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# The effect of peer assessment on problem solving skills of prospective teachers supported by online learning activities

Yasemin Demiraslan Çevik [a,*], Tülin Haşlaman [a,1], Serkan Çelik [b,2]

[a] Hacettepe University, Department of Computer Education and Instructional Technology, 06800 Beytepe, Ankara, Turkey
[b] Hacettepe University, Department of Primary Education, 06800 Beytepe, Ankara, Turkey

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ABSTRACT

This study examined the effect of peer assessment on prospective teachers' performances in complex problem solving. This study also investigated how feedback functions, agreement with peer feedback, and feedback direction affected the use of feedback. The participants included 68 prospective teachers enrolled in the Teaching Methods-2 course during 2012–2013 spring semester and 14 prospective teachers pursuing MA studies on Computer Education and Instructional Technology. The data included prospective teachers' case solutions and MA students' feedback reports. The results indicated that groups in both feedback and non-feedback conditions improved on developing solutions for the problems. Additionally, the results showed that while feedback function and feedback direction predicted the use of feedback, prospective teachers' agreement with feedback was not related to the feedback use. Suggestions were made for further research in line with the findings.



## Introduction

The role of feedback in pedagogy has been associated with numerous positive outcomes of learning including correcting misconceptions, reconstructing knowledge, supporting metacognitive processes, improving academic achievement, gaining self-efficacy, and enhancing motivation (Clark & Dwyer, 1998; Driscoll, 2000; Foote, 1999; Ge & Land, 2003; Wang & Wu, 2008; Warden, 2000). Peer assessment, which is a critical concept in feedback research and the participatory culture of learning (Kollar & Fischer, 2010), can empower users to take control of their own learning and, in the process, transform the educational process (McConnell, 2002; Wasson & Vold, 2011). Noonan and Duncan (2005) also maintain that the focus of instruction within peer feedback environments is not only on the end product(s) but also on the process, and it highlights the value of collaboration and social interaction. A part of the existing literature underlines the improvements in prescribing the feedback methods (Hattie & Timperley, 2007; Shute, 2008) though, there are still many aspects to be explored related to the effect of feedback on learning (Mory, 2004; Shute, 2008). The current study sets out to determine the effect of peer assessment on prospective teachers' performance in an online case-based environment focusing on solving ill-structured problems. Additionally this study also investigates how feedback functions, agreement with peer feedback, and feedback direction affected the use of feedback.

### *Critical notions in peer assessment research*

Despite numerous advantages of peer assessment mentioned within the pedagogical discourse, studies have reported that its success (*the extent to which students utilize feedback to improve their work and ultimately their learning*) is conditioned to a number of interrelated factors including; (a) the type of feedback, (b) the source of feedback, and (c) students' perceptions of the usefulness and importance of feedback (Dochy, Segers, & Sluijsmans, 1999; Hanrahan & Isaacs, 2001; Narciss, 2008; Shute, 2008; Topping, 2005; van Gennip, Segars, & Tillema, 2009; van Zundert, Sluijsmans, & van Merriënboer, 2010).

### *The type of feedback*

Two common issues that have been discussed about the type of feedback include: (a) the content of feedback and (b) the direction of feedback. In terms of the content of feedback, an extensive body of research has reported that feedback that contains elaborated and specific comments have better quality and more positive learning

* Corresponding author. Tel.: +90 312 297 7176.
*E-mail addresses:* yasminey13@gmail.com (Y. Demiraslan Çevik), thaslaman@gmail.com (T. Haşlaman), sercelikan@gmail.com (S. Çelik).
[1] Tel.: +90 312 297 7176.
[2] Tel.: +90 312 297 8625.

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effects than simple and general comments (Bitchener, Young, & Cameron, 2005; Cho & MacArthur, 2010; Gielen, Peeters, Dochy, Onghena, & Struyven, 2010; Hattie & Timperley, 2007; Kim, 2005; Kluger & DeNisi, 1996; Mory, 2004; Narciss, 2008; Shute, 2008; Tseng & Tsai, 2007). Nelson and Schunn (2009) propose that good feedback should include a summary of what the assesse has done, specific comments relating with the problems identified and the solutions to those problems, and clear and concise explanations supporting the feedback. Dominguez, Cruz, Maia, and Pedrosa (2012) noted that feedback that lacked these features was mostly neglected by students. Some researchers further described specific functions of feedback according to its content. Based on Flower, Hayes, Carey, Schriver, and Stratman (1986) model of the functions of feedback in review process, van den Berg, Admiraal, and Pilot (2006) identified four functions of feedback on writing including analysis, evaluation, explanation, and revision, which were also utilized in the current study to examine the effects of each function on the use of feedback. Analysis refers to understanding of what the text is about, evaluation indicates judgment about the quality of the text, explanation specifies any argument supporting the evaluation, and revision contains explicit suggestions for the improvement of the text. In a later study, van der Pol, van der Berg, Admiraal, and Simons (2008) found out that analytical and evaluative feedback comments were positively related to the use of feedback only if they were more task-oriented and asked objective questions for elaboration. The researchers also illustrated that the more feedback contained concrete suggestions for revision the more receivers made corresponding changes in their writings. This finding is similar to those reported by both Kim (2005) and Tuzi (2004). Furthermore, Li, Steckelberg, and Srinivasan (2008) showed that students demanded for more constructive feedback that included concrete suggestions, supported with sound reasons, for how to improve their work. In a recent study, Lu and Law (2012) also reported that feedback including problem identification and suggestions improved assessees' performance.

As indicated earlier, the second issue concerning the type of feedback is the polarity of feedback (positive versus negative feedback). Some researchers argued that positive feedback is beneficial only if it incorporates task-related information rather than just affective comments (Cho & Cho, 2011; Hattie & Timperley, 2007), while others reported that positive affective feedback helped enhance the motivation, performance, and confidence of assessees (Lu & Law, 2012; Tseng & Tsai, 2007). Hattie and Timperley (2007) further argue that the learning effects of positive and negative feedback vary depending on the level of students' task commitment. Students who have high task commitment are more likely to learn from positive feedback for self-confirmation, while students having low task commitment are more likely to learn from negative feedback as a motivating factor to improve themselves. Hattie and Timperley (2007) state that, "when we are committed to a goal, we are more likely to learn as a function of positive feedback, but when we undertake a task that we are not committed to (and hence have to do), we are more likely to learn as a function of negative feedback (we need to be driven, in the older motivation terminology" (p. 99).

Based on the aforementioned research results, we assume feedback that incorporates concrete suggestions for revision and elaborative explanations pointing to the sources of the problems or errors associated with student responses will more likely to lead to the use of feedback than general and unsupported feedback. Additionally, we expect that while positive feedback can boost students' motivation, the learning effects of positive–negative feedback will vary depending on students' level of task commitment.

*The source of feedback*

Topping (2009) defines peer assessment as "...an arrangement for learners to consider and specify the level, value, or quality of a product or performance of other equal-status learners". She goes on explaining that "Equal-status can be interpreted exactly or with flexibility; in the latter case, a peer can be anyone within a few years of schooling" (p. 21). In a similar vein, Harris and Brown (2013) stated that "this [peer assessment] was a student-led assessment process; whether a student assessed his/her fellow student's work or a more experienced student assessed another student whom he/she does not know well". In this study, we utilized feedback from more experienced students to eliminate or at least minimize some of the pitfalls of peer assessment indicated in the literature. One of the main concerns about peer assessment is students' negative perceptions relating with the fairness and reliability of assessment provided by a peer. Studies have identified that students were doubtful about and even criticized the quality and objectivity of feedback that they received from peers (Dochy et al., 1999; Li et al., 2008; Orsmond, Merry, & Reiling, 1996; Wen & Tsai, 2006). In fact, a number of studies have revealed that subjective biases (i.e., friendship-marking and free-riding) occurred due to social relations among peers (Carvalho, 2012; Maiden & Perry, 2011; Sluijsman, Moerkerke, van Merriënboer, & Dochy, 2001; Vu & Dall'Alba, 2007). Nelson and Schunn (2009) further showed that students were less likely to use feedback if they did not trust their peers' competencies. Researchers also propose that students, who are involved in peer assessment, often do not perform well in providing constructive and elaborated feedback unless they have high level of subject matter knowledge and experience in peer assessment (Lu & Law, 2012; Sluijsman et al., 2001; Topping, Smith, Swanson, & Elliot, 2000; van Zundert, Sluijsmans, Könings, & van Merriënboer, 2012). Another important challenge related to peer assessment is students' unwillingness to criticize the work of their peers. Studies have reported that students often are reluctant to assess fellow students' work and perceive themselves to be unqualified for peer assessment (Kaufman & Schunn, 2011; Liu & Carless, 2006; Papinczak, Young, Groves, & Haynes, 2007; Sluijsman et al., 2001).

By utilizing feedback from more experienced students whom the participants of the current study do not know well, we expected that the assessors' high level of subject matter knowledge and experiences in teaching would increase prospective teachers' trust to their peers' competencies in peer assessment while maintaining the objectivity of feedback.

*The usefulness and importance of feedback*

Students' perceptions of the usefulness and importance of peer feedback influence the extent to which they utilize feedback for revision. Van der Pol et al.'s (2008) study revealed that the more students perceived the feedback as important, the more they agreed with it and in turn showed a higher level of use of the feedback. However, perceived usefulness of the feedback did not relate to use of the feedback for revision, and the researchers suggested that qualitative analyses should be conducted to improve our understanding of the reasons underlying students' ratings of feedback usefulness or importance and how these ratings were related to decisions regarding subsequent revisions. Some scholars argue that if students do not agree with the assessor's ideas, they will be unwilling to make any changes based on feedback (Cho & MacArthur, 2010; Topping, 2010). Similarly, Hattie and Timperley (2007) state that "students who wish to confirm positive self-belief rather than focus on learning goals are more likely to adopt or seek feedback that maximizes positive self-evaluations and/or minimizes negative self-evaluations" (p. 103). Accordingly, feedback can be largely ignored when individuals have too much confidence in the correctness of their responses (Hattie & Timperley, 2007).

Research has demonstrated that students' perceptions of feedback usefulness and importance are closely related to the

type and source of feedback. To illustrate, Dominguez et al. (2012) observed that the type of feedback had a significant influence on students' perceptions of the usefulness of feedback. The researchers indicated that students perceived feedback with elaborated and specific comments to be more useful than simple and generic feedback. Others have reported similar findings as well (Narciss, 2008; Shute, 2008). According to Kaufman and Schunn (2011), students' perceptions of the usefulness and importance of peer feedback also depend on the degree to which they think that feedback they received is unbiased. As suggested by Strijbos, Narciss, and Dünnebier (2010), feedback from a competent person is perceived to be more credible, satisfactory, agreeable, and useful.

Consequently, we expect positive and significant relationships between the use of feedback and students' perceptions of the usefulness and importance of feedback. The next section describes relevant research and theory on the role of peer feedback and assessment in ill-structured problem solving.

### *Peer assessment as a method for scaffolding ill-structured problem solving*

The educational potential of problem solving has led to a large body of research focusing on instructional strategies for developing students' problem solving skills in dealing with ill-structured tasks (Cho & Jonassen, 2002). Ill-structured problem solving includes vague goals and requires domain-specific and structural knowledge of how concepts within a domain are interrelated and requires integration of declarative knowledge into useful knowledge structures (Feltovich, Spiro, Coulson, & Feltovich, 1996; Ge, 2001). That is to say, complex, real-world problems require the learner to use metacognitive skills to monitor problem solving processes, to reflect on the targets and solution processes, and to construct rationales for the proposed solutions.

The current study is driven by the demand to explore effective instructional strategies to improve students' online problem solving skills. Cases were utilized as pedagogical tools to help prospective teachers advance in complex problem solving skills (Bruning et al., 2008; Choi & Lee, 2009; Merseth, 1996; Rich & Hannafin, 2008; Shulman, 1992; Sykes & Bird, 1992). In order for the cases to be effective, many scholars advocate supporting prospective teachers', especially novices', solving of complex, authentic cases (i.e., Cho & Cho, 2007; Clark, 2009; Spiro & DeSchryver, 2009). Similarly, other studies revealed that students need externalized support or scaffolding for solving ill-structured problems (Ge, 2001; Ge & Land, 2004; Hall & Vance, 2010). Bernard, Rojo de Rubalcava, and St-Pierre (2000) underline that trained students may hold a scaffolding role in an online collaboration activity as in the current study. Peer assessment as a form of scaffolding whereby experienced students evaluate their peers' performances can enrich a feedback oriented learning process. When peer assessment is employed, students may experience cognitive dilemmas that stimulate them to explore and justify their thoughts, elicit new information, and come up with alternative point of views (Brown & Palincsar, 1989; Lin, Hmelo, Kinzer, & Secules, 1999; Oh & Jonassen, 2007). Webb (1989) pointed out that use of feedback for problem solving will lead to a high level of elaboration, which in the end causes greater academic achievement. The study conducted by Hall and Vance (2010) on the theoretical prediction that self-efficacy is enhanced by feedback that fosters problem solving skills revealed that students in the feedback group showed significantly higher problem scores over the no-feedback group.

In summary, the previous research on feedback has concluded that peer feedback fosters learning outcomes (Shute, 2008), enriches the pedagogical process (Dysthe, Lillejord, Wasson, & Vines, 2009), and helps to develop metacognitive awareness (Falchikov, 2003). Additionally, previous research supports the effectiveness of peer assessment in scaffolding problem solving processes by deeming into problems, constructing the problem spot, and articulating contextual constraints (Greene & Land, 2000; Lin et al., 1999). However, there is lack of true or quasi-experimental studies on peer assessment (van Zundert et al., 2012). The existing literature on feedback and assessment includes few experimental studies that mainly considered students' perceived learning as an outcome variable rather than examining actual learning effects of peer assessment (Strijbos et al., 2010; van der Pol et al., 2008).

The current study aims to determine the effect of peer assessment on prospective teachers' performances in complex problem solving in authentic case-based learning environments. In the light of abovementioned research findings, it is postulated that peer feedback may scaffold prospective teachers' problem solving on ill-structured tasks and can also prompt them to regulate and reflect upon their problem solving processes. Additionally, the current study also aims to respond to a lack of research focusing on a number of interrelated factors on the success of feedback at a time which are (a) the type of feedback, (b) the source of feedback, and (c) students' perceptions of the usefulness and importance of feedback (Dochy et al., 1999; Hanrahan & Isaacs, 2001; Narciss, 2008; Shute, 2008; Topping, 2005; van Gennip et al., 2009; van Zundert et al., 2010). Overall, the research questions guiding this study are as follows:

1) Does receiving peer feedback have an effect on students' problem solving outcomes (problem representation, developing solutions, solution justification, and evaluating solutions) in ill-structured case problems?
2) Do the different functions of peer feedback, students' agreement with the peer feedback, and feedback direction have different effects on students' use of feedback to revise their case solutions?

## Method

### *Context*

This study was conducted in Teaching Methods II, a required 3-credit hours course open only to majors in Computer Education and Instructional Technology (CEIT), offered in a large university in Ankara, Turkey. Typically, third year students in the program take Teaching Methods I during the fall semester and Teaching Methods II during the spring semester. The first Methods class focuses on theories and research about a variety of teaching strategies, methods, and techniques including inquiry, direct instruction, case studies, and problem solving. This class, however, did not have any case-based problem solving component, which generally requires the application of theoretical knowledge to realistic classroom situations. Teaching Methods II, on the other hand, emphasizes the theory, research, and practice related to the application of four basic constructivist methods (case studies, problem solving, project-based learning, and collaborative learning) in Internet-based learning environments. This course had both theoretical and lab sessions, each took 2 h in a week. As part of theoretical sessions, students were assigned text on and had lectures and class activities on teaching methods. During lab sessions, students worked in small groups (4–5 students in each group) and engaged in several learning activities designed to help them apply what they learned in class to solve ill-structured problems related to course topics. To supplement face-to-face sessions, the instructor created an online environment in the Coursesites learning management system, allowing students to access course materials, submit their individual or group work, track their performances, and use a variety of tools

including discussion boards and wikis to facilitate their group work. The research study discussed in this paper was woven into online activities designed to help students reason about and solve complex case problems related to the use of different teaching methods in real-life classroom settings. All students in the class were expected to complete these activities; students who completed the activities received class participation points as a normal part of the course.

*Participants*

This study had two groups of participants. The primary participants of the study initially consisted of 68 third-year prospective teachers enrolled in the course during 2012–2013 spring semester. Among those, 14 groups (7 experimental and 7 control groups), varying between 4 and 5 members in each group, were formed. While groups 4, 5, 7, 8, 9, 11, 13 were assigned as experimental groups, groups 1, 2, 3, 6, 10, 12, 14 were labeled as control groups. Of 14 groups, one control group (group 14) failed to complete the activities; therefore, the final sample consisted of 64 students in 13 groups. As the secondary participant group, 14 fifth-year prospective teachers pursuing MA studies in Computer Education and Instructional Technology (CEIT) at another university participated in the current study as experienced feedback providers to the aforementioned groups. The feedback providers are MA students and are enrolled at one of the most distinguished universities of Turkey (Bilkent) which admits BA and MA students with very high achievement scores and thus is known as graduating very successful teachers. Besides, all of these MA students have been chosen by one of the authors who taught at this distinguished university as well. Typically, teacher education programs in Turkey are 4-year programs awarding the graduates with a BA degree. However, a few teacher preparation programs in the country offer a specialized MA degree that requires students to complete one additional year with taking extra courses and finishing a one-semester student teaching experience. The secondary participants in the current study were in their last semester in such a program and had student teaching experience in real-life classrooms.

*Study design*

A one factor, two groups, between-subjects experimental study was conducted to address the research questions. Dependent variables included four components of ill-structured problem-solving, which are described in the measures section. Groups including undergraduate students were equally assigned into feedback and non-feedback conditions as the independent variable of the study. In assigning the groups into the conditions, we first randomly formed small groups, each having 4–5 members. Then, we calculated an average group scores for each group based on individual course scores of group members in Teaching Methods I class offered in Fall 2011–2012 semester. The average score for the groups in the feedback condition was 75.99 (out of 100) and 75.89 for the groups in the non-feedback condition. An independent *t*-test results showed no significant difference between the mean scores of the two conditions ($t = -.018$, $p > .05$). In each condition, students worked collaboratively in Coursesites environment to analyze and solve case problems related to teaching methods. Additionally, each group in the feedback condition was provided with feedback from two MA students as experienced peers. Each treatment group had the same MA students as feedback providers for each case problem.

*Instructional materials*

The cases used in instruction consisted of two cases involving typical teaching methods issues (e.g., selecting the most appropriate method or methods for the children with learning and motivation problems) selected or adapted from instructional materials designed for prospective teachers. Each case was examined by three faculty experienced in teaching methods in elementary level. At the end of each problem case, we included question prompts, to scaffold students' reasoning and analysis, direct their attention to specific aspects of problem solving, and facilitate their online group discussions (e.g., what are the problems in this case? Why do you think these were problems?). The same question prompts were used to create a template to be completed by groups when generating their problem solving reports. Feedback suppliers were also provided with a template including 10 question prompts to facilitate their analyses of prospective teachers' problem solving reports (e.g., developing solutions: are the solution alternatives sufficient to solve the problems? What other alternatives can you suggest?). The template was available for just MA students, and it also had the potential to serve a formative function to improve prospective teachers' problem solving performance.

*Measures*

*Problem solving outcomes (pretest–posttest)*

The problem solving outcome measures were oriented toward group performance. The first and second case problems constituted the pretest and posttest respectively. Each case problem required students to identify the challenge in the problem scenario, provide a description of their solutions, provide evidence to justify their decisions, and evaluate the solutions. For comparison purposes, we ensured that both cases had similar difficulty levels. Three faculty and three PhD students read both cases and rated the similarity of the two cases in terms of their level of difficulty on a scale ranging between 1 and 4, not similar and very similar respectively. To guide the raters, we provided them with a list of criteria that they needed to consider when judging the difficulty levels of the two cases. These criteria included the case context (familiar or unfamiliar to the students), the number and nature of problems in the cases, and the principles, concepts and facts that students needed to know to solve the cases. We also asked the raters to compare the cases in terms of text difficulty metrics including word types (academic, non-academic), sentence length, paragraph length, sentence difficulty, etc. (Nelson, Perfetti, Liben, & Liben, 2012). We believe that these criteria facilitated the raters' judgment by helping them to do the comparison on common ground. The result of the rating scale indicated that the mean score for the similarity of the two cases regarding their difficulty level was 3.33 out of 4.

We used a rubric, adapted from Ge and Land (2003), to score students' problem solving reports that they produced for each case problem. The rubric included four major components of ill-structured problem solving, (a) problem representation, (b) developing solutions, (c) solution justification, and (d) evaluating solutions. Problem representation consisted of two sub-components: identifying the causes of the problems and identifying relevant information. Developing solutions consisted of two sub-components; proposing or developing solutions and quality of solutions. Finally, solution justification consisted of two sub-components: constructing arguments and providing evidence. An example of the scoring rubric is provided in Appendix 1.

The first and the second authors individually scored the entire problem solving reports. The interrater reliability was analyzed using Kappa coefficients (Cohen's *k*). The results showed a high level of agreement between the raters in constructing argument, $k = .859$, $p < .05$; and moderate levels of agreement in identifying causes, $k = .712$, $p < .05$; identifying relevant information, $k = .726$, $p < .05$; developing solutions, $k = .685$, $p < .05$; quality of solutions, $k = .629$, $p < .05$; providing evidence, $k = .641$, $p < .05$; and evaluating solutions, $k = .607$, $p < .05$. Further discussions on the

differences in the scoring were carried out to come to an agreement on the final values of scoring before the data analysis. A total score for each of the three major components (problem representation, developing solutions, and solution justification) was calculated by combining the scores of corresponding sub-components. Additionally, the development of students' problem solving skills was measured by computing gain scores (i.e., subtracting the score on the pretest from the score on the posttest) for each of the four problem solving outcomes.

*Feedback functions*

The unit of analysis used to code feedback reports was the response provided for each question prompt. That is, feedback comments (some included only one sentence whereas some other contained two to three sentences) referring to the analysis and evaluation of the specific aspect of students' case solutions (i.e., problem identification, solution generation etc.) were identified and then were coded in terms of four variables including feedback function, students' agreement with feedback, feedback direction, and the use of feedback. The function of the feedback was coded by analyzing feedback content using the coding scheme developed by van den Berg et al. (2006).

The four functions of feedback, as identified by van den Berg et al. (2006), included analysis, evaluation, explanation, and revision. 'Analysis' was used for feedback comments that were directed toward understanding the general content and structure of the text. 'Evaluation' was used for the comments that were used to judge the quality of the text. Arguments supporting the evaluation were coded 'Explanation'. Suggestions for the improvement of the text were coded 'Revision'. In the current study, we also defined 'Detailed revision' as a function to differentiate between a general and a specific revision. To illustrate, if a feedback comment incorporated exploratory information or an example regarding the details of a suggestion, it was coded 'Detailed revision', otherwise it was coded 'Revision'. An example for each feedback function is provided in Table 1. The first and second authors of the paper individually coded a total of 14 feedback reports in terms of feedback function, students' agreement with feedback, feedback direction, and the use of feedback. The Kappa coefficient indicated a high level of consistency between the two raters in feedback function (Cohen's $k = .813$, $p < .05$).

*Agreement with feedback*

Treatment groups' online discussions on the feedback as well as their revised case solutions based on feedback were explored to evaluate students' agreement with the feedback. Accordingly, each feedback comment was coded as 0 if a group did not agree with a specific feedback comment, 1 if they partially agreed with the feedback comment, and 2 if they completely agreed with the feedback comment. The level of consistency between the two raters was moderate to high (Cohen's $k = .732$, $p < .05$).

*Feedback direction*

If the direction of a feedback comment that students attended to was negative then it was coded as 0, otherwise, it was coded as 1. An example of a negative feedback is that the feedback provider criticized the idea of providing students with external rewards for the fullfilment of course requirements by stating; "*it is not a good idea to promise students spare time as a response to their learning performances, because students may get used to it and teacher has to do it in every occasion*".

*Use of feedback (level of change)*

The use of feedback was measured by comparing the levels of revision in treatment groups' case solutions after they received feedback. That is, each feedback comment that students attended to was given a score depending on the degree to which it led to a revision in a case solution (0 = no revision, 1 = superficial revision, 2 = detailed revision). A high level of consistency between the two raters was obtained (Cohen's $k = .813$, $p < .05$). An example of superficial revision and detailed revision is presented below.

In the feedback provided as a response to group 5's solution related to the use of team work as a strategy to deal with the case problem, it was underlined that there may be students who disrupt effective team work and that teachers should be attentive to such issues. Based on a suggestion asking the group to explain the measures that teachers should take to deal with this problem, the group members made a superficial revison:

> "...to have eye contact with the students as they are working and/or students who are behaving out of the order, and observing group work closely is essential to generate a solution."

The feedback provided to group 9 asked for a clarification regarding the reasons for "*....why the group decided on using drama technique to solve students' participation problem*?". The revision (detailed revision revision) of the group 9 on the rationale of their choice of drama technique is as follows:

> "What made us to prefer drama technique is that we perceived the problem of (the teacher as class management and inadequacy of student involvement. We chose the drama technique as we thought the reason of method change done by the teacher is to overcome the lack of student interest toward the course. Throughout the technique, students were expected to involve into the process by exploring the pros and cons of the technological tools they animated (dramatized). This approach was taken for granted to promote students' participation into the learning activities."

*Procedures*

During the four-week intervention that took place between March 19th and April 16th, students in each condition worked collaboratively in the Coursesites environment to analyze and

**Table 1**
Feedback functions.

| Function type | Example |
|---|---|
| Analysis | For the solution of the first problem, by underlining the age levels of the students, learners proposed to exploit games to get their attentions |
| Evaluation | While explaining the problem situation, learners seemed to ignore the actual reasons of the problem and their comments remained at a very surface level |
| Explanation | Some logical solutions were offered such as utilizing cartoons for accelerating the 4th graders' motivation |
| Revision | Teachers can help students to focus on the content through project works |
| Detailed Revision | Besides, individual and group discussions of the students on the web portal may be assessed identically so that learners can closely observe the details and steps within the process rather than having a quick look to final product of the task |

solve two case problems. During the first week of the intervention (between March 19th and 25th), each group reviewed the first case, discussed and shared ideas in their group discussion board, and submitted their problem solving report in their group wiki page using the template including question prompts regarding the major components of problem solving. In the second week of the intervention, the course instructor collected the problem solving reports of seven groups in the feedback condition and sent them to the secondary participants (feedback suppliers) along with the template including question prompts via The distribution of the problem solving reports to the feedback suppliers was conducted in a way that two MA students would individually analyze and provide feedback to the same problem solving report based on the template. The MA students turned in their feedback for the corresponding problem solving report in three days. The first author combined the two feedback reports provided for the first case solution and uploaded them in each of the seven groups' group wiki pages. Groups read and discussed on the feedback they received from peers and finalized their case solution in four days (between March 29th and April 1st). Students followed similar procedures during the third (April 2nd–April 8th) and fourth (April 9th–April 15th) weeks of the intervention. They read the second teaching case, discussed on the questions, solved the case problem, and if in the feedback condition, received feedback from peers, discussed on the feedback, and revised (if necessary) their case solutions.

### *Data analysis*

We examined the rubric data to determine if it met normality assumptions and if variances were approximately equal between the two conditions (feedback and non-feedback). The results of this initial data screening indicated that the groups had equal variances for the majority of dependent variables except evaluating solutions, but revealed a violation of normality assumptions (based on severe right skewness and significant Shapiro–Wilk test results, $p < .05$) in a number of variables. Also considering the small number of sample size ($n = 13$), we decided to conduct non-parametric statistical methods to analyze the effect of feedback on the four dependent variables related to ill-structured problem solving skills (Field, 2005). While Mann–Whitney *U* tests were conducted to analyze between group differences on the pretest and the development of the problem solving skills, Wilcoxon Signed Ranks tests were used to examine within group differences from pre to posttest. Since each dependent variable had a different subtotal of scaled points (6 points for Problem Representation, 8 points for Developing Solutions, 7 points for Solution Justification, and 3 points for Evaluating Solutions), the percentage was used for the scores to indicate the possible points earned out of the total. The use of the percentage helped to create a common basis for the mean comparison among the four dependent variables. Additionally, the effects of feedback function, agreement with feedback, and feedback direction (independent variables) on the use of feedback (dependent variable) were analyzed using multiple linear regressions.

## Results

### *Effect of feedback on ill-structured problem solving outcomes*

Research question 1 asked if students' ill-structured problem solving outcomes in (a) problem representation, (b) developing solutions, (c) solution justification, and (d) evaluating solutions changed from pre to posttest and between the groups. To examine if there were initial differences between the experimental (feedback) and control (no feedback) groups, we conducted a Mann–Whitney *U* test on the pretest scores corresponding to the four dependent variables with treatment group as the independent variable. Table 2 presents the median, mean, standard deviation, mean rank, and Mann–Whitney *U* test results for the experimental and the control groups. With alpha set at .05, the results revealed no significant differences between the two conditions in any of the problem solving outcomes; problem representation, $U(13) = 18.00$, $Z = -.44$, ns, $r = -.12$; developing solutions, $U(13) = 16.50$, $Z = -.66$, ns, $r = -.18$; justifying solutions, $U(13) = 12.50$, ns, $Z = -1.28$, $r = -.36$; and evaluating solutions, $U(13) = 13.00$, $Z = -1.32$, ns, $r = -.37$. Based on the results, it can be concluded that the two conditions did not differ significantly in their initial problem solving skills.

Subsequently, students' development on aspects of ill-structured problem solving was analyzed at the level of the four dependent variables. A Mann–Whitney *U* test on gain scores with treatment group as the independent variable yielded no significant differences between the experimental and control groups in problem representation, $U(13) = 18.50$, $Z = -.36$, ns, $r = -.10$; developing solutions, $U(13) = 18.50$, $Z = -.37$, ns, $r = -.10$; justifying solutions, $U(13) = 20.00$, $Z = -.16$, ns, $r = -.04$; and evaluating solutions, $U(13) = 18.00$, $Z = -.50$, ns, $r = -.14$. Table 3 presents the median, mean, standard deviation, mean rank, and Mann–Whitney *U* test results for the experimental and the control groups. The results suggest that the changes in problem solving outcomes were similar in both experimental and control conditions, that is, peer feedback might have no effect on the development of students' problem solving outcomes.

Next, a Wilcoxon Signed Ranks test was conducted to evaluate whether the experimental condition had differential scores from pre to posttest at each level of problem solving outcomes. The results showed a significant pre–posttest difference only on developing solutions ($Z = -2.04$, $p < .05$, $r = -.83$), indicating that the groups in the experimental condition developed higher quality solutions on the posttest (Mdn = 75.0) than on the pretest (Mdn = 50.0). Similarly, a Wilcoxon Signed Ranks test on the pre and posttest scores of the control condition showed that the difference from pre to posttest was significant only for developing

**Table 2**
Results of the Mann–Whitney *U* test of the difference in the mean ranks of problem solving outcomes on the pretest between experimental and control groups.

| | | Median | Mean | Std. Dev. | Mean Rank | *U* |
|---|---|---|---|---|---|---|
| Problem representation | Experimental (feedback) | 50.00 | 47.62 | 27.93 | 6.57 | 18.00 |
| | Control | 50.00 | 52.78 | 19.48 | 7.50 | |
| Developing solutions | Experimental (feedback) | 50.00 | 57.14 | 18.90 | 6.36 | 16.50 |
| | Control | 62.50 | 64.58 | 20.03 | 7.75 | |
| Justifying solutions | Experimental (feedback) | 28.57 | 24.50 | 17.91 | 5.79 | 12.50 |
| | Control | 42.86 | 38.10 | 23.33 | 8.42 | |
| Evaluating solutions | Experimental (feedback) | 33.33 | 42.86 | 16.27 | 5.86 | 13.00 |
| | Control | 66.67 | 55.56 | 17.22 | 8.33 | |

**Table 3**
Results of the Mann–Whitney *U* test of the difference in the mean ranks of problem solving outcomes based on gain scores (posttest–pretest) between experimental and control groups.

| Gain scores | | Median | Mean | Std. Dev. | Mean Rank | *U* |
|---|---|---|---|---|---|---|
| Problem representation | Experimental (feedback) | 16.67 | 9.52 | 21.21 | 6.64 | 18.50 |
| | Control | 16.67 | 11.11 | 40.37 | 7.42 | |
| Developing solutions | Experimental (feedback) | 12.50 | 16.07 | 13.91 | 6.64 | 18.50 |
| | Control | 18.75 | 18.75 | 13.11 | 7.42 | |
| Justifying solutions | Experimental (feedback) | 0.00 | 14.29 | 28.57 | 7.14 | 20.00 |
| | Control | 0.00 | 7.14 | 11.95 | 6.83 | |
| Evaluating solutions | Experimental (feedback) | 0.00 | 19.05 | 26.23 | 7.43 | 18.00 |
| | Control | 0.00 | 11.11 | 17.21 | 6.50 | |

solutions ($Z = -2.04$, $p < .05$, $r = -.83$). The quality of solutions was higher on the posttest (Mdn = 87.5) than on the pretest (Mdn = 62.5). These two results imply that the improvement on the developing solutions in both conditions might be because of their experience with the task.

*Results from the groups' online discussions on the feedback*

The discussions of the groups on the feedback contents revealed that the ratio of the feedback taken into account depended on the group members' involvement of the discussions about the feedback. To exemplify, 35% and 58% of the feedback was taken into account in groups 4 and 11, for which nearly all members contributed in the discussions. Correspondingly, while the first feedback was taken into account at a rate between 38% and 81% in the groups 5, 7, and 9 where members actively involved into the discussions, the rate decreased to 28% for the second feedback in the groups where just two members contributed into the discussions. On the other hand, very little feedback was taken into account in the group 8 and 13 who did not discuss on the feedback seriously (see Table 4). Qualitative data revealed that active involvement into the discussions and negotiation on the feedback content improved the participants in taking decisions as a group on what they were going to do with the feedback. Thus, group involvement had positively affected the profound exploration of the feedback as a whole group rather than assigning just a few group members to examine it.

The results indicated that groups mostly focused on the negative feedback (Evaluation, Explanation, and Analysis) as well as suggestion type feedback (Revision and Detailed Revision). They mostly ignored the positive evaluations, explanations, and analyses. This finding can be explained with the high motivation of the members in determining their flaws and attempting to get rid of them within such a restricted time.

Groups' responses toward the negative feedback varied depending on the extent to which they agreed with the feedback. When the groups did not agree with the feedback, they tended to explain the reasons for their previously stated answers and/or defend them. In general, therefore, it seems that since the groups were certain with their opinions, they attempted to explain their ideas and perceptions.

If the groups partially agreed with the negative feedback, they either defended their previous decisions or tended to revise their ideas with novel suggestions. What is interesting here is that the groups in which there was lack of participation into the feedback discussions inclined to defend their positions rather than coming up with novel solutions and ideas. To illustrate, the members of group 13, who slightly involved into the discussions, defended their own statements toward the feedback they partially agreed with. Conversely, group 11, whose members were observed to be actively involved into the discussions, proposed novel solutions after negotiations.

Groups' responses were observed as differentiating toward negative but agreed feedback. These are: proposing new ideas for missing parts, expressing their agreements with partial reasons, withdrawing from previous ideas without any reasons, demanding suggestions to remove flaws, and explaining their previously expressed answers. The responses of 'expressing their agreements with partial reasons' and 'withdrawing from previous ideas without any reasons' were frequently observed in the second feedback. This finding is not unexpected because of the fact that the second feedback round was examined very little by the most of the groups. For instance, three groups (5, 7, and 8), who expressed their agreement on the negative feedback in the first feedback report, explained why ignored or missed the points that were asked to be clarified in their case reports. In group 7, one of the group members' opinion for the negative feedback on their ignorance of classroom management in their case solutions is as follows:

> It is not because we do not know classroom management; the reason is that we could not handle the problem in various aspects including class management. We tried to solve the problems mainly exploiting teaching methods. As I read the feedback, I managed to comprehend the solutions clearly from

**Table 4**
Frequency distribution of the received peer feedback and considered peer feedback for each case solution by group.

| Experimental groups | Case 1: Total feedback | Case 2: Total feedback | Case 1: Considered feedback | Case 2: Considered feedback |
|---|---|---|---|---|
| Group 4 | 17 (%8.95) | 38 (%22.49) | 6 (%7.59) | 22 (%37.29) |
| Group 5 | 34 (%17.89) | 18 (%10.65) | 15 (%18.99) | 5 (%8.47) |
| Group 7 | 42 (%22.11) | 21 (%12.43) | 16 (%20.25) | 6 (%10.17) |
| Group 8 | 32 (%16.84) | 16 (%9.47) | 3 (%3.80) | 1 (%1.69) |
| Group 9 | 16 (%8.42) | 24 (%14.20) | 13 (%16.46) | 7 (%11.86) |
| Group 11 | 24 (%12.63) | 31 (%18.34) | 13 (%16.46) | 14 (%23.73) |
| Group 13 | 25 (%13.16) | 21 (%12.43) | 12 (%15.19) | 5 (%8.47) |
| Total | 190 (%100) | 169 (%100) | 79 (%100) | 59 (%100) |

the classroom management point of view. I guess we pay attention to this issue more while working on the following case.

In each group, the group members revised their solutions by providing new ideas and explanations on the topics. As opposed to the first feedback, few members contributed into the discussions on the second feedback report and expressed their agreement on the negative feedback without explaining the reasons of their statements. To exemplify, the following excerpt belongs to one of the members of group 8 who commented on the negative feedback regarding the potential motivation problems that may occur while students work within social media such as Facebook, twitter, etc.

Teacher should keep students focused while working with social media in order to save their times and raise their production.

Another feedback function that the groups mostly focused on included suggestions for revision (Revision and Detailed Revision). Groups who agreed with the general suggestions neither provided any reasons on their agreements nor mentioned these suggestions in their revised version of solutions. The fact that some suggestions made in the first feedback were repeated in the second feedback implies that they were not taken into consideration by the members. Groups were observed as requesting explanations for the general suggestions (Revision) they did not agree with and providing partial reasons of their disagreements especially for the second feedback round. As a result of the vagueness of the effect of suggestion on the solution, groups might not have understood the suggestion, waited for extra explanations or had to provide vague reasons for expressing their disagreements. To illustrate, the members of group 4 requested for explanations on the points they did not understand about the suggested revisions in the second feedback. Correspondingly, the views of two group members regarding the need to underline the importance of school administration's attitude in order to provide more elaborated solutions is as follows:

Feedback: The attitude of the school administration should be explained.

How would the attitude of the school administration be exemplified?

More group discussions and negotiations were made on specific suggestions comparing to those in general manner. Since the way to utilize the suggestions to solve the case was clearly put, groups were able to comment on the appropriateness of the suggestions. To exemplify, group 9's discussions for the first feedback based on a specific suggestion related to the use of discussion method to solve the case problem. Group members focused on the strengths and weaknesses of the suggestion, discussed how it should be implemented and came up with a unique solution, which was expressed by a group member as follows:

Our method should include the whole class rather than targeting a small part of the students who are generally active in the class. We should also meet the expectations of the actively participating students so that they do not feel demotivated. So, instead of a single method, there should be complex and versatile method supported by various methods such as discussion, Q&A, and group work methods.

If the groups were in consensus on the specific suggestions which they ignored or did not do previously, they tended to discuss them in a detailed way and reflect them to the revised versions. However, while the first feedback round received more elaborated discussions and negotiations, the second round included very little and superficial discussions. With respect to specific suggestions they did not agree with, groups declared clear reasons and explanations. Since the suggestions were elaborated, groups managed to comprehend and evaluate them. Within the first feedback report, group 5 critically elaborated on the feedback provided as detailed suggestions which they did not agree with at all and provided specific explanations and examples on why they did not agree with those suggestions. For example, they have thoroughly discussed the idea of bringing an experienced teacher to the class to monitor the actual teacher. Group members declared their views toward the idea:

In my opinion, bringing Miss Ebru to the class is nonsense. I would understand the idea of exploiting the experience and authority of Miss Ebru but taking her to the class may damage the role and prestige of the teacher for students. Miss Ebru would monitor Mr Fatih at a lesson in order to give him advice on teaching but in this circumstance, monitoring would not work effectively.

However, for the second feedback only two members in group 5 expressed their opposition to the suggestion without explaining the reasons of their statements. In a similar vein, group 9 declared their disagreements on the specific suggestions in the second feedback, but they neither provided any profound explanation of this disagreement nor addressed the suggestions in the revised version. The reason of students' negligence to specific (detailed) feedback may be explained with the superficiality of the discussions on the second feedback reports.

In addition, the results revealed that feedback that include arguments supporting evaluative comments seem to lead more change than those incorporating only quality statements. Thus, it can be postulated that evaluative feedback is not compelling enough on its own and requires a rationale on the way they were evaluated.

*Effects of feedback function, students' agreement with the peer feedback, and feedback direction on the use of feedback*

Research question 2 asked whether the different functions of peer feedback, students' agreement with the peer feedback, and feedback direction had different effects on students' use of feedback to revise their case solutions. To answer the research question, multiple regression analysis was conducted with feedback use as the dependent variable and feedback functions, agreement with the feedback, and feedback direction as the predictor variables. After providing the descriptive analyses regarding each variable, the results of regression analysis are presented below.

By analyzing 14 feedback reports provided by MA students, we identified 359 feedback functions, of which 52.92% ($n = 190$) was provided for case 1 while 47.08% ($n = 169$) was provided for case 2. Among these functions, 13.1% ($n = 47$) was analysis, 33.1% ($n = 119$) was evaluation, 18.4% ($n = 66$) was explanation, 22.3% ($n = 80$) was revision, and 13.1% ($n = 47$) was detailed revision. The analyses of the online discussions of the groups in the experimental condition as well as their revised case solutions after they received peer feedback revealed that groups attended to 38.44% ($n = 138$) of total feedback comments. Of 138 feedback comments, 57.25% ($n = 79$) was given for case 1 and 42.75% ($n = 59$) was given for case 2. With respect to feedback functions, 9.4% ($n = 13$) was analysis, 25.4% ($n = 35$) was evaluation, 18.8% ($n = 26$) was explanation, 26.8% ($n = 37$) was revision, and 19.6% ($n = 27$) was detailed revision. In terms of the direction of feedback, 41.3% of the total attended feedback ($n = 138$) was negative and 58.7% was positive. While 73.7% of negative feedback included evaluation and explanation functions, 76.5% of positive feedback incorporated revision and detailed revision functions.

**Table 5**
Summary of hierarchical regression analysis for variables predicting students' use of feedback ($N = 138$).

| Variable | Model 1 | | | Model2 | | |
|---|---|---|---|---|---|---|
| | *B* | SE B | *β* | *B* | SE B | *β* |
| Constant | 1.11 | 0.15 | | 1.68 | 0.25 | |
| Feedback function | | | | | | |
| Analysis versus detailed revision | 0.27 | 0.26 | .10 | −0.27 | 0.33 | −.10 |
| Evaluation versus detailed revision | −0.20 | 0.20 | −.11 | −0.55 | 0.23 | −.30* |
| Explanation versus detailed revision | 0.08 | 0.21 | .04 | −0.31 | 0.25 | −.16 |
| Revision versus detailed revision | −0.46 | 0.20 | −.26* | −0.46 | 0.19 | −.26* |
| Feedback direction | | | | −0.568 | 0.20 | −.35** |
| Agreement with feedback | | | | −0,01 | 0.09 | −.01 |
| $R^2$ | .06 | | | .12 | | |
| $F$ for change in $R^2$ | 3.36* | | | 8.74** | | |

*Note:* Feedback function was represented as four dummy variables with detailed revision serving as the reference group.
* $p < .05$.
** $p < .01$.

Multiple regression analysis was conducted to evaluate whether the different functions of peer feedback, students' agreement with the peer feedback, and feedback direction significantly predicted students' use of feedback to revise their case solutions. The results indicated that the feedback function alone explained 9.2% of the variance (adjusted $R^2 = .06$, $F(4,133) = 3.36$, $p < .05$), and the feedback function and feedback direction together explained 14.8% of the variance ($R^2$ change = .06, adjusted $R^2 = .12$, $F(1,132) = 8.73$, $p < .01$). Table 5 presents the summary of hierarchical regression analysis for variables predicting students' use of feedback.

In terms of feedback functions, the results showed that the use of feedback went down as a feedback function changed from detailed revison to evaluation ($\beta = -.30$, $t(132) = -2.44$, $p < .05$), and from detailed revison to revision ($\beta = -.26$, $t(132) = -2.41$, $p < .05$). This finding suggests that detailed revisions led significantly higher levels of change in the case solution than both evaluation and revision functions. As for the feedback direction, the results indicated that the use of feedback increased significantly more with negative feedback compared to positive feedback, $\beta = -.36$, $t(132) = -2.96$, $p < .01$. The agreement with the feedback was not a significant predictor of the use of feedback, $\beta = -.01$, $t(132) = -.10$, $p > .05$.

## Conclusions and discussions

This study investigated (a) the impact of peer feedback on prospective teachers' problem solving outcomes (problem representation, developing solutions, solution justification, and evaluating solutions) in ill-structured tasks, and (b) the relative impact of feedback function, students' agreement with the feedback, and feedback direction on the use of feedback for revision.

The results of the current study indicated no significant effect of peer feedback on the development of students' problem solving outcomes. Similar findings on the lack of the learning effects of peer feedback were reported in previous research (Li & Steckelberg, 2004; Li et al., 2008; Orsmond et al., 1996; van den Boom, Paas, & van Merriënboer, 2007). Although the effectiveness of peer feedback on improving students' learning has been substantiated in some studies (Dochy et al., 1999; Falchikov, 1996), the results are still inconclusive (Topping, 2003). In the present study, the possibility of learners' negligence toward peer feedback could be one of the reasons of not seeing any effect of peer feedback on learners' problem solving skills. The number and the content of the learners' discussions provided some insights on to what extent learners valued the peer feedback. Accordingly, the group dynamics can be viewed as a factor that affected the uptake of feedback by groups. The qualitative analysis of the online discussions revealed that while some of the groups performed more collaboratively and most group members discussed the feedback, efficient involvement could not be attained in some of the groups where just a few members contributed into the discussions. As a significant finding, feedback was adopted more intensively in the groups with more discussion. Thus, it was noted that group involvement led to a more comprehensive exploration of the feedback as a whole group comparing to examination by a few group members. In a similar vein, students in the current study created a revised version of their work based on online group discussions on the feedback they received. Therefore, whether or not to incorporate particular feedback comments into the revised work was the result of group thinking or decision. The difficulty in building consensus among group members on a decision might cause students to focus on a smaller amount of feedback (Hattie & Timperley, 2007). The relationships between the nature of group dynamics and the acceptance and use of feedback merit further exploration. For instance, it can be interesting to study the degree to which different group sizes (i.e., small, large) and group composition (i.e., homogenous, heterogonous) affect the building of consensus among group members on the feedback use and acceptance, and whether these factors are related to overall feedback effectiveness.

Another possible reason for the insignificant effect of peer feedback in the current study may be the prospective teachers' lack of practical experience in solving ill-structured problems. Contrary to our expectations, the results implied that peer assessment alone was not sufficient to scaffold these students, who can be considered as novices in the application of theoretical knowledge to complex classroom situations. The relevant literature maintains that novice problem solvers, due to their lack of structural knowledge and metacognitive awareness, have some challenges in various aspects of ill-structured problem solving such as defining the problem situation, eliciting potential solutions and supporting the proposed solutions with evidences and arguments (Feltovich et al., 1996; Gick, 1986; van Gog, Paas, & van Merriënboer, 2005). On the other hand, one of the more significant findings to emerge from this study is that groups in both conditions (feedback and non-feedback) improved only on the developing solutions, meaning that they generated more explicit and higher quality solutions on the posttest. The improvement observed on the developing solutions in both conditions might be because of their experience with the task and collaborative group work. In other words, students might develop a better understanding of the task on their second problem solving, and an improved collaboration among group members might stimulate generating more quality solutions. Besides, developing solutions may be regarded as relatively easier comparing to the other problem solving steps.

That is to say, while the step of developing solutions only necessitates group members to propose and explain their solutions, the processes such as defining the problem, eliciting among the proposed solutions, supporting the recommended solutions with evidences and arguments, and predicting the results of the solution requires learners to think elaboratively and come up with shared decisions. Another interesting result in this sense is that the majority of the feedback content (around 47%) provided to the groups are revision and detailed revision, which are feedback functions generally including suggestions for the solution of the problem. These suggestions might help learners to develop solutions in a positive way. Since the feedback in detailed revision format led to more change, learners tended to exploit this kind of feedback in developing solutions.

Our second research question concerned the relative impact of feedback function, students' agreement with the feedback, and feedback direction on the use of feedback for revision. In the current study, a differentiated revision model was employed. Revisions including specific explanations or examples were coded as detailed revisions and it was hypothesized that compared to simple revisions, detailed revisions would induce more change in students' case solutions. The results supported this assumption. van der Pol et al. (2008) found that the more feedback includes suggestions for revision the more it is used. They explained this result as that "these concrete suggestions for revisions give the receivers the most direct lead for a potential change in their text" (van der Pol et al., 2008). However, the study by van den Berg et al. (2008) did not include any seperation between revision and detailed revision. One possible reason for why students made more changes in accordance with the detailed revisions is that, the explanations and examples in detailed revision may helped learners to envisage the proposed solution and elaborate on it. In line with this, existing research demonstrated that feedback including revision suggestions along with a rationale resulted in higher levels of change in students' products (Dominguez et al., 2012; Kim, 2005; Papinczak et al., 2007; Tuzi, 2004). At the same time, the results of the current study showed that detailed revision comments had more effect than the evaluation comments on changing of the case solutions. A post hoc analysis on the evaluative feedback comments suggested that these comments generally included simple value judgments confirming or disconfirming students' case solutions (i.e., the solutions you created are compatible with constructivist approach; the problem definition is not adequate). Apparently, the negative and explicit assessments cause more change compared to positive and implicit assessments done with vague criteria (Hattie & Timperley, 2007). Qualitative analysis on the content of students' online discussions also supported this argument.

Additionally, the results of this investigation indicated that the level of change increased significantly more with negative feedback compared to positive feedback. This result seems predictable due to the role of negative assessments on helping learners understand the flaws of their performances. Learners may not have needed to focus on the parts they have received as positive feedback. Another significant result of the qualitative analysis of the online discussions is that most of the groups were inclined to take negative feedback into account. While Kluger and DeNisi (1996) argued for the valuable effects of both positive and negative feedback on learning, Hattie and Timperley (2007) point out that learners pay attention to the feedback when they encounter with unexpected results of their works and tend to ignore feedback when they are not so sure with the results of their works. Since negative feedback could cause a cognitive dissonance by conflicting with learners' perceived thoughts and beliefs, they might have exploited the negative feedback to negotiate on and revise their works. On the other hand, the ignorance of the positive feedback except for the suggestions does not mean that feedback should only include negative or deficient aspects of the performance, because, positive feedback functions as an accelerator of learner motivation (Deci et al., 1999; Lu & Law, 2012; Tseng & Tsai, 2007). The relationships between motivational variables and feedback direction deserve further exploration. To exemplify, interviews may shed light on students' evaluations toward positive and negative feedback and its impact on the learner motivation. Besides, the effect of positive and negative feedback may be related to cultural traits where in oriental societies (i.e., Turkey) on the contrary of negative feedback, positive feedback is rare and not perceived as critical to revise the work. Cross-cultural studies can contribute to understanding the culture-specific roles of positive and negative feedback.

Hattie and Timperley (2007) further argue that the learning effects of positive and negative feedback vary depending on the level of students' task commitment. Students who have high task commitment are more likely to learn from positive feedback for self-confirmation, while students having low task commitment are more likely to learn from negative feedback to improve themselves. Hence, the greater emphasis on negative comments in this study suggests that the students had lesser task commitment.

Another important result that emerged from this study is that the agreement with the feedback was not related to the use of feedback, which, however, was not supported by the qualitative analysis of students' online discussions. This result also contradicts with that of the study by van den Berg et al. (2008), who found significant and positive relationship between agreement with the feedback and its use for revision. Similarly, Cho and MacArthur (2010) and Topping (2010) argued that if students do not agree with the assessor's ideas, they will be unwilling to make changes based on direct and possibly conflicting feedback. In the current study, within the perspective of positive and negative feedback's effects discussed above, learners were expected to explain why they agreed or disagreed with the received feedback, which might point out unexpected aspects of the work. One possible reason for the lack of a relationship between agreement and use of feedback is that group members might have had problems in comprehending any negative feedback they agreed without providing any reasons. Thus, they might have ignored this feedback in revised versions due to their lack of understanding (Hattie & Timperley, 2007; Nelson & Schunn, 2009). Correspondingly, feedback was not used when a solid consensus could not be attained among the group members.

Another possible cause for the insignificant relationship between students' agreement with feedback and its use for revision might be our indirect measurement of feedback agreement which was limited to the feedback comments on which students explicitly discussed and made a group decision regarding their level of agreement. That is, instead of directly asking them to rate their level of agreement with a specific feedback comment, we used a coding scheme to analyze if they reached a group consensus on the agreement with each feedback comment they attended to. Similar to van den Berg et al. (2008), we might have used likert-type scales to measure students' perceptions of the usefulness and importance of feedback and analyze the relationships between these perceptions and their agreement with the feedback. Thus, it could be possible to comment on the relationship between learners' agreements on the feedback and their perceptions toward its importance and usefulness.

Taken together, the results indicated that feedback function and feedback direction accounted for 15% of variance in the use of feedback for revision which suggests that much is unknown regarding why students decided to use or ignore specific feedback

comments. The great potential of peer assessment in promoting epistemological power sharing between students and teachers has been underlined by the current pedagogical point of views, which consider assessment as a process in which students are involved as active contributors rather than a tool managed by the teacher. Nevertheless, the success of peer feedback is dependent on some interrelated factors including feedback quality, competence of assessors, perceptions of the usefulness and importance of feedback and so on (Dochy et al., 1999; Hanrahan & Isaacs, 2001; Narciss, 2008; Shute, 2008; Topping, 2005; van Gennip et al., 2009; van Zundert et al., 2010). The effects of these notions on the feedback should be investigated through empirical research designs so that required conditions and instructional designs should be clarified for efficient feedback. Besides, instead of a one-shot intervention, peer feedback should be implemented in an iterative way (van Zundert et al., 2010) and be considered as an integral part of a class (Sluijsmans, Prins, & Martens, 2006). Sluijsmans, Straetmans, and van Merriënboer (2008), based on their constructive alignment theory, argued that the success of peer assessment depends partly on the degree to which learning, instruction, and assessment are closely related. In such an integrated learning environment, peer assessment acts as a functional learning event focusing on the performances, reflective judgments, and interactions of the learners in the process of learning. As van der Pol et al. (2008) put forth, peer assessment, which can be characterized as a form of collaborative learning, can result in learning effects for both feedback receivers and producers. Future research has the potential to contribute to determining the factors affecting the learning effects of feedback and designing effective peer assessment applications.

One limitation of this study is that we only measured group gains over time between two conditions. Future studies may examine individual gains between different conditions. With the addition of measuring individual achievement, the different effects of the two groups may be captured. Besides, the effect of factors such as feedback function and agreement with feedback on the use of feedback at the individual level would be an interesting research topic. Additionally, in many peer assessment models, students perform as both assessors and assessees. There is also research evidence indicating that assessing peers' work and providing feedback is more beneficial than receiving feedback from peers (Chen & Tsai, 2009; Li, Liu, & Steckelberg, 2010; Topping et al., 2000; Tsai, Lin, & Yuan, 2002). In the current study, however, we focused on examining the extent to which peer assessment and feedback affected assessees' problem solving performance. Studying the different impact of providing and receiving feedback on students' learning may be a fruitful direction for future research. Furthermore, all students in the class were expected to complete the instructional activities described in this study and students who completed the activities received class participation points as a normal part of the course. Therefore, students' interest in getting a good class grade might also drive the students to revise their work based on feedback. Future research may control the effect of grade on students' willingness to use feedback.

## Appendix 1

Scoring rubric for assessing students' problem solving skills.

| | | | | |
|---|---|---|---|---|
| 1) Problem representation: | | | | |
| a. Identifying the causes of the problem | 0: No possible causes of the problem are identified. (Mischaracterizes problems and/or overlook issues) | 1: 1–2 possible causes of the problem are identified | 2: 3–4 possible causes of the problem are identified and examined | 3: 5 or more possible causes of the problem are identified and examined |
| b. Identify relevant information (key issues and constraints | 0: 0–2 known factors and constraints (stated in the criteria) are not identified at all | 1: 3–4 of the known factors and constraints (stated in the criteria) are identified | 2: 5–6 of the known factors and/or constraints (stated in the criteria) are identified | 3: 7–8 of the known factors and constraints (stated in the criteria) are identified |
| 2) Developing solution(s): | | | | |
| a) Proposing or developing solutions, with explicit explanation. | 0: No solution is proposed or developed. | 1: Solutions are proposed or developed, but without any explanation on how they work | 2: Solutions are proposed or developed, with minimal explanation on how they work | 3: Solutions are proposed or developed, with explicit explanation on how they work |
| b) Quality of the solutions | 0: No solution has been suggested | 1: Poor 2: Weak | 3: Good 4: Excellent | 5: Exceptional |
| 3) Making justifications for the proposed solution(s) | | | | |
| a) Constructing argument | 0: No argument is constructed | 2: Argument is poorly constructed | 4: Argument is well constructed | |
| b) Providing evidence | 0: No evidence is provided | 1: Evidence to support the argument is weak or irrelevant | 2: Evidence to support the argument is relevant | 3: Evidence to support the argument is strong and relevant |
| 4) Monitoring and evaluating of the problem space and solutions | 0: The solution is not evaluated | 1: Evaluation of the solution is stated, but no constraints are mentioned | 2: The proposed solution is evaluated, and constraints are mentioned, but no explanation on how these constraints can be eliminated is provided | 3: The proposed solution is evaluated, and constraints are discussed, supported with explanation on how these constraints can be eliminated |

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