# EVE: AN AFFECT-SENSITIVE PEDAGOGICAL AGENT

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## ABSTRACT

*Easy with Eve is an affect-sensitive tutoring system that features Eve, an animated pedagogical agent that adapts to student emotion based on the results of an observational study of human tutors. This paper presents the methodology and results of a study of the effectiveness of Eve, showing evidence that facial expression detection may have enhanced the effect of the presence of Eve on student motivation and beliefs about how much they were able to learn by interacting with the tutoring system, and suggesting areas of improvement to enhance the effectiveness of this system in business training and other context.*

*Keywords*: computer based learning, affective systems, human factors, intelligent tutoring systems.

## INTRODUCTION

One of the established strengths of human tutors is their ability to adapt to the affective and motivational states of the students (Lepper, Aspinwall, Mumme & Chabay, 1990; Fox, 1991; Merrill, Reiser, Ranney & Trafton, 1992; Sarrafzadeh, Alexander, Dadgostar, Fan & Bigdeli, 2006). For this reason, many researchers feel strongly that Intelligent Tutoring Systems (ITSs) would be significantly enhanced if computers adapted according to the emotions of students (Picard, 1997; Kort, Reilly & Picard, 2001; Alexander, Sarrafzadeh & Hill, 2008]. This idea has spawned the developing field of Affective Tutoring Systems (ATSs): ATSs are ITSs that are able to adapt to the affective state of students in the same ways that effective human tutors do (Alexander et al, 2008; de Vicente, 2003). ATSs have a very short history: it seems that the term "Affective Tutoring System" was first used just a decade ago (de Vicente, 2003), although the popular concept of an ITS adapting to perceived emotion can be traced back at least as far as Rosalind Picard's book Affective Computing (Picard, 1997). However, the field of ATSs is sufficiently young that up until now, few fully functional ATS's has yet been implemented, although much research has focused on tutoring systems that can detect student emotions (D'Mello, Picard & Graesser, 2007; Litman & Forbes-Riley, 2006) or can display simulated emotions through an animated pedagogical agent (Johnson, Rickel & Lester, 2000; Predinger & Ishizuka, 2004).

There have been some results that suggest that student affect is related to cognitive performance. In a meta-study of affective states associated with the use of learning technologies, such as intelligent tutoring systems, it was found that engagement or flow, boredom, confusion, curiosity, happiness, and frustration do appear frequently during the use of affective learning technologies (D'Mello, 2013). This suggests that "…the enhanced interactivity, personalized instruction, rapid feedback, and other features of ALTs have the intended effect of engaging students."(D'Mello, 2013, p. 1093). This is encouraging, since it implies that affect may provide useful clues into the student's emotional state, if affect can be accurately detected and integrated into a student model as a part of an adaptive strategy for learning systems. Still, very little research has focused on the question of how an ATS should adapt in real-time to student displays of emotion.

In response to this shortcoming, the current research has explored the pioneering development of an ATS that bases its tutoring strategies on the tutoring actions of real human tutors. As previously described in Sarrafzadeh, Hosseini, Fan & Overmyer (2003), an observational study of human tutors interacting with students has been carried out, on the basis of which a novel, fuzzy, case-based method for affective tutoring strategies has been developed (Alexander & Sarrafzadeh, 2004). In an attempt to validate the feasibility of an emotion-sensitive tutoring system, this tutoring strategies method has been implemented in a system for tutoring counting and addition for elementary students, Easy with Eve. Easy with Eve features an affect-sensitive animated pedagogical agent, Eve (Alexander, Sarrafzadeh & Hill, 2006), that is able to detect student affect using a real-time facial expression analysis system, which was developed in-house (Sarrafzadeh, Alexander, Dagdostar, Fan & Bigdeli, 2006).

In this pap
er the methodology and results are presented of a study using Easy with Eve that was carried out to test both the effectiveness of adding emotion detection to the tutoring strategies module and the impact of the presence of the animated pedagogical agent. The following section briefly discusses the implementation of Easy with Eve, after which the methodology and results of the study are presented. The paper concludes with a short discussion of the findings from this study, and some suggestions for future work.

# EASY WITH EVE

## Domain

Easy with Eve is an ATS that is designed to help primary school students with the concept of part-whole addition; the domain is based on a previously existing exercise developed by the New Zealand Numeracy Project (New Zealand Ministry of Education, 2003). In this exercise, students learn to add two numbers together by transforming the initial equation so that the first addend is made up to the next 10: for example, 14 + 8 would become 14 + 6 (to make 20) + 2 = 22. Students learn this reasoning by manipulating tens frames and counters. As students progress through the exercise the tasks become increasingly abstract, until by the end of the exercise students must apply the principle of part-whole addition to equations without using the tens frames and counters at all.

## Detecting Emotions

Emotion detection in the ATS is achieved using a real time facial expression analysis system developed in-house (Overmyer, Hosseini, Fan, & Sarrafzadeh, 2003). The emotion classification is achieved by using support vector machines, and is able to detect 8 different facial expressions: neutral, smiling, laughing, surprised, angry, fearful, sad and disgusted. Unlike other facial expression analysis systems, facial information is automatically detected without the need to manually mark facial features. Initial tests on artificial data sets (using computer generated faces) have yielded a successful recognition rate of approximately 90% (Sarrafzadeh et al, 2006).

## Displaying Emotions

Easy with Eve is able to display the simulated emotions of a human tutor through an animated pedagogical agent, Eve, who is shown in Figure 1. Animated characters have been shown to carry a persona

effect, which is that the presence of a lifelike character can influence students to perceive their learning experiences more positively (Clark & Choi, 2005). The persona effect (van Mulken, Andre & Muller, 1998) has been shown to increase learner motivation, especially in technical domains, although its overall benefits are unclear (Clark & Choi, 2005).

Eve is able to display a range of emotions through facial expressions; she is also able to deliver spoken teaching content. Her repertoire of tutoring actions includes giving positive or neutral feedback, asking questions, discussing problems or solutions, giving hints, or answering her own questions.

## Adapting to Emotions

The tutoring actions of Eve are generated by a novel fuzzy case-based tutoring strategies module, discussed in detail in Alexander & Sarrafzadeh (2004). The system searches for close matches to the current tutoring scenario in data that was collected from an observational study of human tutoring interactions, presented in Sarrafzadeh et al., (2003). The primary reason for adopting this approach to tutoring strategies in the ATS was due to the absence in the literature of studies explaining how human tutors adapt to student emotions on a low-level, turn-by-turn basis; this would have made any form of rule-based approach problematic.

# METHODOLOGY

## Goals

Easy with Eve was user-tested at two local primary schools in Auckland to investigate its impact on student performance, motivation and perceptions of the tutoring experience. In particular, these goals can be summarised as follows:
-To find out whether or not emotion detection would improve student performance.
-To find out whether or not emotion detection would affect student perceptions of the ATS.
-To find out whether or not the presence of Eve would improve student performance.

## Participants

As can be seen from the list of goals, the two independent variables in the study were firstly whether or not the ATS adapted to student emotion (i.e. student facial expressions) as well as student answers, and secondly whether or not the animated tutoring character (Eve) was present. The first independent variable, whether or not the system detected student emotion, was of particular interest as existing ITSs adapt only to student answers.

Therefore, a 2x2 between-subjects experimental design was chosen for this study. There were four different versions of the tutoring system:
- where the animated agent was present and facial expressions were detected (as a measure of student emotion to be used by the tutoring strategies module);
- where the animated agent was not present (text-based feedback was used) but facial expressions were detected;
- where the animated agent was present but facial expressions were not detected; and
- where neither the animated agent was present nor facial expressions detected.

In total, there were 62 participants in the study, 30 males and 32 females. The participants were all 8-9 year old students at one of two local schools in Auckland; the students were exposed to different versions of the tutoring system. However, data from 3 of the students was unusable, leaving a total of 59 participants.

Each participant was told that the web-cam on the monitor (used by the facial expression recognition system) only worked half of the time – but the participants were not told whether their facial expressions were being detected or not. This was so that later on it could be seen how much of a difference the facial expression detection made to student perceptions about the tutoring system.

Ethical approval was sought and obtained from the Massey University Human Ethics Committee before the participants were contacted and the study carried out.

# Measures

There were two measures chosen to investigate the effects of the two independent variables: the first was a measure of student performance using a pre-test and a post-test, and the second was a questionnaire. This paper only focusses on the first measure which is the student performance and not the questionnaire.
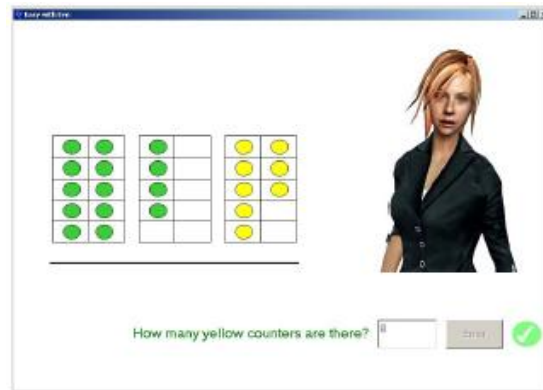


**Figure 1: Screenshot of Easy with Eve**

**Pre- and Post-Tests**

The aim of the pre- and post-tests was to determine whether or not students improved their counting and addition through using Easy with Eve, and to generate a measure of exactly how much students improved. The pre- and post-tests would also determine whether some groups improved significantly more or less than others.

Both the pre- and post-tests were integrated into the ATS so that the entire pre-test, tutoring session, post-test sequence was introduced and explained by the tutoring system; the system also explained the transitions between the pre- and post-tests and the tutoring system proper. Where Eve was present, this was all explained to the student by Eve; otherwise it was explained by text.

The content of the tests was based on problems from each of the levels in Easy with Eve; each test was scored out of a maximum of 15. The questions in the pre- and post-tests were identical in style and difficulty, with the addends themselves being the only difference. The tests were designed to take about 5 to 7 minutes each.

# Procedure

The study was carried out on site at two local primary schools in Auckland, New Zealand, in a meeting room and a remedial teaching room respectively. Four computers were used in the testing, with each computer running a different version of Easy with Eve. The computers were arranged so that there would be a minimum of distraction from the other participants.

Each of the four computers was equipped with a web cam and a set of headphones, regardless of whether or not Eve was present or facial expressions were being detected on that version of the tutoring system. The aim of this was to make it possible to test whether or not students could tell whether or not their facial expressions were being detected based solely on the tutoring system's responses.

Up to four participants at a time were welcomed into the meeting/remedial teaching room, and given a brief overview of the pre-test, tutoring system and post-test; then participants began the pre-test.

As participants completed the pre-test, the ATS introduced the next phase of the testing, which was the session with the tutoring system proper. This was designed to take approximately 18 to 20 minutes; participants began their last problem immediately after the first time that they completed a problem after 17 minutes had

elapsed. When participants had completed the tutoring session, they then began the post-test. The results of the pre- and post tests were written to a file.

# RESULTS

The data showed a significant overall increase in test scores between pre-tests and post-tests. As shown in Figure 2, there was an improvement from pre to post test. A 2 (presence of agent) x2 (facial expression input) x2 (pre-/post-test) mixed design ANOVA revealed a main effect of test. Post-test scores (M= 9.34, SD= 2.23) were significantly greater than pre-test scores (M= 8.42, SD= 2.28), $F (1, 55) = 7.48$, $p = 0.01$.

**Figure 2: Increase from pre-test mean to post-test mean**
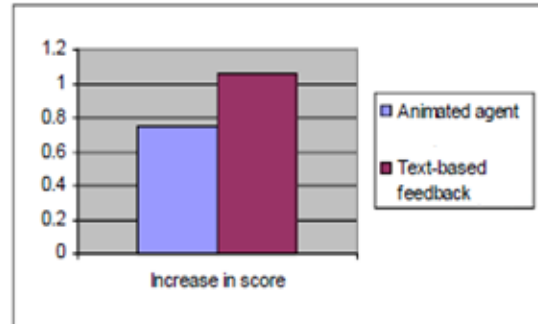


# DISCUSSION

The results from the study showed a statistically significant overall increase in student scores from pre-test to post-test. This result is certainly very encouraging, as it goes some considerable way towards validating the use of an affect-sensitive tutoring system as a tool to help students improve their learning.

# CONCLUSIONS AND FUTURE WORK

The work presented in this paper has demonstrated the feasibility of developing an Affective Tutoring System that adapts to student emotion based on a case-based approach to human tutor-based tutoring strategies. The results of the study showed a significant overall increase in test scores between pre-tests and post-tests. There was also evidence in favour of persona effect of Eve. This suggests that further work to this agent would be valuable and improvements could further enhance the student learning and level of the persona effect.

There is some evidence that participants have more confidence in an agent represented as a young female peer, rather than an older teacher (Jordine, Wilson & Sakpal, 2013). For future versions of Eve, it could be appropriate for the user to have the opportunity to choose an avatar with which they are most comfortable. As a part of future work, a range of avatars will be made available for learners to choose from depending on age and the context of the learning.

Future work should also investigate whether the tutoring strategies module can be improved by extending the observational study of human tutors upon which it is based; the accuracy of the facial expression detection with real images should also be verified, and the overall study of the effectiveness of Easy with Eve should be repeated with a larger sample size to test for substantial effects. It would also be useful to repeat the study in different contexts (such as in training of employees) as if this Affective Tutoring System was to be used in contexts outside the pre-higher education sector it would be useful to determine the effectiveness in a variety of contexts including social science and business education contexts. It is particularly valuable to assess the effectiveness of ATSs in business and sales education and training where emotion might play a more substantial role than areas such as mathematics education.

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