My English Teachers Are Not Human but I Like Them: Research on Virtual Teacher Self-study Learning System in K12

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Abstract. English is the most used second language in the world. Mastering vocabulary is the prerequisite for learning English well. In middle school, students direct their own studying outside the classroom to facilitate memorizing and understanding. However, the lack of teacher guidance in the self-study process will negatively affect learning. Producing video lecture materials including talking teachers costs time, energy, and money. The development of artificial intelligence makes it possible to create such materials automatically. However, it is still unclear whether a system embedded with AI-generated virtual teachers can facilitate self-study compared with the system with merely the speech in self-study in K12. To address this gap, we conducted a user study with 56 high school students, collecting learning outcomes, user experience, and learning experience. Results showed that the virtual teacher helps to improve the student's English learning performance both in retention and transfer. Participants reported high user and learning experience. Our findings shed light on the use of virtual teachers for self-study students in K12.

Keywords: Virtual teacher · Self-study · Video lecture · Second language learning · K12

1 Introduction

English is the most used second language in the world. Mastering vocabulary is the prerequisite for learning English well. Students often need to spend extra

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time outside the classroom to practice the language. Making excellent teaching resources often require much time, financial resources, and energy. Additionally, one of the biggest challenges for learners to self-study is the lack of teacher guidance and companionship, leading to distraction and shallow cognitive processes during learning. The development of artificial intelligence makes it possible to create such materials automatically. However, it is still unclear whether a system embedded with AI-generated virtual teachers can facilitate self-study compared with the system with merely the speech in self-study in K12.

To address this gap, we first propose a self-study vocabulary learning system, providing teaching videos and vocabulary exercises. The videos were automatically generated by the engine [30], only with a photo or a clip and a lecture text. Then, to evaluate whether the virtual teacher and the system can help middle school students improve their learning performance and to investigate students' subjective feelings, we conducted a user study in middle schools and focused on three following questions:

- **RQ1:** Can the virtual teacher promote learning outcomes?
- **RQ2:** What's the learning experience when learners study English with and without the virtual teacher?
- **RQ3:** What's the user experience when learners study English with and without the virtual teacher?

Then we conducted a user study with 56 high school students, collecting learning outcomes, user experience, and learning experience. Results showed that the virtual teacher helps to improve the student's English learning performance both in retention and transfer. Participants reported high user and learning experience.

2 Related Work

In this section, we discuss the work related to pedagogical agents in interactive learning environments. The use of digital learning equipment and resources in an informal setting is as important as learning in a formal education environment [23]. However, learning in an informal environment lacks teacher supervision, and management relies on student self-discipline, so teaching materials need to be carefully designed and organized to enhance learning. In addition, as the COVID-19 pandemic spreads around the world for a long time, face-to-face learning has been hindered. Students need to complete more learning at home, and schools and teachers need to build a large number of digital learning materials suitable for learners to use at home. Providing practical and rich teaching resources is an urgent issue.

2.1 English Learning System

With the development of digital teaching technology, more and more English-assisted teaching tools have been developed to support students' after-school learning. Sandberg [27] developed a mobile English learning APP that supports

after-school learning, providing gamification methods such as word spelling, picture-word matching, and judgment questions for elementary school students to review the words they had learned in class. The results indicated that learners who used the mobile app performed better than learners who did not use the app when completing word tests. Chen [7] designed a personalized mobile English word learning system that recommends suitable words for learners based on their vocabulary ability and memory cycle, aiming at improving learners' performance interest in learning. Liu [22] proposed a handheld English language learning organization, in which learners scan a QR code into an augmented reality environment to complete English learning in the company of a virtual companion, and the study results show that the system is helpful for college students to learn English. Sun [28] used WordNet technology to design a word learning system to help students distinguish between the confusing near-synonyms and similar-looking vocabulary (NSSL). The results showed that students using the system could effectively help them identify NSSL words. Cheng [10] developed a campus English learning system(Student Partner) to help students find English practice partners on campus. This system supported learners to communicate using text, pictures, and voice. Their results showed that students believed that such a system would help students learn English well. Hwang [19] developed a mobile game for practicing English listening and presentation skills in which learners construct sentences based on cards and questions and give oral responses. The findings indicated that learners using the app performed better than controls groups on verbal post-test. Still, there was no significant difference between the two groups on the listing post-test. Chen [8] developed a mobile English learning system, which provides timely news and automatically retrieves vocabulary from articles that are new or unfamiliar to learners to enhance learners' English reading skills and vocabulary skills.

Although existing research provides many learning tools for English learning, they mainly focus on the design of the technology and tools. Less consideration is given to the role of teaching agents in teaching tools. Students use digital tools to complete learning freely, lacking supervision and guidance. It is crucial to consider how to design teaching agents in learning tools to promote learner concentration to improve learning effectiveness.

2.2 Social Agency Theory

Social agency theory argues that social cues in multimedia learning are conducive to allowing the learner to feel social companionship and they are communicating with another person [12]. Agents as a social presence can improve the overall attention of the learner and promote the deep cognitive processing of learning materials to obtain better learning results [6]. Teacher-student interaction is one of the most significant contributors to learner satisfaction with the curriculum and perceived learning [15]. Wang [29] conducted an eye-tracking experiment on math instructional videos with or without teachers, and the results showed that when learning materials are relatively simple, teachers can help learners maintain attention and promote their cognitive processing of learning materials.

Mayer [24] studied the effects of teaching agent posture, facial expressions, gaze orientation, and anthropomorphic movements on learning outcomes in multimedia learning. They found that social cues had a positive impact on learning transfer testing. Guo [17] study found that agents speaking in videos caused students to be more engaged with the learning content than without agents. Moreno [25] compared the effectiveness of teaching with and without agents and found no difference in learning retention, but learners who learned with agents performed better on learning transfer tests. Meanwhile, they reported a higher level of interest and motivation.

Nonverbal communication plays a vital role in human-to-human interactions, as it is in online learning and video teaching [1]. The teaching agent is embedded in the learning video as a visual stimulus, providing non-verbal interaction cues, such as expression, gaze, and posture. Teaching agents can provide nonverbal communication to enhance learners' comprehending of the learning content [29]. Chen [9] compared the effects of lecture recording with lecturer and sliders, portrait plus video recording, and voiceover on learners. They found that participants felt significantly lower cognitive load and better learning with teacher pictures compared with the sound-only teaching video. Johnsoncite [20] studied the effects of animated female teaching agents with indicative movements and eye gaze on students' learning of circuit knowledge and found that learners with lower prior knowledge were more likely to benefit from teaching agents.

2.3 Teaching Agent

A teaching agent is an image that appears on a screen to provide teaching support and motivation to learners in the multimedia learning environment [14]. The teaching agents guide learners to focus on meaningful learning content by gaze or gesture. They show the prerequisites, relationships, or results related to the learning content to assist the learner in processing the information [18,21]. Teaching agents can exist in the form of animated or static images, human or non-human [11].

An animated teaching agent is an animated image that appears on a teaching screen to facilitate learning in a computer learning environment [18]. Prior studies have shown that animation pedagogical agents improve learning by stimulating social interaction and increasing engagement. Animation agents with speech are more conducive to learners in terms of learning retention and migration than animation agents that render text [13]. Baylor [3] compared the teaching agent of anthropomorphic animation with the teaching agent of static pictures and found that there was no significant difference in the effects of the two on learning retention. 3D teaching agents use 3D modeling techniques to generate three-dimensional human or other images, often used in virtual reality or augmented reality environments to interact with students on the fly. Ashoori [2] built an augmented reality learning environment for disease knowledge teaching, a virtual animated agent that can be moved is provided, the agent recognizes the learner's need for help or lost clues and volunteers to consult them. The results show that the learner feels a personalized experience when using the

agent. Instructional agents also provide navigation guidance to prevent learners from getting lost during exploration in complex virtual reality or augmented reality environments.

Realistic pedagogical agents look natural and more likely to be trusted by learners. Unnatural agent images can distract learners [4]. Most teaching agents appear in cartoon animations or 3D models in existing studies. Cartoon animation renders the outline of the agent without presenting realistic details and is not rich enough in terms of emotional expression. Three-dimensional models can simulate the 3D sense of real people. Still, the 3D model characters in most of the current studies are relatively rough, the movements and expressions are relatively blunt, which is easy to cause a sense of distrust among learners. Well-produced animations and 3D model effects often require a high time, human resources, and financial resources. Therefore, this study uses virtual teacher generation tools to convert character pictures and texts into lecture teacher videos, which is easy to produce and can achieve realistic teaching agent effects. The virtual teacher plays the learning support and motivational role. The study aims to provide a new direction for the teaching agent field under computer-supported teaching.

3 User Study

This user study explores how AI-generated pedagogical agents impact learning performance, usability, user experience, and learning experience in self-study.

3.1 Participants

We recruited 60 participants, who were junior high school first-year students, aged between 12 and 13 (M = 12.3, SD = 0.47). We randomly selected two classes in seventh grade. Four students were excluded because they failed to submit a complete questionnaire. Finally, 56 participants were included in this study (27 males and 29 females).

3.2 Experiment Design

The participants were randomly assigned to two groups: the experimental and the control groups. The experimental group used the application with a pedagogical agent (see Fig. 1 left), while the control group used only the speech version (see Fig. 1 right). We asked the two groups to complete a prior-knowledge test online a week before the experiment to ensure that the two groups had no prior knowledge bias. In the prior knowledge test, participants were asked to give the Chinese meanings of the English words to be learned. As shown in Table 1. We found that there was no significant difference between the experimental group (Mdn = 3) and the control group (Mdn = 3) in the prior knowledge test, $U = 261.5$, $Z = -1.020$, $p > 0.05$, $r = -0.08$.

Table 1. Prior knowledge test.

Group	Prior knowledge test
	p
Virtual teacher	>0.05
Non-virtual teacher	

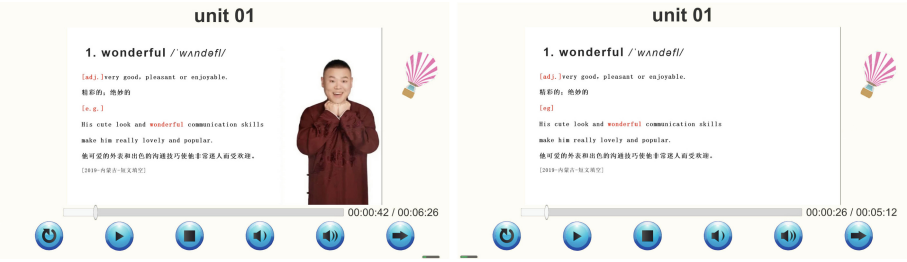

Fig. 1. The interface of the English learning system with a virtual teacher (left) and without virtual teacher (right)

3.3 Dependent Measures

The dependent variables included learning effect, user experience, and learning experience, as shown in Table 2. We tested learning retention and transfer as performance. The learning experience questionnaires were from Ramsden [26], and the user experience questionnaires were adapted from Bourgonjon [5].

Table 2. Dependent measures.

Variable	Category	Questions	Type	Min/max
Learning retention	Learning effect	9	Blank filling	
Learning transfer	Learning effect	9	Single choice	A-E
Perceived usefulness	User experience	4	5 point Liket	1–5
Perceived ease of use	User experience	5	5 point Liket	1–5
Perceived usability	User experience	4	5 point Liket	1–5
Use intention	User experience	3	5 point Liket	1–5
Emotion and motivation	Learning experience	3	5 point Liket	1–5
Social presence	Learning experience	4	5 point Liket	1–5
Cognitive load	Learning experience	2	5 point Liket	1–5
Interest and satisfaction	Learning experience	4	5 point Liket	1–5

3.4 Learning Materials

The learning system was developed using Unity2019, including explanation videos and practices. The practices in the applications offer feedback. The talking pedagogical agent was generated by an engine proposed by the work [30]. In this experiment, the image of the pedagogical agent was a famous comedian.

The learning materials were selected from English vocabulary in Grade seven English textbooks. Nine words were used. As shown in Fig. 1, the explanation videos included slides to present words, phonetics, Chinese interpretation, and word examples. The pedagogical agent explains the meaning, the usage, and examples. The application in the control group only offered speech.

3.5 Procedure

The experiment was conducted in a room equipped with computers with the procedure as shown in Fig. 2. We installed and tested the applications in advance. The students were informed of the experimental contents and then learned by themselves. After learning, students completed the tests and filled out questionnaires. The whole experiment was about forty minutes.

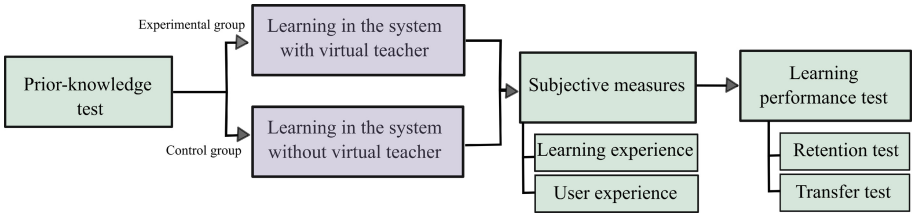

Fig. 2. The experimental procedure.

4 Results

This section reports the data analysis results related to the learning outcome questionnaire (learning retention and learning transfer) and subjective questionnaire (user experience and learning experience). All the data of learning outcomes were tested by the Shapiro-Wilk test. The results showed that the data was non-normal distribution, so the test method used is a non-parametric test. The analysis methods used are the Mann-Whitney U test and the Wilcoxon test. Mann-Whitney U test was used to compare the differences between two independent samples, Wilcoxon was used to testing the difference between two related samples. The learning outcome data were analyzed in SPSS. The boxplot of subjective questionnaire was drawn in Spyder using the seaborn library of Python.

4.1 Learning Outcome

As shown in Table 3, there was a significant difference between the prior knowledge performance (Mdn = 3) and post-test performance (Mdn = 9) in the experimental group, $Z = -4.435$, $p < 0.01$. There was also a significant difference between the pre-test performance (Mdn = 3) and post-test performance (Mdn = 7) in the control group, $Z = -4.021$, $p < 0.01$. Results showed that the design of learning systems and learning materials helped improve learners' performance.

Table 3. Prior knowledge and retention performance.

Group	Virtual teacher	Non-virtual teacher
	p	p
Prior knowledge test	<0.01	<0.01
Retention test		

As shown in Table 4, there was a significant difference in learning retention between the experimental group (Mdn = 9) and the control group (Mdn = 7), $U = 125$, $Z = -4.492$, $p < 0.01$, $r = -0.346$. There was significant difference in learning transfer between the experimental group (Mdn = 7) and the control group (Mdn = 4), $U = 148$, $Z = -3.210$, $p < 0.01$, $r = -0.248$. The results showed that the use of AI-generated pedagogical agents facilitated learning retention and transfer more.

Table 4. Retention and transfer performance.

Group	Retention test	Transfer test
	p	p
Virtual teacher	<0.01	<0.01
Non-virtual teacher		

4.2 Subjective Questionnaire Measurement

As shown in Fig. 3, the learning experience included satisfaction, attention, reliability, social presence, and cognitive load. The box plot results showed that the median of satisfaction, attention, reliability and social presence were all 5, reflecting the high evaluation by learners. The median of the cognitive load was 3.5, showing that the cognitive load was not high.

The utility is used to evaluate whether the functions integrated into a system are available, while usability is used to measure the use effect of these functions when completing specific tasks and the satisfaction brought to users [16]. Ease

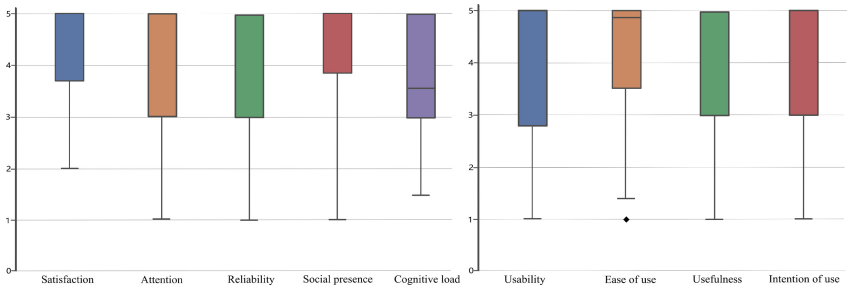

Fig. 3. The boxplot of learning experience (left) and user experience (right)

of use is used to measure the ease of operation of a system, Intention to use indicates whether users are willing to use the system regularly or recommend it to others. These indicators are key indicators to measure the effectiveness of a system. As shown in Fig. 3, the usability, ease of use, usefulness and use intention felt by learners when using the system are investigated. The median of usability, usefulness and use intention is 5, and the median of usability dimension is 4. The results showed that the user experience evaluation of the system is high.

5 Discussion

- **RQ1:** Can the virtual teacher promote learning outcomes? The results indicated that both experimental group students' retention and transfer test significantly outperformed the control group. The presence of teachers in the vocabulary learning system helps promote learners' learning output. This result is consistent with social agency theory, namely, pedagogical agent as a social cue can facilitate students' in-depth understanding and processing of learning materials. Although the learners who did not use virtual teachers also improved their learning performance through learning on the system, the degree of progress was significantly lower than that of the experimental group.
- **RQ2:** What's the learning experience when learners study English with and without the virtual teacher? What's the learning experience when learners studying English with the virtual teacher generated by artificial intelligence? Most learners showed high satisfaction with virtual teachers. They could concentrate on learning content with the help of teachers. The presence of teachers' images makes learners feel the social presence, and the cognitive load is normal. This conclusion is consistent with the previous conclusions on the impact of teachers on learners in video learning, that is, teachers' verbal, nonverbal, and appearance images have an impact on learners' learning input and feelings. The teacher used in this system is a well-known comedian. Its amiable image, smiling expression, and natural mouth shape provide learners with a very friendly figure of teachers and partners to promote learners to participate in learning.

– **RQ3:** What's the user experience when learners study English with and without the virtual teacher? The English vocabulary system designed in this study to support learners' after-school practice has been highly praised by learners in terms of functional integrity, functional effectiveness, and ease of use. Learners showed a strong intention to use the system and were willing to use it as a tool for their daily learning and recommended it to others. The possible reason might be that the system has designed a clear and concise interface, easy-to-use interaction, and teachers' accompanying learning. The selected learning contents were closely related to students' classroom knowledge so that learners felt the practical role of the system.

6 Limitations and Future Work

Although the results of this study proved the effectiveness of our virtual teacher and English learning system, there are still limitations in this study. First, the experimental duration was not long and was only conducted once in middle school. Excellent learning results and experience may be affected by the novelty of students using virtual teachers for the first time. Thus, we will conduct an extensive experiment to study how AI-generated pedagogical agents impact learning over a long period. Second, this study only compared the conditions with and without virtual teachers. We will investigate more conditions about virtual teachers. Finally, the learning system only supports the after-school practice of English vocabulary. In English learning, learners need to practice grammar, listening, reading, and writing simultaneously. As an after-school English learning system, we should consider designing more comprehensive learning content to support English learning in an all-around way.

7 Conclusion

The study explores the impact of AI-generated virtual teachers on secondary school students completing after-school English learning. In this study, we conducted an experiment involving 56 participants. First, we investigated the influence of virtual teachers on learning performance. The results show that virtual teachers exist in teaching videos as social cues can significantly improve learner achievements and promote learners' understanding and application of learning content. Second, we investigated subjective experience. The results showed that the use of virtual teachers made learners feel a high sense of trust, satisfaction, social presence, and an appropriate level of cognitive load. This indicated learners' acceptance of the AI-generated pedagogical agents as the teacher. Finally, we investigated the user experience. Most learners believed that the system was easy to use. The results showed the system's feasibility as an after-school English learning for middle school students. Virtual teachers generated with photos can be used to assist teachers in developing digital teaching resources that are conducive to learning, which significantly saves the time and energy cost of making teaching resources. For students, using such an after-school English learning tool

with virtual teacher teaching, simulating the completion of learning under the guidance and supervision of teachers, is beneficial to the learning effect and learning experience.

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