Emotive characters can make learning more productive and enjoyable:  

*It takes two to learn to tango*  
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**Abstract.** In this paper we explore a new direction for pedagogical computer agents, also called computer characters, which we believe will maximize students’ learning gains and enjoyment. To the traditional scenario where students interact primarily with a single coach or tutor character on-screen, we introduce the addition of both a social, animate colearner, and the student’s own avatar character. Variations of the colearner’s attributes, informed by research literature on human partners, are explored through an online testbed application of English language idioms. Results from an experimental study with 76 Japanese college students reveal that cooperative colearners have a positive impact on students’ performance and experience, as well as increasing perceptions of the character’s intelligence and credibility. Findings provide grounding for a fruitful new direction for pedagogical characters, where students learn alongside emotional companions.

**Computer Characters and Pedagogical Applications: A Perfect Match**

Drawing inspiration from traditional cartoon animation and comic layout processes, computer characters resemble actors in their emotional range and improvisational responses. Appearing on screen as embodied entities – whether humans, or anthropomorphized objects and animals – these agents facilitate our interactions with software applications and are rapidly gaining prevalence in our everyday online activities. Embodied conversational characters bring with them a host of social expectations and behavior patterns. In situations where time and efficiency are of the essence, the added layer of a social exchange may add to the cognitive load of the human interacting with them. Yet for cases when the social aspects of the interaction are the center, or central to, the human interactor’s objective, characters rule the day -- and with good reason! Computer characters have been shown to be effective proxy sellers, customer service representatives, and teachers, by engaging us – consciously or unconsciously – through life-like language, presence and behaviors. Of particular importance for the educational domain, computer characters generate additional interest and motivation in the content presented, as well as influence proactive changes in everyday behavior.

In fact, computer characters are perhaps the best interface modality for teaching and learning because they allow for mimicry and mirroring, fundamental aspects of learning. Beyond the explicit lesson plan, educational exchanges are fraught with implicit social content and tacit knowledge that instructors model for students. Through learning and teaching, we implement information gathering and problem solving skills that best exemplify our cultural practices and beliefs, whether the subject matter are skateboard moves on staircases learned from peers, algebra or Shakespeare in the classroom, or customization of characters in online gaming environments.

Every day, societal values and norms for acceptable behaviors, affective and motivational exchanges, role models and speech patterns, are taught alongside lessons in classrooms around the globe. The richness of the social and emotional exchanges that make computer characters challenging to integrate in productivity suite applications make them ideal for communicating these additional channels of expressiveness in educational content, through their gestures, word choice, affective reactions, and facial expressions, among others (Maldonado and Hayes-Roth, 2004). Characters can reliably showcase the same pattern of behavior, with slight improvisations, for many users. This makes computer agents
particularly interesting from the researchers’ perspective, leading to detailed analysis of different learning effects and behaviors based on each student’s characteristics and preferred learning situations.

Pedagogical characters, have appeared in language learning applications, middle school curricula, oral storytelling, corporate training, health behavior change interventions, and even military instruction. Yet research and industry applications including embodied conversational computer characters in pedagogical domains have structured the interaction as a one-to-one tutoring or coaching intervention. The learner primarily interacts with one character on the screen at a time; when more than one character is present simultaneously in the application, their roles tend to be supplementary or supportive ones, providing background tips for the interaction as an articulate “Help” menu, or acting as movie extras in the background.

**A new paradigm: Learning together online**

We believe that giving the student a virtual presence in the environment, and enriching the learner’s world with a colearner, will lead to greater gains in learning and enjoyment of the educational application. To evaluate these claims, we have designed and built online application testbeds, with which we vary characteristics of the colearner according to research-based predictions of factors that maximize achievement and enjoyment. We’ll report in this article on the eSchool application, focused on teaching Japanese college students American idioms. This system has shown great promise for breaking free of the traditional paradigm of a single interactive character on the screen (for detailed discussion on these experiments, please refer to Maldonado et al, 2005).

Today, computer characters exhibiting realistic behaviors in the pedagogical arena tend to follow three primary models, mirroring Taylor’s 1980 taxonomy of computer usage in schools: tutor, tool and tutee. Characters may be cast as expert teachers or coaches, presented as role-play partners in simulations of real-world situations, or act as learners whom the human student teaches. Most often, computer characters inhabit the role of expert or knowledgeable teacher, experienced coach, or erudite tutor. The second category, where characters are presented as partners in role-play simulations is prevalent for on-the-job training and eLearning situations, is prevalent in cases where the learner may be older and more experienced. Computer characters act as colleagues and coworkers, with whom the student practices concepts, strategies, and behaviors. The third mode of interaction with computer characters prevalent today presents the computer character as a learner, progressing alongside the human student, or being taught by him or her. Peer characters are perceived as possessing as no more content knowledge on the subject as the human learner, and often less. When students teach the peer character, the cyclical act of preparing content for teaching, and successfully communicating it becomes the learning experience in itself.

In the last twenty years since Taylor published his taxonomy, we have developed the technologies to implement and render believable, animate characters, yet we have made comparatively little progress in developing applications for these characters that maximize the social and emotional relationship with human interactors. For starters, the human student tends to be implicitly present alongside the character, rather than visually embodied on screen, and the interaction is limited to exchanges between the human learner and a single computer character. Few graphical representations of the human interactors appear on-screen in pedagogical applications, despite how common these “avatars” are in commercial sociable applications and games. We propose a radical reframing of the learning context in which students interact with animated pedagogical computer characters, which we believe will maximize the students’ learning gains and enjoyment.
**Introducing eSchool: Our Experimental Testbed**

In the eSchool application we have developed, students interact with two computer characters at the same time, a teacher and a peer fellow student, within one screen. Students are themselves represented through an avatar, who they can direct in emotional and subject matter responses. The avatar’s conversational behaviors and gestures are autonomously derived from the directions of the human learner and this learner’s answers to the questions. This mode of interaction is perceived as more natural than avatars whose behaviors are minutely controlled by the users.

The colearner, or classmate, learning alongside the human student, has no additional knowledge on the subject nor explanations to provide, and is called to answer questions as often as the student, on average; it also exchanges friendly banter with the student’s avatar. We have introduced this presence in the learning environment to determine the effects that learning alongside a social animate character has upon the student’s performance and attitudes, rather than using the colearner to elicit nuanced explanations from the student, or model understanding, as is the case with some intelligent tutoring systems.

Figure 1 shows the first eSchool interface for handheld computers using cartoon characters, and Figure 2, the current interface on a PC using photographic images at the same moment in the interaction. In both cases the teacher character is located on the upper right hand side of the screen, above the chalkboard, which displays the multiple choice interpretations the student must decide between, mimicking the learning space of a classroom. In Figure 1, the students’ avatar is Neko the cat, and the colearner is Taro the Tiger, while in Figure 2 the students’ avatar is Susy and the colearner is Ryota. Each of the three interactors has their own emotions and embodiment.

The content of our learning application is an intermediate English language lesson, with accompanying video and evaluation instruments, primarily aimed at Japanese college students. Students progress through multiple-choice questions about American idioms (such as “being a pain in the neck,” and “getting cold feet”). Both the topic and character design were explicitly developed to be appropriate for the target audience. As we shift our focus globally with the online release of eSchool, we have redesigned the interface with photorealistic characters. The eSchool environment allows students to conduct all their interactions online, logging students’ progress throughout the course even across different days and computers.
Students can choose the look and feel of their avatar and their colearner from a wide range of embodiment options, of several ethnicities, age, appearance, and genders. Actions the avatar and colearner take affect each other’s emotions accordingly, and this change is reflected in their facial expressions. Answering a question right, for example, increases the student’s confidence and happiness, and also affects the emotions of the autonomous colearner, depending on his or her personality traits. The emotion model is a novel, patent-pending design, product of a unique collaboration between Omron Corporation and Stanford University (for more implementation details, please see Morishima et al, 2004; Nakajima et al, 2004), and allows for a synchronous learning experience as well. That is, two students can interact through their avatars online in eSchool, although for the purposes of our experiments we have isolated the behaviors under analysis by modifying specific attributes of the colearner as an autonomous character.

**Evaluating Colearners: Research, Experiment, and Results**

Thus far, experimental research and evaluations of character systems has focused primarily on the modality of the exchanges between the teacher character and the human student, as well as the character’s believability: text vs. voice, photo-realistic vs. drawn representations; two vs. three dimensional presence; human-like vs. anthropomorphic animals. Some past studies have varied the degree of animated behaviors, and others have explored ethnic and gender combinations between the learner and the character tutor. In contrast, we are conducting several experiments evaluating the effects that different dimensions of the colearner have on the students’ performance. Among the colearner dimensions we are studying are social ones (competitiveness and cooperativeness), personality traits (degrees of introversion and extroversion), and performance (high- to low-achiever).

We inaugurated the colearner research field by isolating the effects of the autonomous colearner in an experimental study to determine if the colearner had any effects on the students’ learning and enjoyment by its mere presence, and whether its emotional expressions were required. We believe that emotions are key, as research suggests that studying in a cooperative group leads to greater learning gains than individual or competitive conditions, with improvements in critical thinking skills, and to greater gains in motivation. While most previous research attributes the performance gains of students in a cooperative group to shared reasoning and dialogue, we are interested in exploring the effects that colearners’ social banter may have on the student’s performance, when it is devoid of educational content relevant to the learning activity at hand. The colearner’s social nature was manifested through facial expressions and utterances directed at the student’s avatar, making compliments and showing concern.

For this first evaluation of the eSchool system and underlying emotion-generation architecture, we partnered with an English language college class at International Christian University, in Tokyo, Japan, and sought to determine the impact of the colearner character on the students’ understanding, recall, recognition, and motivation. Students were randomly selected to learn with an emotive colearner, an unexpressive coleaner, or with no colearner present; before and at the conclusion of the interaction they were asked to fill in a questionnaire.
Our findings are very encouraging: participants accurately perceived the substantial differences in the treatment variable, and correctly interpreted the emotive colearner to be expressive and caring. Participants who leaned alongside the unexpressive colearner rated their colearner as less trustworthy and less intelligent than those that learned alongside the emotive colearner. Since credibility and intelligence are considered key in persuasion and motivation, it should come as no surprise that these participants did not perform as well in the post-experience evaluation with respect to learning. As Figure 4 shows, interacting with an unemotional colearner also diminished enjoyment of the system.

In fact, our beliefs on the effectiveness of emotive colearners held through the learning assessment. We concentrated on the open-ended questions posed, as they signal a deep knowledge of the idiomatic expressions presented interactively through eSchool. Participants that interacted with an emotive colearner performed significantly better compared to those who learned alongside an unexpressive colearner, and those who did not interact with a colearner throughout the application, as can be seen in Figure 5. It would seem that the mere appearance of an additional face does not trigger the same level of motivation unless it expresses emotions.
How Can Colearners Maximize Learning and Enjoyment? Future and Ongoing Research

Now that we know colearners – even autonomous ones – can impact students’ performance, we are looking forward to following up this experimental study to determine other characteristics of colearners that may also contribute to the enjoyment of the experience and learning gains. An overarching goal is to find out if it will be possible to design a colearner in the future that will maximize learning for every student it interacts with, regardless of age, culture, subject matter, preferences, or personality traits. Perhaps such a super-colearner is not feasible, yet we would be delighted to shed additional light into the characteristics of successful dyads in academic environments. Through this new line of research with pedagogical characters we may be able to realize the promise of personalized learning through companions, recommending a combination of colearner attributes to maximize enjoyment and achievement based on a short personality quiz and background profile. There are many factors that make it difficult to arrange and evaluate such matches in real-world classrooms: among them, students social networks and status differentials, heterogeneity of student responses and high levels of distractions. Yet in online teaching environments it may be possible to customize the colearner to best fit the needs of every learner, and to progressively adapt should these change.

A recent experimental study within our lab (Ju et al, 2005) seems to indicate that American students prefer interacting with cooperative rather than competitive colearners. Forty-four undergraduates participated in a follow-up to our pilot study, using a web-based prototype similar to eSchool in their use of a colearner, avatar, and teacher. However, in this instantiation, the characters appeared on screen next to the chalkboard as stick figures, completely scripted and devoid of facial expressions. Rather than evaluating American idioms, this stick-figure study focused on Morse code lessons. As with human student dyads, participants with high-achieving colearners performed significantly better in this study than those paired with low-achieving colearners. We are very interested in replicating these results, both those varying the colearner’s performance and social banter, and hope that this research will enrich the understanding of how the interaction of these different characteristics of the colearner affects participants’ learning and enjoyment.

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