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Development and Validation of an Interactive Game Learning English with Recommendation System and Pronunciation Recognition

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Abstract*— Children possess fluent English proficiency by 2030 mandated by Ministry of Education. Universities do not offer compulsory courses and internships of English teaching. Preschool teachers have no required competencies to teach English that is the rationale for the study. The methodology is an experimental study on interactive games learning English with recommendation system and pronunciation recognition. There are 162 children aged 4-6 years from 3 & 3 International Education CORP with 72 of experimental group and 90 of control group. The underlying theory of recommendation system and pronunciation recognition are based on AI, deep learning, machine learning and natural language processing. Instruments developed include four animation English picture books, four interactive wall games learning English, and a recommendation system with a dataset. Equipment for human-computer interaction comprises radar instrument, laser short-cross projector, induction device and interactive wall. All records including pronunciation recognition keep update in dataset with a recommendation system. Experimental children reach significantly higher scores than those of control group. There are strongly significant positive correlations between motivation, confidence, favorites, and satisfaction in learning English in experimental group. One implication is to create employment opportunities of being a qualified English teacher. Another implication is to attract recruitment in universities.

***Index Terms*—Human-computer interaction, recommended system, pronunciation recognition.**

I. INTRODUCTION

The purpose of the study is to develop and validate four English animation interactive games with recommended system and pronunciation recognition for preschoolers. In order to propose research framework, the researcher review the theories and related studies on three index terms.

A. Human-Computer Interaction

Human interacts with computer is a sort of machine learning or deep learning. The larger the amount of data, the higher the verification rate of pronunciation recognition. Pronunciation recognition technology relies on natural language processing [1]. The mechanism of pronunciation recognition is machine learning. First of all, the researcher designs the database with the function of automatic analysis. Secondly, the researcher develops a vocabulary database. Thirdly, child's pronunciation will automatically be converted into text. Fourthly, the text will be automatically compared with the vocabulary database to recognize the accuracy of the pronunciation. Fifthly, the database is updated by deep learning through continuous training of natural language processing [2]. The practical application of this study is to provide feedback by accurately analyzing the pronunciation accuracy on the interactive wall screen. Pronunciation recognition accuracy depends on the massive data analysis and training [3].

B. Recommended Systems

Recommended systems are executed by popularity of the products based on collaborative-filter, content-based approaches, and a fuzzy expert system [4][5].

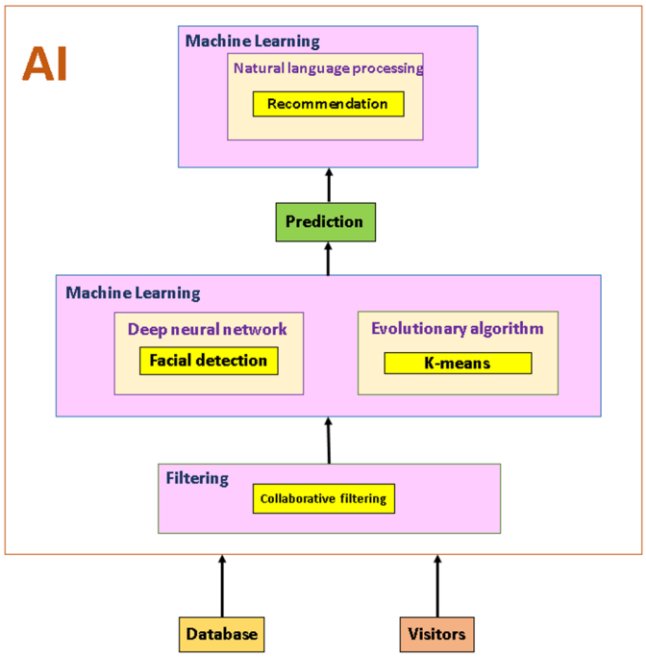

Fig.1 Interactive Games with Recommended Systems

This study is to invent two innovative techniques with the recommended systems and pronunciation recognition. The

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higher scores, the easier games. Recommended systems are designed to first pop out the highest score game for child to interact for success. The indicators of the validation are child's motivation, confidence, favorites, and satisfaction in learning English. This study intends to validate that the recommended system and pronunciation recognition to individualized generate interactive games customized by the most appropriate difficulty level.

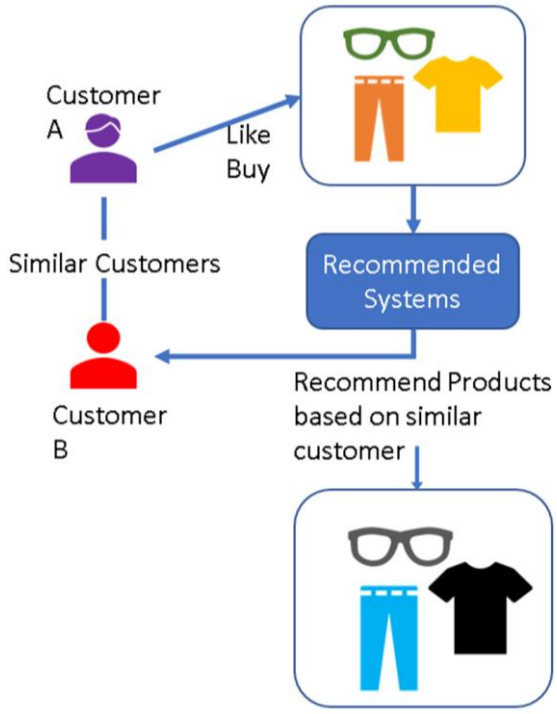

Fig. 2 Conceptual Framework for Recommended Systems

C. Pronunciation Recognition

Pronunciation recognition is a technique that applies natural language processing, deep learning and machine learning [6]. In this study, we set up a database with statistical analysis function. The researcher uses fuzzy theory, natural language processing, artificial intelligence, and machine learning. It was found that the more data analyzed, the more opportunities for machine learning and training, and the more accurate the pronunciation recognition will be [7][8].

How does this study determine whether a child pronounces English correctly?

1) Algorithmic Procedure

a) Use Google voice service or Amazon's Alexa voice service. Pronounce the text in English.
b) Use a recording device to record child's pronunciation.
c) Evaluate the accuracy of the pronunciation by comparing the above two pronunciations using a pronunciation recognition evaluation algorithm. A score will be calculated.
d) There are *two types of pronunciation recognition assessment algorithms* that can be used here.

- *Traditional algorithms*: Levenshtein's distance algorithm, DTW algorithm, etc. The Levenshtein's distance algorithm can be used to evaluate the accuracy of the above two items.
- *Modern deep learning algorithms*: Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Transformer, and so on.

2) Tools Available

a) Praat: This is a free acoustic analysis software. It can be used to compare acoustic waveforms, analyze speech intonation, and so on. It provides a series of analysis tools and speech synthesis tools to help users in their speech research.
b) Wavesurfer: This is a free open source acoustic analysis software. It can be used for acoustic waveform comparison, speech intonation analysis, pronunciation recognition, and more. It supports a variety of sound formats, including WAV, MP3 and so on.
c) SpeechAce: This is a web application. It helps users to practice and evaluate their pronunciation. It provides an easy-to-use interface that allows users to record their own pronunciations and compare them with standard pronunciations. It also provides detailed evaluation reports on pronunciation accuracy and fluency.
d) LinguaMetrics: This is a machine learning based speech evaluation platform. It can be used for acoustic waveform comparison, speech recognition, and more. It is based on advanced speech recognition and acoustic analysis techniques. It can help users to quickly and accurately assess the accuracy of their pronunciation [9].

II. METHODS

A. Methodology

The method of the study is experimental methodology. The experimental treatment is English animation interactive games with recommended system and pronunciation recognition. The underlying theory of recommendation system and pronunciation recognition are AI, deep learning, machine learning and natural language processing [10].

B. Participants

There are 162 children aged 4-6 years from 3 & 3 International Education CORP with 72 of experimental group and 90 of control group.

C. Instruments

Instruments developed include four animation English picture books, four interactive wall games learning English, and a recommendation system with a dataset. Equipment for human-computer interaction comprises radar instrument, laser short-cross projector, induction device and interactive wall.

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Fig. 4 Schematic diagram Pronunciation Recognition Programming

Fig. 4 explains the pronunciation recognition programing schematic diagram.

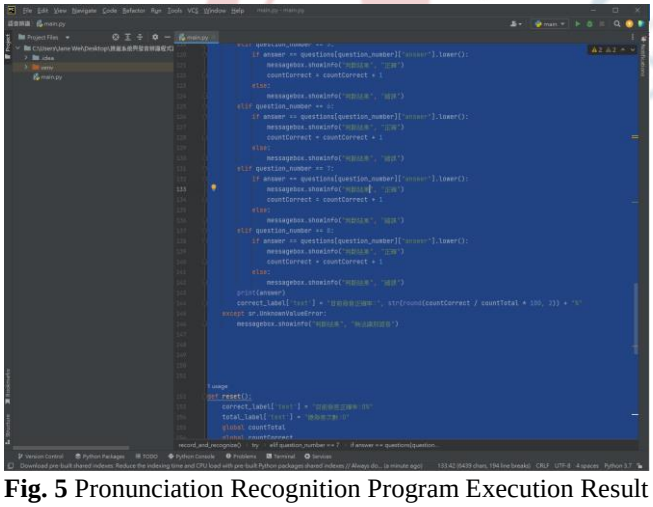

Fig. 5 Pronunciation Recognition Program Execution Result

Fig. 5 shows the execution results of pronunciation recognition programming.

D. Procedures and Analysis

1) *Interactive Game Operational Instruction Video*: This study first develops the interactive game playing methods animation short.

2) *Develop Four English Animation Interactive Games with Recommended System and Pronunciation Recognition*:

In this study, four English picture books were developed into four sets of English animated interactive games. Each set of English animated interactive games was divided into four lessons for children to choose from. Each lesson consisted of three parts: video viewing, interactive games for learning English (including unlimited pronunciation recognition practice games), and game assessment. A total of 16 sets of English animated interactive games, 32 interactive game assessments, and 4 pronunciation recognition game assessments were developed in this study.

3) *Design Database Functions*: According to the research purpose, define statistical functions each column.

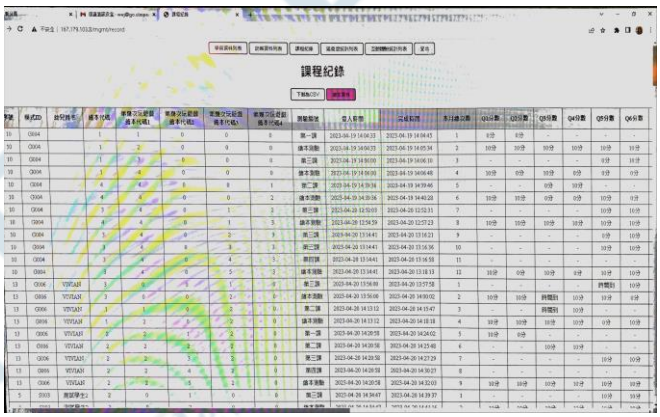

Fig. 6 Database Design with Automatic Statistical Analysis Function

This study analyzed the correlation between the response rate and the number of seconds of response in the eight-question game assessment of each picture book to verify the validity of the recommendation system. The higher the answer rate, the lower the difficulty level. The lower the response seconds, the lower the difficulty level. The correlation between the response rate and the number of seconds should show a significant negative correlation.

4) Develop Database Programming Source Code

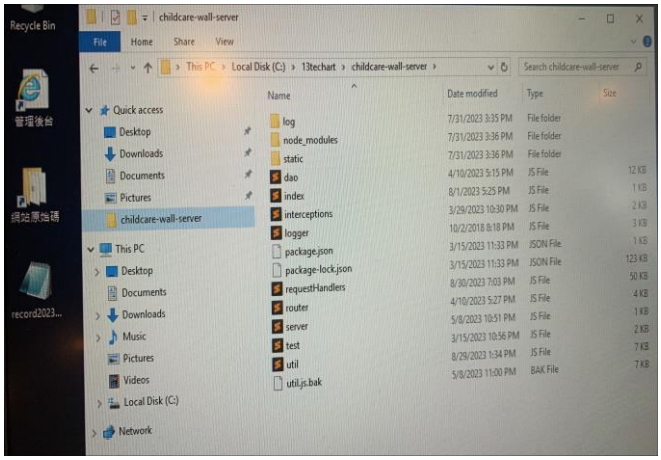

Fig. 7 Recommended Systems and Pronunciation Recognition Database

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5) Clouding Raw Data Files

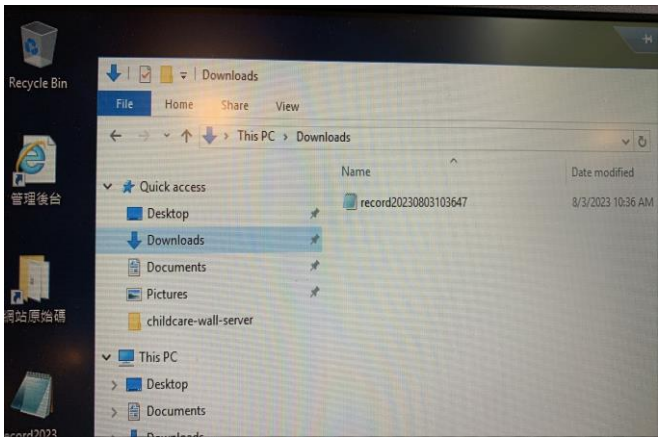

Fig. 8 Clouding raw data files

Fig. 8 indicates front-end data uploading of clouds-stored child record files to database.

6) Recommended Systems Programming

This study analyzed the correlation between the exact response rate and the number of seconds of response in the eight-question game assessment of each picture book to verify the validity of the recommended systems. The higher the exactly answer rate, the lower the difficulty level. The lower the response seconds, the lower the difficulty level. The correlation between the correct response rate and the number of seconds should show a significant negative correlation.

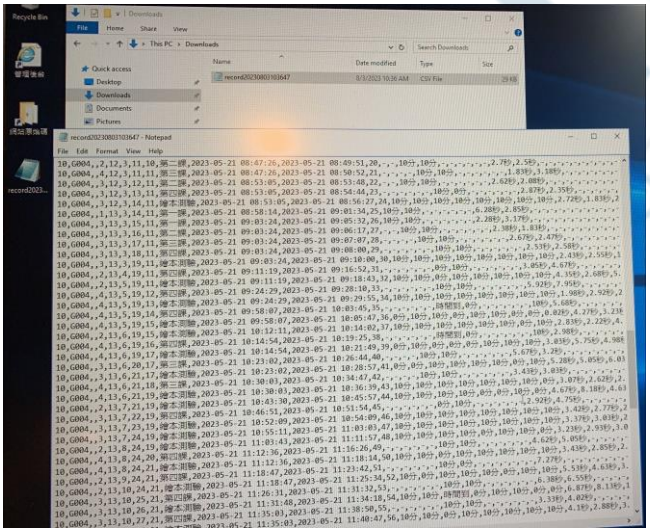

Fig. 9 Seconds taken to interact with eight quiz games

Fig. 9 shows that the raw data of seconds and accurate answers of Q1~Q8 games difficulty criteria for the recommended systems validation. The difficulty level depends on the length of time that all children interact with the eight quiz games. The shorter the time, the easier it is. The recommended system first pops out the easier game for learning. Recommended systems may increase children's adhesion to the game. Also, the recommended system creates individualized learning and sense of achievement.

7) Log in to the database administration backend

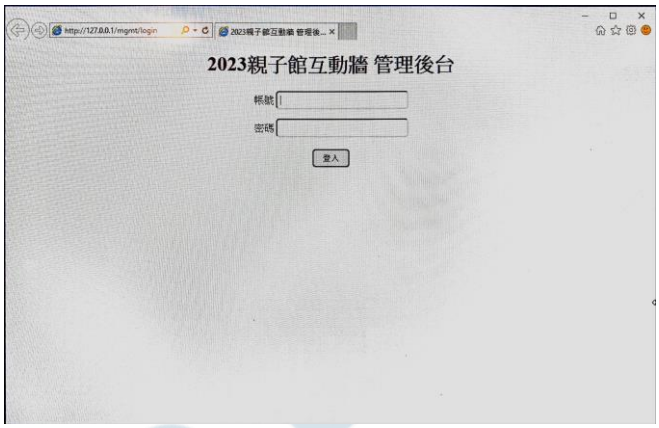

Fig. 10 Back Office Management Platform

According to research purpose, the study designs database columns with automatically statistical function. Researcher can download the raw data and further run SPSS as needed.

8) *Develop database*

Database development is the basis for recommending systems. The more data you have, the more accurate the recommendation will be.

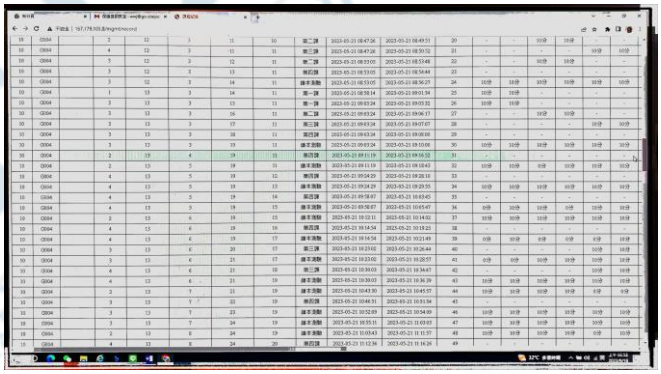

Fig. 11 Clouding raw data files

Thirty children were individually selected from four animated picture books. Each animated picture book has four short films. Children selected one short movie to learn English through interactive play. Children were assessed with eight games. All children's learning records are uploaded to the database.

It is recommended that the system be able to identify more appropriate learning modes and progress trajectories in a single animated picture book interactive wall teaching material, or in the whole set of four animated picture book interactive wall teaching materials.

a) If the seconds of completion are calculated separately for each animated picture book interactive wall game, it can be regarded as the ease of learning (difficulty level) of different animated picture book materials. The average number of seconds of completion for material A is lower (lower difficulty level), and the average number of seconds of completion for material B is higher (higher difficulty level), so it can be ranked

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as the more suitable "Recommended Learning Trajectory" of learning A and then B. b) If the seconds of completion are calculated for each question, it can be regarded as the recommended learning sequence of the same illustrated picture book materials.

b) If the number of seconds completed is calculated by each question, it can be regarded as the recommended learning sequence for the same picture book material.

9) *Formal Experiment*

E:\電競筆電桌面檔案\口頭發表用檔案\An example of one child participates in the experiment.MP4

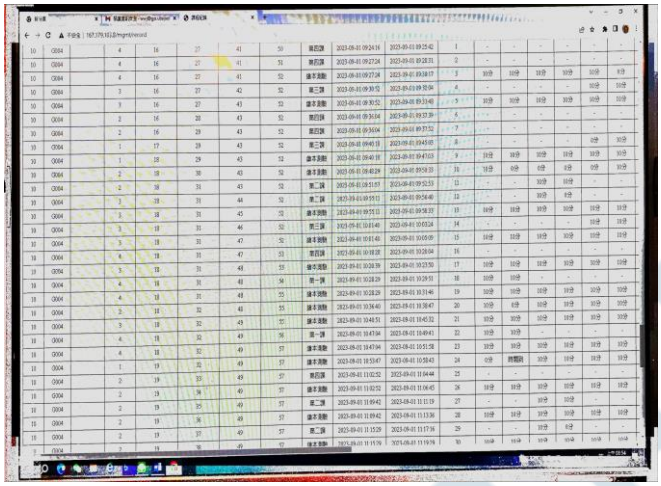

Fig. 12 Recommended System Raw Data

Children choose one of the four English animated picture books. Toddler A chooses one of the four short, animated movies to enjoy the content. Children start to play the interactive game to learn English pronunciation. The recommendation system randomly plays the first question of the game to the children. The recommendation system finds the closest child's score to the first question in the database, child B, and recommends it. Sequence B's eight scores. Recommend the game to A in order of B's score.

10) *Recommend the learning effectiveness of interactive games for learning English* :

A) English Pronunciation Accuracy Recognition: The child's pronunciation is converted to text. The system recognizes the correctness of the words.

B) Correctness Analysis: Correctness = (number of correct questions/8) *100%.

C) Difficulty Analysis: The system automatically records the number of seconds needed to complete the eight questions. The least number of seconds is the easiest.

D) Preference Analysis: Five-star rating to measure how much children enjoy the interactive experience.

E) Satisfaction Analysis: The five-star rating measures children's willingness to recommend the game to others.

11) *Validity and Reliability Study of the Recommendation System*:

This study analyzed the correlation between the response rate and the number of seconds of response in the eight-question game assessment of each picture book. The higher the accurate response rate, the lower the difficulty level. The lower the response seconds, the lower the difficulty level. The correlation between the response rate and the number of seconds should show a significant negative correlation. This study will conduct reliability study by Cronbach's α analysis.

12) *Data Cloud*:

All records including pronunciation recognition keep update in dataset with a recommendation system. Automated big data analysis with real-time database updates. Automatically download raw data for further analysis at any time.

III. RESULTS

Here is one case of English animation interactive games with recommended systems and pronunciation recognition. English animation interactive games have been validated that experimental children reach significantly higher scores than those of control group. There are strongly significant positive correlations between motivation, confidence, favorites, and satisfaction in learning English in experimental group.

A. Development of English Animation Interactive Games with Recommended Recognition and Pronunciation Recognition

1) Module of English Animation Interactive Games

Four English picture books were animated in this study (Fig. 13). The researcher develops each English animation picture book with four lesson short films (Fig. 14). In total, this study develops 16 sets of English animation interactive games, 32 games assessment, and pronunciation recognition games.

Fig. 13 Four English picture books were animated

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Fig. 14 Each animation was divided into four lessons

The content of the animation in each lesson consisted of three parts: a movie, an interactive game for pronunciation practice, and an eight-question interactive game for assessment (Fig. 15).

Fig. 15 Movie, interactive games for pronunciation practice, game assessment

In Fig. 15, child firstly watches movie for English learning. Secondly, child learns English by interactive games practice pronunciation. Finally, child plays for assessing learning effectiveness and pronunciation accurate ratio.

2) Development of English Animation Interactive Games with Recommended Systems

The first question of the first interactive game for Child A is the simplest game randomized by the system. The recommended system finds out of database that Child B's average score of the 8 test games is the closest to Child A's first question score. The recommended system sequences Child B's eight scores from highest to lowest score. The order of the games recommended by the system for Child A is from Child B's highest scoring (simplest and easiest to succeed) game to the lowest scoring game.

Fig. 16 Examples of assessing games

3) Development of English Animation Interactive Games with Pronunciation Recognition

Fig. 17 Pronunciation Interactive Games

Fig.17 shows that child use hand to approach learning target on the interactive wall and it will be sensed automatically with voices.

Fig. 18 Pronunciation Games Practices

Fig. 18 provides child no limits of opportunities to listen the voices as many times as he wants. Child may repeat pronunciation practices until he familiarizes it.

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B. Validation of English Animation Interactive Games with Recommended Recognition and Pronunciation Recognition

a) Content Validity Study on the Recommended Systems

Accuracy % and game seconds are two criteria for difficulty determination of recommended systems. The study analyzes the correlations between accuracy % and game seconds to validate the recommended systems. Results are in Table 1.

Table 1 Summary Table of Recommended System Difficulty Validation Results

Difficulty Analysis		Q1~Q8 Accuracy %	Q1~Q8 game seconds
Q1~Q8 Accuracy %	Pearson	1	-0.239*
	Significance		0.043
	Number	72	72
Q1~Q8 game seconds	Pearson	-0.239*	1
	Significance	0.043	
	Number	72	72

Table 1 indicates that there is a significantly negative correlation between correction % and play seconds ($r=-0.239^{*}$). Findings support that the higher correction %, the shorter play seconds. What does it mean that the child takes shorter time in interacting English animation games?

a) Child is very good at answering (the questions were simple, so he answers each question correctly and quickly) : Child reflects on positive response. The recommended system continues to recommend more difficult ones. The toddler keeps moving forward and forward to a higher difficulty level. Child is leveling up. He realizes that his level has increased. His confidence has increased, and he is able to move up to a higher level. The more he learns, the more his level increases, which means that the recommended systems can give positive learning effects.

b) Child feels very interested: No matter the answer is right or wrong, he keeps on playing, which means the interface is very beautiful and attracts me, so he keeps on playing. He thinks it is fun, so he interacts quickly and takes very little time for each question. Child is active in learning. He keeps repeatedly practicing and interacting with each other because it is fun.

c) Child who does not have a sense of learning to play casually: Just for fun, he keeps interacting and finishing each question very quickly, in fact, should not achieve the effectiveness of learning. Just because of the novelty and fun to operate a little.

d) In addition to the difficulty of operating for a long period of time, it may also reflect the confusion problem. However, with this test subject, it is not possible to analyze this data because almost all of them are beginners or first-time users, while some of them are very good at it because they have already learned it. In the absence of repeated practice, the errors in the responses were only due to short-term memory failures or inattention and should not have been to the extent that confusion and indecision between the two answers resulted in a long response time. The time spent on studying is too little, and the level of proficiency is not yet advanced.

b) Effectiveness Evaluation on English Animation Interactive Games with Recommended Systems and Pronunciation Recognition

Table 2 Descriptive statistics analysis of two groups children for "Little Benny Has a Farm" theme

Learning Score of English	N	Mean	Standard deviation
Control group	27	8.9120	1.96264
Experimental group	23	7.8804	1.61820

Table 3 t-test of two groups children for "Little Benny Has a Farm" theme

scores	F test	Significance	t	degrees of freedom	Significance
	0.001	0.981	2.005*	48	0.05

From Table 2 and Table 3, it can be seen that the means of the two samples were 8.9120 and 7.8804 respectively, and the Levene test for homogeneity of variance was not significant ($F=0.001$, $p=0.981>0.05$, n.s.). There is no significant difference in the dispersion between the two samples. The t-value and significance of equality of variances were found to be significant for the test. Findings indicates that there are significant differences between the experimental group (interactive wall game learning) and the control group (traditional paperback picture book teaching) children in terms of English learning achievement ($t_{(48)}=2.005^{*}$, $p=0.05$). Related studies support that child's learning effectiveness is significantly better with Kinect interactive games than touching games [11].

c) Reliability Study

Table 5 indicates that Cronbach's Alpha 0.744 is a high reliability coefficient.

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Table 4 Summary of Observation Processing

		Number	%
Observations	Valid	90	100.0
	Exclusion	0	.0
	Total	90	100.0

The Cronbach's alpha coefficient value for the seven items measured in this study was 0.744, suggesting that the seven items had a high degree of internal consistency. Generally speaking, the degree of consistency of the items is related to the content of the measurement, and the larger the Cronbach's alpha coefficient value, the stronger the internal consistency. Previous studies have suggested that as long as the Cronbach's α coefficient is greater than 0.7, we consider that the consistency between items is better.

Table 5 Reliability Statistics

Cronbach's Alpha	Cronbach's alpha for standardized items	Number of items
.744	.760	8

Table 5 states that the standardized reliability coefficient is 0.760, corrected to take into account the effect of unequal variance of individual questions. The Cronbach's alpha 0.760 based on Standardized Items ("Cronbach's alpha based on Standardized Items") refers to the Cronbach's alpha coefficient calculated by standardizing all items with a variance of 1. It is also known as the Spearman-Brown stepped-up reliability.

Table 6 ANOVA

Source of Variation		Sum of Square	df	Mean square	F	Sig
Between people		2181.563	89	24.512		
Within	People	144.410	7	20.630	3.288	0.002
	Between measure	3908.715	623	6.274		
	Residual	4053.125	630	6.434		
Total		6234.688	719	8.671		

Grand mean = 9.0208

Table 6 is a summary Table for Analysis of Variance Test.

ANOVA is used to test the significance of a reliability coefficient of an entire model (F=3.288**, p=0.002<0.01).

IV. APPLICATIONS AND SUGGESTIONS

A. Applications

1) *Interactive Wall Games Learning English with Pronunciation Recognition:* One application is to create employment opportunities of being a qualified English teacher. Another implication is to attract recruitment in universities.

2) *Interactive Wall Games Learning English with Recommendation Systems*:

It is recommended that the system be able to identify more appropriate learning modes and progress trajectories in a single animated picture book interactive wall teaching material, or in the whole set of four animated picture book interactive wall teaching materials.

a) If the seconds of completion are calculated separately for each animated picture book interactive wall game, it can be regarded as the ease of learning (difficulty level) of different animated animation interactive game. The average number of seconds of completion for material A is lower (lower difficulty level), and the average number of seconds of completion for material B is higher (higher difficulty level), so it can be ranked as the more suitable "Recommended Learning Trajectory" of learning A and then B.

b) If the seconds of completion are calculated for each question, it can be regarded as the recommended learning sequence of the same illustrated animation interactive game.

c) If the number of seconds completed is calculated by each question, it can be regarded as the recommended learning sequence for the same animation interactive game.

B. Suggestions

This study intends to apply for a patent for the invention of "Parent-Child Interactive English Story-Oriented Contextual Experience System with AI Machine Learning to Determine the Correctness of English Readings", which is an exclusive right to exclude infringement and claim damages for the unique technical parts of the technology that are innovative, progressive, or effective in its methodology.

This study will work towards technology transfer. The specialized techniques that will be transferred in this study are:

1) AI Machine Learning Pronunciation Correctness Interpretation.
2) Production and application of bracelet sensors.
3) Hardware and software integration development and construction.
4) Interactive wall game English recommendation system.

This study will endeavor to train the following technical personnel in the direction of entrepreneurship, create employment opportunities, and increase enrollment.

1) Train interactive picture book content development technical personnel: Develop human resource who are responsible for scene design, animation design, interface design, English voice-over, background music and sound effects.
2) Train interactive equipment environment construction technology: Develop human resource who are

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responsible for field space measurement hardware construction, including short-focused single shotguns, bracelets and sensor pillars, Bluetooth modules, wireless microphones, hosts and other hardware facilities troubleshooting and maintenance.

3) Develop backend database developer: Develop human resource who are responsible for program manager, front and backend interface and system analysis.
4) Develop machine learning AI Recognition Technician: Develop human resource who are familiar with unity interactive program design, AI machine learning to judge the accuracy of English reading, Google Cloud voice-to-text API.
5) Develop early childhood American teacher training talent: Create employment opportunities and attract enrollment.

V. CONCLUSION

A. Review the Main Points of the Paper

What are the main points of recommended system and pronunciation recognition for kindergarten teachers, university researchers, program developers, and funders?

1) Kindergarten teachers can know the distribution of difficulty from Q1 to Q8. The last question in the recommendation order is the one that is difficult for children to cross.
2) Teachers, university researchers, and program developers can get feedback and modifications. For example, teachers can give hints or ask questions in different ways. The teacher identifies the child's bottleneck. Teachers can chop up the pain points a bit and learn them in segments. University researchers and program developers can break down the most difficult game topics into three parts for repetition.
3) Recommended systems and pronunciation recognition for parents: Parents can learn English with their children. Parents become companions.
4) Recommended systems and pronunciation recognition for funders: The partner company knows what is easy for teachers of young children to learn. The partner knows what is easy for teachers to learn and what is not. The curriculum can be revised. The sponsor can see the effectiveness of the teacher training in teaching American as a foreign language.
5) Ease of learning has two aspects. a). The content itself is easy to learn: This is the objective beginner level. b). The program is designed to be easy for the learner to learn: The program is friendly and designed to be easy to learn. Where can this be differentiated? It can be seen as a direction to continue design research and add more information.
6) If the seconds of completion are calculated separately for each animated picture book interactive wall game, it can be regarded as the ease of learning (difficulty level) of different animated picture book materials. The average number of seconds of completion for material A is lower (lower difficulty level), and the average number of seconds of completion for material B is higher (higher difficulty level), so it can be ranked as the more suitable "Recommended Learning Trajectory" of learning A and then B. b) If the seconds of completion are calculated for each question, it can be regarded as the recommended learning sequence of the same illustrated picture book materials.
7) If the number of seconds completed is calculated by each question, it can be regarded as the recommended learning sequence for the same picture book material.
8) The recommendation system can identify more appropriate learning modes and progress trajectories in a single set of animated picture book interactive wall materials or in the whole set of four sets of animated picture book interactive wall materials.

B. Elaborate on the Importance of the Work

1) One of the innovative values of AI is to use AI machine learning technology to analyze the accuracy rate of reading English picture books aloud by young children or parents and children, so as to enhance the interest of parents and children in reading English together.
2) The second is that, because of the use of the bracelet to store it up, in addition to parent-child libraries, it will be developed into the field application of English learning in after-school classes (tutoring classes) or picture book libraries in the future (targeting at the parents and children who come to listen to English picture books on a regular basis will have a schedule).
3) Promote the recommended systems and pronunciation recognition to be applied to more than 60 early childhood education organizations (including kindergartens, non-profit kindergartens, parent-child centers, and tutorial classes) currently operated by the partner companies, to help the partner companies extend their industries in the future, and to accumulate children's progress to where they are, and then continue to extend them down the road.

C. Suggest Applications and Extensions.

Decision makers can rely on the data base and recommendation system trajectory to find out the learning mode, learning level, and gap between urban and rural areas.

For business, there can be different business models or product planning according to different regional targets;

For education authorities, there can be education policy programs to promote, enhance the disadvantaged, identify the strengths of the key cultivation targets, is a policy direction, just need a strong backing investment, implementation, or leading the trend to promote, but also need a lot of money and financial resources, but that would be outside the scope of the discussion, professors are responsible for the output, and those who have the heart and money are responsible for the implementation and make money [12].

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