A Mobile Game for Learning English Vocabulary with Augmented Reality Block Builder

Lap-Kei Lee[1](✉), Chi-Pang Chau[1], Ki-Nam Tsoi[1],
Nancy Ling Yang[1], and Nga-In Wu[2]

[1] School of Science and Technology, The Open University of Hong Kong,
Ho Man Tin, Kowloon, Hong Kong SAR, China
`lklee@ouhk.edu.hk`, `{gll41l002,gll40853,`
`gll40698}@study.ouhk.edu.hk`
[2] Division of Communication and Social Sciences, Hong Kong Community
College, Hong Kong Polytechnic University, Kowloon, Hong Kong SAR, China
`ninwu@hkcc-polyu.edu.hk`

Abstract. English learning is an essential part in modern education, and English vocabulary development has been shown particularly important in English learning. Yet, learners often found the process of English vocabulary learning dry and tasteless. This paper explores the possibility of using mobile game and Augmented Reality (AR) technology to improve the experience of English vocabulary learning. Our mobile game allows learners to play and learn anywhere and anytime. It is a multi-player word-guessing game, where a player can construct a virtual figure for an English word using an AR block builder and other players can guess the correct word from the virtual figure using their imagination. Preliminary user evaluation showed that our game facilitates players' learning on English vocabulary and also fosters their creativity. We believe this game will help forming a learning community, which can serve as a stepping stone for more involved collaborative learning activities on English learning.

Keywords: Augmented Reality · English vocabulary learning · Educational game · Mobile game · Block builder

1 Introduction

English learning is an essential part in modern education. English is one of the most widely spoken languages across the globe. Many countries include English as a second language in their education system, and children are required to learn English at a young age; for example, children in China are required to learn English starting from Grade 3 of the national education system (Wang 2007); all or nearly all (at least 99%) primary school students in the European countries including Italy, Spain, Austria, Norway, Cyprus, Malta learnt English as a foreign language (Eurostat Statistics Explained 2018).

English vocabulary development is particularly important in English learning. Huckin (1995) showed the main and biggest obstacle in second language acquisition is the lack of vocabulary knowledge. August et al. (2005) also found that students with slow English vocabulary development are likely to perform poorly on comprehending text and are at risk of being diagnosed as learning disabled.

Yet English vocabulary learning is often considered as a boring and tasteless process especially for learners growing up in the digital age (Yip and Kwan 2006). The reasons include that the learners have to memorize a large number of unfamiliar words and their spelling (Long 1996; Huyen and Nga 2003), and that the learners are typically asked to complete lots of rote learning of vocabulary activities (Yip and Kwan 2006). Education practitioners and researchers have devised methods for teaching and learning English vocabulary in a fun and attractive way, which includes using educational games (see, e.g., the work of Yip and Kwan (2006), Ashraf et al. (2014) and AlShaiji (2015), and references therein) and using the Virtual Reality technology (e.g., Chen (2016)) and the Augmented Reality technology (e.g., Lee et al. (2019)).

Pictionary. One of the educational games for English vocabulary learning is *Pictionary*, which is a board game played by a group of players. Pictionary is basically a word-guessing game, as follows:

1. One player called *describer* is given a *target word* corresponding to a category game card.
2. The describer sketches or draws a related picture without the words on a blank screen (e.g., paper or chalkboard).
3. Then, the other players called *decoders* try to guess the correct target word from the picture.

Pictionary and its variants were used in English vocabulary learning, e.g., Townsend and Collins (2009) and Bakhsh (2016). These games are lively and productive ways to associate a picture with a word; students will remember the target words they labored to visualize in the game even after a long time (Sökmen 1997). These games also enable students to make connection between the target word and other words from their own prior knowledge (Townsend and Collins 2009). Draw Something (OMG-POP, Inc. 2012) is an online version of Pictionary, which is a mobile application allowing players to play anywhere and anytime.

Augmented Reality in Education. Augmented Reality (AR) is a technology that enables computer-generated virtual 3D objects to augment the physical world, and the users can interact with the 3D objects like a real object on the screen of a mobile device with a camera. The survey by Billinghurst et al. (2015) showed different applications of AR, and an important application is education (Wu et al. 2013). AR enables the visualization of complex spatial relationships and abstract concepts, e.g., anatomical education (Thomas et al. 2010), and also enables the simulation of a learning environment that was not possible using other technologies, e.g., radiation-polluted environment (Chang et al. 2013). AR offers a lot of benefits in education: it engages, stimulates, and motivates students to explore learning materials from different angles (Kerawalla et al. 2006); it provides students different ways to engage with the content,

and thus promote active learning and enhance learning experience (Garrett et al. 2018); and it fosters students' creativity and imagination (Klopfer and Yoon 2004).

Our Contribution. This paper explores the possibility of combining the benefits offered by Augmented Reality (AR), mobile learning, and the multiplayer educational game Pictionary in English vocabulary learning. We present the design of a multiplayer mobile word-guessing game with an AR Block Builder. Like Pictionary, players of a game include a describer and a number of decoders. The describer will be given an English target word in some difficulty level, and will be required to use the AR block builder to assemble a virtual figure for the target word using virtual blocks of different types and colors in a creative and fun way. Then, the decoders can observe the virtual 3D figure in different angles using AR and try to guess the correct English word with their imagination.

Preliminary user evaluation using a survey on 50 respondents including students, teachers and parents showed that our game facilitates players' learning on English vocabulary and also fosters their creativity. Our game is a fun and attractive way for learners to play and learn English vocabulary anywhere and anytime. We believe this game will help forming a learning community from the players, and such community can serve as a stepping stone for more involved collaborative learning activities on English learning.

1.1   Related Work

Using Educational Games in English Learning. Besides board games like Pictionary, educational games can also be implemented as video games and computer games. Yip and Kwan (2006) showed in an experiment on 100 college students that students learning English vocabulary through a number of educational web games outperformed those learning with conventional activity-based lessons using pre- and post-tests. Ashraf et al. (2014) showed a similar result for educational online games on 24 Iranian low-intermediate EFL (English as a Foreign Language) students. AlShaiji (2015) investigated the impact of educational video games on promoting the English vocabulary retention of 60 Saudi kindergarten students, and showed that video games are effective in teaching English vocabulary to the students. There is, however, existing work showing the opposite result. Calvo-Ferrer (2017) showed that the differences in L2 vocabulary acquisition between educational video games and conventional instruction are small. Yet they also showed that educational games increase students' extrinsic motivation in learning, as they are more attractive and fun comparing with conventional learning methods.

Using VR in English Learning. Virtual Reality (VR) is a technology allowing a user to see a virtual 3D world by wearing a VR headset, e.g., HTC Vive (www.vive.com), and to create, modify and manipulate virtual 3D objects like physical objects without real-world limitations by holding a remote controller (Bricken 1991). Chen (2014) developed a VR courseware for learning occupational English and showed that 120 freshmen and sophomore EFL students gradually increased their vocabulary competence via learning with the VR courseware. Chen (2016) considered the VR platform

Second Life, which is widely used in higher education (Warburton 2009), and showed how Second Life can serve as an online multiplayer learning environment for adult EFL learners and teachers to participate in virtual class activities.

Marker-Based and Markerless AR. AR is based on techniques developed in VR, but AR only requires a mobile device while VR requires both the VR headset and the remote controller. Therefore, AR offers greater portability and convenience than VR. Two primary types of AR implementations are marker-based and markerless AR (Siltanen 2012). Marker-based AR relies on a reader (e.g., camera) to read a special image called *marker* (e.g., QR code) to produce the virtual 3D objects; while markerless AR detects a surface in the camera image and produce the virtual 3D objects on top of the detected surface. Marker-based AR is easier to develop and provide a more stable environment for the virtual 3D objects, but the use of a physical marker makes it less convenient than markerless AR.

Using AR in English Learning. There are lots of existing work on using AR in teaching and learning of English vocabulary. AR-animals (www.ar-animals.com) is a marker-based AR mobile application for English vocabulary education, where the learning material is a book with markers of a price $18. Lee et al. (2017) showed the design of a markerless AR mobile application for kindergarten students to learn English vocabulary, and the mobile application has a monitoring system for parents to monitor and control children's usage in real time. Chen et al. (2018) developed a markerless AR mobile application for learning English vocabulary and an experiment on 46 primary students showed that the AR application can significantly improve students' motivation and learning effectiveness. Lee et al. (2019) showed how kindergarten teachers can apply a marker-based AR mobile application coupled with classroom management functionality in their English vocabulary lesson to make the lesson fun and attractive.

Organization of the Paper. Section 2 presents the design details of our multiplayer mobile word-guessing game. Section 3 gives the preliminary evaluation result. Section 4 discusses the evaluation result and concludes the paper.

2 Our Multiplayer Mobile Game

This section presents the detailed design of our multiplayer mobile word-guessing game. Our mobile game can be run on a mobile device with the operating system Android 4 or above, and equipped with a camera and at least 1 GB RAM of memory. Each player needs to play with his/her own mobile device. Our game was developed using the game engine Unity and the Vuforia Augmented Reality SDK. Our mobile game contains three components: an AR block builder (which requires a QR code as a marker), a word-guessing game, and a revision on history of games.

2.1 AR Block Builder

The AR block builder allows a player (describer) to assemble a virtual figure for the English target word using virtual building blocks of different types and colors in a

creative and fun way. It employs marker-based AR and requires the mobile device's camera to read a QR code image (Fig. 1) as a marker, and then a virtual *assembly area* for the building blocks will be displayed on top of the marker (Fig. 2).
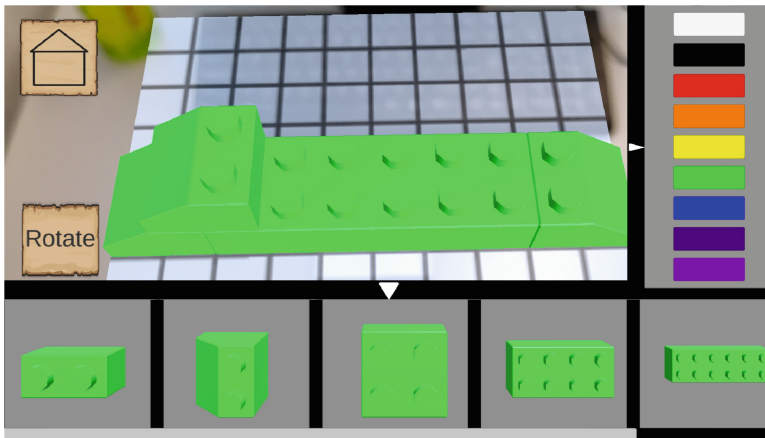

Fig. 1. Our   AR marker.
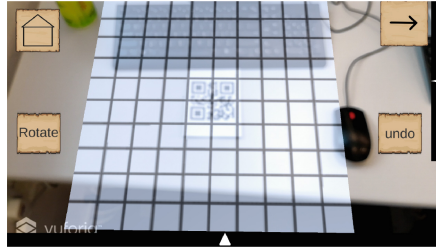
Fig. 2. Virtual assembly area for the building blocks.

The *building block panel* and the *color panel* are hidden in the bottom and right boundaries, respectively, in the user interface shown in Fig. 2. Pressing the white arrows in the boundaries invoke the corresponding panels (Fig. 3).

Fig. 3. Building block panel (bottom) and color panel (top-right).

Building Block Panel. The building block panel provides 6 different types of virtual building blocks in different sizes and shapes. Once the describer select a building block, he/she can click a location on the assembly area to place the building block there. If the describer clicks on an existing building block in the assembly area, the new building block will be placed on top of the existing one.

The user interface shown in Fig. 2 contains four buttons. The upper-left button is the *home button* for returning to the game menu page (to be introduced in the next

subsection). Pressing the home button also triggers a prompt asking the user to save any unsaved work (if there is any). The lower-left button is the *rotate button* for rotating a building block by 90° clockwise. The lower-right button is the *undo button* for removing the most recently placed building block in the assembly area. The upper-right button is the *complete button* for completing the assembly of a virtual figure for an English target word. Pressing the complete button will prompt the describer to select a number of friends as decoders to play the game.

Color Panel. The color panel contains 9 different colors (white, black, red, orange, yellow, green, blue, violet, and purple). Pressing one of these colors will change the color of all building blocks shown in the building block panel.

As to be shown in the next subsection, the combination of different colors and types of building blocks allows us to assemble figures for different target words.

2.2 Word-Guessing Game

The word-guessing game has game rule similar to the game Pictionary. In each game, there is one describer, who is given an English target word and is required to assemble a virtual figure of the target word using the AR block builder. The other players are decoders, who try to guess the target word by observing the virtual figure in different angles and combining their imagination.

To ease connecting with friends, all players are required to login with their Facebook account (Fig. 4). After login, the game menu page is shown (Fig. 5).
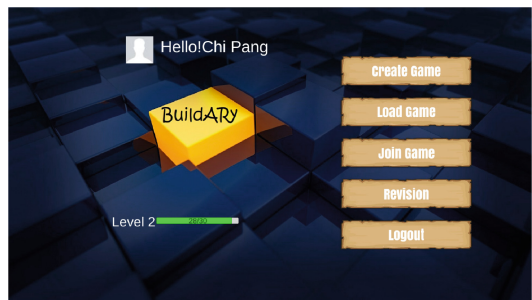

Fig. 4. Login page.

Fig. 5. Game menu page.

Create a New Game as a Describer. The player can act as a describer to start a new game using the *Create Game* button in the game menu. The player can choose vocabulary from three categories: Food, Animal, and Place (Fig. 6), and then select a target word in three difficulty levels: Easy, Medium, and Difficult (Fig. 7). It is also possible to use a custom target word. After selecting the target word, the player can build the virtual figure for the target word in the AR block builder.
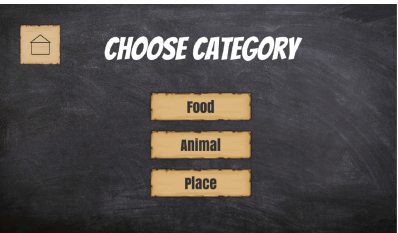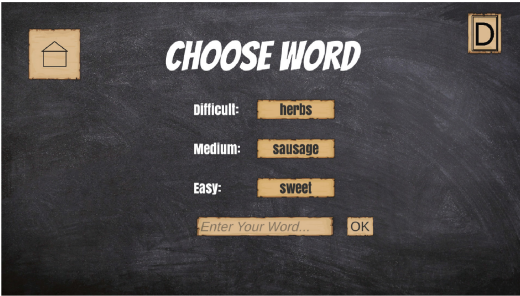
Fig. 6. Categories of vocabulary.   **Fig. 7.** Difficulty levels of vocabulary.

Load a Saved Game. A describer can quit the AR block builder anytime, and the virtual figure in progress can be saved. The *Load Game* button in the game menu allows the describer to continue the assembly of a saved figure.

Invite Decoders. When a describer completes the virtual figure for the target word (by pressing the *complete button* in the AR block builder), the describer can invite a number of friends from the Facebook friend list (Fig. 8) to play the game as decoders.

Join an Invited Game as a Decoder. The player can press the *Join Game* button to see the list of invited games created by other players. For each game, the category and difficulty level (Easy, Medium, Difficult, Custom) of the target word are shown.

Figure 9 shows the gameplay of a decoder for the target word "crocodile" under the category "Animal". Like the AR block builder, the QR code image is used as the AR marker. On the screen of the mobile device, the real-time camera image is overlaid with the virtual figure, which is placed on top of the AR marker. The size and direction of the virtual figure will change according to the player's movement of the mobile device such that the player can zoom in/out and view the virtual figure in different directions as if the virtual figure is a real object placed on top of the AR marker. In the bottom of the user interface, the mobile game will generate a number of character blocks, and the decoder is required to click the correct character blocks in the correct order and then click *OK* to check whether the game is completed correctly.
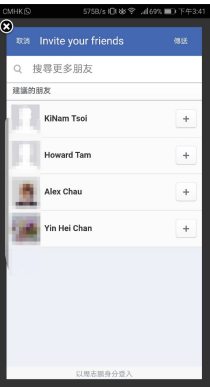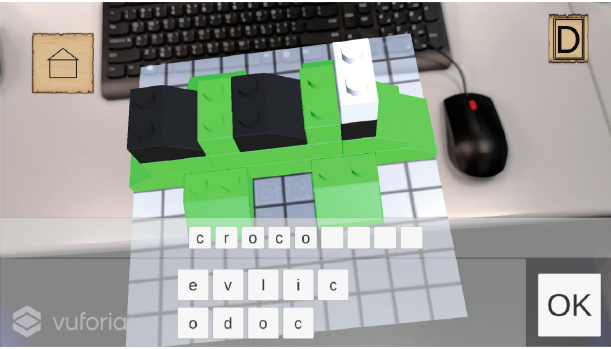

Fig. 8. Inviting decoders.   **Fig. 9.** Game for the word "crocodile" under "Animal".

The Power of Augmented Reality (AR). Different from the game Pictionary and its variants (Townsend and Collins 2009; Bakhsh 2016), our 3D virtual figure for the target word allows details to be hidden in different sides of the virtual figure. For example, it may be unclear that the virtual figure shown in Fig. 10 (left) is a "bedroom" under the category "Place", but viewing it in another angle as shown in Fig. 10 (right) would make the answer clear when the decoder is able to identify the bed and makeup table, respectively.
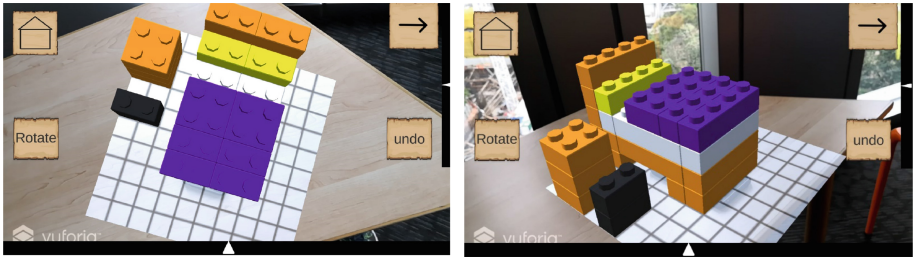
Fig. 10. Game for the word "bedroom" under the category "Place".

The word "bruise" under the category "Food" refers to the damage mark on the skin of a fruit. Figure 11 shows that the bruise can only be found in some particular angle of the virtual figure; it can be seen in right figure but not the left one. We believed that the learners will find the game more fun and interesting when looking for such hidden details in the virtual figure from different angles of view.

Fig. 11. Game for the word "bruise" under the category "Food".

Translator. A translator can be invoked in different parts of the game to facilitate learning. The player can press the "D" button in the user interface, e.g., Fig. 7 (when creating a game) and Fig. 9 (when guessing a word), and then the translator will be shown that supports translation from English to Chinese or vice versa (Fig. 12).

Fig. 12. Translator for translating words between Chinese and English.

2.3 Revision on History of Games

Inspired by the finding of Sökmen (1997) that students can remember the target words they labored to visualize in Pictionary even after a long time, our mobile game supports revision on previous games. This functionality can be assessed using the *Revision* button in the game menu (Fig. 5). Then, a list of previously played games will be shown as in Fig. 13. The target word, its vocabulary category and difficulty level is shown, and players can view the corresponding virtual figure again using AR.

Fig. 13. Revision on history of games.

3   Preliminary Evaluation

This section presents the result of a preliminary evaluation on our game design from different stakeholders of English vocabulary learning.

Participants and Setting. We invited 50 participants including students, teachers and parents to complete an online survey. In the online survey, each participant is given a demonstration video introducing different functionality of our mobile game, an installation file of the mobile game that contains three pre-created invited games, and an online questionnaire to be filled after the participants view the demonstration video and/or play our mobile game on their mobile devices. Among the 50 respondents, 25

participants (50%) installed and played the game; the other 25 participants only watched the demonstration video because they don't have an Android device (n = 12, 24%), or they are not interested in playing the game (n = 11, 22%), or for other reasons (n = 2, 4%).

Results. The online survey used a 5-point Likert scale (1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree), which has 13 items related to game design (Items 1–4), gameplay (Items 5–9), and comparison with traditional learning methods (i.e., reading books and attending classes) (Items 10–13). Table 1 shows the results on the 25 game players, who answer all the items; and Table 2 shows the results on the other 25 non-players, who did not play the game and thus did not answer items for gameplay (Items 5-9).

Table 1. Survey result on game players.

Item	1	2	3	4	5
(1) The AR function attracts you to play the game	4%	4%	8%	76%	8%
(2) The game helps you to understand the vocabulary	0%	20%	8%	60%	12%
(3) The AR function helps promoting creativity	0%	8%	8%	68%	16%
(4) The UI is easy to use	4%	20%	8%	64%	4%
(5) The game control is easy	8%	28%	8%	48%	8%
(6) The vocabulary learnt is useful in daily life	0%	4%	4%	80%	12%
(7) The vocabulary has a suitable difficulty level	4%	8%	8%	68%	12%
(8) The translator helps you to learn more effectively	0%	8%	8%	64%	20%
(9) The revision is useful for reviewing learnt words	0%	4%	8%	68%	20%
(10) The game helps learning English	0%	4%	4%	80%	12%
(11) The game is more attractive than the traditional learning method	0%	20%	8%	52%	20%
(12) The game helps you understand a word better than using the traditional learning method	0%	16%	8%	60%	16%
(13) You prefer learning using the game over using the traditional learning method	0%	20%	8%	64%	8%

Table 2. Survey result on non-players.

Item	1	2	3	4	5
(1) The AR function attracts you to play the game	4%	32%	4%	56%	4%
(2) The game helps you to understand the vocabulary	4%	40%	0%	56%	0%
(3) The AR function helps promoting creativity	4%	20%	4%	68%	4%
(4) The UI is easy to use	4%	8%	4%	80%	4%
(10) The game helps learning English	4%	24%	0%	68%	4%
(11) The game is more attractive than the traditional learning method	4%	16%	4%	64%	12%
(12) The game helps you understand a word better than using the traditional learning method	4%	32%	4%	44%	16%
(13) You prefer learning using the game over using the traditional learning method	8%	40%	4%	36%	12%

4   Discussion and Conclusion

Table 1 shows that the majority of the game players agreed that the AR function is attractive and helps promoting creativity. The majority of the game players also agreed that the game helps them to understand the vocabulary, and the UI is easy to use. Yet, only 56% of the game players agreed that the game control is easy (Item 5). It may be due to the use of a physical QR code image as the AR marker; physical markers are consumable and would be damaged that greatly affects usability (Lee et al. 2017). For the remaining items, the majority of the game players agreed that the game and revision can help learning vocabulary and the vocabulary are useful in daily life and in suitable difficulty levels. They also preferred learning English vocabulary using the game over using traditional learning method.

Table 2 shows the survey result on non-players. Only 60% of them agreed that the AR function is attractive (Item 1), and only 56% of them agreed that the game is helpful in understanding the vocabulary (Item 2). Similarly, only 60% of them agreed our game helps learners to understand a word better than using traditional learning methods (Item 12), and only 48% of them preferred to use our game as learning tool over using traditional learning methods (Item 13). One reason for these negative results may be that 11 of these non-players (i.e., 44% of the non-players) are not interested in playing our game in the first place, and thus they do not try to install the game and actually try the functionality offered by our game. Nevertheless, aggregating both the game players and non-players, the overall majority of participants agreed on Items 1, 2, 12 and 13. For the remaining items, the majority of the non-players also agreed on them.

To sum up, this paper presented the design of a multiplayer mobile word-guessing game that combines the benefits offered by Augmented Reality (AR), mobile learning, and the multiplayer educational game Pictionary in English vocabulary learning. The preliminary evaluation showed that our game is a fun and attractive way for learners to learn English vocabulary and foster their creativity anywhere and anytime. The players of this game can form a community on English learning, and we believed that such community will be ready for more involved collaborative learning activities.

Limitation and Future Work. Our preliminary evaluation only provides limited information on the players' learning effectiveness on learning English vocabulary. A future work is to perform pre- and post-tests to compare the performance of learners using our mobile game and using the traditional learning methods as learning tool, respectively. Another direction of future work is to replace marker-based AR with markerless AR, which does not require a physical AR marker and is expected to improve the game experience of the learners.

References

AlShaiji, O.A.: Video games promote Saudi children's English vocabulary retention. Education **136**(2), 123–132 (2015)

Ashraf, H., Motlagh, F.G., Salami, M.: The impact of online games on learning English vocabulary by Iranian (low-intermediate) EFL learners. Procedia-Social Behav. Sci. **98**, 286–291 (2014)

August, D., Carlo, M., Dressler, C., Snow, C.: The critical role of vocabulary development for English language learners. Learn. Disabil. Res. Pract. **20**(1), 50–57 (2005)

Bakhsh, S.A.: Using games as a tool in teaching vocabulary to young learners. English Lang. Teach. **9**(7), 120–128 (2016)

Billinghurst, M., Clark, A., Lee, G.: A survey of augmented reality. Found. Trends Hum. Comput. Inter. **8**(2–3), 73–272 (2015)

Bricken, M.: Virtual reality learning environments: potentials and challenges. ACM SIGGRAPH Comput. Graph. **25**(3), 178–184 (1991)

Calvo-Ferrer, J.R.: Educational games as stand-alone learning tools and their motivational effect on L 2 vocabulary acquisition and perceived learning gains. Br. J. Edu. Technol. **48**(2), 264–278 (2017)

Chang, H.Y., Wu, H.K., Hsu, Y.S.: Integrating a mobile augmented reality activity to contextualize student learning of a socioscientific issue. Br. J. Edu. Technol. **44**(3), E95–E99 (2013)

Chen, Y.L.: Virtual reality software usage in an EFL scenario: an empirical study. J. Softw. **9**(2), 374–381 (2014)

Chen, J.C.: The crossroads of English language learners, task-based instruction, and 3D multi-user virtual learning in Second Life. Comput. Educ. **102**, 152–171 (2016)

Chen, S.Y., Hung, C.Y., Chang, Y.C., Lin, Y.S., Lai, Y.H.: A study on integrating augmented reality technology and game-based learning model to improve motivation and effectiveness of learning English vocabulary. In: 1st International Cognitive Cities Conference (IC3), pp. 24–27. IEEE, August 2018

Eurostat Statistics Explained. Foreign language learning statistics, September 2018. https://ec.europa.eu/eurostat/statistics-explained/index.php/Foreign_language_learning_statistics

Garrett, B.M., Anthony, J., Jackson, C.: Using mobile augmented reality to enhance health professional practice education. Curr. Issues Emerg. eLearning **4**(1), 10 (2018)

Huckin, T.: Second Language Reading and Vocabulary Learning. Ablex, Norwood, NJ (1995)

Huyen, N.T.T., Nga, K.T.T.: Learning vocabulary through games. Asian EFL J. **5**(4), 90–105 (2003)

Kerawalla, L., Luckin, R., Seljeflot, S., Woolard, A.: "Making it real": exploring the potential of augmented reality for teaching primary school science. Virtual Reality **10**(3–4), 163–174 (2006)

Klopfer, E., Yoon, S.: Developing games and simulations for today and tomorrow's tech savvy youth. TechTrends **49**(3), 33–41 (2004)

Lee, L.K., Chau, C.H., Chau, C.H., Ng, C.T.: Using augmented reality to teach kindergarten students English vocabulary. In: 2017 International Symposium on Educational Technology (ISET), pp. 53–57. IEEE, June 2017

Lee, L.K., et al.: Improving the experience of teaching and learning kindergarten-level English vocabulary using augmented reality. Int. J. Innov. Learn. **25**(2), 110–125 (2019)

Long, M.H.: The role of the linguistic environment in second language acquisition. In: Ritchie, W.C., Bhatia, T.K. (eds.) Handbook of Second Language Acquisition, pp. 413–468. Academic Press, New York (1996)

OMGPOP, Inc. Draw Something [Mobile application software] (2012). http://itunes.apple.com

Siltanen, S.: Theory and Applications of Marker-Based Augmented Reality. VTT, Espoo (2012)

Sökmen, A.J.: Current trends in teaching second language vocabulary. Readings in Methodology, pp. 152–161 (1997)

Thomas, R.G., William John, N., Delieu, J.M.: Augmented reality for anatomical education. J. Vis. Commun. Med. **33**(1), 6–15 (2010)

Townsend, D., Collins, P.: Academic vocabulary and middle school English learners: an intervention study. Read. Writ. **22**(9), 993–1019 (2009)

Wang, Q.: The national curriculum changes and their effects on English language teaching in the People's Republic of China. In: International Handbook of English Language Teaching, pp. 87–105. Springer, Boston (2007)

Warburton, S.: Second Life in higher education: assessing the potential for and the barriers to deploying virtual worlds in learning and teaching. Br. J. Edu. Technol. **40**(3), 414–426 (2009)

Wu, H.K., Lee, S.W.Y., Chang, H.Y., Liang, J.C.: Current status, opportunities and challenges of augmented reality in education. Comput. Educ. **62**, 41–49 (2013)

Yip, F.W., Kwan, A.C.: Online vocabulary games as a tool for teaching and learning English vocabulary. Educ. Media Int. **43**(3), 233–249 (2006)