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### Can performance feedback during instruction boost knowledge acquisition? Contrasting criterion-based and social comparison feedback

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## Can performance feedback during instruction boost knowledge acquisition? Contrasting criterion-based and social comparison feedback

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Feedback indicating how well students are performing during a learning task can be very stimulating. In this study with a pre- and post-test design, the effects of two types of performance feedback on learning results were compared: feedback during a learning task was either stated in terms of how well the students were performing relative to other students (social comparison feedback) or relative to an absolute criterion (criterion-based feedback). Thirty-four students in secondary vocational engineering education were randomly assigned to one of two conditions. In both conditions, students worked together in small groups. All groups completed a math learning task, during which they received either social comparison feedback or criterion-based performance feedback. The findings showed that the type of feedback had a strong effect on learning outcomes: the post-test scores and gains of students in the social comparison condition were significantly higher than those of students in the criterion-based feedback condition.

**Keywords:** interactive learning environments; performance feedback; social comparison; teaching/learning strategies; collaborative learning; mathematics

### Introduction

In educational settings, formative feedback is an important determinant of the successful acquisition of knowledge and skills. This type of feedback is delivered while the learning task is still in progress and “is intended to modify the learners’ thinking or behavior for the purpose of improving learning” (Shute, 2008, p. 154). The use of computer technology in the classroom is particularly suited for tailoring feedback to what individual students do (Serge, Priest, Durlach, & Johnson, 2013). Computer software can be designed to interact with students, react to their responses to questions and assignments, help students with planning and regulating their learning processes, and focus their attention on critical information in the learning environment. Hoska (1993) states that one important function of feedback is often overlooked in computer-based instruction, that is, its potential to motivate students. She argues that this motivational function can be critical in learning situations, because it affects the way students perceive and react to learning tasks. An example of

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using feedback to motivate students is providing *performance feedback*. This type of feedback informs students about their progress toward one or more desired goals (Shute, 2008).

Performance feedback can have two major advantages. First, performance feedback is a crucial element to make instruction more challenging (Malone, 1981), because it helps students to notice progress in their own learning and to achieve (sub)goals, which can be a very rewarding experience, driving them to expend effort, to persist, and to focus attention on the task (Garris, Ahlers, & Driskell, 2002). Second, performance feedback provides students with a reality check on their current performance level. A repeated finding in empirical studies is that students do not estimate their own performance accurately (Glenberg & Langston, 1992; Glenberg, Wilkinson, & Epstein, 1982; Labuhn, Zimmerman, & Hasselhorn, 2010). Students are often overconfident about their capability to perform a certain task (Dunlosky & Lipko, 2007; Dunlosky & Rawson, 2012; Lipko et al., 2009). Being overly confident about one's own learning performance and achievement is often a reason for poor learning performance. Overconfident learners are not likely to expend the required effort to accomplish a task; they may not engage in effective comprehension monitoring or deploy appropriate strategies (Labuhn et al., 2010). Performance feedback can help students to identify and assess discrepancies between current performance and the desired performance level (Brusso & Orvis, 2013; Carver & Scheier, 1981, 1990; Kluger & DeNisi, 1996, 1998). In general, the *sign of the feedback message* is either positive or negative. *Negative feedback*, that is feedback that performance is falling short of the goal, is thought to motivate and stimulate learners to invest more effort or change their strategies (Cianci, Klein, & Seijts, 2010; Locke & Latham, 2002). A universal task-related strategy in response to negative feedback is to work harder, persist, and focus on the tasks. If this strategy fails, learners may look for more task-specific plans or develop new strategies (Kluger & DeNisi, 1996, 1998). There are different views in the literature about how learners respond to *positive feedback*, that is feedback indicating that performance is exceeding the standard. From the perspective of control theory, the expectation is that learners will reduce or maintain effort in response to positive feedback (Carver & Scheier, 1990; Kluger & DeNisi, 1996, 1998). From the perspective of goal-setting theory, positive feedback may signal that the task provides opportunities for self-enhancement and this may lead to setting a higher goal (Bandura, 1989; Kluger & DeNisi, 1996, 1998; Locke & Latham, 2002), such as trying to solve problems faster, with fewer steps, or increasing the difficulty level (Malone, 1981).

Learners' progress may be defined relative to an absolute, criterion-based goal or relative to the performance of others (social comparison) (Dweck, 1986; Nicholls, 1984). *Criterion-based goals* focus on the development of competence and task mastery. Each student's performance is compared to some pre-established criterion, such as learning objectives or the student's prior degree of mastery of the objectives. The level of performance is determined on the basis of the student's current degree of mastery of the objectives, regardless of the performance of other students on the same objective (Kim, Lee, Chung, & Bong, 2010). Criterion-based standards tend to focus individuals on learning and to evoke a mastery motivational pattern, which is characterized by a positive affective stance toward learning, a preference for challenging tasks, and persistence in the face of failure (Elliot & Harackiewicz, 1996). *Social comparison goals* focus on the student's competence relative to others. Such comparisons are thought to be driven by motives such as evaluating one's own abilities, protecting or enhancing the ego, improving one's performance, or combinations of these motives (Dijkstra, Kuyper, van der Werf, Buunk, & van der Zee, 2008). In a review of social comparison in the classroom, Dijkstra et al. (2008) conclude that in general, students strongly prefer to compare their performance with students who

perform better than they do, and this upward comparison often leads to better performance. Others claim that social comparison feedback has little or no positive effect (Deci & Ryan, 2000; Rakoczy, Harks, Klieme, Blum, & Hochweber, 2013). However, this lack of effect may have to do with performance feedback in general, not social comparison feedback only, because in studies in which criterion-based and social comparison performance feedback have been compared, no significant effects of feedback type on learning outcomes were observed either (see, e.g. Labuhn et al., 2010; Rakoczy et al., 2013).

One explanation for the lack of effect, could be that most, if not all, empirical studies about social comparison in the classroom focus on comparing grades. Grades are usually provided *after* the course and test or exam have been completed, and are therefore a form of *summative* feedback, not *formative* feedback. A logical consequence is that comparing grades can affect future performance, but it comes too late to change current performance (Bälter, Enström, & Klingenberg, 2013). Not much is known, though, about the effects of social comparison feedback *during* learning tasks.

Social comparison feedback also introduces a competitive element into the learning process. Such game elements can help increase student motivation and engagement (Dominguez et al., 2013). However, in higher level problem-solving tasks such as in trigonometry, the domain used in the present study, competition alone is not likely to be enough. Problem solving has been found to be better supported by collaboration in dyads than by competitive (individual) learning (Qin, Johnson, & Johnson, 1995).

The question central to this study is whether students are stimulated to learn better when they are provided with social comparison feedback rather than criterion-based feedback during a learning task in a collaborative learning setting.

## Method

### *Participants*

A total of 34 students in secondary vocational engineering education participated, all boys (no female students were enrolled in the engineering courses). The study was approved by the school board and the participants' parents. Students' ages ranged from 16 to 20 years old ( $M = 16.88$ ;  $SD = 0.95$ ). This study was part of a project that focused on inquiry learning with computer simulations in secondary vocational engineering education. In this type of education, students are trained for clearly defined professions or tasks (e.g. becoming mechanics or electricians) (Slaats, Lodewijks, & van der Sanden, 1999). Students in secondary vocational education often learn better by experience and have difficulty with abstract theoretical models and methods (Slaats et al., 1999; Vreman-de Olde, 2006; Vreman-de Olde & de Jong, 2004; Vreman-de Olde, de Jong, & Gijlers, 2013). Teaching and learning in vocational education is often a great challenge to educators (Shen, Lee, & Tsai, 2009). Secondary vocational education in the Netherlands is, for example, facing several major problems such as high dropout rates and "huge motivational problems among a majority of the students" (Meijers, 2008, p. 239). Like students in vocational education elsewhere, they largely do not seem to care much about their grades and do not get involved adequately in their schoolwork (Lee, Shen, & Tsai, 2010; Shen et al., 2009). Research about learning with simulations often focuses on other types of education, for example, primary and secondary education and universities, but not on (secondary) vocational education. Apparently, inquiry learning with simulations is assumed to be too demanding for students in the latter type of education. Now, however, evidence begins to emerge that this instructional approach can indeed be very effective for those students (see, e.g. Kollöffel & de Jong, 2013).

**Design**

A between-subjects design was used, with the type of performance feedback to the groups of collaborating students (criterion-based versus social comparison feedback) as the independent variable and post-test scores and pre-to-post-test learning gains as dependent variables. Participants were randomly assigned to either the criterion-based feedback condition ( $n = 18$ ; age:  $M = 17.00$ ;  $SD = 1.03$ ) or the social comparison feedback condition ( $n = 16$ ; age:  $M = 16.75$ ;  $SD = 0.86$ ).

**Materials****Learning environment**

Participants were provided with a simulation-based inquiry learning environment about trigonometry. The environment was created with SimQuest authoring software (van Joolingen & de Jong, 2003; de Jong et al., 1998; Swaak & de Jong, 2001). The learning task was divided into two phases: a first phase during which students learned without performance feedback, and a second phase in which they were provided with performance feedback. In the first phase, the students were presented with a basic introduction to trigonometry. The learning environment contained assignments and simulations that the students could use to explore the basic concepts of triangles and the relations between angle measure and the lengths of the sides in a triangle. The participants moved on from the first phase to the second as soon as they felt confident about their competence. In the second phase, the students still had access to the simulations and assignments. In this phase they were also presented with a set of 12 exercises that they could use to test their understanding. After completing this set, the students received feedback indicating how well they performed on the set of exercises. After this, the students revisited the simulations and assignments to study the topic and to practice some more. Then the another set of 12 exercises was presented, after which the students again received performance feedback. After this, they revisited the simulations for the last time and then the learning phase was completed (see also Procedure section, and Figure 2 for an overview).

The performance feedback for both experimental conditions was actually based on the same standard. This standard was the percentage of correct responses (Table 1). The only difference between the conditions was how the feedback was phrased. In the social comparison feedback condition, the feedback was stated in terms of how well the students were performing in relation to other students. In the criterion-based feedback condition students received information about their level of performance in relation to an absolute

Table 1. Feedback categories and messages.

Percentage of correct responses	Condition	
	Social comparison feedback	Criterion-based feedback
<50% (low)	Your score is lower than that of most other students. If there are things you don't understand, you can ask your teacher.	This could be better. If there are things you don't understand, you can ask your teacher.
50–75% (intermediate)	Your performance is equal to that of most other students.	Your performance is satisfactory.
>75% (high)	Very good! You are performing better than most other students!	Very good! You are performing very well!

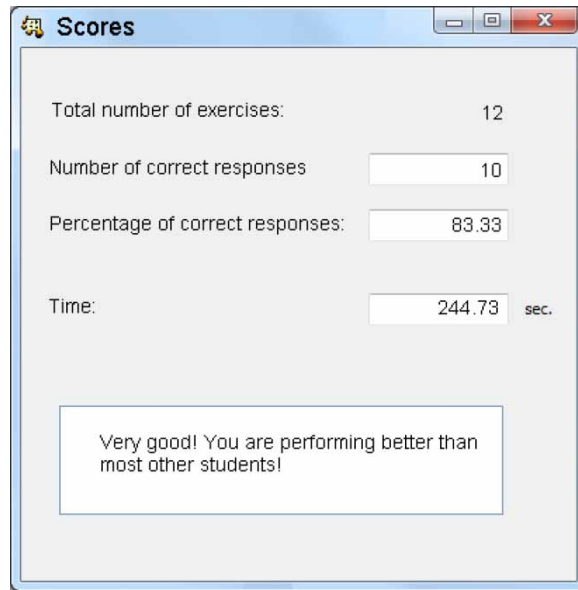


Figure 1. Example of feedback in the social comparison feedback condition.

criterion. Three categories of feedback message were available (Table 1). The system displayed the feedback message corresponding to the students' current percentage of correct responses. The categories (low, intermediate, and high) were based on the performance of students in a pilot study. At two points, the students received feedback.

An example of how such feedback was delivered is displayed in Figure 1.

Students were asked to rate their mood, task interest, and mental effort. They were asked to do so three times: once at the beginning of the second phase in which they would receive performance feedback and twice during this phase (on-task). These quick ratings were presented by means of pop-up screens, and the students rated these measures as a group. The screens popped up at moments when the students had completed a task and had not yet entered their next task. Therefore, the chance that the screens would interfere with the students' problem-solving processes was minimal.

### *Pre-test and post-test*

Two knowledge tests were used in the experiment: a pre-test and a post-test. Both tests contained 29 open-ended items. The pre-test and the post-test were essentially the same test, with some surface changes to mask the similarities.

### **Procedure**

The experiments were performed over three sessions each separated by a one-week interval, and took place in a real school setting. Trigonometry is a domain that plays an important role in the curriculum (in courses such as mechanical engineering, forces, and momentum), but is, at the same time, notoriously difficult to grasp for these students. Figure 2 provides an overview of the sessions and activities.

Session	Activity
Session 1 (45 min.)	1.1. Introduction 1.2. Background information 1.3. Pre-test 1.4. Introduction of and practice with learning environment.
Session 2 (45 min.)	2.1. Choosing partners 2.2. Learning with simulations and assignments (Without performance feedback) 2.3. Learning task (With performance feedback) Step 1: Quick rating of mood, interest, and effort (three 1-item ratings) Step 2: Revisiting simulations Step 3: Set of 12 exercises Step 4: Performance feedback Step 5: Quick rating of mood, interest, and effort (three 1-item ratings) Step 6: Revisiting the simulations Step 7: Set of 12 exercises Step 8: Performance feedback Step 9: Quick rating of mood, interest, and effort (three 1-item ratings) Step 10: Revisiting the simulations
Session 3 (45 min.)	3.1. Post-test 3.2. Debriefing

Figure 2. Overview of sessions and activities.

In the first session, students received some background information about the purpose of the study, the domain of interest, and the learning goals. This was followed by the pre-test. Students completed the pre-test individually. The duration of this first session was limited to 45 minutes. During the last 15 minutes of the session, the students received an explanation of how the learning environment operated, and they could practice with the environment.

A week later, in the second session, students were randomly assigned to conditions and worked in small groups of two or three students with the learning environment, eight groups in each condition, although the pre-test and post-test were completed individually. The duration of this session was set at 45 minutes. Students were allowed to choose their partners themselves. Communication between students was on a face-to-face basis: the collaborating students were sitting next to each other, using the same computer terminal. They worked together on the assignments and simulations in the learning environment. Everyone could complete all the exercises and assignments within the time given. If exercises were completed incorrectly, students could do them again.

The third session was set at 45 minutes. In this final session, the students completed the post-test individually. After the post-test, the students were debriefed about the background and purpose of the study, and they each received a small gift.

## Results

The pre-test and post-test scores are displayed in [Table 2](#). The highest possible score on both pre-test and post-test was 29.

In the present study, students in both conditions worked in small groups of two or three students. Therefore, two-level nested analyses of variance were used to analyze the data in [Table 2](#). A nested ANOVA is an extension of a one-way ANOVA in which each group (our experimental conditions) is divided into subgroups (our groups of collaborating students). In the two-level ANOVAs, two null hypotheses were tested. One null hypothesis was that



Table 2. Pre- and post-test scores.

	Condition							
	Criterion-based feedback ( <i>n</i> = 18)				Social comparison feedback ( <i>n</i> = 16)			
	<i>M</i>	SD	Min	Max	<i>M</i>	SD	Min	Max
Pre-test score (max. 29)	12.44	5.72	2	23	10.69	3.59	4	15
Post-test score (max. 29)	10.72	5.83	4	25	15.44	5.23	11	29

the groups of collaborating students within each condition had the same means, the second null hypothesis was that both conditions had the same means.

The results of the nested ANOVA of the *pre-test scores* were  $F(14, 18) = 0.76, p = .70$  for groups and  $F(1, 14) = 1.32, p = .27$  for conditions, without the Satterthwaite correction. When the Satterthwaite approximation was used, the test of the effect of condition was only slightly different ( $F(1, 12.14) = 1.34, p = .27$ ). It can therefore be assumed that students in both conditions had comparable levels of prior knowledge and it can also be assumed that the groups within each condition had comparable levels of prior knowledge.

Significant differences between conditions were found on the *post-test scores*. The results of the nested ANOVA were  $F(14, 18) = 0.61, p = .82$  for groups and  $F(1, 14) = 8.29, p = .01$  for conditions (or  $F(1, 11.70) = 8.58, p = .01$  with Satterthwaite approximation). Here, the students in the social comparison feedback condition outperformed students in the criterion-based feedback condition. There were no significant differences between the groups within conditions.

The results of the nested ANOVA of *learning gain from pre- to post-test* were  $F(14, 18) = 0.49, p = .91$  for groups and  $F(1, 14) = 29.35, p < .0001$  for conditions (or  $F(1, 11.15) = 31.09, p < .001$  when Satterthwaite approximation is used). These results show that students in the social comparison feedback condition showed significantly higher learning gains than students in the criterion-based feedback. No significant differences were observed between groups within each condition.

The data in Table 2 could suggest that the post-test scores of students in the criterion-based feedback condition were even lower than their pre-test scores, but there is actually no significant difference between their pre- and post-test scores.

Students were asked to rate their mood, task interest, and mental effort at several points during the phase in which they received performance feedback. Due to technical challenges the data could only be partially retrieved. Therefore, these data are not further considered here.

## Discussion and conclusion

Even though the sample size in our study was relatively small with 34 students, the results already show that social comparison feedback had a highly significant effect on learning gains: students' test scores in this condition showed a considerable improvement from pre- to post-test compared to the criterion-based feedback condition. This finding contradicts the idea that social comparison feedback has little or no positive effect, (Deci & Ryan, 2000; Rakoczy et al., 2013) and it also deviates from findings in other studies in which criterion-based and social comparison performance feedback have been compared, and no significant effects of feedback type on learning outcomes were observed (see,

e.g. Labuhn et al., 2010; Rakoczy et al., 2013). The question then is which factor or set of factors in the present study could possibly have caused the effect on learning outcomes. *Within* our study, the only difference was the way the performance feedback was stated, so the observed effects on learning can only be attributed to this difference. It would be interesting though, to compare our study with other studies. Perhaps this would help to explain which factor or set of factors contributes to (or inhibits) the effects of social comparison performance feedback on learning outcomes. Below, some main characteristics of our study will be listed that might have played a role: the feedback itself and the context of the study.

Characteristics of the feedback itself involve several aspects. First, the *timing* of providing feedback. Usually, students must wait until a teacher or experimenter has scored their work before feedback is provided. In our study, feedback was integrated within the electronic learning environment and delivered on-task. Instant feedback allows students to stay focused on the task. Second, the level of *elaboration* provided in the feedback message. According to Hattie and Timperley (2007), effective feedback answers three questions: “where am I going?”, “how am I going?”, and “where to next?”. Butler and Winne (1995) argue that effective feedback offers information about the domain (product) as well as information that helps to regulate the learning process, for example, which strategies to use or not to use (process). Rakoczy et al. (2013) assume that combining the answers to Hattie and Timperley’s (2007) three questions and Butler and Winne’s (1995) product and process-oriented information should help to improve the effectiveness of feedback, but as we noted above, their study did not find an advantage for social comparison feedback. In our study, however, the feedback messages were neither elaborate nor information-rich, which may be a better approach for this type of feedback. Instead, the feedback messages were concise, focusing on performance only. For questions about the domain and/or strategies, the students in our study could turn to the teacher or the experimenter, something that never happened, by the way. The reason that this did not happen possibly has to do with the learning *setting*, a contextual factor that will be discussed next.

The present study can also be characterized by the context of the study. First of all, the experiment took place in a *collaborative* learning setting, so the students worked in small groups and therefore could turn to each other. They studied the domain together, worked on the assignments together, and discussed problems and possible solutions together. This has been found to lead to better results in higher level problem-solving tasks, such as those in trigonometry (Qin et al., 1995). Second, the *domain* might have played a role as well. Although quite complex, the domain of trigonometry has a limited solution space; there are only a few strategies that can be used to solve trigonometric problems, and if one strategy fails, then it is often quite obvious which of the other strategies can be used to solve the problem. It is possible that students made mistakes, but given the limited solution space, were still able to find their own ways and solutions, without help from a teacher or from elaborate feedback. A third contextual factor is *gender*. The present study was part of a line of research focusing on technical secondary vocational education. Not many female students are enrolled in this type of education. Therefore, it happened that our sample consisted of boys only. As a result, we do not know if gender differences could play a role in how students respond to performance feedback in general, and to social comparison feedback in particular. We think that attempts to replicate our results in other settings in which gender is more equally represented would be a valuable contribution to insight into the effects of performance feedback on learning outcomes.

Other suggestions for future research could include taking intra-personal factors into account, such as perceived competence and achievement goal orientation. Both factors

have been found to mediate how people respond to criterion-based and social comparison performance feedback. In a series of fMRI studies, Kim et al. (2010) manipulated the participants' *perceived competence* on an unfamiliar task. Participants were made to believe that they were either highly competent or not competent. It was found that participants with high perceived competence responded with a negative effect to criterion-based feedback and positive to social comparison feedback, whereas participants with low perceived competence showed strong negative responses to performance feedback. In our study, students were only exposed to performance feedback when they had decided that they were confident about their competence. This may have made them more susceptible, open, or positive toward the social comparison feedback. In a future study, it would be interesting to assess the attitudes of the participants toward the different types of feedback, and link this information to the levels of their perceived competence.

For now, however, we conclude that the present study contributes to our understanding that social comparison feedback can be very effective in improving learning outcomes, and the study also shows that these results can be obtained in a highly ecologically valid setting, the classroom itself.

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No potential conflict of interest was reported by the authors.

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Bas Kollöffel is an assistant professor of Instructional Technology at the University of Twente. His main research interests are in innovative learning environments, inquiry learning, formative feedback, and achievement goals.

Ton de Jong is full professor of Instructional Technology at the University of Twente. His main interests are in problem solving in science, inquiry (simulation-based) learning environments, learners' cognitive processes, instructional design, and man-machine interfaces.

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