Motivate the Learners to Practice English through Playing with Chatbot CSIEC

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Abstract. CSIEC (Computer Simulation in Educational Communication), is an interactive web-based human-computer dialogue system with natural language for English instruction. In this paper we present its newest developments and applications in English education. After brief introduction of the project motivation and the related works, we illustrate the system structure with a flow diagram, and describe its pedagogical functions in details, including free chatting, chatting on a given topic and the chatting scoring mechanism. We review the free Internet usage within six months, and evaluate its integration into English classroom. The summarization and assessment findings confirm that the chatting function has been enhanced and fully used by the users, and the application of the CSIEC system in English instruction can interest the learners to study English and motivate them to practice English more frequently. Finally we discuss the application driven approach of system development, and draw some conclusions for the further improvements.

Keywords: CSIEC, English Learning, Chatting, Playing, Scoring, Motivation.

1 Introduction

1.1 Motivation

English, as an international language, is treated as a key tool for the development and cultivation of the cross-cultural communication ability. English language is now listed as one of the three core courses in China's elementary and secondary education, and as a compulsory course in higher education. Statistical data shows that there were more than 176 million people learning English in China in 2005 [1].

However, some problems exist in the English education in China. First of all, one of the best ways to learn a foreign language is through spoken dialogue with native speakers. But it isn't practical in the classroom due to the one-to-one student/teacher ratio it implies, especially in China and other countries with English as a foreign language. A number of factors ranging from the lack of time to shyness or limited opportunity for quality feedback hamper using the target language [2]. The language environment and few qualified English teachers in China can't supply enough chance of authentic talking. So school teachers often complain of working burdens, and don't

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have enough time to converse with students in English. Secondly, although learning English through communication and application has been emphasized recently, passing examinations is the main motivation of many students to learn English. Thirdly the grammar instruction is crucial to China's English education, because Chinese differs greatly from English in grammar [3]. Without basic grammar knowledge, the students can't make great progress, as they mostly only practice English in school time, and can't learn it spontaneously from the social environment.

A potential solution to these problems is to apply computer spoken dialogue systems to role play a conversational partner. If we could design an interactive web-based system which could chat with the English Learners anytime anywhere, their great demand for learning partners could be fulfilled. Such a system should aim at helping the learners improve their skills of using English through frequent chatting with them in English, as well as encouraging them through playing and scoring mechanism. Motivated by the great demand for English instruction, we in 2002 began to design such a system. Our design principle is application and evaluation oriented. So long as the system is applicable, we put it into free use in the Internet and get the user feedback. We also cooperate with the English teachers and integrate the system into English instruction. Through the systematic application and evaluation we get more suggestions and critiques, which can direct our research more effectively.

1.2 Related Works

Brennan defined a chatbot as "an artificial construct that is designed to converse with human beings using natural language as input and output" [4]. ELIZA [5], the first chatbot, used key words to analyse input sentence and created responses based on reassembly rules associated with a decomposition of the input. The syntactic way of NLP (Natural Language Processing) exemplified by ELIZA has been developed significantly from 1960s up to now, leading to the development of various chatbots. Since 1990s with the improvement of natural language processing, chatbots have become more practical, and have also been applied in education.

Graesser et al. [6] used "AutoTutor", an intelligent tutoring system with mixed-initiative dialogue simulating a human tutor via conversation with the learner in natural language, to enhance the learner's engagement and the learning depth.

Seneff [7] described several multilingual dialogue systems designed to address the need for language learning and teaching. A student's conversational interaction was assisted by a software agent functioning as a tutor with translation assistance anytime.

Kerfoot et al. [8] described an experimental use of chatbots as a teaching adjuvant in training medical students. Their web-based teaching using chatbots increased test scores in four topics significantly and learning efficiency three-folds.

Abu Shawar and Atwell [9] developed algorithms for adapting a chatbot to chat in the language and topic of the training corpus. The evaluation feedback from language learners and teachers indicated that these adaptive chatbots offered a useful autonomous alternative to traditional classroom-based conversation practice.

Kerly et al. [10] described an experiment to investigate the feasibility of using a chatbot to support negotiation. Its result showed that most students liked the chatbot as the chatbot helped them understand their learner model.

The related works above show the usage of chatbot systems in education is drawing more attentions from related researchers. This trend confirms our determination to further the development of the CSIEC system and its application in English education.

2 System Compositions and Technologies

In the system design, contrary to the partial parsing adopted in many other systems, we attempt the fully syntactical and semantic analysis of the user inputs, as the logician G. Frege pointed out: "The meaning of a sentence exists in the meanings of all words within the sentence and their conjunction method" [11]. After parsing the user input we obtain the user information in the form of XML, i.e. NLML and call them the user facts. The facts are retrieved from natural language expressions, and also represented with the annotation of natural language in the sentence ontology. These facts function as the main contextual source of the robot dialogue reasoning. This thought originates from L. Wittgenstein's theory (1918/21) about the world, facts, objects and human language: "The world consists of facts, the facts consist of objects. The facts are reflected in the language. A logical picture of facts is a thought." [12]

The current CSIEC system is version 9. The whole system is mainly made up of the following components, which are illustrated in Fig. 1.

A. HTTP request parser resolves the user request from http connection and gets some parameter values: input text, scenario topic, agent character, speech speed, spelling and grammar checker, etc.

B. English parser parses the user text into NLML (Natural Language Markup Language). NLML is a dependency tree in XML form, and structurally labels the grammar elements (phrases), their relations and other linguistic information.

C. NLML parser parses the NLML of the user input into NLOMJ (Natural Language Object Model in Java) which represents the grammatical elements and their dependency with the Sentence ontology in the working memory [13]. Through NLOMJ the declarative sentence is retrieved and decomposed into atomic facts consisting of only one subject and one verb phrase.

D. NLDB (Natural Language Database) stores the historical discourse, the user atomic facts in the form NLML, the robot atomic facts which are also expressed in NLML, and other data.

E. World model contains common sense knowledge which is the basis for response generation and logical inference. It is now represented by WordNet [14].

F. CR (Communicational Response) mechanism comprehensively takes into accounts the user facts stored in NLDB, the world model, the personality of the user expressed in the previous dialogue, and that of the robot itself selected by the user.

G. Scenario dialogue handler creates the robot output corresponding to the user input within a given scenario.

H. Scenario show handler creates the random robot-robot talk show scripts within a given scenario.

I. Scenario DB stores the robot-robot talk show scripts and human-robot dialogue scripts which are manually written by designer, for example English language teacher.

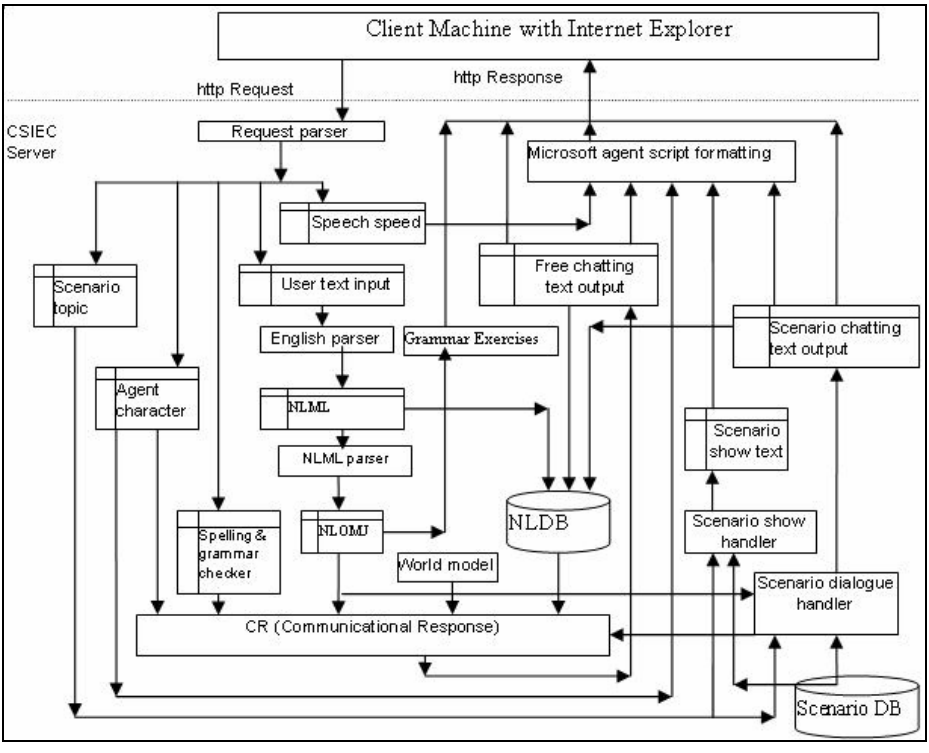

Fig. 1. The compositions of CSIEC system

J. Microsoft agent script formatter transforms the output text into VB scripts, considering the selected agent character and speaking speed.

K. Browser/Server interface processes the http request from client machine and responds with the robot output, either in text or with VB script.

3 Functions: Chatting, Playing and Scoring

3.1 Multimodal User Interface and Selectable Chatting Pattern

Human-computer dialogue in natural language is the most specific function of the CSIEC system. As in human being's authentic dialogue situation, the Internet users have various preferences for the dialogue simulation. In order to adapt to variant user preferences the CSIEC provides several user interfaces and dialogue patterns.

First of all the user can chat with the robot either through text or via voice. The users can hear synthesized voice and watch the avatar performance through Microsoft agent technology. They can also speak to the robot through a microphone with the help of a third party program like IBM ViaVoice.

Secondly the robot can check the spelling and grammar of the input text upon the user's request.

Thirdly the chat topic between the user and the robot can be either free (unlimited) or specific (limited). The unlimited dialogue simulation doesn't specify the dialogue topic and content. It suits the need of the users whose English is fluent or who are at least good at written English, as well as users who are extroversive or conversational. However, users whose English is poor, or who are introversive, have little to chat with the virtual chatting partner. For those users, an instructive dialogue in a specific scenario guided by the agent is more helpful.

In normal human talking these two chatting patterns are not absolutely separated, but often interleave each other. Our system considers this interaction too. In the next 2 subsections we introduce the two patterns in details, as well as their relationship.

3.2 Free Chatting Adaptive to User Preference and Topic

In the free chatting the users with different characters and personalities may choose different types of chatting pattern. For example, some users may prefer to chat with someone who listens to them quietly most of the time; while some others may hope the chatting partner can tell stories, jokes or news. For the sake of user dialogue personalization we designed five Microsoft agent characters which represent different kinds of chatting patterns [15]. Christine always tells the user stories, jokes and world news. Stephan prefers to listen quietly when the users share with him their own experiences. Emina is a curious girl, and is fond of asking users all kinds of questions related with the users' input. Christopher provides comments, suggestions and advices on the user's input. Ingrid behaves as a comprehensive virtual chatting partner, who gives users responses corresponding to both the input text and the discourse context.

Upon user registration to the chatting system the user's profile is obtained and recorded, such as the gender, birthday, educational level, and province. So the corresponding chatting topic and content can be generated based on the personal information. Certainly if the user wishes to change the chatting topic during the process of the robot's narrating comments or asking questions, the robot should terminate this process and transfer to another topic. If the user specifies a topic, for example, "*I want to talk about sport*", the robot changes the topic to it. If the user just expresses the wish to change the topic, but doesn't determine a topic, such as "*I want to talk about another topic*", the robot selects one from the waiting topics list which has not been talked about with the given user.

The user's interests are also expressed in the input texts, e.g. the mentioned nouns and verbs in the sentences. So the chatting topic can be triggered by nouns and verbs, and their combination. More frequently one noun is or several related nouns are talked about, the related topic is more emphasized. The chatting between the user and robot can be regarded as guided chatting or chatting in some context.

Then we deal with the chatting on a given topic in two ways. The first one is predefining some comments or asking some questions about this topic. By talking about this topic only one statement or question will be randomly selected and given out. The second way is to search the topic or related topic in the guided chatting within a given scenario, and then transfer the chatting to the guided chatting in a given scenario, which will be introduced more in next subsection. In Figure 1 the arrow from the scenario dialogue handler to the communicational response indicates this relationship.

Summarily the goal of free chatting is to motivate the user's talking desire. For this purpose the robot tries to adapt itself to the user's interest, and launch new topics.

3.3 Guided Chatting in a Given Scenario

We then explain our approach to guide the chatting with the robot in a given scenario. The dialogue should be developed step by step around a red line or a topic for this scenario. Due to the extreme complexity of natural language this dialogue development is exceedingly nonlinearly complicated. It can be described by a complex tree structure with many branches. These branches can be pragmatically and semantically countable, but syntactically uncountable. So this dialogue scenario tree is much more complicated than the classical chess decision making programs, which has finite state change selections in every step.

We use scripts to describe the decision tree in the dialogue on a given topic. The script is made up of lines of dialogue steps (states), every of which is a branch in the decision tree. Suppose the robot speaks at first. In every line there must be the text output from the robot and its order number in the dialogue. This output may be triggered by specific user input, which we call the prerequisite of this output text. The robot may also expect the user inputs certain texts, or some texts with specific semantic or syntactical characters, which we call the expectation of this output text. We write the line in the script with the following format:

Nr. <prerequisite> (text) <expectation>

The "Nr." and (text) are the necessary two components in every line. The "Nr." is an integer which indicates the line order in the whole script, whereas the "text" can be any text from the robot, either statement, or question, and so on, and it is written within closed brackets.

In a script line the prerequisite and expectation are optional. If they appear they must be written within closed sharp brackets. If the prerequisite exists and is satisfied the output text can be given out by the robot. The expectation means the robot hopes the user responses to this text with some specific syntactic and/or semantic features, and can be applied to instructional goal. For example if the user's input does not satisfy the robot's expectation he/she will face the previous robot output again, until the expectation is fulfilled. This dialogue pattern can be used for drill. Another alternative is that the user is given a high mark if his input satisfies the robot output, otherwise a low mark, although the robot continues the next dialogue. This pattern can be used in test or examination.

The format of the prerequisite is:

<Nr, variable 1: value 1, value 2...; variable 2: value 1, value 2...>

The format of the expectation is:

<variable 1: value 1, value 2...; variable 2: value 1, value 2...>

Both are almost the same form. Only the prerequisite needs an order number indicating the expectation of which line this condition fulfills. There may be more than one value for a given variable. This means if the variable equals any one of the listed values, the condition is fulfilled, i.e. the values for a given variable have the relation of logical disjunction. There may be also more than one variable and its corresponding values. The relation among these variables is logical conjunction.

This discourse script is difficult to be written by normal authors, for example the English teachers who want to use this program to train the students. Even an error with a bracket will cause the misunderstanding of the computer program. Thus we have designed a Java GUI, i.e. DSE (Discourse Script Editor) for editing the scripts step by step more easily. With it a normal user such as an English teacher needs not to pay attention to the writing format, but to the discourse content and process. However, he/she has to spend much time on planning this discourse script between the robot and the human user, just like a film director. This work is not just the language teaching, but also the teaching of response strategies through natural language.

3.4 Listening Training

We use the Microsoft agent technology to synthesize the output text, because the agent's voice is lifelike, the agent's figures, movements as well as actions can be designed very vividly, and it can also synchronously display the spoken text, which facilitates the aural understanding and activates the user's interests. We have also designed seven facial expressions (neutral, happy, sad, feared, disgusted, angry and surprised) for every agent character and hope the textual emotional expressions can be accompanied by the agents' facial changes. The robot's reading speed can be adjusted by the users at any time. We have also designed a text-reading webpage where the agent can read any texts inputted or pasted by the user.

Different from the traditional audio technologies such as audio players, the user confronts with unexpected robot text and voices, just like talking with a real human being. So it is hoped that this function can benefit the user's listening comprehension and prompt response.

3.5 Talk Show of Two Robots

This function is designed to aid the user's chatting on a given topic. With it the users can watch the talk show of two robots before the human-computer interaction. The talking texts are predefined by the teacher for the specific context or topic. However, the actual texts for a given meaning can be expressed randomly. So this kind of talk show is different from the monotone one presented in the traditional video or audio cassette. It will enforce the learner's spontaneous listening and understanding. The talk show script texts can be readily written by the teachers with any text editor.

3.6 Automatic Scoring of Gap-Filling Exercises without Well-Defined Answers

Traditional computer-based gap filling exercises require a definite answer or a set of definite answers. For the questions whose answers are difficultly to be listed, the human manual check is still unavoidable. However, this kind of exercise without predefined answers can advance the creative thinking of the students.

With the spelling and grammatical check function the CSIEC system can decide if a filled gap-filling sentence is grammatically correct. Therefore it can be applied to automatically assess the gap-filling exercises and relieve the teachers' burden. So currently the system provides the interface for teachers to design new gap-filling

exercises, as well as the interface for learners to do these exercises and then to get the automatic assessment results.

An example of gap-filling exercises is: "*I ( ) a student*." The correct answer to the gap can be: "*am", "want to be", "will be", "have been", "need", "help"*, etc.

3.7 Scoring Mechanism

In order to motivate the users to learn English we trace users' usage of different functions and give them certain scores. The scoring principle is encouraging the usage of chatting with agents, and with spelling and grammar checking. By the chatting on a given context, the user is given a high mark if the input satisfies the robot output, otherwise a low mark. This mark also contributes to the total score.

The user can review his performance and scores after entering the system. This function is very important and helpful for self learning. A special user who is labeled as the teacher can access the performance and scores of all the users who are classified as his/her students. This automatic monitoring function is very necessary for the teacher to assess the students' learning behavior and progress.

4 Application and Evaluation

4.1 Summative Evaluation of Free Using in Internet

The internet users get to the CSIEC website (www.csiec.com) mainly through search engines, because our website has become one of the top 5s in the searching results of famous search engines such as google.com, yahoo.com and baidu.com by related keywords such as "chatbot", "English chatbot", "Online English learning" in Chinese or in English, although we haven't made any large-scale advertisement. The effectiveness and attractiveness of the system's adaption to English learning in China has been somewhat demonstrated by this practical achievement.

With the human-computer dialogues recorded in the database, we make a summarization of the system's chatting function from Jan. 20th 2007 to June 20th 2007. The different users who accessed the CSIEC during this period count 1783. The analysis of the demographic distribution of the users shows that more than half of the users are undergraduate students. The second large user population is middle school students. Except 45 students required to use the system in the evaluation, there are still 377 free users. Totally more than 80% of the users are different kinds of students.

4.1.1 Dialogue Duration

The chatting quality can be measured by the chatting duration between the user and the robot. To calculate the chatting duration we define two terms: round and number of the rounds. A round means a user input and a corresponding robot output to the user. Therefore the total rounds of a given user cover all dialogs between the user and the chatbot, and can be used to describe the duration of the user's chatting with this chatbot. We divide the number of the rounds into 4 classes, as Table 1 shows.

Table 1. The relation between the duration of dialogues and number of users

Dialogue duration	Range of the rounds numbers	Number of users	Number of users/ Total user number	Number of users/ Total user number in [16]
Short	(0, 10]	871	48.85%	62,34%
Long	(10, 50]	685	38.42%	30,10%
Longer	(50, 100]	136	7.63%	4,78%
Very long	(100, 580]	91	5.10%	2,79%
Total user number		1783	100.00%	100,00%

The average rounds number is 27.4 (48840/1783). The number of the rounds from each user varies from 1 to 580. From table 1 we draw the conclusion that c.a. 49% of the users chat with the robot briefly (<=10 rounds); c.a. 46% (38.42%+7.63%) of them chat with it long or longer; and only few, c.a. 5%, chat with it very long (>100 rounds). Compared with our previous finding in [16] which is listed in the last column of Table 1, the percentage of the brief chatting with the robot has decreased by 21.78%. Proportionally the percentage of the long and longer chatting has increased.

4.1.2 The Distribution of User Chatting Patterns

The CSIEC system provides multimodal user interface and selectable chatting patterns. Thus we investigate the distribution of chatting patterns. 84.7% of the chatting is held with the free chatting pattern, and only 15.3% uses the chatting in a given context. The reason may be that the free users do not understand what is chatting in a given context very well so that most users of the context chatting are the students in our project English classes. Among the chatting for a given context the text pattern is used almost as frequently as the agent pattern. It can be explained by our team's assistant and tutoring about the system usage, especially the installation and usage of Microsoft agent characters, in every unit of the English class.

Among the free chatting more users select the text version instead of agent version. One reason may be that the text pattern is more simple and convenient than the agent version, as the unskilled computer users may encounter some setting problems, what is proven by some users' feedback complaining that they can't use the agent version.

Among the free chatting the chatting without spelling and grammar check (c.a. 66%) is much more used than with check (c.a. 18%). This result reflects most free users treat the system as a chatting partner, so they'd like to chat with it more fluently instead of worrying about grammar and spelling errors. Human-computer chatting is the most unique function of the CSIEC system, therefore the users like to fully use it.

4.1.3 User Feedbacks

In the foot of almost every webpage of the CSIEC system we leave a feedback text area so that the users can straightforwardly enter their comments, critiques and suggestions. Through analysis of the user feedbacks we find as many critiques as praises. For example there are the following positive comments:

The robot is more advanced than before, and also personalized.
The access speed is faster than before.

The dialogue is fluent. I hope the master to enrich the robot's language.
The kind of communication can improve our English.

The negative comments point out either technical problems or content shortcoming. Some complain that they can't use the agent version or the agent voice sounds curious. Other problems include: the access speed is too low, the robot response is too slow, the dialogue for a given context is too short, in free chatting the robot always repeat a same sentence, etc. These problems should be tackled in the further improvement.

4.2 Formative Evaluation of English Class Integration

After discussing with the English teachers about the class integration and evaluation of the CSIEC system we came to a decision that the instructional instruments are on one side the talk show by two chatting robots and on the other side students' talking in English with one robot on a given topic corresponding to the textbook content. The main application goal is to facilitate role-playing activities in the English classes.

45 high school students in Grade 2 attended the study, and the teacher required the students to use the system together in the computer room. For the 10 units course content we designed 40 scenario scripts for the role-play talk show and human-robot chatting. During the whole term we formally evaluated it through questionnaires, observations in the classes, surveys with teachers and students focus groups.

The survey contained 6 items about the students' attitude toward the CSIEC's application in English instruction: enhancing fluency of English, enhancing confidence in communication, enhancing learning interest, mastering practical expression, improving listening skills, and reviewing key points in course units. All they were measured with a five-points Likert agreement scale, i.e. the value 5 indicates the maximum best agreement, and 1 is no agreement. The mean is 2.5, 2.8, 3.3, 3.2, 2.9, and 3.3, respectively. It shows that high school students feel the CSIEC-based English learning can help with course unit review, make them more confident, improve their listening ability, and enhance the interest in language learning.

Another item in the questionnaire shows 60.5% of the students "*liked*" or "*liked very much*" such a form of English learning, whereas only 2.3% disliked it. 60.5% of them would continue using the system after class, even without the teacher's request.

Through the integration and assessment of the system in English class instruction, some new functions have been added to the system according to the students and teachers' suggestions and comments. They include the adjustment of speaking speed of the agent character, two robots talk show, unlimited gap-filling exercises, etc. Thus the application and evaluation guide the development of the CSIEC system in the direction of users' practical learning needs.

5 Conclusion and Discussion

The original goal of the system is supplying a virtual chatting partner for English learner. So the chatting is the most fundamental function. The statistical analysis about the users' behavior indicates that the users have a preference for chatting without spelling and grammar checking. This fact proves that the users prefer the

unique chatting function which is lacked in other systems. So we must continue to reinforce this primary utility.

The chatting quality can be somewhat demonstrated through the chatting length. The increased percentage of the long and longer chatting shows that the free chatting quality of CSIEC is becoming better. The underlying design principle, i.e. fully syntactical and semantic analysis of the user input, and communicative response mechanism, as well as the effort of chatting personalization and adaptation contribute to that quality progress. Certainly the content analysis of the dialogues should also be conducted furthermore in order to investigate the chatting quality more exactly.

The chatting on a given topic is mainly used by the students in the evaluation study, and is also the main function of the whole system the students have used. The formal evaluation results indicate the application of CSIEC system in English class can better assist their language learning, e.g., enhance the fluency of English, the confidence on English communications, the interest in English, the mastery of practical expressions, and listening skills. The planned system functions including free chatting and chatting on a given topic, and listening training have been brought into pedagogical play.

The CSIEC has been practically applied since its birth. We continue to improve its interface and content according to the user feedback, either from free Internet users or from the English class students. Such new functions as talk show and adjustable speaking speed of the agent characters are originally suggested by the users. The design, implementation, application and evaluation are not separated, but integrated together. This kind of application-driven research can quickly transfer the user's demands into technical implementation, and new emerging technologies into pedagogical application. It is also consistent with the design-based research theory, which came into birth in 1990s with the goal to fill the gap between the practice and the traditional evaluation research about the integration of technology and education, and to enhance the integration of technology into curriculum and learning efficiency through practice oriented research. It combines the learning environment design and theoretical development, and stresses the research via continuous and upgraded rotation of design, implementation, feedback and analysis [17].

Through the application and evaluation we find currently there are still some user requirements which haven't been fulfilled well, for example, the system's stronger ability of natural language understating and generation, which is the fatal factor influencing the human-computer communication, the lifelike synthesized agent voice and high response speed, which also have been addressed in the users' feedback. Solely in NLP many problems are still hard to be solved, such as the textual ambiguity and entailment [18]. How to overcome these problems with current available technologies is still a great challenge to us.

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