



Far from Success – Far from Feedback Acceptance? The Influence of Game Performance on Young Students’ Willingness to Accept Critical Constructive Feedback During Play

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Abstract. In a learning situation, feedback is of great importance in order to help a student to correct a possible misconception. However, previous research shows that many students tend to avoid feedback regarding failures, including critical constructive feedback (CCF) that is intended to support and guide them. This is especially true for lower-achieving students, who might perceive feedback as an ego-threat, and therefore protect themselves by neglecting it. However, it has been shown that such neglect can be suppressed by using teachable agents (TA’s). Another, but less studied factor that influences feedback acceptance is the degree or extent of failure when trying to solve a task. The present study explores if and how momentary performance levels influence middle school students’ willingness to accept CCF when playing an educational game in history – with or without a TA. On the basis of teacher assessments of the students’ general skills, data logs and analyses of sequential patterns, we concluded that the willingness to accept CCF differs between students, but also between conditions and situations. One major finding is that a TA supports the students to more readily embrace CCF, even if the effect is larger for lower-achieving students. Another finding is that indications of being far from succeeding, such as low success rates or repeated trials and revisions, have a negative impact on feedback acceptance, even if a TA mitigates some of this influence. The implications of these results are discussed in relation to meta-cognitive aspects of learning and to educational software design.

Keywords: Critical constructive feedback · Feedback neglect · Teachable agents · Lower-achieving students

1 Introduction

We know from previous studies that feedback can be an important factor for students’ learning. It can provide the student with information and clues on how to proceed with a task, as well as work as a motivator, pushing the student further, into self-regulating activities and improvement [1–5].

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Feedback on errors is especially important for students with low prior knowledge and students lacking appropriate learning strategies but must be balanced and well designed to not hinder learning [6]. Nevertheless, feedback aiming at scaffolding students to not only identify, but also to evaluate and correct errors through proper instructions, can have a significant effect on learning outcomes [4, 7]. In this text we refer to this type of feedback as *critical constructive feedback* (CCF). This feedback provides the learner with some type of assessment, pointing at the need for correction of the task, or part of task (hence critical). Further, the feedback scaffolds the learner towards improvement by providing informative hints or directions (hence constructive).

This said, for feedback to have an effect, not only does it have to be carefully formulated, it also needs to be adequately attended and responded to. And, unfortunately, the latter is not always the case.

1.1 The Problem with Feedback Neglect

Despite the beneficial learning effects of feedback in general – and CCF in particular – we also know that students neglect it to a great extent [8, 9]. In for example the study by Segedy and colleagues, the authors realized that approximately 77% of the CCF statements delivered in an educational science learning game were ignored by the students [9]. Further, in an eye-tracking study performed by Tärning et al., they found that as many as a third of the presented feedback texts in an educational history game were not even noticed [8].

The avoidance or neglect of feedback can be influenced by many factors. One is the feeling of personal failure. Critical constructive feedback indicates that the student has failed in one way or another and this might cause feelings of uneasiness [10]. CCF may also be seen as an evaluative punishment [3], and the tendency to avoid it is more frequent amongst lower-achieving students and students with low self-efficacy [11]. Not only are these individuals exposed to more negative critique due to repeated mistakes, they are also at risk for being convinced of their incapacity to succeed, whatever strategies they might apply [11].

Another factor influencing the effects of feedback is the learner's control over it. Traditionally, research on feedback has focused on situations where the feedback is provided to the learner – whether she asks for it or not [12, 13]. This is also the most common situation in an everyday classroom. When the student has no impact on the delivery of feedback, she is left with little control over her learning situation, something that often is ill correlated with motivation or other emotional states important for learning [14].

There are, however, some studies on students' control over feedback [15–17]. For example, Cutumisu and colleagues studied the effects of letting students choose between critical and confirmative feedback, provided to them in a game about graphical design principles [17]. Results showed that the students' game performance correlated significantly with both their tendency to choose critical feedback and their tendency to revise their tasks. Evidently, higher-achieving students not only have a stronger shield towards criticism than lower-achieving students, they also tend to seek this criticism voluntarily, presumably with an understanding of its importance for their own learning and development.

1.2 Protecting the Student’s Ego by Using Teachable Agents

One way of addressing the problem with feedback neglect is to try to strengthen the student’s ego, another one is to provide her with tools that helps her maintain attention to problems and tasks when failing. In an educational software context, both can be obtained by using a *Teachable Agent* (TA).

A TA is a type of agent based on the instructional approach of “learning by teaching” [10, 18, 19]. A student playing with a teachable agent takes the role of a teacher and hence learns for herself in order to later teach her TA. Learning on behalf of the TA has been shown to lead to a general increase in effort and motivation as well as to better learning and performance [10]. That is, having a protégé can make the student engage in behavior they otherwise might be prone to avoid, such as the up-take of critical-constructive feedback. In particular, the benefits of interacting with a TA are more pronounced for lower-achieving students [10, 20, 21]. The reasons are many, but one is that in this situation the student is positioned as the most capable, teaching someone less knowledgeable. Being in such a position can influence students positively since they view their own competence differently [22]. Lower-achieving students are less likely than higher-achieving students to take the role of a teacher in the classroom and hence, they have less experience of being the ‘expert’ on a subject. Consequently, such an experience is likely to be more beneficial for this group.

Another positive consequence of the TA is what is proposed by Chase and colleagues as the *ego-protective buffer*, indicating that the TA has protective qualities in that it shares the responsibilities of a possible failure with the student [10]. By letting the TA solve tasks or take tests and (perhaps) fail, the student is also transformed – from a more or less capable learner into a more or less capable teacher. And since students often treat the TA as an autonomous creature, they also – at least partially – tend to blame it for its own failures. Consequently, the ego protective buffer has also been suggested to decrease feedback neglect, since it is the TA that is being tested and hence receives critical constructive feedback and not the student [23].

1.3 Research Aims and Research Questions

Given the theoretical and empirical background presented above, studying students’ inclination to accept or reject CCF during different conditions and situations, is of great interest. Working with digital educational tools gives us a unique opportunity to do so, since these conditions can be manipulated, while the students’ behaviour may be evaluated in detail through data log analyses. To our knowledge, this kind of studies on feedback neglect are rare. Consequently, the study at hand focused on the probability of students accepting CCF when failing on tasks - to a larger or lesser extent. The CCF was provided to them in a teachable-agent based educational game, where the students, after receiving information about the success-rate on a task, were given an opportunity to accept or dismiss elaborations on errors and how to correct them. After this, the students were free to follow the instructions or not (see Sect. 2.1 below for a more detailed description of the game structure and experimental design). More specifically, our research questions were:

- 1) *When playing an educational game and failing on a certain task, does the students' momentary performance level have an impact on their inclination to accept CCF?*
- 2) *Does the introduction of a teachable agent influence the students' inclination to accept CCF?*
- 3) *Does the inclination to accept CCF differ between lower- and higher achieving students?*

2 Method

The work presented in this paper constitutes a post hoc analysis of data collected in a study performed in spring 2019 in the south of Sweden with 289 middle school children from 6 schools [23]. While the comprehensive study focused on aggregated data and general differences between conditions, this specific study utilized details in the data logs to find behavioral patterns and sequences related to the research questions. An overview of the original experimental setup, together with a description of the stimuli and a definition of the parameters relevant for this particular study is presented below.

2.1 The Educational Game

The material used in the study consists of an educational game in history, where the students visit historical scenes and persons, search for text-based information and solve tasks (on the format of a concept map, a timeline, a sorting task or a set of multiple-choice questions) (Fig. 1).



Fig. 1. (Left): An example dialogue from visiting Gutenberg and his apprentice (Right): Teaching activity where the student shows the TA “Timy” how to construct a timeline.

To be able to continue and progress in the game, the tasks (six in total) need to be completed one at a time. The students have unlimited attempts to revise the tasks, and may, if they want, revisit scenes to repeat facts or gather new information. After presenting a solution on a task, the students receive feedback in two parts: i) a general task assessment, and ii) CCF about errors together with suggestions about how to acquire useful information by revisiting relevant scenes. Depending on the level of correctness, the first part is formulated as follows:

- 100% correct (Passed): “The task is approved, everything is correct. Great work!”
- 100–80% correct (Passed): “Only some minor error. The task is approved. Great work!”
- 75–80% correct (Failed): “The major part is correct, great work!”
- 60–74% correct (Failed): “A fair amount is correct, not far to go now, great work!”
- 30–59% correct (Failed): “Some things are correct, but there is some way to go, so keep on working!”
- <30% correct (Failed): “A lot is missing or wrong, unfortunately. Keep on working!”

This verbal information is always provided, but without presenting the exact amount of errors. In other words, the student mainly receives a hint about the remaining effort necessary for success. The game can then be set to deliver the more constructive part of the feedback automatically (*automatic condition*), or to ask the student if he or she wants this information or not (*choice condition*). The subsequent CCF is structured in the following way: “Some facts concerning Mrs X’s relation to A and B are not correct. Travel back and speak to her, locate the item C on the shelf behind her and find out more.” After receiving the CCF-dialogue, which varies in phrasing and content depending on the errors made, the student can choose to act upon it, by revisiting historical places, or by simply revising the task by trying to make use of the information. The overall structure of the game is described in Fig. 2 below:

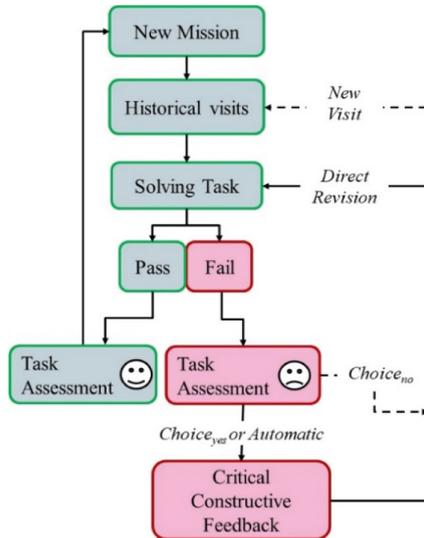


Fig. 2. Game structure with automatic or optional delivery of CCF. In the latter, the students are asked if they want the critical constructive feedback or not.

A central aspect of the game is the presence of a digital tutee, a *Teachable Agent (TA)*, whom the student is set to teach. Within a traditional learning context without a TA, the students perform tasks and tests ‘themselves’, and consequently they are also exposed

to potential CCF. By contrast, in a setting *with* a TA it will be the agent that receives critical remarks on its performance, and not the student. Consequently, by configuring the game with and without the TA, we can evaluate its impact on the students' inclination to accept or neglect feedback.

2.2 Participants, Procedure and Instruments

Since this study focused on the inclination to voluntarily accept or dismiss CCF, the problem area only accounts for students in the choice condition. This left us with 121 students, 60 played in TA-condition and 61 in NoTA-condition. These were all equally distributed in all participating classes. Due to the game's consistently text-based content, the students' in-game performance is strongly related to their reading skills. Thus, prior to the study all teachers provided assessments (lower, mid, higher) of each student's reading proficiency. The ability to process text-based information also impacts a student's overall achievement in social science subjects. When conducting their first mission and solving their first task, it became clear that the performance levels for the 'mid-achievers' were diversified. Based on their effort in the first mission (put more accurately: the number of revisions necessary for solving the task), the students of this group were therefore allocated into either the higher- or the lower-achieving group. The final distribution of the students in different TA-conditions is shown in Table 1 below:

Table 1. Number of higher- and lower-achieving students in the used data set, assigned to the TA or the NoTA-condition (choice-condition only).

	TA	NoTA
Higher	27	29
Lower	33	32

Each class played the game during three sessions à 60 min (approximately one session per week) in their ordinary classroom setting. During this time, two researchers were present, not to directly help the students with the actual tasks but for technical support and general guidance and observation. Since all students were playing at their own pace, some of them finished all tasks before the end of third session, while others didn't finish many. The actual contribution to the data set from each student does thereby vary. In the introductory phase, the students were informed that they would be exposed to a post-test on the historical content after finishing playing. This test was distributed after the final session, the result of this is, however, not used in this study.

2.3 Defining Parameters, Categories and Hypotheses

The main research question addresses the student's willingness to attend to CCF in relation to game performance. It is hypothesized that the amount of failure and/or success during play influences the student's self-efficacy, her attitude towards trying and learning,

or her general state-of-mind in a way that she either embraces more information about errors, or simply rejects it. To estimate the probability that a student accepts the CCF at a specific moment in the game, the following variables were used to formulate a logistic regression model with repeated measures and mixed effects:

Accepting offers of CCF: *CCFaccept* (binary dependent variable). Classified as 1 if the student answered “yes” to the question “Do you want to know more about the errors you have made?”, and 0 if the student responded “no”.

Teachable Agent Condition: *Agnt* (categorical independent variable, fixed effects). Two conditions: TA and NoTA.

Student Achievement Level: *Achv* (categorical independent variable, fixed effects). Two levels: Higher and Lower.

Task assessment category: *TaC* (categorical independent variable, fixed effects). The primary measure for momentary game performance. For failed tasks, the assessment had four levels: Almost Correct (75–80%), Quite Correct (60–74%), Quite Wrong (30–59%) and Very Wrong (< 30%). See Sect. 2.1 above for verbal descriptions.

Number of previous trials on task: *Tnr* (numerical independent variable, fixed effects). The second measure for game performance. Only the first six unsuccessful trials for each mission were included in the dataset. Students with only one single failed trial were eliminated. Hence, each student contributed with everything from 2 to 36 trials.

Proportion of pervious trials with accepted CCF’s: *CCFp* (numerical independent variable, fixed effects). A measure of possible “feedback fatigue” due to repeated feedback acceptance (%).

Student subject: *Id* (categorical independent variable, randomized effects).

Interaction effects: The TA-condition was also hypothesized to generate interaction effects on the achievement level (*Achv*), the task assessment category (*TaC*) and on the number of previous trials (*Tnr*).

The following logistic model predicting CCF-acceptance was hypothesized:

$$\text{logit}(\text{CCFaccept}) = \beta_0 + \left[\frac{1}{Id} \right] + \beta_1 \text{Agnt} + \beta_2 \text{Achv} + \beta_3 \text{TaC} + \beta_4 \text{Tnr} + \beta_5 \text{CCFp} \\ + \beta_6 \text{Agnt} : \text{Achv} + \beta_7 \text{Agnt} : \text{TaC} + \beta_b \text{Agnt} : \text{Tnr}$$

3 Results

In general, the students’ inclination to accept CCF was high. In total, 1316 task trials were evaluated, and 81% of these were followed by CCF-acceptance. The distribution of trials between groups and conditions (CCF-accepted or not) was the following (Table 2):

A mixed-effect binomial logistic regression model containing subject (*Id*) as random effect was fit to the data set in a step-wise-step up procedure. As postulated, the student achievement level (*Achv*) showed significant effect on the probability for feedback acceptance, revealing that higher-achieving students more often accept CCF than lower-achieving students. The general interaction effect between the TA and the achievement level was almost significant ($p = 0.055$) and had a moderate contribution to the

Table 2. Number of trials related to achievement levels in the TA or the NoTA-condition.

	TA	NoTA
H	295	327
L	354	340

model as a whole. However, as shown in Table 4, the TA had a significant positive impact on CCF-acceptance for lower-performing students, making them almost as keen as higher-achieving students to accept CCF. No other interaction effects were found.

With regard to in game performance, both the total number of previous trials (*Tnr*), and the task assessment category (*TaC*) were significant for the model, although the importance of the latter varied between categories, revealing significance only between ‘Almost Correct’ and ‘Very Wrong’. The effect from the proportion of previous trials with accepted CCF’s (*CCFp*) was not significant. Hence, the main findings consist of a negative correlation between the number of previous trials (*Tnr*) and the willingness to accept CCF, and that a large amount of errors on a task (>70%) also influence CCF-acceptance in a negative manor. These effects are visualized in Figs. 3 and 4 below.

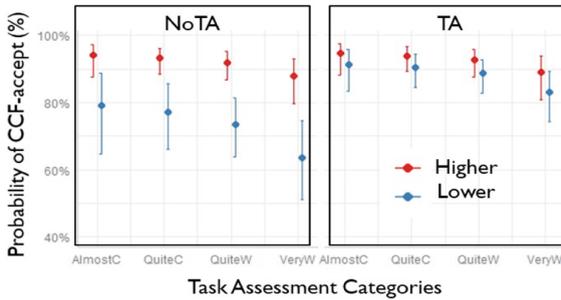


Fig. 3. Probability of CCF-acceptance in relation to TA-condition, achievement-levels and the task assessment category (Almost Correct, Quite Correct, Quite Wrong and Very Wrong).

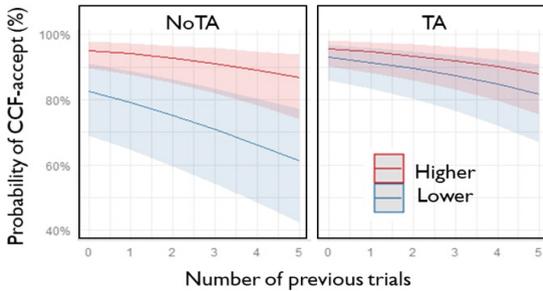


Fig. 4. Probability of CCF-acceptance in relation to TA-condition, achievement-levels and the number of previous trials on the same task (no 0–5).

The final minimal adequate model for *CCFAccept* performed significantly better than an intercept-only base line model ($\chi^2(8)$: 147.6, $p < .001$), and had a reasonable fit (C-value: 0.83, Somers Dxy: 0.65). See Tables 3 and 4 for more details and statistics.

Table 3. Summary of the final minimal adequate binomial logistic mixed-effects regression model fitted to predict CCF acceptance (*CCFAccept*).

<i>Random effects</i>		<i>Variance</i>		<i>Std. dev.</i>	
Id ($N = 121$)		0.77		0.88	
<i>Fixed effects</i> (<i>no of obs = 1316</i>)	Coeff.	OddsRatio	Std. err.	z-value	Pr(> z)
Intercept	2.98	19.30	0.42	7.10	<0.001 ***
Agnt[TA]	0.11	1.11	0.38	0.29	0.78 ns
Achv[Lower]	-1.42	0.25	0.33	-4.25	<0.001 ***
Agnt[TA]:Achv[Lower]	0.93	2.44	0.48	1.92	0.055.
Tnr	-0.22	0.79	0.05	-4.50	<0.001 ***
TaC[QuiteCorrect]	-0.11	0.87	0.37	-0.31	0.76 ns
TaC[QuiteWrong]	-0.31	0.74	0.34	-0.92	0.36 ns
TaC[VeryWrong]	-0.77	0.45	0.37	-2.11	0.03 *
Model statistics					Value
AIC					1147
C-value					0.83
Somers' Dxy					0.65
Likelihood ratio test	$\chi^2(8)$: 147.6, $p < .001$				

Table 4. Post-hoc analysis on the interaction effect between achievement level and TA-condition.

Linear hypothesis	Coeff.	Std. err.	z-value	Pr(> z)
Agnt[TA].Lower – Agnt[NoTA].Lower	1.04	0.31	3.39	0.001**
Agnt[TA].Higher – Agnt[NoTA].Higher	0.11	0.38	0.29	0.95 ns

4 Discussion

As expected, students with greater reading proficiency (in this study classified as higher-achieving students) were more inclined to accept CCF. This is hardly surprising since these students ought to be more capable of comprehending text (compared to students with lower reading skills) and therefore also should make use of the presented feedback with less effort and cognitive load.

Further, when looking at the amount of errors on a task, we saw how trials with few mistakes followed by the task assessment “The major part is correct, great work!” lead to a significantly higher probability to accept CCF than trials with many errors (followed by the formulation “A lot is missing or wrong, unfortunately. Keep on working!”). This finding is in line with previous research on feedback rejection and severe failing [11], as well as to studies on motivation and self-regulation within learning contexts [24, 25]. Additionally, research on gaming behavior reveals that gamers having ‘near-wins’ tend to stay highly motivated for continuing playing, even if their effort has nothing to do with the possibility to succeed – such as in using slot machines [26]. Evidently, the feeling of ‘being on the right path, not far from success’ is significantly more motivating and strengthening than being totally unsuccessful. It should be noted, however, that in this particular case, we do not know if it is the specific *formulation* of the CCF (“Unfortunately...”) or its underlying *content* (many errors) that has an effect. It might very well be both – but that remains to be studied.

The more trials students had, the less probable it was that they accepted CCF when failing. This relates to the research mentioned above, in that repeated failure might wear the students out, convincing them of their incapacity to succeed, and that the feedback will not help them. By turning the number of previous trials to an independent numerical variable, the study is treated as an experiment with repeated measures, adding a random effect from each subject. Yet, when including this kind of order-effects, we cannot be sure of the exact reasons behind it. Perhaps the CCF accepted in earlier rounds was perceived as confusing or hard to understand, making the students negative towards it. Or perhaps a student at a later trial remembered CCF’s from former trials and was trying to make use of these instead of accepting a new one.

Looking at the impact of the TA, the results are even more interesting. The group of students in TA-condition was more inclined to accept feedback compared to the group in NoTA-condition. This benefit was higher for the lower-achieving students, closing the gap between them and the higher-achieving students. Even though accepting feedback is not the same as reading it or understanding it, we know that it at least is better than neglecting it. This turns the TA into an interesting tool in educational software, not at least for empowering lower-achieving students to more easily embrace CCF and to try harder. Even though we didn’t find any significant interaction effects between the TA and game performance, the diagram in Fig. 2 reveals a tendency for students without a TA to have steeper curves in relation to the number of previous trials than the students with a TA. It is quite possible that the students take a greater responsibility when teaching someone else as compared to themselves, which is in line with other research [10].

Finally, we know from research on meta-cognition, motivation and learning, that the student’s knowledge monitoring has an impact on both learning outcomes and on self-regulating activities, such as spending time on delivered feedback [2]. That is, if a student is convinced that she has failed on a task, she is more reluctant to process and act on feedback messages. On the other hand, if the student thinks she has succeeded, and seeks confirmation, she is generally more receptive to negative feedback, which in this case comes as a surprise. Evidently, the importance of maintaining lower-achieving students’ self-esteem, even if failing, can’t be emphasized enough. Yet how feedback in

educational software should be designed to deal with these matters is still not obvious and needs to be further investigated.

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