



Emotionally Adaptive Intelligent Tutoring System to Reduce Foreign Language Anxiety

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Abstract. Quality education is associated with two necessary factors: learners' cognitive and emotional states. An adaptive system that takes the emotional state into account can enhance learning. We implemented an emotionally adaptive intelligent tutoring system that detects foreign language anxiety and provides appropriate intervention as needed. Note that the current experiment is still ongoing, and the results reported here are based on the data we currently have. We compared the adaptive approach with fixed feedback strategies. Our preliminary results revealed a statistically significant effect of using adaptive feedback to reduce foreign language anxiety. Also, we found a statistically significant improvement in the learning gains with a moderate effect size when using adaptive feedback.

Keywords: Affect detection · Foreign language anxiety · Machine learning · Animated agent · Emotional support · Adaptive feedback

1 Introduction

Modeling learners' affect plays a critical role in shaping Artificial Intelligence in Education. In recent years, researchers built emotionally intelligent tutoring systems to support STEM [14] and linguistic [15] fields. Within these systems, researchers detect emotions such as motivation, engagement, confusion, frustration, and anxiety. They use both sensor-full and sensor-free metrics to detect these emotions.

Previous research demonstrated that an adaptive affective system was effective within a science domain [7]. Here, we evaluate the effectiveness of adaptive feedback to enhance learning and reduce foreign language anxiety (FLA).

Previous research mentioned that an emotionally intelligent tutoring system can simulate a human tutor which helps the learner to perform better and reach a positive emotional state [19]. A successful learning environment is built on cognitive and affective support because all individuals are different and adapt to various emotional support, needs, and personalities [21]. To study the effectiveness of adaptive feedback for English as a foreign language, we analyzed the following research questions:

Research Question 1: “How effective is an adaptive feedback approach relative to a fixed feedback approach for reducing FLA?”

Research Question 2: “How effective is an adaptive feedback approach relative to a fixed feedback approach for increasing learning?”

2 Related Work

Foreign language anxiety (FLA) is one of the main impediments to learning a new language. It has a long-term effect on willingness to communicate in the foreign language [3, 16, 18]. Also, it inhibits language acquisition, especially by increasing the learner’s reluctance to practice [10, 11, 16, 17]. Moreover, it hinders performance [16, 17] and achievements [8].

The goal of assessing when to provide emotional support when teaching English as a second language is to improve positive emotions, reduce negative emotions, and enhance achievements. Providing an adaptive system that takes into account the current emotional state can be a key factor for students to succeed academically [9, 15]. A system that understands when to provide support can accelerate learning [6]. Adaptive support can be beneficial because each intervention could have positive or negative side effects, like providing emotional support when it is not needed [6].

Previous research mentioned that getting benefits from an animated agent that provides emotional support depends on different factors, such as the learner’s current emotion, gender, or achievement [2]. The effectiveness of an adaptive, supportive animated agent for reducing FLA and increasing learning acquisition is an active research question. Christudas et al. previously found that personalized e-learning improves learning achievement and satisfaction [4]. They took into account learner behavior and feedback; though they didn’t measure the learner’s emotional state. Other research mentioned that, when comparing adaptive and non-adaptive e-learning systems, the adaptive system which took into account the students’ knowledge outperformed the non-adaptive system [1]. There was an increase in motivation, engagement, and learning for learners who used the adaptive system [1]. This study did not, however, take into account the learner’s anxiety state. Therefore, we hypothesize that using emotionally adaptive feedback would enhance both the emotional state and learning.

3 Method

To build an emotionally intelligent tutoring system, we developed a machine learning model to detect FLA. We implemented a Random Forest chain regressor model using the scikit-learn Python machine learning library [20]. We predicted FLA [13], change in FLA, and which intervention would be most beneficial. In a previous experiment, we tested 6 different approaches for delivering feedback: Motivational supportive feedback and explanatory feedback presented by text, voice, and agent. The explanatory feedback explains the correct answer without alluding to the incorrect answer. The motivational supportive feedback provides

explanatory feedback between two positive comments. To build the machine learning model, we divided the dataset, which consisted of 3940 records, into 6 groups based on the intervention used. For each group, we implement a Random Forest Chain regressor algorithm to calculate FLA [13], and the change in FLA after receiving the feedback. In each model, we used 10-fold cross-validation and 100 random generations for the chain order. There were 9 independent features [13] and two dependent variables. Then we predicted the intervention based on Random Forest algorithm, which chose the intervention that caused the maximum reduction in FLA. This means finding the intervention which causes the maximum difference between anxiety self-report and anxiety predicted by the model.

Based on [12], motivational supportive feedback presented by the agent could reduce FLA the most followed by explanatory text feedback. Thus we used motivational supportive agent and explanatory text as a fixed strategy conditions. Previous research mentioned that using voice with text helps foreign language learners to focus and increase learning gain [5], thus we used explanatory feedback presented by voice and text as a fixed strategy. In our preliminary experiment, participants were randomly assigned to four different groups. The adaptive feedback provided explanatory or motivational supportive feedback presented by the text, voice with text, or agent with voice and text. The machine learning algorithm decided which intervention would better support the learner's emotional state. This algorithm was built based on previous research [12]. The fixed feedback were either motivational supportive feedback presented by agent, voice, and text; explanatory feedback presented by voice and text; or explanatory feedback presented by the text. We had 80 participants (Adaptive N = 20, Voice Explanatory N = 15, Agent Supportive N = 22, Text Explanatory N = 23).

First, the participants read and agreed to the informed consent. Then they provided some demographic information (age, gender, English level, educational degree, native language, employment status, and number of years studying English). After that, they filled FLCAS questionnaire to measure their anxiety during English class. Then they started the pre-test, which consists of five sections (vocabulary, listening, grammar, reading, and writing). After that, they did 26 exercises with the intelligent tutoring system. After each exercise, the machine learning algorithm calculated the anxiety level and then provided feedback based on the assigned group. If the participant was in the adaptive group they received feedback based on their anxiety level. Otherwise, if the participant was in one of the fixed groups, they received the same feedback but delivered according to their assigned group (motivational supportive agent, explanatory voice, or explanatory text). Then the participants filled out a self-report about their current anxiety level. After finishing the 26 exercises the participants answered 5 post-test questions.

4 Results

4.1 Reducing FLA

RQ1 asked about the effectiveness of adaptive feedback for reducing FLA. To address this, we did an ANOVA to compare the reduction of learners' FLA when using adaptive feedback vs. fixed feedback. We found a significant reduction in anxiety in the adaptive condition $F(3, 2071) = 9.454, p < .001$. Table 1 presents the mean and standard deviation for the change in FLA after receiving the feedback. To investigate this in more detail, we did a separate ANOVA with two factors: adaptive vs. agent supportive. Although there was a difference, it did not reach the $\alpha < 0.05$ threshold: $F(1, 1086) = 3.631, p = .057$. We also did an ANOVA with adaptive vs. voice explanatory feedback as factors. We found a significant result, $F(1, 906) = 6.054, p = .014$. Finally, we did an ANOVA with adaptive vs. text explanatory as factors. We found a significant difference, $F(1, 1112) = 28.931, p < 0.001$.

Table 1. Difference in FLA between groups

	Mean	SD
Adaptive	6.88	32.47
Voice explanatory	1.56	31.91
Agent supportive	3.01	34.33
Text explanatory	-3.32	30.7

4.2 Learning Achievement

To ensure that there is no difference in the prior knowledge between the four groups, we did an ANOVA and found no significant difference $F(3, 399) = .254, p = .859$. To answer the second research question about the effectiveness of adaptive feedback in increasing learning gain, we evaluated the results of the pre- and post-test using paired t-test analysis. We found that post-test scores were significantly higher ($M = 58.31, SD = 37.24$), than pre-test scores ($M = 44.66, SD = 30.24$), $t(99) = -3.487, p < .001$. The effect size for this learning gain ($d = .4$) is considered moderate. We found that post-test scores were significantly higher than the pre-test for the fixed groups: emotional supportive feedback present by agent $t(109) = -2.655, p = .009$, explanatory text feedback $t(114) = -3.544, p < .001$, but the effect size for was small ($d = .27, d = .36$). However, for explanatory voice feedback $t(74) = -3.755, p < .001$ the effect size was moderate ($d = .47$).

5 Discussion and Conclusion

Our first research question was whether adaptive feedback could reduce FLA or not. To answer this question, we compared adaptive feedback with fixed feedback. We found that an adaptive emotionally intelligent tutoring strategy reduced anxiety more than fixed strategies. This is aligned with [15] who found that an affective intelligent tutoring system reduces anxiety when learning Japanese as a foreign language. However, we did not reach the $\alpha < 0.05$ threshold between the adaptive feedback and the fixed emotionally supportive agent. The presence of the emotionally supportive agent helped in reducing FLA regardless if the system is adaptive or not. This echoes previous research, which found that emotionally supportive agents reduce FLA [3, 12]. The adaptive feedback significantly reduced FLA compared to text explanatory feedback. This implies that it is important to provide appropriate feedback when needed [6].

When looking at the pre- to post-test results, the adaptive feedback increased the learning gain more effectively than the fixed strategies. It was not a big change, but it may not be surprising considering that the tutoring system's content is relatively difficult, on par with TOEFL and IELTS English language standardized tests. This may limit the amount by which the learners' anxiety levels would be reduced over the course of the experiment and, in turn, limit the extent of their learning achievement.

One limitation of this work is the small sample size $N=80$. Another is that there was a high dropout rate, which may also be due to the difficulty of the content. It should be noted that this experiment is still ongoing, and we hope that having more data for the conditions will allow us to draw more concrete conclusions.

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