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# Using Augmented Reality to Facilitate Music Learning for Preschool Children

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**Abstract:** New technologies such as Augmented Reality (AR) have been widely used in education fields. AR's deep integration of virtual objects and real environments meets the diverse learning needs of learners. However, relatively few studies have explored the application of AR in preschool music education. Therefore, this study developed a mobile AR application for preschool children in learning music and investigated its impact on children's learning achievement and enjoyment. We used a mixed research method, measuring academic performance through pre-test and post-test, a questionnaire for children's enjoyment, and interviews to determine children's views of AR usage in music learning. Sixty participants in two kindergarten classes participated in this study. The children in the experimental group used mobile-based AR applications for music learning, while the control group learned the same content through the traditional teaching method. The results showed that compared with the traditional teaching method, mobile AR has significantly improved children's academic performance and enjoyment. In addition, the interview results also showed that the children considered AR learning activities to be very interesting and that they are willing to use AR for music learning in the future. The conclusions provide a concrete practical case on how to effectively integrate AR into preschool music education.

**Keywords:** Augmented reality, preschool children, music learning, academic achievement, enjoyment

## 1. Introduction

Music is important for promoting children's comprehensive and harmonious development (Klim-Klimaszewska, 2015). Generally, music learning is mainly conducted through visual and auditory activities, and traditional teaching methods (e.g., singing) (Francesconi et al., 2013). However, He (2019) proposed that traditional ways of teaching music are usually the teacher sings first, and then children sing alone, which is unattractive and boring. Previous studies have proposed that Augmented Reality (AR) can be regarded as strategies to improve music teaching levels (Lu et al., 2022). Therefore, incorporating AR in music learning provides the potential to promote learners' effective learning.

AR is a technology that integrates the real environment with the virtual environment which provides learners with an interactive learning experience (Azuma, 1997). AR superimposes designed virtual objects on the real environment through various technologies to achieve the effect of virtual and real fusion (Karagozlu et al., 2019). Cote and Diaz (2017) believed that AR plays an active role in music education, and the AR music teaching materials produced can cultivate students' autonomy. However, few studies explored the application of AR in preschool music education. Therefore, this study aims to integrate AR into musical learning and explore its impact on children's academic performance and enjoyment. The following research questions were as follows:

- Is there a significant difference in the academic performance of children who use AR and the traditional teaching method?
- Is there a significant difference in the enjoyment of children who use AR and the traditional teaching method?
- What are the children's views on using AR in music learning activities?

## 2. Background

### *2.1 Music Learning in Early Childhood Education*

Many studies have shown the importance of music learning in the process of early childhood development. Pearce and Rohrmeier (2012) proposed a link between music and cognitive science in their study. The results showed that music is a universal feature of all people, and plays a vital role in our daily lives, as well as in different stages of human development. Qiao (2016) proposed that music education is a practical activity with rich emotions that can promote the emotional development of preschool children. Moreover, music learning can stimulate preschool children's imagination, improve creativity, activate thinking and intelligence (Klim-Klimaszewska, 2015), promote social interaction, cultivate a good sense of social responsibility (Hallam, 2010), and develop positive social values (Ozturk & Can, 2020).

### *2.2 AR in Music Learning*

Some scholars have used AR music systems for music therapy. For example, Correa et al., (2009) showed that AR music learning system can provide therapeutic intervention in cognitive, motor, and psychological aspects to help children with cerebral palsy recover. Correa et al., (2017) showed that the AR music system was beneficial to the rehabilitation of children with disabilities. Moreover, Huang et al. (2011) created an AR-based markerless piano teaching system for piano beginners, their results demonstrated that the AR system increased the sense of accomplishment and interest. Lu et al. (2022) found that using AR to learn chord knowledge in music theory has a positive impact on children's learning and creativity. The above-mentioned studies demonstrated the advantages of AR in music therapy and education. However, research on the effects of using AR for music learning in early childhood education has not been explored.

## 3. Development of a Mobile-based AR Music Learning Application

### *3.1 Learning Material*

In this study, we used the Unity game engine to develop an application that can be installed on the Android system. Variety of technologies, such as cube recognition, and multi-image recognition was utilized to develop the AR system. The learning material is the "Forest Kingdom Concert", which aims to improve children's singing skills in contextualized learning. There are three main steps, and the specific learning content is shown in Fig 1.


*Figure 1.* The Home Page of the Learning Activity.

### *3.2 Activities for Numbered Musical Notation and Musical Scales*

Before learning the numbered musical notation, we selected five different heights of cubes as the identification objects (see Fig 2a). It presented the numbered musical notation of “Do, Re, Mi, Fa, Sol” respectively. When the children scan the yellow-black cube with a mobile phone (see Fig 2b), the 3D virtual model will run out from behind the cube and rotate around the cube, making a “Hello, I’m Fa” sound. Children can control the 3D virtual model through operations (zooming in, zooming out, rotating, etc.). During the musical scale learning process, we used two bar images with different heights and colors to present musical scales: “Do, Re, Mi, Fa, Sol” and “Sol, Fa, Mi, Re, Do” (see Fig 2c). When children scan the musical scale picture, the 3D virtual object is superimposed on the picture, accompanied by the sound of musical scales (see Fig 2d). The two learning activities each last 35 minutes.

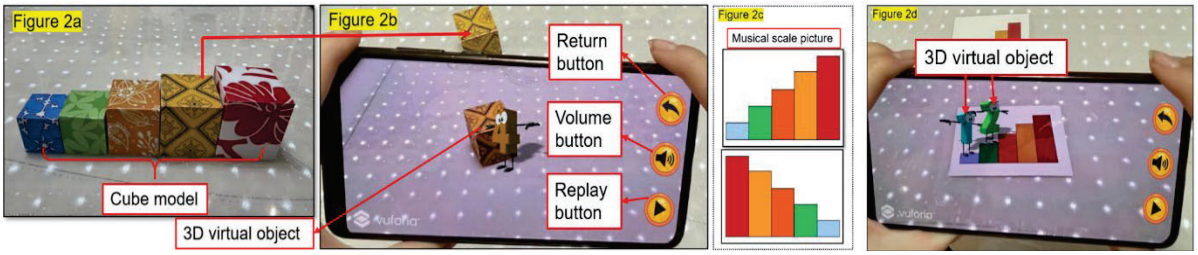


*Figure 2.* Numbered Musical Notation and Musical Scale Learning Activity Screen.

### *3.3 Activities for Sing Learning*

In the singing learning activity (see Fig 3), the animal’s feet for the 3D virtual object coincide with the footprints of the image to achieve the effect of virtual and real fusion. Children can freely observe and manipulate the 3D virtual object. For example, they can zoom in or out of a 3D virtual object with two fingers and rotate them with one finger (see Fig 3b). After that, the children can click the animal buttons, and click on the animal’s footprint (virtual button) to interact with a 3D virtual object (see Fig 3a). At this time, the lamb’s singing video shown on the picture for children to learn (see Fig 3c). This learning activity lasts 35 minutes.

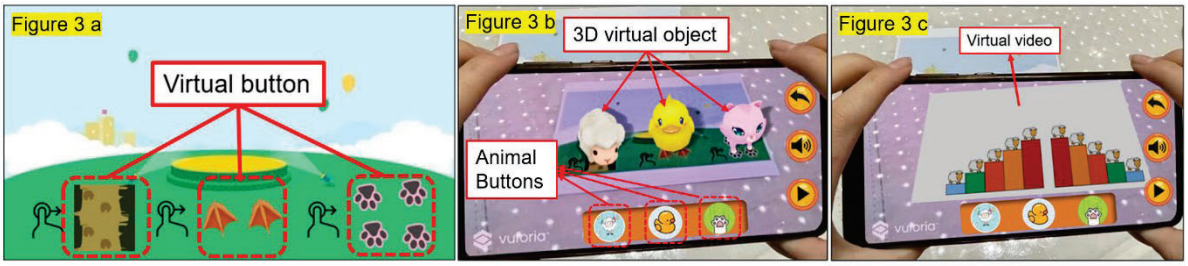


*Figure 3.* Singing Learning Activity Screen.

## 4. Methods

### *4.1 Research Design and Participants*

In this study, we used a mixed-study method. Before the experiment, both groups of children took a pre-test determining that they had equal prior knowledge levels. Following that, the experimental group used AR to learn music, and the control group learned through traditional methods. After the experiment, a post-test and enjoyment questionnaire was administered to the two groups of children, and a semi-structured interview was conducted. Participants came from two large classes in a kindergarten in northwestern China, each with 30 children, an average age of 6. The children in both groups were taught by the same teacher and were familiar with mobile device.

### *4.2 Measurement Tools*

#### *4.2.1 Learning Achievement Tests*

The content of the pre and post-test were the same and was developed by the researcher. The pre-test aimed at assessing whether the children had the same knowledge level before the experiment. The post-test explores whether children who use AR apps for music learning show better academic performance compared to the traditional method. Both pre and post-test questions consist of 10 items, consisting of 5 choice questions, and 5 yes or no items, with a maximum score of 100. For example, the choice question is: “Please select the numbered musical notation of Do”. The reliability of both tests was assessed using Cronbach’s alpha value, which is greater than 0.80, indicating good internal consistency.

#### *4.2.2 Enjoyment Scale*

The enjoyment scale was used in this study based on Dalim et al. (2020). It consisted of 7 items (e.g., “I enjoyed doing this activity very much”), assessed using a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). To measure happiness, we use a smiley image instead of the Likert scale’s answer categories. The scale is used by preschool children to find emojis that fit their answers with their fingers, and all are filled out by the teacher. The Cronbach’s alpha values for the enjoyment scale were above 0.83, indicating good reliability.

#### *4.2.3 Semi-structured Interviews*

The semi-structured interview focuses on understanding preschool children’s views of the AR technology learning experience. In this semi-structured interview, questions include children’s feelings and willingness to use AR applications.

### *4.3 Procedure*

The experiment lasted for about three weeks. In the first week, we pre-tested two groups of children. Moreover, the children in the experimental group were required to be familiar with the operation of AR. In the second week, children in the experimental group learned music through AR, while the control group learned the same material through the traditional method. In the third week, post-test and enjoyment questionnaires were administered to both groups of preschool children. Preschool children in the experimental group also conducted semi-structured interviews.

## 5. Result

### *5.1 Learning Achievement*

As shown in Table 1, the M and SD of the pre-test scores were 29.93 and 10.26 for the experimental group, and 29.50 and 11.24 for the control group, respectively. The *t*-test results ($t = 0.16$, $p > 0.05$) showed that there was no significant difference between the two groups. Therefore, both groups had the same prior knowledge before learning the activity.

After the experiment, the M and SD of the post-test were 87.03 and 6.84 for the experimental group, and 83.50 and 5.38 for the control group, respectively. The *t*-test results ($t = 2.22$, $p < 0.05$) showed significant differences between the two groups, indicating that children who use AR applications in music learning showed better academic performance compared to children with the traditional teaching method.

Table 1. *T-test Result of the Learning Achievement for Both Groups*

| Test | Group | N | M | SD | *F* | *t* |
|---|---|---|---|---|---|---|
| Pre-test | Experimental group | 30 | 29.93 | 10.26 | 0.42 | 0.16 |
| | Control group | 30 | 29.50 | 11.24 | | |
| Post-test | Experimental group | 30 | 87.03 | 6.84 | 1.02 | 2.22* |
| | Control group | 30 | 83.50 | 5.38 | | |

*p < 0.05.

### *5.2 Enjoyment*

Table 2 shows the *t*-test results of the enjoyment, the M and SD were 4.22 and 0.57 for the experimental group and 3.85 and 0.69 for the control group, respectively. The *t*-test results ($t = 2.28$, $p < 0.05$) showed that AR applications for music education had a significant impact on the enjoyment of preschool children.

Table 2. *T-test Results of the Enjoyment for Both Groups*

| Item | Group | N | M | SD | *F* | *t* |
|---|---|---|---|---|---|---|
| Enjoyment | Experimental group | 30 | 4.22 | 0.57 | 0.91 | 2.28* |
| | Control group | 30 | 3.85 | 0.69 | | |

*p < 0.05.

### *5.3 Interview*

From the interview results, most children believed that AR has a positive effect on their music learning. Among them, 80.33% of children considered that AR music lessons are very interesting, and learning content makes them feel very happy. 90.33% of children like to use AR for music learning. 82% of children are willing to continue using AR for learning in the future. Here are a few examples taken from interviews with children: “I hope the teacher will let us play AR games next time.” “I like the little animals in AR.”

## 6. Discussion and Conclusion

In this study, we developed a mobile-based AR application and investigated its effect on preschool children’s music learning. Results found that the children who use AR in music learning achieved better academic performance and enjoyment compared to the traditional teaching method. Moreover, Through the interview, it can be found that the children gave positive feedback on the use of AR in music learning. Regarding achievement, the findings are consistent with previous research findings (Lu et al., 2022). AR increases the fun and provides preschool children with an interactive experience. In addition, in terms of enjoyment, it can also be concluded that the experimental children have higher enjoyment in musical activities than the control group. This is similar to previous research findings (Aladin et al., 2020). In addition, interview results showed that many children believe that AR technology has a positive impact on their music learning, and they enjoy using AR for music learning and look forward to using AR to learn music in the future. AR provides learners with an interactive teaching process and rich learning forms and provides a reference for educators who implement activities in similar fields.

However, this study also has some limitations. First, the children’s influence on the novelty of AR technology may contribute to children’s high satisfaction. Second, some practical activities may be carried out, allowing teachers to lead children to interact with each other. Third, the teaching time of this experiment is relatively short. Future research should enlarge more related knowledge into the music curriculum to form a unified teaching.

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