Interactive English Phonics Learning for Kindergarten Consonant-Vowel-Consonant (CVC) Word Using Augmented Reality

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Abstract—This paper is described about Interactive English Phonics Learning in Kindergarten Consonant-Vowel-Consonant (CVC) Word using Augmented Reality (AR) Technology with aims to make phonics learning more interesting, interactive, and effective. The image marker based technique of Augmented Reality technology allowed children to interact with virtual phonics content through physical manipulation. With this courseware, children are allowed to learn the phonics sound and CVC word matching through phonics card matching. Phonics card here is the image marker. This interaction method provides a better learning experience for children.

Index Terms—English Phonics; Consonant-Vowel-Consonant; Interactive Learning Experience; Augmented Reality; Image Marker.

I. BACKGROUND

Phonics is the relationships of letter and sounds. The knowledge of phonics is important for children to develop and improve their English reading skill. However, phonics is one important component of high quality comprehensive reading program that being lack taught in government kindergarten. Interview sections with both Malaysia's government and private kindergarten have been done. English learning in government kindergarten is not focus on phonics but is whole word reading and alphabet spelling. On the other hand, phonics learning in private kindergarten is more on phonics singing with hand movements, phonics reading using flash card, and paper worksheet. Hence, interactive phonics learning should be used and enhanced in order to help children increase their knowledge retention and attracted to phonics learning [1, 2]. According to Oxford Dictionaries, "Interactive defines as the two-way flow of information between a computer and a computer-user" [3]. In order to make phonics learning becomes more effective, here comes a project with aims of designing an interactive English phonics learning courseware for Kindergarten using Augmented Reality (AR) technology. AR technology allows the physical images or object mixed with a virtual layer. AR started applying in education in order to make learning more interesting and effective [2, 4, 5]. To achieve the objectives of this project, research has been done to identify the phonics content for interactive courseware development, to identify suitable AR development platform, to design an interactive AR courseware framework, and to develop a prototype using the framework designed.

II. RELATED WORK

Several studies are done to determine the phonics content and AR development platform that can use in this proposed project.

A. Phonics Content for Interactive Courseware Development

According to National Institute of Child Health and Human Development, there are five types of phonics instructional methods and approaches which are analogy, analytic, embedded, phonics through spelling, and synthetic phonics [6].

Learners are learning unfamiliar words by analogy to known words in analogy phonics approach. Leaners know the simple words and they can always recognize the rime segment of unfamiliar words which is similar to the known words. For analytic phonics approach, learners can analyze the relationship between letters and sounds through previously learned words to avoid pronouncing sounds in isolation. The whole word will be taught for learners followed by letters linking systematically of the word with their respective sounds. Embedded phonics is an approach that typically less explicit and will be used less frequently. Learners need to practice phonics skills by embedding phonics instruction or phonics rules in text reading.

For phonics through spelling approach, it focuses on spelling the words phonemically. Learners are taught to break down the words into phonemes and to select letters for those phonemes. Synthetics phonics approaches begin by learning the phonics sound and blend the sounds together to read the words. Children should learn the common sounds for vowel patterns in order to become fluent readers. They are able to learn the pattern of words and learn the changes of whole word by changing of letter or letter position through making words. This lesson helps to develop phonemic awareness of children as they hear the order of the sounds. This lesson should come with the words that child known such as cat, van and so on.

B. Courseware Evaluation Criteria

Courseware evaluation criteria act as a parameter to measure the effectiveness and the usability of the developed courseware. There are four courseware criteria extract from the study on [7] and [8] which are appropriateness of content, presentation of content, evaluating learning, and technical support and update. First, the appropriateness of content is the criteria used to determine whether the courseware learning

content is suitable for the target user. Second, the presentation of content is the criteria used to measure whether the presentation method of courseware can improve learning efficiency. Third, the evaluating learning is the criteria to measure whether there are quizzes, test or game included in courseware in order to test the understanding and strengthen the memory of children. Forth, the technical support and update process is the criteria used to measure whether the courseware will under regular maintenance and up to date. The review on related courseware is based on the courseware evaluation criteria.

1) Ultimate Phonics

This courseware is targeted on learners with ages 4 and above [9]. It fulfills the criterion of appropriateness of content as it has logical order of learning level as it start lesson from basic to advance level. It has enough content coverage as it contains 262 lessons, 4400 words and 2100 sentences. The interaction method is mouse-over and clicks. Immediate and positive feedback provided.

2) Reading Bear

Reading Bear is a free online courseware that teaches learners about the main phonics patterns of written English systematically [10]. This courseware is targeted on beginning learners with ages of 4-7. It fulfills the criterion of appropriateness of content as has logical order of learning level as it start lesson from basic to advance level. It has enough content coverage as it covers about 50 presentations and illustrating over 1200 vocabulary items. The interaction method is mouse clicks. This courseware provide quiz in each lesson.

3) Phonics Guessing Game

This is a free Android-based two-in-one courseware which combines Phonics Cards and Guessing Game [11]. This courseware is targeted on preschool children. It fulfills the criterion of appropriateness of content as it meets the objective of phonics learning. The interaction method is touch based and flips. This courseware used game to evaluate learning.

4) Kids Learning Phonics Lite

Kids Learning Phonics Lite is a free Android-based courseware which covers the phonics letter A to J [12]. This courseware is targeted on preschool kids. It fulfills the criterion of appropriateness of content as it meets the objective of phonics learning. The interaction method is touch based and drag and drop. For evaluating learning criteria, this courseware used game during learning process.

5) Augmented Reality English Vocabulary Learning System (AREVLS)

AREVLS is the phonics courseware that used AR technology. The marker type that this courseware used is template marker [13]. AREVLS courseware is developed based on ARToolKit. This courseware is targeted on preschool children. The interaction method is mouse-click and marker matching. For evaluating learning criteria, this courseware used test during learning process.

6) Majalah Upin

Majalah Upin dan Ipin is the first AR magazine in Malaysia [14]. This is a Malay language educational magazine targeted for preschool and primary school children. The interaction method is marker and touch screen. For evaluating learning criteria, it does not have any test or game provided.

C. Augmented Reality Tracking Teachnique

AR application can be designed based on three tracking techniques which are Location Based Tracking (LBT), Marker-less Tracking, and Marker-based Tracking. Global positioning system (GPS) is one of the LBT that provides success and accurate location tracking in outdoor setting. Those applications used the aids of GPS, compass, and the phone camera to augment location-based information for the user [15]. Marker-less tracking also known as feature tracking does not require a special marker in application setting. Phone camera or PC camera can recognize and extract the specific required features based on the computer vision algorithms such as objects, buildings, and face [16].

Marker-based tracking of AR is used suitable in AR courseware development. There are several types of marker-based tracking: template, 2D Barcodes, and imperceptible markers. Template marker consists of a square with a black and white color and a pattern inside the black border. It has the limitation that the efficiency of tracking will be affected as the complexity of the marker pattern. 2D barcodes are also black and white marker but they offer better results as the pattern included an ID number but not image [16]. Image marker is one of the imperceptible markers which can use the natural (color) image as markers [15]. It can be an image marker with frame or without frame. Image marker without frame can be used in the education area as AR courseware can pop-out 3D image or animation by using the images of existing books.

D. Software Development Toolkits

There are several AR software development toolkits available for AR courseware development.

ARToolKit is a free AR software development kit (SDK) that can be run on Windows, Linux, Mac OS X, iOS, and Android OS. ARToolKit can tracks template marker and ID marker in the video frame. These types of marker are black and white marker squares with user-definable patterns ARToolKit uses computer vision techniques for real camera position and orientation relative to square shapes or flat textured surface calculation. The virtual object can overlays and aligns with real world objects. The virtual layer that supported by ARToolKit are both video and optical see-through augmented reality [17].

FLARToolKit is a free SDK that used to develop web-based AR application. It is one of the most popular marker-based AR tracking library developed by Dr. Hirokazu Kato [17]. Marker tracking of FLARToolKit is the ID Marker [18]. The border with square shape is the standard shape of the marker. Thousands of different marker patterns with no additional performance per detectable pattern would be supported in this marker system. Marker detection will be more accurate and fast as lower pattern resolution result [18].

Vuforia SDK is one of the AR SDK that is free and can create an AR application runs on any Android device [19]. Vuforia SDK can detect and track image marker. Developers able to upload the target images to Vuforia SDK "Target Management System" and downloads the target resources for application development usage. The image features are extracted by applying of Vuforia SDK's proprietary algorithms and encoded description of an image is created.

The proprietary recognition and tracking algorithms for marker images can be implemented by Vuforia SDK's proprietary library. Vuforia SDK can be used in the Unity system by working with Unity Game Development Tools. Unity system allows easier management of 3D scene.

III. REQUIREMENT ANALYSIS AND DESIGN

This paper proposes a solution as to develop a prototype of Interactive English Phonics Learning in Kindergarten Consonant-Vowel-Consonant (CVC) Word using Augmented Reality based on the related work discussed. The courseware development criteria will be applied in this proposed project to create a good courseware. The phonics instructional approach that applied in this project is synthetic phonics. This means that the designed courseware will begin with the learning of phonics sounds and then blends the phonics sounds together to read the CVC words. Augmented Reality Technology (AR) is chosen in order to make a hand on phonics card interaction for children to learn phonics sound and CVC word matching. The Vuforia SDK is chosen and the phonics and question cards act as image marker. The following section will discuss about the hardware requirement, software requirement, phonics content requirement, and design framework of this proposed project.

A. Hardware Requirement

Android-based Smartphone and tablets are very ideal hardware devices for AR courseware because they are powerful, all-in-one, and popular. Hardware devices can be Android version 2.2 (Froyo) and above. The most important features of the AR courseware that provided by Android device is built-in camera essential for vision-based tracking, powerful processor for heavy AR computation handling, and high quality display for graphic rendering.

B. Software Requirement

Vuforia SDK also known as Qualcomm's AR SDK is the main SDK that can develop a vision-based AR application. The Vuforia SDK extension for Unity not only enables vision detection and tracking functionality within Unity IDE but also allows developers to create AR applications with better scene management [20]. Developers can register the target images in the device database of the Vuforia Target Manager through online. The images' features will be extracted and stored in a database which can be downloaded and packaged together with the application. It is easier for the Vuforia to do the runtime comparison when target images tracked.

C. Phonics Content Requirement

The phonics instructional approach that applied in this courseware is synthetic phonics. Synthetics phonics approaches begin by learning the phonics sound and blend the sounds together to read the words. The words decided in this courseware are CVC words. This AR phonics courseware would be created based on the extracted courseware criteria: appropriateness of content, presentation of content, evaluating learning, and technical support and update.

1) Appropriateness of Content

Firstly, this proposed project would fulfill the criteria of appropriateness of content. Since CVC word is suitable for Kindergarten phonics learning lesson, it is selected to be the content for this project. The phonics instructional approach

will be used is synthetic phonics. Thus, children need to begin with learning the phonics sound and blends the sound together to read the words. This courseware applied the logical order of learning level. The first level is single phonics sound. When children show one phonics card in front of the device camera, they are allowed to learn the phonics sound. The second level is word matching. When children match three markers to form a word in front of the device camera, they are allowed to learn the one-by-one letter phonics sound and blend together to form a CVC word. The third level is assessment. Children need to choose the correct answer by touching the button on the question cards. The content coverage is only vowel /a/, /e/, /i/, /o/, /u/ and 15 CVC words.

2) Presentation of Content

The second criterion needed to be fulfilled is the presentation of content. Interactive courseware allows two way flow of information between courseware and children. The interaction method of touch-based, and hands on marker matching is applied. Android-based devices support touch based interaction. Once the children open this courseware, a simple instruction will be presented. Children need to touch on the screen to continue the lesson. After that, they are allowed to show the single or triple phonics cards in front of the device to learn the phonics sound and how to blend the sound to be a word.

Phonics card in this project is an image target which will be captured through device camera. It needs to be registered in device database of the Vuforia Target Manager. The image target should be 8 or 24 bit PNG or JPG format, JPG must be RGB or grayscale images, and image size should be less than 2MB [21].

Children hands on and image marker matching are effective interaction method for phonics learning. Once the children give a response by using phonics cards, immediate feedback provided through sound effect and 3D graphics. The good quality sound effect with MP3 format is more suitable for mobile platform. The 3D object and animation will be drawn in Blender and imported to Unity for implementation process. For the courseware graphic, nice color tone should be provided and have high contrast with the background.

3) Evaluating Learning

The third criterion needed to be fulfilled is evaluating learning. An assessment will be given for children to evaluate their understanding. Five question cards are provided. Each question card has three buttons. Children need to answer the question by pressing the button on the question card. Immediate and positive feedback will be provided in the assessment process.

4) Technical Support and Update Process

The last criterion needed to be fulfilled is technical support and update process. However, technical support and update process would not be under consideration yet since the final result would be a prototype only.

D. Prototype Design Framework

Figure 1 shows that the AR interactive phonics prototype design framework consists of three main modules and device camera. The modules are Database Management Module, Phonics Card Detection Module, and AR Interaction Module.
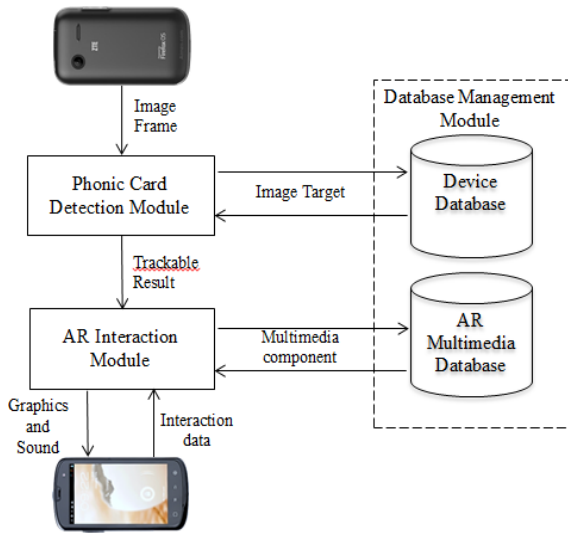
Figure 1: AR interaction phonics courseware design framework.

1) Database Management Module

This module used to prepare and manage databases. Pre-prepare phonics cards are stored in Device Database whereas virtual graphics and sounds are stored in AR Multimedia Database. For device database, the phonics images and question images should be prepared for the courseware learning usage. These images are the image target that can be downloaded online or created by Developer. The ideal image target should have good contrast, no repetitive patterns [21].

Since Unity software with Vuforia SDK allowed the developer to switch databases for different functional purpose, phonics images and question images will be uploaded to different database. Each Device Database is not more than 100 image targets. The Device Databases will be created online at the Vuforia Target Manager. The phonics images will be uploaded to two databases for two purposes, which are single phonics card interaction and triple phonics card interaction. The question card will be uploaded to another database for assessment purpose. The size of image target will be specified before upload to the device database in order to make sure the pose information returned during tracking will be in the same scale. All of the images need to be printed out. Therefore, children can hold the physical card in front of the device camera to learn phonics and answer question.

The AR Multimedia Database is used to store 3D single letter models, five static 3D question models, 15 animated 3D CVC word models, and 37 related sound effects. 3D graphic can be drawn using Blender. All of these graphic will be in .FBX format and imported to Unity with Vuforia. The phonics sound will be recorded for courseware feedback usage. The sound effect will be downloaded online. The sound effect should provide positive feedback like "Good Job", and "Try Again". The word sound should applied synthetic phonics approach which is playing the phonics sound then blends the sound together to form a word. All of these sounds should be good quality and in MP3 format.

2) Device camera

Device camera is used to capture the phonics card and question card. Once the proposed courseware is opened, the device camera will be triggered. Children are allowed to show the cards in front of the device camera. The using of camera

is to ensure that every phonics card frame is captured and passed to the Phonics Card Detection Module. Back camera will be chosen as children are easier to put the physical cards behind the camera, and view the feedback on the device screen. The device camera provides access to per-frame camera image which is useful in effect rendering. The current frame of camera image get will be RGB565, grayscale after developer registers the image format as RGB565, grayscale [22].

3) Phonics Card Detection Module

The phonics card frame data that get from the device camera will be processed in this module. First, the camera format (e.g. YUV12) will be passed to Pixel Format Converter. This converter will convert the camera format to a suitable format for OpenGL Embedded System (OpenGL ES) rendering (e.g. RGB565) and for tracking internally (e.g. luminance). Next, the frame data will be passed to the Image Target Tracker. This tracker will undergo frame data analyzing process. This tracker will define the basic properties of the frame data and compares the features of the analyzed frame data with the features of the phonics images data that have been stored in the Device Database previously.

4) AR Interaction Module

The trackable result that gets from Phonics Detection Module will then call the related AR multimedia component from the AR Multimedia Database through this module. Virtual graphic that related to the phonics card or question card will be rendered to the device interface. Besides, the sound effect will be transmitted to children.

Moreover, this module supports single letter phonics sound learning, phonics cards matching, and assessment for children. There are three mode selections in the Option page of this courseware which are *Phonics* mode, *CVC* mode and *Test* mode. The *Phonics* mode is the default mode of this courseware. When children show one phonics card under the device camera, the same procedure will be undergoing from the device camera until virtual graphic rendering and phonics sound transmitting. Children are allowed to double tap on the device screen to change mode. When children choose *CVC* mode, they can match three phonics cards under the device camera to form a word, the same procedure will be undergoing from the device camera until state object. The trackable result will be updated in state object. The script behind will identify which three card have been matched together. The important method used here is collision method between phonics cards. The related virtual graphic and sound will be displayed through this module.

Besides, when children choose Test mode, question card can be captured by device camera. The device interface will displayed question like "Question 1" and a sound instruction about the question will be played. Children need to answer the question by pressing the button on the question card. The same procedure will be undergoing from the device camera until state object. The script behind will identify which button has been chosen. The important method used here is virtual button. Sounds like "Good Job" and "Try Again" will be given to encourage children.

5) Output

Table 1 shows the output by proposed courseware.

Table 1
Output of proposed courseware

Option	Output in Device's Screen	Description
Phonics Mode		When a phonics card "a" detected by device camera, a 3D static letter "a" model will be presented on the device screen with sound.
CVC Mode		When matching phonics cards with the letter "c", "a", and "t" detected by device camera, 3D animated model "cat" will be presented on the device screen with sound.
Test Mode		Related feedback will be shown on device screen as related button chosen.

IV. TESTING AND EVALUATION

Testing of this interactive AR courseware prototype is mainly focuses on the interactive, accuracy and efficiency of the image marker techniques of AR technology. Testing is categorized into two ways, which are prototype testing and user acceptance testing.

A. Prototype Testing

Prototype testing is done according to the single phonics card interaction, triple phonics cards interaction, and assessment. The *Phonics* mode of the prototype allowed children to learn single letter phonics sound through single phonics card interaction. This interaction testing is used to measure the accuracy of this prototype whether each unique phonics card will result its related 3D model. From the testing result, it is accurate that all 16 phonics cards results its related 3D letter model with sound.

The *CVC* mode of the prototype allowed children to do hands on marker matching by matching three phonics cards together to form a CVC word interactively. This interaction testing is used to measure the accuracy and effectiveness of this prototype whether three phonics card matches together can form an expected CVC word. The testing result shows that all the 15 CVC words can be displayed on the device screen according to the related phonics cards matched. The maximum distance between phonics cards in this mode is 4cm. When children want to change one of the phonics cards to form another CVC word, the phonics card must be taken away in front of the device camera. Thus, the previous memory can be cleared in order to accept another phonics card.

The *Test* mode of the prototype allowed children to answer questions by pressing the button on the question card. This interaction testing is used to measure the accuracy of this prototype whether the output displayed related to the button pressed. The testing result shows that each button pressed will display related output. However, this prototype has slow detection when reflection on the cards occurred.

B. Children Acceptance Testing

Testing among children in kindergarten is to measure whether the proposed courseware is interactive and attractive to children. There are a total of 30 children from kindergarten Creative Kids and Childcare and kindergarten SK. St Michael participate in the testing stages. Creative Kids and Childcare is a private kindergarten located at Pelita Heights, BDC while SK. St Michael is a government kindergarten located at Entingan, Kota Samarahan.

During the learning section, most of the children are attracted by the proposed courseware. They look excited when learning through the proposed courseware. They gain new learning experience when interact with the proposed courseware which developed using AR technology. For example, the teacher will ask them to choose phonics cards of "c", "a", and "t", the children will find the phonics cards for teacher. When the phonics cards matched together and a 3D cat displayed with sound, the children will know the result is a "cat" and read the "cat" word together with the phonics sound. When teachers ask them to read the CVC words together with the phonics sound, they will follow what they heard from the proposed courseware. In *Test* mode, teacher will ask them to choose the correct answer and put their finger on the button. They feel happy when they answer it correctly.

C. Performance Evaluation

Since the government kindergarten syllabus more focuses on Malay language, three children who have high understanding, moderate understanding, and low understanding in English language in kindergarten SK. St Michael are selected and participate in proposed courseware' performance based evaluation. Children need to read the 15 CVC words before and after using the proposed courseware.

The children who have low understanding and moderate understanding in the English language do not know how to read the 15 CVC words before phonics learning through the proposed courseware. Besides, children who have a high understanding in English language are able to read 13 CVC words out of 15 CVC words in 40 sec. After that, the proposed courseware is used to teach the children about phonics sound and CVC words. After one hour, all of the children have improvement. The children who have low understanding and moderate understanding in English language can read some CVC words correctly. On the other hand, the children who have a high understanding in English language can read all CVC words correctly in 22 sec. Figure 2 shows the

percentage of correctness among these children before and after phonics learning using the proposed courseware.
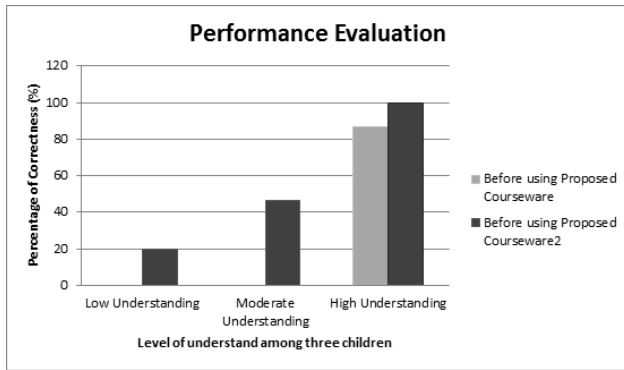

Figure 2: The percentage of correctness of children before and after phonics learning using the proposed courseware.

D. Evaluation among teachers

System Usability Scale (SUS) is used to test the usability of the proposed courseware. Usable systems get between 70-80 points. Since there is one English teacher from each kindergarten, total of two English teachers were participating in this evaluation. Based on the result from the SUS evaluation, the proposed courseware is arrives an average of 82.5 points. This means that the proposed courseware is considered as a usable courseware.

V. CONCLUSION

The objectives of this project have been achieved. A prototype has been developed based on an AR interaction phonics courseware design framework. This framework is created based on the review result. AR technology used to make hand on card interaction. The physical phonics cards and question cards act as image marker. The Vuforia SDK is chosen since it supports image marker tracking.

Children can learn the phonics sound with 3D letter presented through single phonics card interaction. They are able to read CVC word together with the phonics sound with related animated 3D model presented through triple phonics card interaction. Collision method and script are used to identify which phonics cards collided together. Besides, children can answer the question with 3D model presented through assessment. Virtual button and script is used to identify which button has been chosen.

Based on the testing and evaluation, the courseware is quite effective, accurate, and well performance. They paid attention during the phonics learning section through the proposed courseware. The result of performance evaluation also shows that children have reading improvement after using this courseware. It is considered as a usable courseware through SUS evaluation taken by teachers. We hope that this study does contribute to the field of AR technology in learning.

VI. FUTURE WORK

There is some limitation found after testing and evaluation. The output will be slow when reflection on the physical card occurred. For the *CVC* mode, children need to move the phonics card away in front of the device camera when changing phonics card. If not, the device camera cannot detect which phonics card is taken away. For the *Test* mode,

children need to touch the button on the physical question card properly and the device camera must be held properly. If not, the output will be stopped immediately. Hence, future enhancement here needs to overcome the above limitation by improving the courseware's stability and quality.

REFERENCES

[1] N. Kim, B. L. Davis "A phonetic approach to consonant repetition in early words," *Journal of Infant Behaviour and Development*, vol. 40, pp. 193-203, 2015.

[2] M. Havy, J. Bertoncini, and T. Nazzi, "Word learning and phonetic processing in preschool-age children," *Journal of Experimental Child Psychology*, vol. 108, no. 1, pp. 25-43, 2011.

[3] Oxford Dictionaries, "Definition of interactive in English", 2013. [Online]. Available: http://www.oxforddictionaries.com/definition/english/interactive. [Accessed: Oct. 17, 2013].

[4] M. Billinghurst, and A. Dunser, "Augmented reality in the classroom," *Computer*, vol. 45, no. 7, pp. 56-63, 2012.

[5] K. Byeon and S. Ha, "The final stop consonant perception in typically developing children aged 4 to 6 years and adults," *Journal of the Korean Society of Speech Sciences*, vol. 7, pp. 57–65, 2015.

[6] National Institute of Child Health and Human Development, *Report of the National Reading Panel. Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*, Washington, DC: U.S. Government Printing Office, 2000.

[7] E. Georgiadou and A. A. Economides, "Evaluation factors of educational software," in *Proceedings International Workshop On Advanced Learning Technologies, IWALT 2000*, pp. 113-120, 2000.

[8] M. Ismail, N. Abdul Mukti and Tg Mohd Tg Sembok, "A theoretical review on evaluation of multimedia courseware," in *Proceedings of 2nd International Conference on Measurement and Evaluationin Education, (ICMEE)*, pp.264 – 272, 2003.

[9] Spencer Learning, "Ultimate phonics reading program," 2013. [Online] Available: http://spencerlearning.com/ultimate-phonics/free-program.html. [Accessed: Oct. 16, 2013].

[10] Reading Bear Organization, "Reading bear: First learn the letter sounds," 2013. [Online] Available: http://www.readingbear.org/About.aspx. [Accessed: Oct. 16, 2013].

[11] Prekscholars, "Phonics guessing game," 2012. [Online] Available: https://play.google.com/store/apps/details?id=com.digitalattic.prekfun.android.guessing. [Accessed: Oct. 18, 2013].

[12] Fun4Kids HoneyBee, "Kids Learning Phonics Lite," 2013. [Online] Available: https://play.google.com/store/apps/details?id=com.honeybee.android.kidsphonicslite. [Accessed: Oct. 17, 2013].

[13] M. C. Hsieh and H. C. K. Lin, "Interaction design based on augmented reality technologies for English vocabulary learning," in *Proceedings of the 18th International Conference on Computers in Education*, vol. 1, pp. 558-562, 2010.

[14] Les' Copaque, "Majalah Upin and Ipin," 2013. [Online] Available: http://upindanipin.com.my/blog/majalah-upin-and-ipin-malaysias-very-first-ar-magazine/. [Accessed: Dec. 27, 2013].

[15] S. Siltanen, *Theory and applications of marker-based augmented reality*, Finland: Julkaisija Utgivare Publisher, 2012.

[16] M. A. Nassar and F. Meawad, "An augmented reality exhibition guide for the iPhone," In *2010 International Conference on User Science and Engineering (i-USEr)*, pp. 157-162, 2010.

[17] ARToolworks, "About ARToolKit," 2012. [Online] Available: http://www.artoolworks.com/support/library/About_ARToolKit. [Acccessed: Oct. 9, 2013].

[18] Transmote, "FLARManager documentation," 2013. [Online]

http://words.transmote.com/wp/flarmanager/flarmanager-documentation/#ftk_patterns [Accessed: Nov. 15, 2013].

[19] A. Craig, R. E. McGrath, and A. Gutierrez, "Technical note: Augmented reality software kits for smart phones," 2011. [Online] Available: https://www.ideals.illinois.edu/bitstream/handle/2142/27688/AR_Smart_Phone_Note_rev3.pdf?sequence=2. [Accessed: Nov. 17, 2013].

[20] Vuforia Developer, "Get Started with Unity Extension," 2013. [Online] Available: https://developer.vuforia.com/resources/dev-guide/getting-started-unity-extension. [Accessed: Nov. 15, 2013].

[21] Vuforia Developer, "Natural features and rating," 2013. [Online] Available: https://developer.vuforia.com/resources/dev-guide/natural-features-and-rating. [Accessed: Nov. 15, 2013].

[22] Vuforia Developer, "Camera and rendering," 2013. [Online] Available: https://developer.vuforia.com/resources/dev-guide/front-camera-support-0. [Accessed: Nov. 15, 2013].

[23] G. A. Coalson and C. T. Byrd, "Phonetic complexity of words immediately following utterance-initial productions in children who stutter," *Journal of Fluency Disorders*, vol. 47, pp. 56-69, 2016.