of the final student protocols was such that 70% required no further expert feedback. Students engaged in a process of intense discussion with peers not only about their own protocols but also on those of their peers. Our results provide evidence for Cho et al. [5] contention that critical and constructive reflection by peers upon the work of fellow students effectively helps to revise the final tasks. In this, a CSCL environment acts as a catalyst of students' reflection as it incentivizes them to write down their ideas, thoughts, and additional explanations [9,20].

Table 4. Number of protocols per profitable and unprofitable review process, overall and differentiated per topic.

	Profitable review processes				Unprofitable review processes			
	Overall	Process 2	Process 4	Process 6	Overall	Process 1	Process 3	Process 5
	%	No.	No.	No.	%	No.	No.	No.
Overall protocols	70	2	8	22	30	4	6	4
Topic 1	63	2	8	19	37	7	4	6
Topic 2	52	5	9	10	48	7	11	4
Topic 3	76	2	10	23	24	3	4	4
Topic 4	78	3	5	28	22	1	4	5

Overall protocols: calculated on 16 subtopics.
Topic 1: calculated on four subtopics.
Topic 2: calculated on two subtopics.
Topic 3: calculated on four subtopics.
Topic 4: calculated on six subtopics.

Table 5. Number of protocols in phases 1, 2, and 3 of the review process.Overall protocols: calculated on 16 subtopics.

	Phase 1: volume of feedback by peers during discussion		
	Protocols with feedback by multiple peers	**Protocols without feedback by multiple peers**	***p*-value**
	No. (%)	**No. (%)**	
Overall protocols	18 (39%)	28 (61%)	$p < 0.001$
Topic 1	21 (46%)	25 (54%)	$p < 0.304$
Topic 2	32 (70%)	14 (30%)	$p < 0.001$
Topic 3	18 (39%)	28 (61%)	$p < 0.001$
Topic 4	12 (26%)	34 (74%)	$p < 0.001$
	Phase 2: effect of peer feedback on protocol revision		
	Revised protocols after feedback by multiple peers	**Unrevised protocols after feedback by multiple peers**	***p*-value**
	No. (%)	**No. (%)**	
Overall protocols	6 (33%)	12 (67%)	$p < 0.001$
Topic 1	9 (43%)	12 (57%)	$p < 0.427$
Topic 2	12 (38%)	20 (62%)	$p < 0.038$
Topic 3	5 (28%)	13 (72%)	$p < 0.001$
Topic 4	4 (33%)	8 (67%)	$p < 0.013$
	Phase 3: effect of task revision on expert feedback		
	On revised protocols after feedback by multiple peers	**On unrevised protocols whether or not after feedback by multiple peers**	***p*-value**
	No. (%)	**No. (%)**	
Overall protocols	4 (29%)	10 (71%)	$p < 0.252$
Topic 1	7 (41%)	10 (59%)	$p < 0.112$
Topic 2	7 (32%)	15 (68%)	$p < 0.293$
Topic 3	3 (27%)	8 (73%)	$p < 0.491$
Topic 4	1 (10%)	9 (90%)	$p < 0.086$

Topic 1: calculated on four subtopics.
Topic 2: calculated on two subtopics.
Topic 3: calculated on four subtopics.
Topic 4: calculated on six subtopics.

Yet, task revision does not automatically ensue from peer feedback. The extent to which the feedback is perceived as helpful can be one of the factors that influenced the decision to revise or not. Peer feedback of low quality or a perceived low value of peer feedback can be a reason to not revise a task. Previous research has shown that students underestimate the capability of a peer to provide good-quality feedback and that they consider peer feedback as less effective than expert feedback [5,30]. When students have a negative perception of peer feedback, they are not willing to revise their task accordingly [12,13]. All things considered, the process of peer feedback does seem to offer advantages, especially since revised tasks receive less expert feedback than unrevised tasks.

This leads us to conclude that task revision ensuing from peer feedback reduces the need for expert feedback, and confirms earlier findings that peer feedback can be an alternative or valuable addition to expert feedback [6–8]. Furthermore, peers even often provide feedback on things that experts do not notice and otherwise should be unaddressed [7,31].

The present study is not without limitations. For instance, the design of this study does not include a control group: All students had to execute the task and had to participate in the discussions. Under the given circumstances in which we did not know what effect the discussion would bring, we wanted all students to provide peer feedback and give them the opportunity to revise their protocol. A second limitation is that we cannot exclude that there were other variables that influenced the decision for protocol revision. For instance, there were discussion groups in which some students did not actively participate in the discussion. This may have adversely affected the quality of the discussions and, with that, the tendency to revise. Earlier research demonstrated that the feedback type “Criticism comments” and “Off-task comments” do not necessarily lead to revision and eventually even result in less inspired written tasks [5,32,33].

Although the majority of students in the present study contributed well to the discussions and provided no “Criticism comments” and a low amount of “Off-task comments” during the discussion, a minority of protocols were revised after discussion. A more plausible reason for a student to not revise their protocol after discussion could be that students did not concur with the feedback from their peers or did not fully appreciate it. Similarly, we cannot exclude that some protocols were of such high quality that revision was not needed altogether. Students who wrote high-quality protocols may have stimulated the knowledge construction of their peers by their advanced contributions to the discussions. However, there was no evidence found to support this statement.

The present study raises several questions. First, the students who participated in this research were little seasoned as to how effective feedback should be provided. A study with students receiving effective feedback training before the task could provide better results than those obtained in the present investigation. Secondly, we observed that students differed considerably in their motivation to participate in a CSCL discussion on the work of fellow students. Future research on varying patterns of participation could shed some light on how students can be motivated to participate. This may bolster the overall quality of CSCL discussions and task improvement.

Conclusion

In a process in which a complex task is reviewed, students make significant contributions. Feedback by peers is an effective instrument to help students revise a written task. Experts mostly provide feedback on protocols that were revised already by peers. Trivial comments in peer feedback do not obstruct medical students’ discussions and the task revision ensuing from them.

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