Robot Assisted Language Learning through Games: A Comparison of Two Case Studies

Omar Mubin[1], Suleman Shahid[2], Christoph Bartneck[3]

[1]University of Western Sydney and MARCS Institute, Australia
[2]Department of Communication and Information Sciences, Tilburg University, The Netherlands
[3]HIT Lab, University of Canterbury, New Zealand

o.mubin@uws.edu.au, s.shahid@uvt.nl, christoph.bartneck@canterbury.ac.nz

Abstract. In our research we advocate using game based scenarios for Robot Assisted Language Learning (RALL). We present two case studies that utilized such a methodology and also analyzed what constructs would have a pedagogical benefit. The constructs included various attributes such as, type of robot, location of learning, role of robot, role of teacher, etc. Our results showed that close linkages with existing curriculum reaped benefits and running RALL for small groups of children is the ideal case. We also reflect on how using game based scenarios for RALL resulted in higher motivation for the students.

Keywords: Human Robot Interaction, Robot Assisted Language Learning, Educational robots, Games

1 Introduction

With advances in digital media, technology is now a well-accepted and integral part of education in primary schools, high schools and universities [1]. There has been research conducted which shows the use of technology has pedagogical value over conventional means of teaching and it provides a rich and engaging learning experience for the students. The integration of technology in education has been diverse in nature ranging from tablets, smart artifacts, mobile phones, novel web based platforms and last but not the least robots.

The incorporation of robots in different levels of education has been discussed in great detail. In addition, work in the area has also contemplated how robots are primarily used in two broad subject areas: technical education (such as robotics and computer science) and non-technical education (such as languages). Robots provide a social and physical embodiment to the concept of teaching and provide rich benefits especially in language instruction. The advantages of using robots in language instruction, also known as robot assisted language learning (RALL) have been greatly discussed in [2]. They include aspects such as the robot can repeat verbal behavior without getting tired (unlike a human instructor), remote instruction is possible and students may not be shy to talk to robots in a non-native language as they might be if the instructor was a human. Other key advantages of RALL over online or conventional language learning include that the robot can essentially include “play” as part of the learning activity without the students getting distracted and technology such as RFID tags can be used to monitor the development of each student.

There has been considerable progress in the area of RALL and research has mostly focused on using robots to teach English as a second language. In the work of [3], where children interacted with the Robovie robot it was shown that over a period of two weeks, the post-test scores improved. Similarly, in [4] it was shown that the English listening skills of children significantly increased.

Although RALL utilized as part of the curriculum has shown to reap rewards w.r.t pedagogical outcomes however employing RALL in a gaming scenario could potentially be even more beneficial. The use of games for language instruction is not uncommon and has shown to be an efficient methodology to train students in a non-native language [5, 6]. Learning a second language is by no means an easy task especially if students are constrained in a typical classroom setting [7] where they might feel bored and reluctant to speak in a foreign language especially when there are no tangible outcomes of their verbal articulations. Therefore integrating the language learning process as part of a game based scenario may overcome some of the afore-mentioned hurdles in language acquisition.

RALL by itself also faces various challenges, some of which we aim to reflect on in this paper. A robot tutor is after all a tutor and hence prone to a feeling of saturation from the students, unless there is renewed excitement or challenge. The novelty effect has been reported in [3], where the process flowed from excitement to stable interaction to saturation while learning English with the Robovie robot. RALL also relies on efficient speech recognition [8], as errors in recognition could seemingly disrupt the learning process of the students. However if the conversations between students and robots occur as game based interaction, the errors in recognition could potentially be integrated as part of the game (rules). RALL through gaming scenarios could consequently be the most appropriate RALL technique. Recent work in RALL using gaming scenarios has been limited with studies primarily focused on virtual avatars [9] and not physical embodied robots.

In general there is considerable research describing the benefits of RALL however several open questions remain regarding what environmental variables support the learning activity in a more efficient manner [10]. For example, should the learning take place inside the classroom and should it be linked to curriculum that is already in place? What role should the teacher have? Should the activity be setup as a game? What role should the robot have (as a tutor, tool or peer)? These were some of the questions that we aimed to answer via our research on RALL using game based interactions.

Therefore the goal of this paper is to advocate RALL through games, as it is a generally untapped area within RALL and present our reflections on the basis of two slightly distinct RALL case studies where both used game based interactions. In addition we aim to reflect what attributes or settings are more appropriate for RALL activities. Both case studies involved teaching children a new language ROILA, which is an artificial language designed to improve human robot communication [11]. We will now delve into each study across various factors, discuss the subjective feedback attained from the students and in conclusion, reflect on what could be the lessons learnt for other researchers in RALL.

2 Research Methodology

Case Study 1 employed the use of the iCat robot (robot that looks like a cat), was conducted in an out of class setting (extra curricular) and with 24 children of the ages 10-12 years old. Case Study 2 revolved around the use of LEGO Mindstorm robots in a formal setting (i.e. in the classroom) and with 24 children between the ages 12-14. Both case studies focused on learning the artificial language ROILA with the help of a certain robot in a gaming scenario. The case studies were setup in such a manner that we manipulated certain constructs within the language curriculum so that we could ascertain what aspects are better for RALL using games. We will now briefly enlist some of the constructs. The constructs are borrowed in part from research on educational robots [12-14], where they are presented as important dissecting criteria on the field of robots in education. In order to be able to compare the two case studies we employed different attributes of the constructs within each case study. The constructs and their attributes are briefly summarized below.

Type of Robot. The two robots that we employed were distinct, one (iCat) being more anthropomorphic than the other (LEGO Mindstorms). The iCat has a cat like embodiment, whereas LEGO Mindstorms is built using LEGO Technic and can take on different representations (see Figure 1).

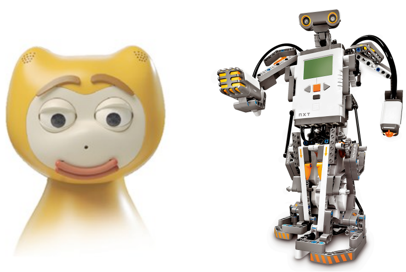

Fig. 1. iCat (left) and Mindstorms (right)

Location of the learning. As stated prior, Case Study 1 was conducted outside the curriculum and outside normal tutoring rooms, while Case Study 2 was executed as an integral part of the curriculum and in the normal classrooms.

Teacher Participation. Primarily with Case Study 1 being extra curricular in nature, it did not involve any teacher participation, where in Case Study 2 the teacher was at hand to mentor the students during their interaction with the robots.

Close linkage with the curriculum. The scenarios in Case Study 1 did not tie back to any of the existing curriculum of the students whereas Case Study 2 was conducted within the Science class.

Role of the robot. In case study 1, the role of the robot was of a peer, i.e. the robot would participate as a co-learner and help the children in verbal articulations by discussing the choices the children could take in the game. Whereas in case study 2 the role of the robot was more of a tool in the language learning process as what the children would say would effect the robot's spatial state.

Collaboration in the learning activity. In case study 1, the children would interact with the iCat robot individually, whereas in case study 2, interaction with the Mindstorms robot was within several groups of 2-3 students each who were all present in the classroom at the same time.

3 Setup

We will now briefly describe how the two case studies were setup. Both studies involved around the aim of teaching students ROILA, an artificial language designed for talking to robots and optimized for speech recognition.

The Curriculum. Due to limited curriculum time available obviously only a subset of the language was provided to the children to learn. For both case studies the allocated vocabulary amounted to about 30 words. Students were also taught phrases that could be made up from these words. The phrases were relevant to the interaction scenario followed in the games.

In Case Study 1, all training material was discussed with the children outside normal curriculum hours and with the help of online and paper based material. They were then allowed one week to practice the material after which they returned to further substantiate their learning by interacting with the iCat robot in gaming scenarios, over a 30-minute session. Since we only had one iCat robot at our disposal, children could only participate in the practical sessions individually.

Case Study 2 was conducted within the Science class of children, where they were taught about Robotics using ROILA and the Mindstorm robots. The activity was spread over 2 lectures of 2 hours each, where the first lecture was about learning the theoretical aspects of ROILA and the second lecture was bringing the theory into practice by actually using ROILA to talk to Mindstorm robots. The theory discussed in Case Study 2 was identical to the learning material provided to the children in Case Study 1. We had about 10 Mindstorm robots customized to use in the lecture and each robot was given to a group of 2-3 children. The science teacher was available in the classroom and along with the researchers would assist the children with any questions or queries that they had.

Setup of the learning activity – game design. For both case studies, practical learning of the ROILA language in the practical sessions took place within gaming scenarios – for case study 1 after a week in a separate session and for case study 1 in a second lecture. The students were requested to play a certain game with the robot in both ROILA and English so that we could compare how the children perceived talking to the robots in both languages. Each student would then first play the game in either ROILA or English followed by playing the game in the other language. All students had sufficient knowledge of the English language and studied English as a separate subject in their curriculum.

1) Game employed in Case Study 1
The game was a simple word matching game in which the children had to match a given word with another word from a set of words based on some logical reasoning (see Figure 2). We anticipated that such a game would encourage the children to be much more verbally involved with the iCat as they would have to discuss the rationale of their choices with the robot (see Figure 3). The iCat was programmed to assist the children in reaching the correct answer by conversing with the children in either ROILA or English. Therefore the iCat was playing the role of a peer in the language learning activity.

2) Game employed in Case Study 2
The game in Case Study 2 was designed around navigation and reaching spatial targets in a certain sequence. The children were required to give navigation commands to the Mindstorms robot so that the robot could reach certain colored targets, sense the color of those targets and then shoot balls in corresponding colored goals (see Figure 2). The robot would give instructions to the children in either ROILA or English (depending on the game type), for e.g. which colored target to approach, etc. Therefore the robot was playing the role of a tool in the language learning activity.

Technical Setup. For both robots iCat and Mindstorms there was no speech recognition processed on the robot, speech processing actually took place on an external laptop (using the Sphinx recognition system [15]), which communicated with each of the robots wirelessly or over the network. The children would talk to the robots using a microphone connected to the laptop with the recognition results being sent to the robots using the network connection. The robots would then respond with behavior based on a simple dialog management system. The robots had the ability to talk back in ROILA or English using the Festival [16] text to speech engine.

Mubin, O., Shahid, S., & Bartneck, C. (2013). Robot Assisted Language Learning through Games: A Comparison of Two Case Studies.
Australian Journal of Intelligent Information Processing Systems, 13(3), 9-14.

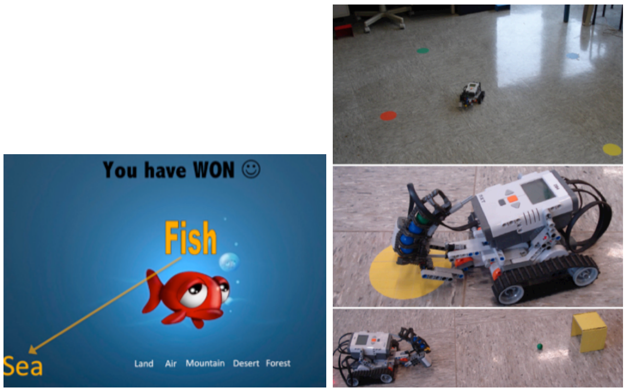

Fig. 2. Snapshots of the game scenarios in Case Study 1 (left) and Case Study 2 (right)

Fig. 3. One of the children interacting with the iCat robot

Measurements. Due to the research being of fairly explorative and non-longitudinal in nature we recorded subjective feedback from children via the SASSI questionnaire [17] on a 5 point Likert scale. The SASSI questionnaire is commonly used in the evaluation of speech based interfaces. It comprises of 6 factors: system response accuracy, likeability, cognitive demand, annoyance, habitability and speed. Our aim in utilizing the SASSI questionnaire was to elicit subjective feedback from the children with respect to how they perceived talking to the robots in both English and ROILA. During the practical sessions of the curriculum, once the student had finished playing one round of the game in a particular language, we would request them to fill the SASSI questionnaire before moving on to the next game in the second language.

4 Results

Case Study 1. For the factors from the SASSI questionnaire we achieved Cronbach alphas of $0.7<alpha<0.8$, which gives us sufficient reliability in the SASSI questionnaire. The type of language (ROILA or English) did not have an effect on any of the factors ($p > 0.05$) according to the results from the repeated measures ANOVA. On average the students ranked English as the more preferred (Likeability for English = 3.31 and for ROILA = 3.00) but as stated prior this difference was not significant.

Case Study 2. We conducted a reliability analysis of the SASSI factors and achieved a sufficient benchmark of $alpha>0.7$ for all factors. To determine if the language type was having an effect on the subjective SASSI ratings of the children a repeated measure ANOVA was conducted. The within factor was language (English or ROILA) and the measurements were the six factors from the SASSI questionnaire. ROILA was evaluated as better on all six factors of the SASSI questionnaire. Three factors, namely System Response Accuracy, Annoyance and Speed were all significant in favor of ROILA ($p<0.05$). Likeability was touching significance.

5 Discussion and Conclusion

The results from the SASSI questionnaire allowed us to interpret the language interaction experience of the students across the two case studies and extrapolating that to their language learning experience. Our results showed that Case Study 2 achieved much more positive feedback from the children. We can now speculate why this may have happened. In Case Study 2 students may have been more proficient in learning ROILA and/or enjoyed the learning activities, which translated to them ranking ROILA better than English on the SASSI questionnaire.

The perception of embodiment of the robot was an interesting variable and the iCat did not generate a positive interaction experience, even though it is more anthropomorphic than the Mindstorms and can exhibit facial expressions. Prior research has advocated anthropomorphic behavior to be integral to RALL [2]. We can attribute this anomaly to the structure of the learning activity. In case study 2, the verbal articulations of the students had a direct influence on the Mindstorms robot, therefore we can hypothesize that the role of a tool for a robot might be better than the role of a peer, especially when it comes to language learning. As one student from Case Study 2 pertinently said: "The robot understands me so well and moves when I talk to it in ROILA".

Our findings also show that RALL is best suited to be run within an existing curriculum in the form of a close association between the new and existing curriculum as in Case Study 2. This allows students to make analogies and linkages and this would also support the theory of constructivism [18] by Seymour Papert, which states that learnt knowledge is shaped by what learners know and experience. However one of the disadvantages of RALL in a big classroom is that speech recognition can become erroneous due to ambient sound. Typically, in RALL one student is given the floor and allowed to interact with the robot while the other students act as audience [19]. Although this may increase the recognition accuracy, it may lead the students to be reluctant to talk confidently in a novel language, as they become the focus of attention. Perhaps the most suitable approach for RALL would be to run small groups of students typically isolated from each other (not a class of 25 and not a single student as in our case studies). Having small groups of students working together in a learning activity has shown to have pedagogical value [20] and has also been advocated in research on educational robotics [21].

Having the teacher in the vicinity of the students led them to be more engaged in the learning process. We noticed that in Case Study 2, on several occasions the students would discuss their findings and results with their teacher, as one student exclaimed: "Hey Miss! (referring to the teacher), the robot just scored a goal!". In summary, similar to results reported in [20], we found that it was beneficial to involve teachers in the learning activity, even if as a facilitator, a common approach when robots are used in education [22].

As a reflection, it is worthy to mention certain limitations of our research. As advocated earlier, since our research was fairly explorative in nature we only accounted for subjective feedback (via the SASSI questionnaire and interviews) from children. Since both case studies lasted for only 2 weeks, the belief within the research team was that measuring objective measures such as speech recognition accuracy might not be a valid instrument in a real setting (a classroom with the teachers involved), i.e. can we truly measure pedagogical value of a completely novel subject domain over sessions lasting for a couple of hours. Therefore we concluded that initially measuring and recording subjective feedback might be the way to go. However, in our future research we aim to execute controlled and longitudinal experiments that utilize recognition accuracy as a dependent variable and therefore inform us which independent variables contribute towards pedagogical value.

In general all students enjoyed the practical part of the lessons the most, i.e. when they could talk to and play with the robots in as they called it "the funny secret language" (ROILA). Hardly any student complained about feeling bored (as a matter of fact many expressed to be highly motivated) at the time of learning ROILA and our approach of RALL using game based scenarios was positively received. Several students appreciated and enjoyed this relatively new style of learning using a game based approach and stated that this was something that they had not encountered before in their language learning classes. We also observed many students comparing game scores and game results with each other and using that to claim language proficiency over their friends and peers.

Our results show that the approach of using games for RALL was in general successful. We have also presented recommendations on how RALL activities should be setup to ensure maximum pedagogical benefit. In our future research we aim to ground our findings by conducting longitudinal research in controlled settings.

Acknowledgements. We thank the children and their teachers and parents for the cooperation.

References.

1. Bates, A.W., Poole, G.: Effective Teaching with Technology in Higher Education: Foundations for Success. ERIC (2003)
2. Chang, C.W., Lee, J.H., Chao, P.Y., Wang, C.Y., Chen, G.D.: Exploring the possibility of using humanoid robots as instructional tools for teaching a second language in primary school. Educational Technology & Society 13, 13--24 (2010)
3. Kanda, T., Hirano, T., Eaton, D., Ishiguro, H.: Interactive robots as social partners and peer tutors for children: A field trial. Human-Computer Interaction 19, 61--84 (2004)
4. Tanaka, F., Matsuzoe, S.: Children Teach a Care-Receiving Robot to Promote Their Learning: Field Experiments in a Classroom for Vocabulary Learning. Journal of Human-Robot Interaction 1, 78--95, (2012)
5. Zhang, Y., Shan, L., Li, S.: Educational game design for teaching Chinese as a foreign language by effective learning environment, flow, motivation. In: New Horizons in Web-Based Learning-ICWL 2010 Workshops, pp. 1--10. Springer, (2011)
6. Seneff, S., Wang, C.: Web-based dialogue and translation games for spoken language learning. In: Proceedings of the Speech and Language Technology in Education (SLaTE) Workshop, Farmington, PA. (2007)
7. Ehrman, M.E.: Understanding Second Language Learning Difficulties. ERIC (1996)
8. Lee, S., Noh, H., Lee, J., Lee, K., Lee, G.G., Sagong, S., Kim, M.: On the effectiveness of robot-assisted language learning. ReCALL 23, 25--58 (2011)
9. Chen, G.-D., Chang, C.-W.: A Task-Based Role-Playing Game with Educational Robots for Learning Language. Learning by playing. Game-based education system design and development, pp. 483--488. Springer (2009)
10. Han, J.: Emerging Technologies: Robot Assisted Language Learning. Language Learning and Technology 16, 1--9 (2012)
11. Mubin, O., Bartneck, C., Feijs, L., Hooft van Huysduynen, H., Hu, J., Muelver, J.: Improving Speech Recognition with the Robot Interaction Language. Disruptive Science and Technology 1, 79--88 (2012)
12. Mubin, O., Stevens, C., Shahid, S., Mahmud, A.A., Dong, J.J.: A review of the applicability of robots in education. Journal of Technology in Education and Learning 1, 1--7 (2013)
13. Alimisis, D.: Educational robotics: Open questions and new challenges. Themes in Science and Technology Education 6, pp. 63--71 (2013)
14. Vavassori Benitti, F.B.: Exploring the educational potential of robotics in schools: A systematic review. Computers & Education 978--988 (2011)
15. CMU Sphinx4 speech recognizer, http://cmusphinx.sourceforge.net/sphinx4/
16. The Festival Speech Synthesis System, http://www.cstr.ed.ac.uk/projects/festival/
17. Hone, K., Graham, R.: Towards a tool for the subjective assessment of speech system interfaces (SASSI). Natural Language Engineering 6, 287--303 (2001)
18. Papert, S.: Mindstorms: Children, computers, and powerful ideas. Basic Books, Inc. (1980)
19. Han, J., Kim, D.: r-Learning services for elementary school students with a teaching assistant robot. HRI 2009, pp. 255--256. ACM (2009)
20. Brom, C., Sisler, V.t., Buchtova, M., Klement, D., Levcik, D.: Turning high-schools into laboratories? lessons learnt from studies of instructional effectiveness of digital games in the curricular schooling system. E-Learning and Games for Training, Education, Health and Sports, pp. 41--53. Springer (2012)
21. Lindh, J.r., Holgersson, T.: Does lego training stimulate pupils ability to solve logical problems? Computers & Education 49, 1097--1111 (2007)
22. Alimisis, D.: Robotics in Education & Education in Robotics: Shifting Focus from Technology to Pedagogy.