The Effect of Feedback Type on Perception of Performance

Jamiahus Walton
*Clemson University*

Stephen B. Gilbert
*Iowa State University*, gilbert@iastate.edu

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Abstract
In an increasingly connected world, it's essential to have efficient teams. Training is a common method used to maintain or improve team performance. However, implementing high quality team training can be costly and require a significant amount of time and effort. An Intelligent Tutoring System (ITS) designed for a team, or an Intelligent Team Tutoring System (ITTS), can provide a solution that would reduce the cost, time, and effort required to implement high quality training. Few studies have examined the influence that feedback delivered by an ITTS has on an individual's perception of their performance and their team's performance. This within-subjects study, in which 117 participants (39 teams) completed a virtual shopping mall task, addresses this gap. Results indicate that user interface (UI) designers should display either Individual feedback or Team feedback, not both, to give users a correct perception of their performance and their team's performance.

Disciplines
Ergonomics

Comments
In an increasingly connected world, it’s essential to have efficient teams. Training is a common method used to maintain or improve team performance. However, implementing high quality team training can be costly and require a significant amount of time and effort. An Intelligent Tutoring System (ITS) designed for a team, or an Intelligent Team Tutoring System (ITTS), can provide a solution that would reduce the cost, time, and effort required to implement high quality training. Few studies have examined the influence that feedback delivered by an ITTS has on an individual’s perception of their performance and their team’s performance. This within-subjects study, in which 117 participants (39 teams) completed a virtual shopping mall task, addresses this gap. Results indicate that user interface (UI) designers should display either Individual feedback or Team feedback, not both, to give users a correct perception of their performance and their team’s performance.

INTRODUCTION

Teams can achieve more than an individual alone. Teams have worked together to send humans to space, fly millions of individuals to distant locations in a few hours, and win athletic championships. Teams must continue to work efficiently and effectively. Training is commonly used to maintain or improve team performance. Many training methods exist, such as cross-training, guided team self-correction, and team coordination and adaptation training (Cannon-Bowers & Salas, 1998). The purpose of team training is for the members to maintain or improve team skills or task skills (Driskell, Salas, & Driskell, 2018). Accomplishing this goal requires time and resources that some institutions may not have available. Intelligent tutoring systems (ITSs) provide a solution that will help reduce the time and resources needed to train a team.

Over the years, ITSs have successfully instructed individuals through automated software (e.g., Graesser, Hu, and Sottilare 2018; Koedinger, Aleven, Hockenberry, McLaren, and Heffernan 2004). However, there are a few examples of successful Intelligent Team Tutoring Systems (ITTSs) (i.e., software that tutors, or coaches, a team). Many challenges arise when authoring an ITTS, such as developing the tutor user interface (TUI) (Gilbert, Dorneich, Walton, & Winer, 2018). Generally, a human interacts with a tutor through the TUI. The TUI can include elements such as feedback, a conversation record, and performance metrics. Barriers arise when attempting to develop the feedback component of an ITTS.

Many characteristics of feedback exist, but three critical dimensions influence the effectiveness of feedback (Gabelica, Bossche, Segers, & Gijseelaers, 2012): Assessment (e.g., is the information based on individual or team performance), Audience ("Player 3, you..." vs. "Team, you..."), and Privacy (public to the entire team vs. private to an individual. This current work focuses on the assessment dimension of feedback. The purpose of this work is to examine how displaying feedback based on individual scores, team scores, and individual and team (I&T) scores influence perception of performance at the individual and team level.
are multiple points of failure in the feedback process that have not been consistently considered in previous research (Figure 1). The receiver must perceive, accept, be inclined to respond to, and respond intentionally to feedback to modify behavior (Ilgen et al., 1979). In short, the receiver must have the motive, means, and opportunity to change their behavior. Assuming the motive, means, and opportunity required to alter a receiver’s behavior is available, does the feedback provided give the receiver an accurate perception of their performance? Explicitly, does the feedback provided by an ITTS in a team setting provide the receiver with an accurate understanding of their performance and the team’s performance?

**Perception of Individual and Team Performance**

The goal of feedback is to provide information that will allow the receiver to modify their behavior to achieve a particular outcome. It is difficult for a receiver to appropriately change their behavior if they do not have a correct understanding of their performance or their team’s performance. Feedback can provide the information required to make an accurate assessment of their performance and their team’s performance. Studies have shown that high levels of team feedback can benefit team learning facilitation (Walter & Van Der Vegt, 2009). Few studies have explored if feedback provided by an ITTS would also help the team learning process. Based on the evidence presented by previous studies, the authors hypothesize that feedback containing both individual and team (i.e., I&T) assessment information (rather than one or the other) will result in a correct perception of both individual and team performance.

To test this hypothesis, the authors implemented a task called the Team Multiple Errands Test (TMET). The TMET was introduced and described previously (Walton, Bonner, et al., 2015; Walton, Gilbert, Winer, Dorneich, & Bonner, 2015). The work presented by Walton, Bonner, et al. (2015) described how the original Multiple Errands Test (MET) could be modified to study team performance in a virtual environment. The work presented by Walton, Gilbert, et al. (2015) implemented the TMET to evaluate how different combinations of the target level of feedback (i.e., Player A, you... vs. Team, you...) and privacy of feedback (i.e., the entire team can view the feedback vs. only Player A sees the feedback) influence team performance. Both of these studies examined how the feedback influenced performance, but they did not consider how the feedback influenced participants’ perception of performance within a team setting, as does the current paper. Limited details on the implementation are described below.

### Method

#### Overview of the Team Multiple Errands Test (TMET)

Participants were asked to complete a shopping mall task presented by Walton, Bonner, et al. (2015) called the Team Multiple Errands Test (TMET). The TMET is based on a task developed by Shallice and Burgess (1991) called the Multiple Errands Test (MET). The task was conducted in a virtual environment created using the Unity3D game engine. In this study, teams had three members, but the TMET platform could support additional team members.

The objective of the TMET is for teams to purchase all the items on their shopping lists using as little time as possible. There were two types of shopping lists: individual lists and a team list. An individual list was given to each team member. The items on the individual list were assigned to a specific player, and that player was the only one who could purchase those items. The items on the team list were not assigned to a particular player, and any team member could buy items on the team list. Items on a player’s individual list did not appear on another team member’s list or the team list. The items on the team list were the same for all members of the team. Similar to the original MET, the participants in the TMET were asked to follow several rules while completing the task (Table 1). Rules 1 and 2 were similar to the rules in the original MET; rule 6 was created to give a location-based timing constraint, identical to the original MET, and to add an element of teamwork. The remaining rules were added to increase the cognitive complexity of the task.

#### Experimental Design

A within-subjects study was implemented with four sessions for each participant. There was one independent variable (feedback content) with four levels. The levels were No Feedback, Individual Feedback, Team Feedback, and I&T Feedback. Each feedback condition displayed information regarding the correct items collected (Figure 2). When at least one error was committed (i.e., a rule was broken), the feedback condition displayed information according to the rules broken (Figure 3). No feedback information was displayed in the No feedback condition. Feedback in the Individual Feedback condition only displayed metrics at the individual level. Feedback in the Team Feedback condition only displayed metrics at the team level. Feedback in the I&T Feedback condition displayed metrics at

<table>
<thead>
<tr>
<th>Table 1. Rules that participants had to follow during each session</th>
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<tbody>
<tr>
<td>Rule 1. Do not spend over your allotted amount of money.</td>
</tr>
<tr>
<td>Rule 2. If you enter a store, you must buy something.</td>
</tr>
<tr>
<td>Rule 3. You must buy only one item from each store.</td>
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<tr>
<td>Rule 4. You can only visit a store once during the duration of a task.</td>
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<tr>
<td>Rule 5. You must buy only items that are on your individual or team list.</td>
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<tr>
<td>Rule 6. Meet up with your teammates at the fountain when the timer is at 0:30 (30 seconds remaining) or earlier, and before the game has ended.</td>
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<tr>
<td>Rule 7. Signal when you are finished or before time has run out.</td>
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<td>---------------------------------------------------------------</td>
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both levels.

In addition to the feedback information shown, overall individual and team scores were displayed to all members of each team during each session. The individual and team scores were based on the correct items collected, the incorrect items not collected, time remaining, and the count of rules not broken. The individual and team scores were calculated using a weighted sum in which all components were weighted equally.

Surveys

Each participant completed a demographic/pre-survey, a post-session survey, a NASA TLX survey, and an overall post session survey. Participants were asked to complete demographic/pre-survey before they conducted the experiment. After each session, the participants were asked to complete a post-session survey and a NASA TLX survey (Hart & Staveland, 1988) after each session, and an overall post-survey at the end. Once the participants completed all sessions and surveys, they participated in a semi-structured group interview. Participants were dismissed shortly after the group interview was complete, and they were given their compensation. Each team’s experience lasted 90 - 120 minutes.

RESULTS

The data presented in this section provides insight into the accuracy of participants’ perception of their performance and their team’s performance. The time remaining at the individual level and team level were used as a metric for performance. The more time that remained, the better the performance. The analyses for the data in the following sections were grouped by feedback condition and session order.

Participants

There were 117 participants (39 teams) in this study. There were 42 (35.9%) female participants, 74 (63.2%) male participants, and 1 (0.9%) participant that identified their gender as other. The majority of the participants (108, 92.3%) were between the ages of 18 and 30 years of age, and the remaining participants (9, 7.7%) were between the ages of 31 and 60 years of age. The majority of the participants (71, 60.7%) identified as an engineering major. The high percentage of engineering students could have led to a ceiling effect in performance (e.g., if the engineering participants were better problem solvers than other participants), but no ceiling effect was found.

Individual Perception vs. Individual Performance

The results in this section compare the relationship between a participant’s perception of their own performance and their actual performance. Results group participants by feedback condition, session, or both. Spearman’s rank-order correlation was used to assess the relationship between the self-reported performance question from the TLX survey (on a scale from 0 - 100, 100 being perfect) and the time remaining at the individual level (0 - 10 minutes). A positive correlation indicated that participants had a correct perception of their own performance. A negative correlation indicated that participants had an incorrect perception of their own performance. A summary of the
correlation results are presented in Table 2.

**Individual Perception vs. Team Performance**

The results in this section compare the relationship between a participant’s perception of their team’s performance and the team’s actual performance. Results group participants by feedback condition, session, or both. Kendall’s tau-b ($\tau_b$) was used to assess the relationship between participant’s self-reported ratings of their team’s performance (i.e., Very poor, Poor, Average, Good, or Excellent) and the time remaining at the team level. Kendall’s tau-b was used because it is better suited to handle data with ties (Siegel & Castellan Jr., 1988). A positive correlation indicated that participants had a correct perception of their team’s performance. A negative correlation indicated that participants had an incorrect perception of their team’s performance. A summary of the correlation results are presented in Table 3.

**LIMITATIONS**

There were some limitations to this study. Team familiarity was not controlled in this study; no mechanism was implemented to ensure similar levels of familiarity among team members. Some studies have shown that team familiarity, especially for tasks where coordination is a challenge, enhances team performance. Consequently, some teams may have had higher performance compared to teams that were strangers.

Each team experienced a control condition (i.e., No Feedback condition), but they all experienced that condition in the first session to reduce any learning effect. However, this approach resulted in confounding the effect of low task experience with the effect of no feedback, essentially resulting in the absence of an actual control group. Future studies should compare the results in this study to a control group.

**DISCUSSION AND IMPLICATIONS**

**Individual Level**

The results at the individual level suggest that participants generally had a correct perception of their own performance when given either Individual or Team feedback. Similar to other researchers (DeShon et al., 2004), this result suggests that participants should be given feedback that contains either Individual or Team information, not both. Participants may not have been able to generate a correct perception of their own performance in the I&T condition because providing both sources of information clouded their perception of their own performance.

The results also suggest that it is important to consider task experience when providing feedback. Specifically, if teams have little task experience (i.e., in Session 2), then they might benefit from Team feedback to support the correct perception of their performance. However, teams that have more task experience (i.e., Session 3) might benefit from Individual feedback to support the correct perception of their own performance.

Overall, the results suggest that user interface (UI) designers should consider a team’s task experience when designing an interface that includes persistent assessment feedback. In situations when a UI designer has limited resources, or it is impossible to customize the UI based on a team’s task experience, then the results suggest that designers should display Individual or Team feedback information, not both.

**Team Level**

The results at the team level suggest that participants had a correct perception of their team’s performance regardless of the level of feedback provided (i.e., Individual, Team, or I&T). This implication is different from the implication at the individual level, which suggests that Individual or Team feedback should be given to improve a participant’s perception of their own performance.

At the team level, the results suggest that the influence of the feedback condition on a participant’s perception of their team’s performance changes depending on a team’s task experience. Specifically, participants with some task experience (i.e., Session 3) might benefit from receiving Individual or I&T feedback to support the correct perception of team performance. Participants that have more task experience (i.e., Session 4)
might benefit from receiving Individual or Team feedback to support a correct perception of team performance.

Overall, similar to the individual level analysis, the results suggest that UI designers should consider task experience when developing a UI that displays persistent assessment feedback. The results suggest that designers may display any levels of feedback (i.e., Individual, Team, or I&T) to support accurate team perception.

CONCLUSION

This study hypothesized that the I&T feedback condition would result in participants having a correct perception of both their performance and their team’s performance. This hypothesis was partially supported at the team level and not supported at the individual level. Between the individual and team level, the results suggest that either individual or team feedback should be displayed to teams, not both. This conclusion is similar to conclusions reached by other researchers (DeShon et al., 2004).

Unexpectedly, the results from the individual and team level suggest that UI designers developing an interface that includes persistent assessment feedback should consider a team’s task experience. In other words, the feedback information displayed to teams should change, or adapt, as teams gain experience with a particular task.

This phenomenon is closely related to a phenomenon known as the Expertise Reversal Effect (ERE). The ERE is an extension of cognitive load theory that states that cognitive workloads can be optimized for an individual if a learning environment dynamically modifies the level of instruction to match an individual’s changing level of knowledge in a domain (Kalyuga, 2007). The results of this study suggest that this idea could be extended to teams. In short, cognitive workloads for individuals in a group setting could be optimized by developing a training environment in which the feedback presented to teams dynamically changes as the teams increase their task experience. This suggestion could mean that providing I&T feedback rarely optimizes cognitive workload in group settings.

The idea of implementing adaptive feedback has been explored in other contexts, such as search-and-rescue simulation-based training (Billings, 2012). Still, future studies should explore this concept when developing an ITTS or human-agent team system.

REFERENCES