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Employing Humanoid Robots for Teaching English Language in Iranian Junior High-Schools

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This paper presents the effect of *robotics assisted language learning* (RALL) on the vocabulary learning and retention of Iranian English as foreign language (EFL) junior high school students in Tehran, Iran. After taking a vocabulary pre-test, 46 beginner level female students at the age of 12, studying in their first year of junior-high participated in two groups of RALL (30 students) and non-RALL (16 students) in this study. The textbook used was the English book (Prospect-1) devised by the Iranian Ministry of Education for 7th graders, and the vocabulary taught and tested (pre-test and post-test) were taken from this book. Moreover, the treatment given by a teacher accompanied by a humanoid robot assistant in the RALL group took about five weeks in which half of the book was covered, and the non-RALL group was taught in a traditional method. Finally, the teacher administered the post-test and delayed post-test whose results of repeated measures ANOVA and Two Ways ANOVA indicated that there was a significant difference regarding participants' vocabulary gain and retention in RALL group comparing to non-RALL group. In addition, the teacher reported the students' positive reaction to RALL in learning vocabulary. Overall, the results revealed that RALL has been very influential in creating an efficient and pleasurable English learning environment. This study has some implications for technology-based education, language teaching, and social robotics fields.

Keywords: Humanoid robots; RALL; second language learning; educational technology.

1. Introduction

For over 50 years, a great deal of effort has been made to improve human efficiency by utilizing robots. Since their invention, robots have been developed to meet specific purposes and needs, quite similar to personal computers in their early days. With the advancement of technology and reduction of costs, it is anticipated that in the near future, one of the cutting-edge technologies to be used in various social, therapeutic, cultural, and educational areas such as "*language teaching and learning*", will be social robotics. Humanoid robots will soon gain more attention as an effective tool for 1st and 2nd language teaching in middle-schools/high schools around the globe.

In recent years, novel applications of robots in the form of socially assistive robots (SAR) have been observed and explored as teaching assistants in a variety of arts and science courses. Since robots tend to capture the interest and imagination of younger students, they have been applied as useful assistants for the teaching of Mathematics and Physics.[1] This and many other examples clearly show that the application of robots is no longer limited to traditional engineering departments and manufacturing industries, but is distributed across a variety of socially important fields like humanities and medicine. As a result of this novel approach to robotics, the use of robots by non-engineering/non-technical instructors has been referred to as a "*robotic revolution*".[2] Due to the rapid development of information and communication technology, teachers, material developers, and educators are trying to keep up with the dramatic changes in our electronic environment.[3–6]

Recently work on *computer assisted language learning* (CALL) and *mobile assisted language learning* (MALL) has taken a great leap in the realm of second language acquisition.[6–10] However, since the mid-2000s robots have also been explored as helpful and innovative tools that have come to the aid of language teaching and learning.[11–14] The work presented here focuses on the study of the adaptable social, interactive, and cognitive aspects of robot behavior in an assistive context designed for young students/individuals seeking to learn English as a 2nd language. We have explored a novel system based on robotics assistive language learning (RALL) trying to provide a more flexible and customizable protocol through motivation, culture, encouragement, and companionship to middle school/high school students in their English language courses in Iran. Initial results indicate that this approach can engage the students and keep them interested in interacting with the robot, which, in turn, increases their positive behavior when it comes to language learning and practice. Even-though humanoid robots today are generally developed for special purposes, it is hoped that in the near future with their mass production along with cost reduction, great changes will be brought about in the art of language teaching/learning process with the use of robotics technology.

2. Shaping of Art with Technology

Teaching and learning a language is known to be an interesting art which combines science and culture with geographical location to produce a person with greater communication capabilities. As an example, taking a look at the language learning process, learning and retaining vocabulary is known to have a great effect on language proficiency. Furthermore, lack of lexical knowledge has been considered as one of the main obstacles to effective communication.[15] Throughout the recent history of language teaching methods, from the audio-lingual method to communicative language teaching (CLT), vocabulary was deemphasized and considered of little importance. However, recently more attention has been paid to the investigation of incidental and intentional learning of vocabulary,[16] use of visuals for better retention,[17,18] application of computer in vocabulary learning/teaching, and the use of MALL for vocabulary learning.[7–10] Nonetheless, very few studies have attempted to design and evaluate vocabulary learning with the help of a robot.[13] Their study concentrated on vocabulary development of a toddler and no studies have focused on the vocabulary learning and retention of junior/high school students using robotics technology thus far.

2.1. *How robots can help language/vocabulary instruction*

The oldest writing systems are known to be between 5100 and 5500 years old.[19] The oldest cave paintings used in communication dates back more than 40,800 years.[20] Humanity has been expressed through visual imagery rather than written words for more than 35,000 years. Also, human desire has always been to replicate itself starting by carving static statues, through mechanical dolls to play music in the mid-1700, and present day robots.[21,23–27] Even today, with complex writing systems at our disposal, people still process visual images more rapidly than text. In the context of studying vocabulary, this has inspired new methods of learning new words, one which turns away from traditional methods and seeks to engage the student's memory in a variety of ways. Humanoid Robots as moving and performing visual objects can be highly effective in the transfer of knowledge and certainly enhance the vocabulary learning process for young students. Developing an extensive vocabulary and using the words accurately in speech and writing is a challenge faced by many foreign students learning English as a second language (ESL).

With humanoid robots as teaching aids, a novel approach to language learning can be anticipated so that young students are able to not only learn new vocabulary words, but commit them to long-term memory with the ability to recall and use them accurately. This is due to the attractive nature of robots that can be programmed to employ and combine definitions with interactive examples to reinforce the new word the student has just learned. By developing and utilizing their intelligence skills through the use of robot, one can expect students to be able to more easily remember new vocabulary. As an example, robots can be readily programmed to play a charade game with students.

2.2. *How robots can increase vocabulary retention in young students*

It is well recognized by scientists that "communication through language" has been the greatest achievement of the human species. Yet, we are unable to communicate if we lack the vocabulary to do so. Young Iranian EFL junior high school students like many other foreign students learn new words largely through example and experience, and not by learning definitions from a dictionary. They learn new words through communication with their environment. However, at a certain age, less of their vocabulary learning comes naturally, and more of it comes through formal education, learning lists of new words in a classroom setting. Obviously, in order to retain new words and use them correctly, they need to practice them extensively. Utilizing various methods of learning new vocabulary, students are better able to remember and use them correctly. This is due to the fact that the more often the word is used, the more easily it transfers to the learner's long-term memory. Short-term memory has a small storage capacity and simply holds information temporarily. To ensure that the new word is stored in the student's long-term memory, new methods must be used.

It is the following features and characteristics of robots that make them an ideal teaching aid to support and enhance language instruction alongside teachers: *Repeatability*; the ability to repeat an action many times without becoming tired/restless, *Humanoid Appearance*; with a human-like appearance robots are easily accepted by students as real teacher assistants which can help to engage and motivate students as well as helping to reduce their anxiety level which plays a crucial role in the learning process, *Intelligence*; this feature helps robots communicate effectively with humans and computers through artificial intelligence, programming, and Wi-Fi systems which preserves many advantages of the previous media for instruction, *Sensing Capability*; gives robots the ability to sense surroundings and awareness of its environment by light/camera sensors (eyes), touch and pressure sensors (hands), chemical sensors (nose), hearing and sonar sensors (ears), and even taste sensors (tongue), *Flexibility*; the ability of being adjusted to the specific level of the learners, *Interaction*; their ability to interact with students effectively and greatly impact the language learning process, *Body Motion/Mobility*; the ability to move and use appropriate gestures when speaking can also greatly enhance the language learning process, *Adaptability*, robots have the flexibility to be programmed and are capable of being readily adapted/adjusted to the specific level of the learner.

Robots as teaching aids can effectively help in defining and practicing new vocabulary with the students so that they can understand the sense of what is being conveyed. This method is obviously superior to cramming a vast amount of information into short-term memory, as it provides the learners with the opportunity to fully integrate new words into their own vocabulary and retain them for long-term use.

A recent trend in vocabulary teaching/learning has been to apply multiple ways of learning new words, such that students can perceive the input through as many channels as possible in order to reinforce the new vocabulary in his/her mind. Therefore, it is important to include a variety of stimuli in teaching. One should also recognize that what works the best for one student may not always work as well for another (Dunn and Griggs: "Learning style is the biologically and developmentally imposed set of characteristics that make the same teaching method wonderful for some and terrible for others").[22] Since students learn in a variety of ways, it is important to include multiple methods a student can take in their study of vocabulary. While some students equipped with RALL may get motivated and gain quicker and more in-depth knowledge from conversation practice and interactive experience with robots, other students may benefit just as well from visual stimulation, tangible objects and/or flashcards. Due to different learning styles, each student may benefit more from a specific type of information. With RALL system, which will be discussed in further detail later, many different options are available to the student.

The main concept behind the development of RALL in vocabulary teaching/learning is the idea of artificial intelligence and robotics which are interlinked with the instructional material and are made to perform the role of a native speaker in the classroom. With conventional methods, there is more emphasis on written definitions and examples. Images are occasionally used, especially in EFL or ESL texts, but not to a comprehensive degree. Most often they are used to depict objects, scenes, or easily illustrated actions or emotions.

2.3. *What is RALL?*

In countries where English is considered as a foreign language, various methods are being used to help the learners become exposed to real-life environment. Direct collaboration with a native speaker has been proven to be the most effective way of instruction[6]; however, in the absence of a native speaker, utilizing computer or mobile-based applications in the classroom may seem the second best choice. Yet, due to the limitations of computers and mobile systems in engaging students and providing an interactive environment other sources of technology have been looked into. Among the fastest growing technologies that have proven to be beneficial to the language learning process are robots. For example, while the idea of creating multiple forms of examples for each word is appealing, it is also a daunting task. Teachers often lack the time and patience that is required to create meaningful examples for long vocabulary lists.

By employing a *Robotic* system and resource available to them as a teaching assistant, teachers will be able to teach vocabulary in new ways, using the previously programmed humanoid robot to reinforce the vocabulary lessons they give their students in the classroom. RALL does not seek to replace teachers in the area of vocabulary instruction, but rather to assist and supplement their lessons and reinforce the material that is being learned by repeated practice. RALL can offer this help in a variety of ways. While similar concepts have been studied, only a few systems have been developed such as intelligent methodology for language teaching and learning.[5,6,11] Depending on the number of words saved with premium content in the RALL's base computer, multiple methods to teach a new vocabulary can be experienced in classroom/home environment with the humanoid robot acting as a live talking dictionary.

Like any fine human teacher RALL provides the student with the option to question and request vocabulary explanation. A robot assistant may provide the learner with not only the word and its definition, but also an example sentence, an audio clip of the word's pronunciation and description. Robot descriptions and audio/interactive entertainment serves as a memory aid to further reinforce the meaning of the new word in the student's memory. It is well known by the experts in the field that the brain processes visual interactions with moving objects or humans more rapidly, and some people are better learners than others, when live interaction reinforces the meaning of the word.

An intelligent RALL system equipped with voice command/recognition and vision capability can provide an opportunity for discussion, and prompt students to think of the word or concept in their native language and make associations with the English word. One other option for RALL can be the advanced quiz capability. Teachers or students can create quizzes based on pre-set word lists, or create their own unique sets of words. Learners have the option of quizzing themselves using words, images, definitions, or example sentences. These RALL quizzes reinforce the words the student is learning, and will continue to re-use the same words until they have been answered correctly. With such an integrated system, it is easy for students to create quizzes that match the words they have been studying.

A well-designed RALL system is ideal for use by a variety of individuals: junior high school students, teachers, ESL and EFL students, and students who are studying vocabulary for a variety of standardized tests. For teachers, it has many advantages, as it is an interactive tool and can be used to stimulate classroom discussion and reinforce concepts and words learned in class. It is believed by the researchers in the field that the more opportunities a student receives to practice new vocabulary in multiple formats, the better he/she will be able to retain it. We believe that exposure to vocabulary by the RALL system may increase the likelihood of retention, which in turn improves the student's overall vocabulary bank and improves his/her ability to communicate effectively.

2.4. *Studies done on RALL*

Research on RALL started around 2004, with Kanda *et al.*'s research on the ROBOVIE robot.[14] Their work was conducted between first and sixth grade elementary students in Japan, which interacted with ROBIVIE in English during recess for two consecutive weeks, and predicting an improvement in English proficiency during the 2nd week. The next most influential research on RALL was conducted on the robot named IROBI. Han and colleagues compared learning with a robot and computer assisted learning in Korea.[3] The results proved IROBI to be more effective than the computer. In 2006, You *et al.* conducted a study on ROBOSAPIEN in Taiwan, where an infrared remote controllable toy-robot used five modes to enhance the learning process: storytelling mode, question and answer mode, cheerleader mode, let's act mode, and pronunciation leading mode.[28] Furthermore, in 2008, Hyun *et al.* studied the use of a robot in the vocabulary learning of preschoolers.[29] The results showed a significant improvement in the preschoolers' vocabulary, story building and understanding and recognition of words compared to computer-based teaching methods. The RUBI robot, used in the study conducted by Movellan *et al.* in 2009, also showed vocabulary improvement in preschoolers compared to computers.[13] In 2011, Park *et al.* designed class material in such a way as to sustain the children's interaction with the robot ROBOSEM, to arouse their motivation and to facilitate the learning process.[30] The results showed a great improvement after four weeks of treatment with ROBOSEM. To date, and within the last decade other interesting and valuable researches were performed in social robotics and human–robot interactions concentrating on various forms of language teaching and learning that has greatly influenced the evolution of RALL research in its present form, some of which are referenced here.[31–39]

3. Research Goals and Objectives

The objective of this research was to study the effect of RALL on enhancing the quality of teaching English as a 2nd language to young middle-school students in Iran. Through our integrated holistic model, robotics and computer engineers along with applied linguists came together to provide a unique structure for teaching and research to assist the 2nd language learning process. Some of the projected educational, economic and societal impacts of this project are listed as follows:

- Enhanced quality of 2nd language learning and increased interest among young learners at middle-schools.
- Reduction and/or elimination of costs for hiring native instructors to teach in EFL classes in Iran.

3.1. *Specific research questions*

Question 1. Is there any significant difference in the RALL group's pre-test and immediate and delayed post-tests vocabulary gains of Iranian junior high school students as measured by their vocabulary knowledge breadth?

Question 2. Is there any significant difference in the non-RALL group's pre-test, immediate and delayed post-tests vocabulary gains of Iranian junior high school students as measured by their vocabulary knowledge breadth?

Question 3. Is there any significant difference in the RALL and non-RALL groups' immediate and delayed post-test vocabulary gains of Iranian junior high school students as measured by their vocabulary knowledge breadth?

4. The Methodology

4.1. *Participants*

This study examined the effect of RALL on vocabulary learning and retention of Iranian EFL junior high school students in a private school in Tehran. A total 60 female students at the age of 12, studying in their first year of junior high participated in this study. They all took a vocabulary pre-test beforehand and those who were at the beginners' level totaling a number of 46 were chosen for the study. The mean evaluated for the pre-test was 13.46 and the students who had received a score of two standard deviations above and below the mean were chosen for the study. About 30 students were randomly chosen and then assigned to the RALL class, and 16 students were assigned to a control group (non-RALL group). The textbook used in this study was the English book (Prospect-1) devised by the Ministry of Education for 7th graders and the vocabulary taught and tested were taken from that particular book. Moreover, the treatment took about five weeks in which half of the book was covered.

4.2. *Instruments*

The present study used the following instruments to collect the necessary data.

4.2.1. *The humanoid robot*

The main instrument used in this study was a kid-sized, autonomous, programmable, humanoid robot NAO developed by Aldebaran Robotics (see Fig. 1).[23] We renamed this robot Nima (a Persian name for boys) for better interaction with Iranian students.

The height of the robot is 57.3 cm, width and depth of 31.1 and 27.5 cm, respectively. It also weights about 4.3 kg.

The robot used for this study was the Robocop version of NAO which has the following features:

- Body with 21 degrees-of-freedom with electric motors/actuators, 2 cameras, 4 microphones, sonar rangefinder, 2IR emitters and receivers, 1 inertial board, 9 tactile, and 8 pressure sensors.
- Communications: voice synthesizer, LED lights, 2 speakers.
- AMD GEODE 500 MHZ CPU (V3.3) located in the head, and a Second CPU located in the torso.
- 27.6-watt-hour battery (60 to 90 min of autonomy).

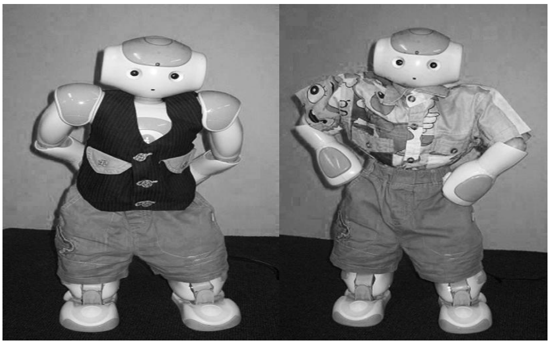


Fig. 1. The NAO (Nima) Robot.[23,31]

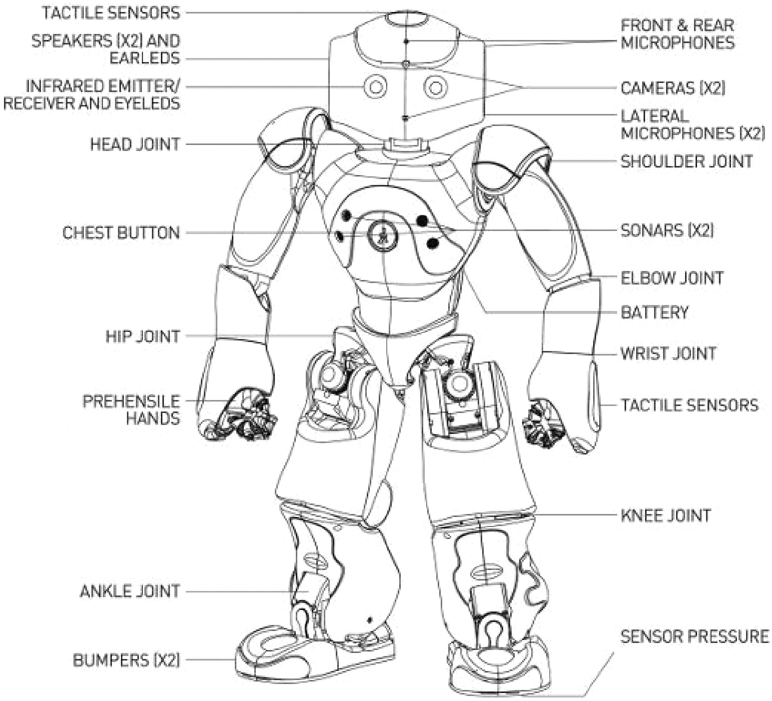


Fig. 2. Schematics of the NAO (Nima) Robot.[23,31]

The Nima Robot has the following abilities which were used in the RALL classroom (see Fig. 2):

***Motion*:** Nima is capable of Omni-directional walking and whole body motion. He can walk on a variety of floor surfaces, such as carpeted, tiled, and wooden floors.

***Vision*:** Nima has two 920p cameras which can capture up to 30 images per second, and can track, learn, and recognize images and faces. The first camera, located on Nima's forehead, scans the horizon, while the second located at mouth level scans the immediate surroundings.

***Audio*:** Nima uses four microphones to track sounds, and its voice recognition and text-to-speech capabilities allow it to communicate in the default languages that are defined on its system. One of the main purposes of humanoid robots is to interact with people. Sound localization allows a robot to identify the direction of sounds. The Nima robot can also apply the following applications; all of which can be useful in the language learning process.

- Human Detection, Tracking, and Recognition
- Noisy Object Detection, Tracking, and Recognition
- Speech Recognition in a specific direction
- Speaker Recognition in a specific direction

- Remote Monitoring/Security applications
- Entertainment applications

***Connectivity*:** Nima currently supports Wi-Fi and Ethernet. In addition, infrared transceivers in the eyes allow connection to objects in the environment.

***Software*:** The Choregraphe is the visual graphical programming language of the robot (see Fig. 3). Its user-friendly software allow the creation of behavior and movements for the Nima robot. It also allows the integration of personally developed modules for the robot to develop new movements and interactive behaviors. The Choregraphe has a library of predefined behaviors, such as walking, sitting down, standing up and to make it talk you have to use the talk behavior. It allows for the changes in voice and pitch and even the pace of talking. Moreover, the software also allows the sequencing of movements in a chronological order.

In this study, the pre-programmed behaviors were mostly used in order to create new behavior. Much modification was needed and at times, the library of behavior was not sufficient enough and Curve Editor was used to edit movements in Python scripts.

In order to make Nima do one of the actions designed for the games, such as soccer player, the combination of many movements were used to create the final behavior. Standing up, bringing his foot back to kick the ball in such a way as to not lose his balance, bringing his hands a little to the sides as to help keep his balance and finally bringing his feet in such an angle to the front as to kick the ball and finally coming to a balanced standing position.

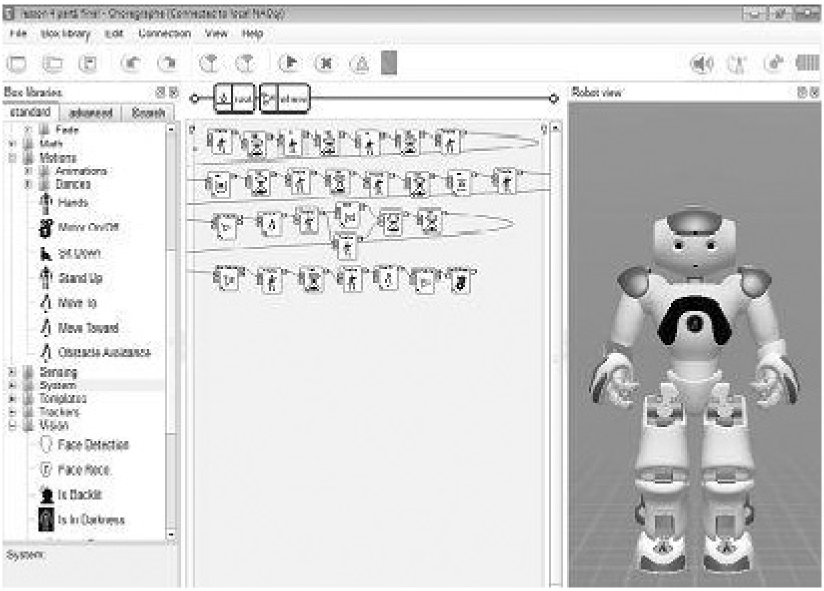


Fig. 3. The Choregraphe; visual graphical programming language.[23,31]

One of the advantages of this program was its ability to test the created behavior on a stimulated robot in a 3D environment before trying it on the real robot. Thus, it allowed us to test and retest the newly developed behavior and in a virtual world without injuring the robot in the real world.

4.2.2. *Pre-test and post-test*

The researchers administered a 45-item vocabulary test (pre-test) taken from their textbook (Prospect-1) to 60 participants in order to check the homogeneity of the students. The test assessed both their vocabulary recognition and production. The students (46 students) who were at the beginner's levels were selected for the study, 30 for RALL and 16 for non-RALL groups. The mean achieved at the pre-test was the criterion of choosing the students for the study. The students who had achieved a score of two standard deviations above and below the mean were chosen for the study totaling a number of 46 students. At the end of the study, the same test was administered as an immediate post-test and the questions were counter balanced and administered as a delayed post-test two weeks after the treatment process. This test enjoyed the reliability of Cronbach alpha of 0.89. Thus, the high reliability obtained is a clear evidence of the consistency of scores over time and that the vocabulary test is a reliable source of data.

4.3. *Procedure, scenario/dialog design, and data collection*

The main purpose of our experiments was to investigate vocabulary learning through interaction with a human teacher assisted by a humanoid robot. Therefore, it was critical for the robot to look real (not just a software agent) and work closely with the human teacher appropriately and gain students attention. To do this, various scenarios and dialogs between Teacher–Robot–Students were designed and presented in class for five consecutive weeks and in two one-hour sessions each week. Although the experimental scenarios were pre-planned and pre-programmed into robot, they were played in real-time with an on-line dialogue between the human "*teacher*", the humanoid robot named "*Nima*", and the "students" as shown in Fig. 1 and in sample video clips.[31] This study attempted to use a true experimental design in order to obtain the desired results and random assignment of students was employed. Since we needed to have more students for RALL investigation, we put about two third of the students in RALL group and one third in non-RALL group randomly. The random assignment of the students ensured that any difference between the groups is attributed to the effect of the treatment and not due to the greater language learning abilities of each group. The use of the quantitative data in immediate and delayed post-tests after two weeks helped the researchers to reach accurate results regarding the retention of the vocabulary items in both groups.

Our study attempted to evaluate the use of robots in the classroom and its effect on the language learning process and compare the results with a traditional method.

The Nima robot programmed in the Choregraphe software by the robotics group at the Center of Excellence in Design, Robotics, and Automation (CEDRA) played a number of games and tests with the students and the data were recorded (see Figs. 4 and 5). For each session, a lesson plan focusing on vocabulary was devised; however, the teacher taught all the material that was in the book regarding each lesson (i.e., grammar, reading, writing, and pronunciation); the teacher achieved to cover half of the book in 5 weeks. The experimental scenario procedure was performed as follows:

The human teacher started a conversation with Nima robot and then with the students (sees Figs. 4 and 5). Students were also asked to talk to Nima, using his own words, as if it was a young native tutor, and repeat after him to practice new words and vocabularies. Nima was pre-programmed to explain each vocabulary items by pictures, pantomime actions, sounds, and their usage in simple dialogues with the human teacher. Words like "teacher", "driver", "police officer", "housewife", "mother", "father", "nurse", "brother", "sister", "uncle", "cousin", "mechanic", "doctor", "engineer", "pilot", "happy", "sad", "smile", "sun", "dentist", "moon", "sport", "age", "pen", "pencil", "paper", "young", "old", "baby", "dance",

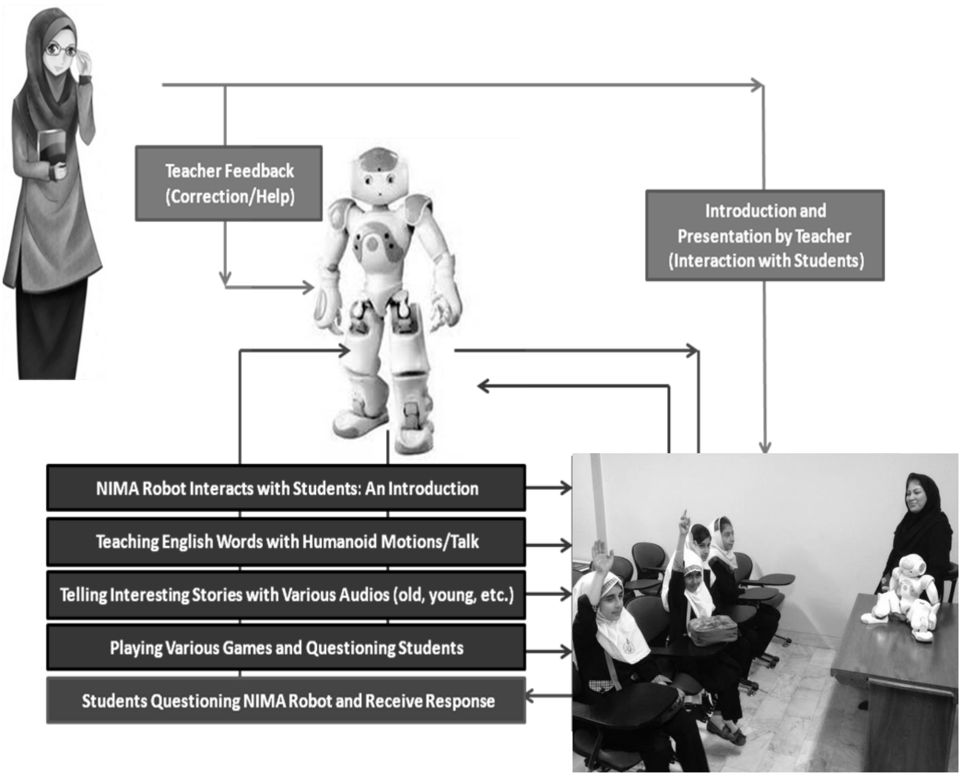
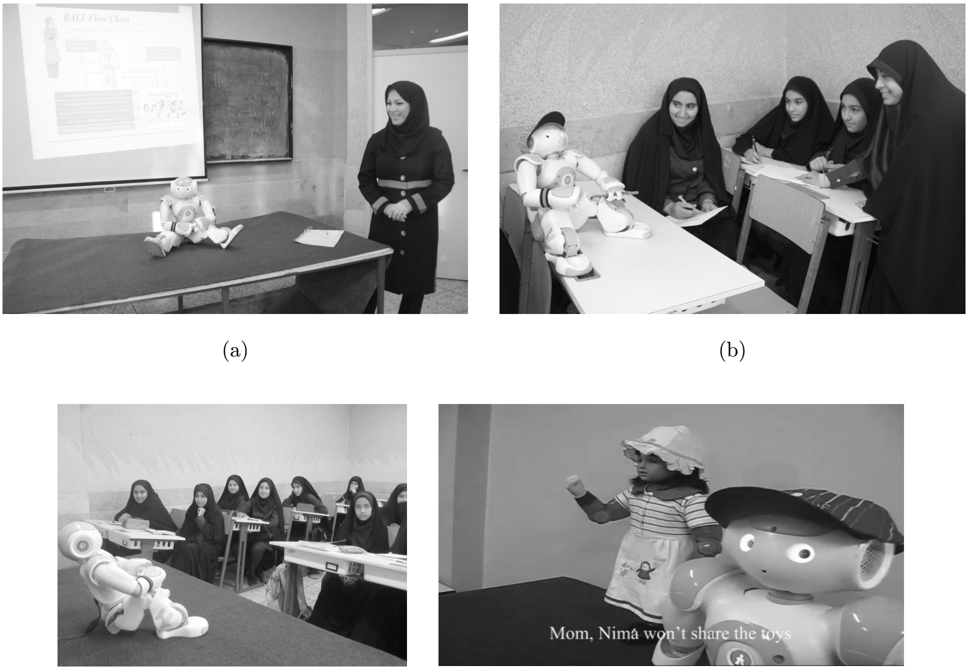


Fig. 4. The lesson plans were devised in a way to enhance the most interaction between the students and the robot.



(a) (b)

(c) (d)

Fig. 5. A model of the RALL classroom at Imam Sadegh (AS) middle-school in Tehran, Iran.

"exercise", "sleep", "share", "toys", and various "colors", "shapes", and "numbers", etc. A video projector equipped with a laptop computer was used to show pictures/ images of various items using power point slides as necessary when Nima would refer to them. Nima would teach each vocabulary item as the picture showed on the screen and then he would ask the students to repeat the phrase. At times he would ask a student the vocabulary item to check what the student had learned. The teacher would also ask Nima the name of each vocabulary item by showing different pictures on the screen. Nima would say the items a second time so the students would learn and have the items repeated. Sometimes, Nima would make mistakes intentionally and get mixed up or he would even mispronounce the words. This helped the students to learn from Nima's mistakes and feel less anxious when being called upon to answer. During each session, the human teacher would intervene in real-time every now and then as necessary to make sure the learning process is well in order and to respond to sudden questions and comments. In addition, teacher's reinforcement was based on expressing approving comments when students come up with correct answers to questions posed by the Nima robot. Comments such as: "well done", "good job", "nice", "wrong", etc. Nima also provided entertainment activities like singing and dancing to reward, encourage, and motivate students in the learning process. This is due to the fact that applying a reward immediately after the occurrence of a positive response increases its probability of reoccurring.

Sample dialogue between Nima, the teacher, and the students:
Teacher is pointing to the screen which is showing a picture of a robot wearing a police officer uniform.

Teacher: Nima, who is this?
Nima: He's my uncle Peyman.
Teacher: What's his job?
Nima: He's a police officer.
Teacher: Wow! A police officer! Can you show us what police officers do?
Nima: Yes, why not?
Nima acts out being a police officer by taking up his gun and shooting.
Then he turns to the class and says: Everyone, please repeat; Police officer.
The students repeat after Nima.
Teacher: Fatemeh, why don't you ask Nima about the next picture?
The student comes to the screen and points to the picture: Who is this, Nima?
Nima: She's my aunt.
Student: What's her job?
Nima: She's a teacher.
Nima acts out being a teacher by taking a piece of chalk and writing on the board.
Nima: Everyone, please repeat; Teacher.
Class: Teacher.
Nima: What's her job?
Student: Teacher.
Nima: Great Job! He will be clapping at the same time.

The same procedure without the robot was done with the non-RALL (traditional method) group, but the same amount of lessons took this class 4 months to be taught. Both classes started out with the same lesson plan outline to cover half of the book while having the same number of lessons each week whereas the non-RALL group fell behind very soon and was not able to finish the lesson plan at the expected time. Therefore, the next session of the non-RALL group consisted of finishing the previous lesson plan. However, the RALL group was able to finish the lesson plan at the expected time and was also able to finish sooner than expected time. Therefore, the non-RALL group took four times more than the RALL group to complete each lesson. A total of 45 vocabulary items taken from the 7th grade junior high school book were emphasized (see Fig. 5). The RALL lessons were planned prior to the class and were practiced beforehand with the robot in the CEDRA's robotics instructional laboratory in order to check and recheck the use of the robot, and to eliminate any possible software problems that might occur. The data obtained from the participants' pre-test and post-tests (using SPSS 16 software) was analyzed using repeated measures ANOVA to see if there was any improvement in terms of vocabulary learning among learners. Moreover, in order to compare the two groups' vocabulary gain, post-tests of both groups were analyzed using two-way ANOVA to see if there was any difference between the RALL and non-RALL groups.

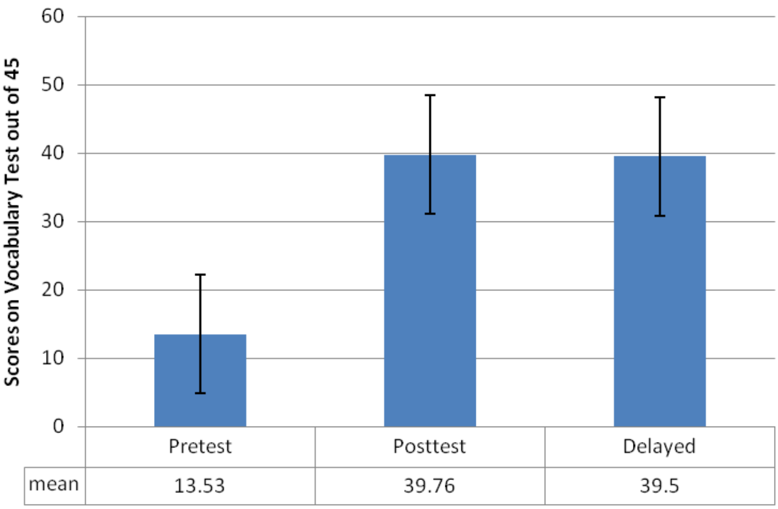
5. Results

In order to answer the first research question on difference between RALL group's vocabulary knowledge in pre-test, immediate and delayed post-tests, first the mean and standard deviation of the pre-test and post-test scores of the RALL group were computed and their scores were compared by running repeated measures ANOVA statistics.

The results obtained from the descriptive statistics show that the mean of the pre-test is 13.53, that of the post-test is 39.76, and mean of the delayed post-test is 39.50. The results clearly show that the students' improvement has been tripled and remained in the delayed post-test, thus providing evidence of the effectiveness of the treatment.

It can clearly be seen in Graph 1 that there has been a large increase in the scores from the pre-test to the immediate post-test; however, no great change has been seen on the delayed post-test. The black error bars shown in Graph 1 represents the standard error showing a decrease in standard deviation from the pre-test to the delayed post-test. Therefore, the results present more homogeneity of scores as time passes. The results clearly show a consistency in the learning and retention of the vocabulary items.

A repeated measures ANOVA was run to compare the RALL group's means on pre-test, post-test and delayed post-test. Based on the results for the pre- and



Graph 1. Descriptive statistics of the pre- and post-tests scores of the RALL group with the standard error bars.

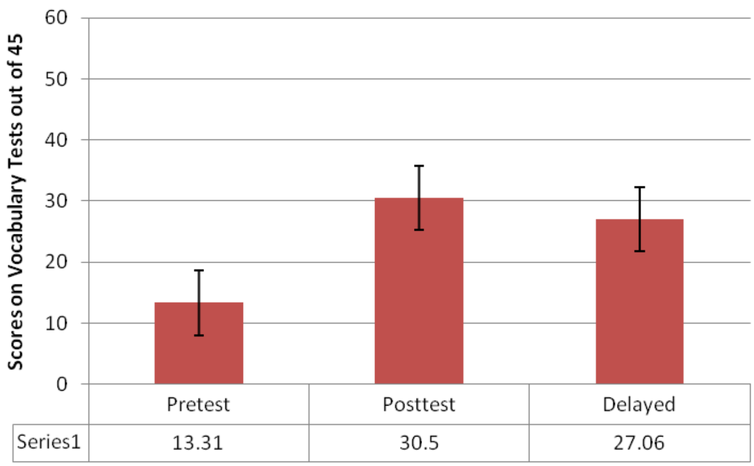
post-test scores of the RALL group ($F(2,28) = 357.39$, $p < 0.05$, Partial $\eta^2 = 0.96$), it can be concluded that there were significant differences between the RALL group's means on pre-test, post-test and delayed post-test. Thus, the above results showed an increase in the grades of the RALL group students.

The results of the *post-hoc* comparison tests indicated that there was a significant difference between the RALL group's means on pre-test ($M = 13.53$) and post-test ($M = 39.76$), (MD $= 26.23$, $p < 0.05$). Moreover, there was a significant difference between the RALL group's means on pre-test ($M = 13.53$) and delayed post-test ($M = 39.50$), (MD $= 25.96$, $p < 0.05$). However, there was not any significant difference between the RALL group's means on post-test ($M = 39.76$) and delayed post-test ($M = 39.50$), (MD $= 0.26$, $p > 0.05$). The results obtained further confirmed the success of RALL in aiding vocabulary learning and retention.

To answer the second research question on the amount of students' vocabulary knowledge gain and retention in the traditional class (non-RALL group), first the mean and standard deviation of the pre-test and post-tests scores of the non-RALL group were computed and their scores were compared by running a repeated measures ANOVA. As shown in Graph 2, the mean of the pre-test is 13.31, that of post-test is 30.50, and the mean of delayed post-test is 27.06.

Graph 2 exemplifies the fact that although the students showed improvement in the traditional class, their scores decreased after 2 weeks. In addition, it must be noted that the black bars represent the standard deviation error.

A repeated measures ANOVA was run to compare the non-RALL group's means on pre-test, post-test, and delayed post-test. Based on the results ($F(2,14) = 150.62$, $p < 0.05$, Partial $\eta^2 = 0.95$) it can be concluded that there were significant differences between the non-RALL group's means on pre-test, post-test and delayed post-test.



Graph 2. Descriptive statistics of the pre-test, post- and delayed post-test scores of the non-RALL group.

Post-hoc analysis revealed that the non-RALL group also significantly increased their scores on the immediate post-test (MD $= 17.18$, $p < 0.05$) showing a gain in vocabulary. However, there was also a significant difference between the RALL group's means on the immediate post-test ($M = 30.50$) and the delayed post-test ($M = 27.06$), (MD $= 3.43$, $p < 0.05$). The results obtained from the pair wise comparison showed a decrease in vocabulary scores of the non-RALL group on the delayed post-test thus demonstrating an inconsistency and vocabulary retention loss among the students in the non-RALL group.

To answer the third research question being: "is there any significant difference between RALL and non-RALL groups' immediate, post-test, and delayed post-test in their vocabulary gain as measured by their vocabulary knowledge breadth", a two-way mixed-model ANOVA was run to investigate the effect of type of treatment (RALL, non-RALL), phase (pre-test, post-test and delayed) and their interaction on vocabulary gains. First the descriptive statistics were calculated to evaluate the overall differences between the scores obtained. As shown in Table 1, the mean of immediate post-tests of RALL and non-RALL groups are 39.76 and 30.50, respectively. It is interesting to observe that their delayed post-tests' means are 39.50 and 27.06, respectively.

Graph 3 shows the consistency of scores in the RALL group on the delayed post-test and the decrease in scores on the delayed post-test of the non-RALL group. Graph 3 is the evidence of vocabulary retention in the RALL group and memory loss in the non-RALL group.

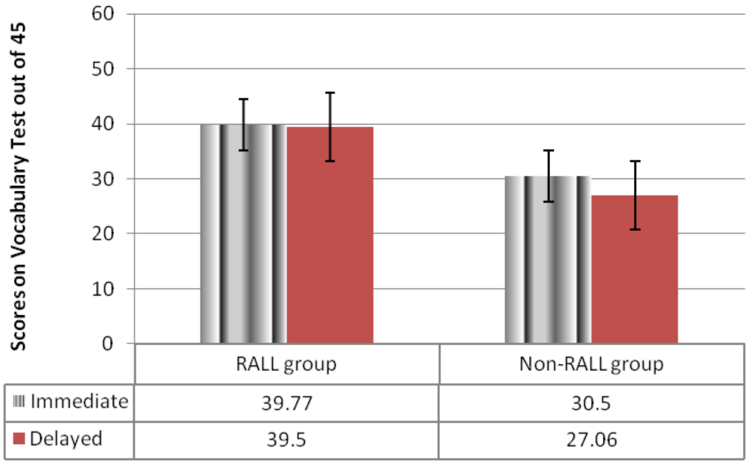
However, Graph 4 compares the two systems in views of the scores on each test. Clearly the scores obtained from the RALL students are much higher than the scores obtained from the non-RALL students, showing the effectiveness of the RALL system over the other method both in short-term learning and also on the long run.

Graph 5 shows estimated marginal means in both groups of RALL and non-RALL. A two-way mixed-model ANOVA was run to investigate the effect of type of treatment (RALL, non-RALL), phase (pre-test, post-test and delayed post-test) and their interaction on vocabulary gains of Iranian junior high school students as measured by their vocabulary knowledge breadth as shown in Table 2.

The results of the two-way mixed model ANOVA (Table 2) indicated that there was a significant difference between the overall mean scores of the RALL

Table 1. Descriptive statistics for the means of RALL and non-RALL groups.

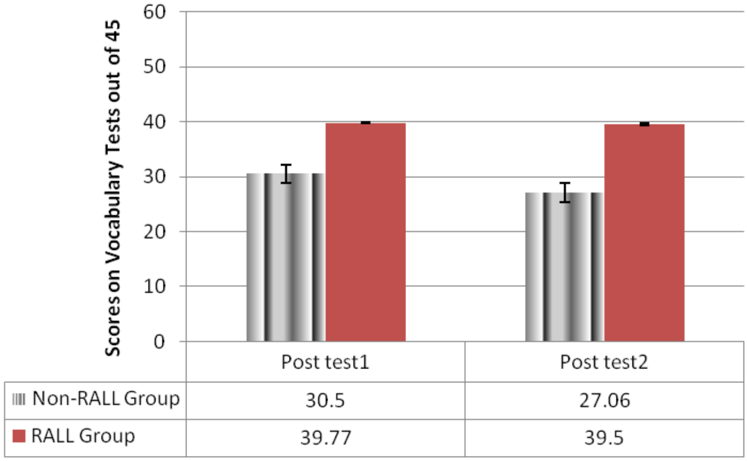
Group	N	Phase	Mean	Std. error	95% Confidence interval	
					Lower bound	Upper bound
RALL group	30	Pre-test	13.53	0.98	11.58	15.47
	30	Post-test	39.76	0.98	37.82	41.71
	30	Delayed	39.50	0.98	37.55	41.44
Non-RALL group	16	Pre-test	13.31	1.34	10.64	15.97
	16	Post-test	30.50	1.34	27.83	33.16
	16	Delayed	27.06	1.34	24.39	29.72



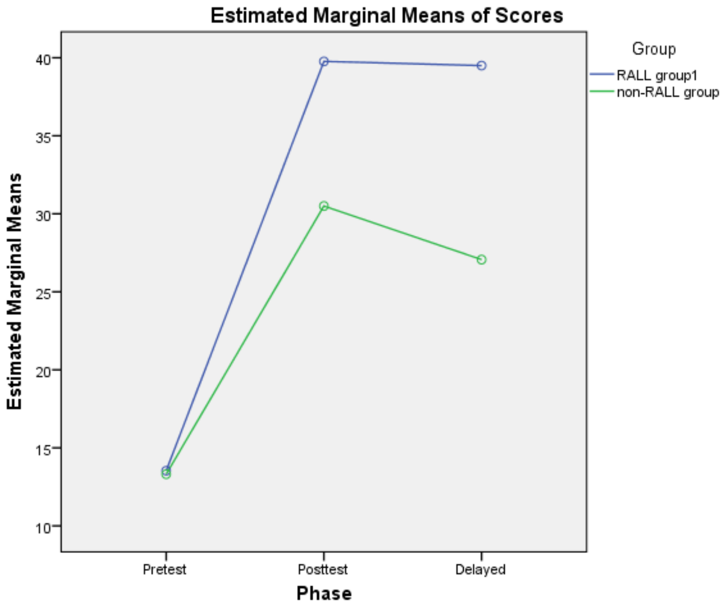
Graph 3. Descriptive statistics of the immediate and delayed post-test scores.

$(M = 30.93, \mathrm{SE} = 0.56)$ and non-RALL $(M = 23.62, \mathrm{SE} = 0.77)$ groups $(F(1, 132) = 57.61$, $p < 0.05$, Partial $\eta^2 = 0.30$ representing a large effect size). It shows that both groups improved in their vocabulary knowledge; however, there was a significant difference in the grades obtained both in the immediate and delayed post-tests. It also revealed that the RALL group was successful in vocabulary learning and retention while the control group was only successful in learning vocabulary and not very successful in retention.

The results of the *post-hoc* Tukey test (Table 3) indicated that there were significant differences between the means on the pre-test $(M = 13.42)$ and post-test



Graph 4. Comparison of RALL-group and non-RALL group by test.



Graph 5. Interaction between group phases.

($M = 35.13$) (MD $= 23.09$, $p < 0.05$) in the RALL group. Also a significant difference was shown between the means on the pre-test ($M = 13.42$) and the delayed post-test ($M = 33.28$) (MD $= 21.72$, $p < 0.05$). However, there was not any significant difference between the mean scores on the post-test and delayed post-test.

There was a significant interaction between groups and phase ($F(2, 132) = 14.45$, $p < 0.05$, Partial $\eta^2 = 0.18$ representing a large effect size). As displayed in Table 3 and Graph 5, the RALL and non-RALL groups showed the same means on pre-test; however, the RALL group gained higher scores on post-test and delayed post-test. The non-RALL group also showed more decrease in their means on delayed post-test. Thus, based on the results obtained, it can be concluded that the RALL system was successful in the learning and retention of vocabulary. It can be concluded that the RALL system is more successful in foreign language learning.

Table 2. Two-way ANOVA results for the difference between RALL and non-RALL groups across tests.

Source	Type III sum of squares	Df	Mean square	F	Sig.	Partial η^2
Group	1672.02	1	1672.02	57.61	0.00	0.30
Phase	12092.18	2	6046.09	208.33	0.00	0.75
Group * Phase	838.70	2	419.35	14.45	0.00	0.18
Error	3830.70	132	29.02			
Total	133012.00	138				

Table 3. *Post-hoc* results for the interaction of the ANOVA for the pre-test, post-test, and the delayed post-test.

(I) Phase	(J) Phase	Mean difference (I − J)	Std. error	Sig.	95% Confidence interval	
					Lower bound	Upper bound
Post-test delayed	Pre-test	23.09*	1.12	0.00	20.42	25.75
	Delayed	1.37	1.12	0.44	−1.29	4.03
	Pre-test	21.72*	1.12	0.00	19.05	24.38

*The mean difference is significant at the 0.05 level.

6. Discussion and Conclusion

The manifestation and developments of humanoid robots has enabled a new approach to investigate the language acquisition by learners, and this report covered the preliminary results in acquiring rudimentary linguistic skills through robots as active teaching assistants in EFL classrooms. Therefore, exploring Human–Robot cooperation for English language teaching and learning in Iranian schools was the main objective of this study. Initial experiments, empirical experience, and a review of recent literature clearly indicate that a combination of Human–Robot instruction in a Teacher–Assistant module forms an intelligent cooperative system that offers enhanced capabilities over conventional English language teaching methods. Nonetheless, a human–robot cooperative strategy in teaching is also advantageous to perform all tasks that cannot be readily executed by just human-based language instruction. The study focused on applying the RALL technology with the aim at providing personalized assistance and motivation to young L2 students in Iran to enhance their vocabulary acquisition. Vocabulary has a central role in language learning, and language learners should know a large number of words to be successful in their learning or to have a successful communication. It also has a vital role in the four skills particularly reading. Because of the importance of vocabularies for school students, this study aimed to investigate the effect of RALL on their vocabulary learning. In fact, the goal of the study was to provide junior high school students with additional exposure to the target words that they studied in their course book with the help of a robot during normal class time, and the findings of this study confirmed the usefulness of RALL on students' vocabulary learning.

The results of the study showed that significant differences were found between RALL and non-RALL groups in vocabulary achievement as measured by the immediate and delayed post-tests. This proves the powerful impact of RALL on the learners' memory in recalling the target words. The retention for the RALL group could be regarded as confirmatory evidence for a strong relationship between retention rates and depth of processing of new words, while retention loss was manifested in the decrease in scores on the delayed post-test in the non-RALL group. This indicates that RALL could be one option when it comes to increasing retention of words. The reason might be the meaningful and attractive action of the robot while talking; it makes it possible for kids to make an association between the word and the robot action. It helps intensive processing of new words for the school kids which leads to better long-term retention. The traditional method provides only superficial processing of the words that may cause retention loss.

Another advantage of RALL is the speed of learning; the results reveal that the teacher could teach half of the book in five weeks in RALL group while it took her four months to do the same job in non-RALL group. The speed of learning that happened in the RALL classroom helped to form an intensive course regarding the learning of vocabulary items. However, this was not limited to learning only. The results provided evidence that the learning experience was followed by retention. Therefore, the findings support the usefulness of RALL in this regard. This finding is consistent with those of prior studies using RALL on general English proficiency or similar studies.[3,13,14,28–33] However, this study is more in line with Hyun *et al.*[29] who worked with preschoolers' vocabulary using RALL and found their improvement was significantly better than the CALL group.

Moreover, learning vocabulary through a RALL system promoted more students' interest in learning English. The results of the study showed that participants feel very positive about this mode of learning and think that this would enrich their vocabulary learning experience. This issue is currently under thorough investigation and results will be reported in a following paper. As opposed to other technological devices, we believe that utilizing robots as teaching assistants in classrooms will remain novel for many years to come, since the participants as new students will keep changing every year, and especially when the robots features and capabilities are enhanced year by year with the advancement of technology. This has been the case with the toys as dolls that have been around for hundreds of years and are still one of the main sources of attraction for children and young students.

The purpose of vocabulary learning is the ability to use the words automatically in a wide range of language contexts, and retrieval of a word for productive use demands vocabulary internalization. Therefore, some techniques are needed to enhance learners' memory in recalling and using the target words contextually appropriate. Overall the results suggest that the method of teaching should have the capacity to encourage the learners and provide them a happy atmosphere. However, further research is needed to confirm these results and get a more in-depth understanding of the effects of this and similar systems. In order to get a more precise picture of the variables involved, the following factors should be considered in future studies: the involvement of a larger sample and longer instruction time and the investigation of other textbooks and learner variables. Also, a comparison of the post-test results after a long period will also shed light on the effectiveness of the treatment in retention in the long run. This study has some implications for technology-based education, language teaching, and social robotics fields.

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