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Research Article

Application of Augmented Reality Technology in Piano Teaching System Design

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Abstract

With the promotion of "Internet +", computer-assisted teaching has been developed rapidly. Due to the particularity of piano teaching, piano teaching is still in a relatively traditional mode. Currently, how to apply Internet technology to piano teaching is the focus of research on piano education. This paper proposed a design principle for piano teaching system based on augmented reality technology, designed a piano teaching system under the guidance of such principle and applied this system in actual piano teaching. The students' feedbacks have been collected to help enhancing the effects of the designed system.

Keywords

Augmented Reality Technology • Piano Teaching System • Emerging man-machine Interaction Technology • Virtual Information

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With the rapid development of modern information technology, multimedia technology and network communication technology, especially the augmented reality technology is widely used in the field of education (Wang, 2012). The design and development of digital teaching resources have been attracted more and more attention to scholars. The operation and presentation of many teaching resources have been transformed from the traditional two-dimensional to three-dimensional. This change of learning mode not only enriches the presentation of learning content, but also gradually enhances learning interactivity, enabling learners to experience virtual, self-exploring and highly immerse learning interactive activities, effectively motivating learners to learn and improving learning efficiency (Akçayır, Akçayır & Pektaş, 2016). As an important branch and research hot spot in the field of virtual reality, augmented reality technology is also an emerging cross-disciplinary research field, as well as a new type of teaching media in the technical field of education. The application value of education has been one of the research and development focuses in the field of education.

Augmented Reality (AR) technology, also referred to as Mixed Reality (MR), is an emerging man-machine interaction technology developed on the basis of virtual reality technology. It superimposes computer-generated virtual information into real scenes around the users through optoelectronic display technology, interactive technology, sensor technology, graphic technology, and multimedia technology, so that the users can feel the virtual information as an integral part of the real environment around them (Wise, Greenwood & Davis, 2011; Davis, Can & Pindrik, 2016). In education field, augmented reality has a significant advantage in facilitating education development and cultivating the students' interests. A complete augmented reality system (Figure 1) consists of markers, computer, camera, display device, and augmented reality software system. The software system plays an important role for the functioning of the augmented reality technology (Zhu, 2011).

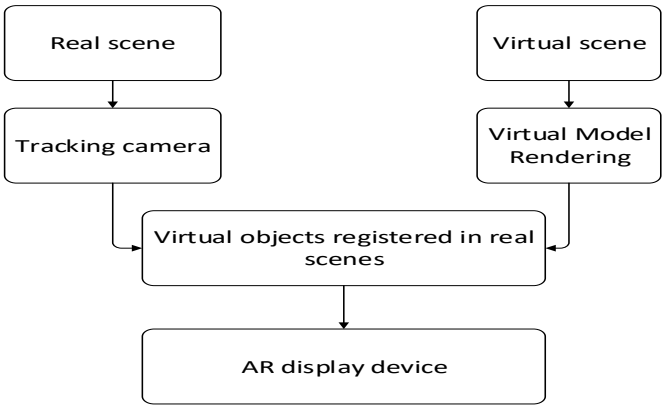

Figure 1. The working principle of augmented reality technology.

Using augmented reality technology to create piano teaching scenarios

Technology can dynamically present information and be used to change the learning environment. The situational piano education originates from the theory and practice of cognitive and situational learning. Such theory believes that it is the learners' participation in social context-based general cultural practices that the

individual knowledge structures are based on. Knowledge obtained in specific situations is more powerful and useful than general knowledge. Therefore learning activity should be conducted in the specific physical or social situation where the knowledge is generated (Enyedy & Danish, 2012; Wang & Cheng, 2016). Based on the theory of situational cognition, by placing education activity practices in the education situation and improving such situation, the study results and cognitive intelligence of the learners can be improved. Piano education situation can be easily established with augmented reality technology for students (Figure 2).

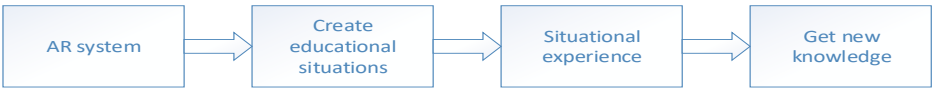

Figure 2. Educational situation created by AR system.

Piano teaching is a dynamic system in which various factors in the teaching process interconnecting and interacting with each other. The experiment started from the various elements in teaching design, optimized the embodiment of situational cognition theory in each element, and improved the arrangement of each teaching design from various angles. Based on the interactions and interconnections between the elements, and between system and external environment, the theory and practice are combined to observe and process the objects based on the system structure and dynamics, in order to achieve the optimized overall function (Huang, Chen & Chou, 2016). With the current "New Music Curriculum Standards", more scientific and systematic piano teaching structure are established in accordance with the peculiarities of piano teaching, as shown in Figure 3 (Wei, Weng & Liu, 2015):

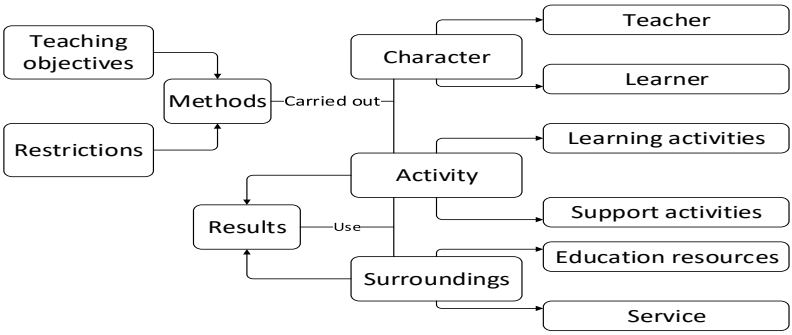

Figure 3. The composition and structure of various elements of the piano teaching system.

This paper proposed a design principle for piano teaching system based on augmented reality technology, designed a piano teaching system under the guidance of such principle and applied this system in actual piano teaching. The students' feedbacks have been collected to help enhancing the effects of the designed system.

The Design of Piano Teaching System based on Augmented Reality Technology

Based on the comprehensive consideration of the merits and defects of the application of augmented reality in piano teaching, and the characteristics of the piano discipline, the author believes that the AR-based piano teaching system should be started from the teaching model design. This design should follow three principles: 1. AR design content should be based on the curriculum, and the time used for AR-based teaching should not be longer than that used to teach the same content with conventional teaching model. 2. The AR system should be flexible enough to allow teachers to adapt AR resources according to the students' needs and teaching content. 3. The actual constraints in real teaching environments should be taken into account (Martín-Gutiérrez, 2015; Akçayır & Akçayır, 2017).

The development of piano teaching system tool design and development

In this piano teaching system, the Unity 3D development engine and augmented reality development plug-ins have been used to design and produce augmented reality teaching tools and 3D teaching resources for Android systems, which are applied in the teaching practices in the piano lessons in a university. The structure of the AR-based teaching tool system is shown in Figure 4. This system consists of four parts: client layer, application layer, data layer, and management layer. Among them, the client layer has three functions: screen capture, virtual reality scene presentation, and human-computer interaction. The application layer functions in three aspects: human-computer interaction, three-dimensional registration, and data read and write. The two parts of the data layer: local storage and cloud storage are used for storing the application data and user information; and the management layer manages cloud data resources (Gelding, Thompson, & Johnson, 2015).

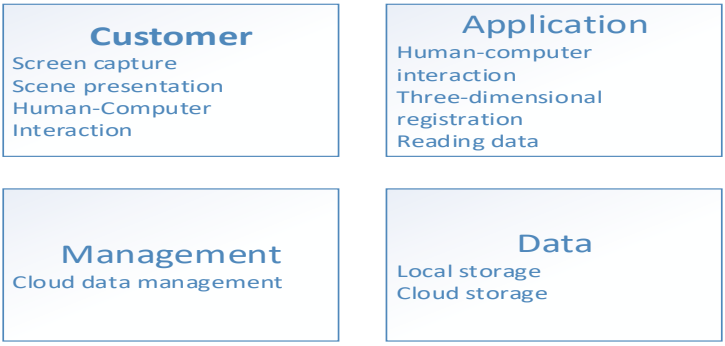

Figure 4. System framework structure.

As needed by the teaching design, Unity 3D development engine is used to create the 3D teaching resources that are used in conjunction with AR teaching tools. Through interface with the management layer of the AR system, the teaching resource can be stored in cloud for teachers and students to download and use in teaching practice.

The analogue piano is a linking demonstration of real-time performance and music scores. It will change based on actual teaching situation. It can be transformed into 32 keys, 49 keys, 61 keys and 88 keys and be

flexibly moved to any desired place. These humanized settings relieve the teachers of the worries of thick fingers and blurry visions.

The piano playing consists of three types, the Piano, the Piano White Key, and the Piano Black Key. As the main body of piano playing, the Piano type manages piano initialization, piano playing, and piano sound. The Piano White Key and Piano Black Key function as single white and black piano key. The integrated diagram for the entire design is shown in Figure 5 below:

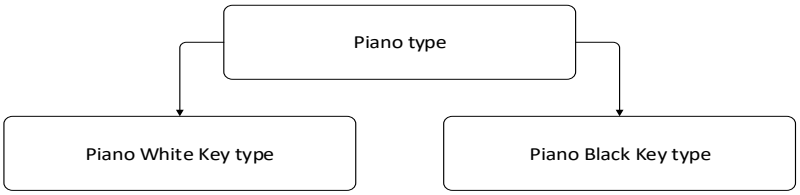

Figure 5. The relationship between the three modules in piano playing design.

The flowchart of piano teaching system design

The piano teaching system is composed of three modules: piano display and control module, piano playing module, and piano sound processing module.

The work flow of the piano display and control module of the system is shown in Figure. 6: the activation of the virtual piano is followed by piano parameters initialization, piano interface display and subsequently the piano interface operation monitoring. When operation on the piano interface is sensed, the operation is firstly processed, and then the piano interface will be re-displayed.

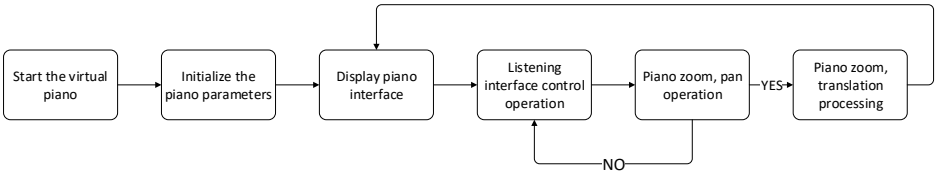

Figure 6. The control flow chart of Piano display control sub-template.

The flow chart of the piano playing module is shown in Figure 7. After the analogue piano is activated and initialized, the piano disk interface will be displayed and playing will be monitored. After playing actions are sensed, different playing events will be processed to update the piano interface so as to present the final effects.

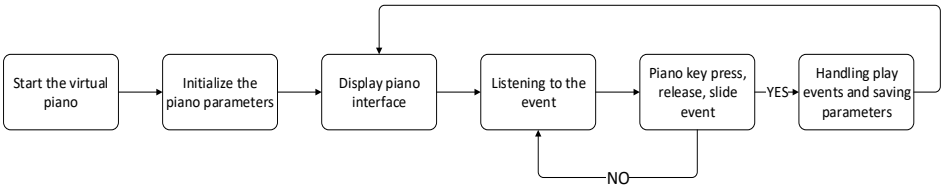

Figure 7. The control flow chart of piano playing sub-template.

The piano sound processing module simulates the piano sound and enhances such sound. After special treatments of the sound, it will be more saturated and more pleasant, thus greatly improving the auditory experience of the teacher and students. By adding a soft sound source, this module will help achieve a better vocal effect. The flow chart of this module is shown in Figure. 8

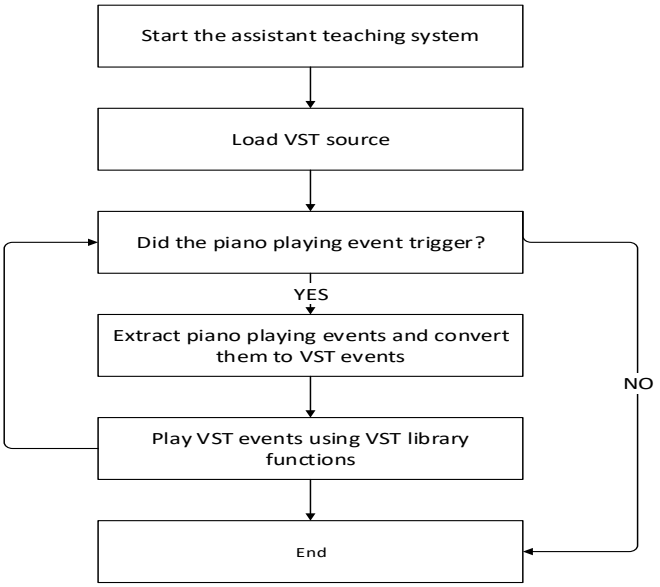

Figure 8. Flow chart of piano sound processing sub-template.

Teaching Application and Feedback after Piano Teaching System Design

A piano teaching course of a university in Zhengzhou has been selected to conduct the experiment of AR-based piano teaching. During the course, the students watches the 3D animations and 3D models as needed via the AR teaching system smart devices, assisting in explaining the notes in piano playing to help the student understand the piano playing knowledge. The questionnaire and investigation towards the students attending this course has showed that most of the students have great interests in AR technology, believing that such AR-based teaching will promote their study and their knowledge because it is more ornamental than traditional still pictures or films and could be viewed repeatedly according to their own needs. When asked if they would use the augmented reality teaching tools to conduct coursework, most students expressed their willingness to use it.

The Experimental Results

After piano teaching system design has been applied in teaching, the table of piano learning interest and learning ability has been distributed again. The purpose was to compare students' learning situation before and after the experiment to show the teaching effect after using the piano teaching system. The teachers and students

are also interviewed and communicated again to understand the effectiveness and shortcomings of teaching. The statistics are as follows:

Table 1
Study Interest, Study Ability Questionnaire Statistical Table (After Piano Teaching System Design has been Applied in Teaching)

	Number (person)/percentage (%)				
No.	A	B	C	D	E
1	14 / 25%	29 / 51.78%	5 / 8.93%	5 / 8.93%	3 / 5.36%
2	16 / 28.57%	25 / 44.64%	8 / 14.29%	5 / 8.93%	2 / 3.57%
3	16 / 28.57%	21 / 37.5%	12 / 21.43%	4 / 7.14%	3 / 5.36%
4	14 / 25%	18 / 32.14%	10 / 17.86%	9 / 16.07%	5 / 8.93%
5	26 / 46.43%	20 / 35.71%	6 / 10.71%	3 / 5.36%	1 / 1.79%
6	15 / 26.79%	21 / 37.5%	11 / 19.64%	6 / 10.71%	3 / 5.36%
7	17 / 30.35%	18 / 32.14%	12 / 21.43%	8 / 14.29%	1 / 1.79%
8	15 / 26.79%	19 / 33.93%	12 / 21.43%	6 / 10.71%	4 / 7.14%
9	24 / 42.85%	10 / 17.86%	7 / 12.5%	8 / 14.29%	7 / 12.5%
10	12 / 21.43%	23 / 41.07%	14 / 25%	3 / 5.36%	4 / 7.14%
11	7 / 12.5%	11 / 19.64%	15 / 26.79%	13 / 23.21%	10 / 17.86%
12	16 / 28.57%	22 / 39.29%	9 / 16.07%	3 / 5.36%	6 / 10.71%
13	16 / 28.57%	19 / 33.93%	10 / 17.86%	6 / 10.71%	5 / 8.93%
14	12 / 21.43%	13 / 23.21%	18 / 32.14%	8 / 14.29%	5 / 8.93%
15	14 / 25%	14 / 25%	12 / 21.43%	7 / 12.5%	9 / 16.07%
16	11 / 19.64%	19 / 33.93%	13 / 23.21%	3 / 5.36%	10 / 17.86%
17	17 / 30.35%	10 / 17.86%	15 / 26.79%	14 / 25%	—

The SPSS data analysis of each option before and after the experiment was compared and concluded, the results as shown in table 2:

Table 2
Paired Sample Statistics

		Mean value	N	Standard deviation	Standard error of mean
Pair 1	A1	20.7976	17	9.12508	2.21316
	A2	27.5200	17	7.88596	1.91263
Pair 2	B1	26.0494	17	9.14956	2.21909
	B2	32.7724	17	9.48906	2.30144
Pair 3	C1	21.7447	17	7.23362	1.75441
	C2	19.8241	17	6.18836	1.50090
Pair 4	D1	17.8582	17	10.12105	2.45471
	D2	11.6600	17	5.85804	1.42078
Pair 5	E1	13.5500	17	7.47160	1.81213
	E2	8.1941	17	5.43285	1.31766

Where option variable before experiment: X1, option variable after experiment: X2, X is optional A -- E.

Table 3
Paired Sample Test

		Difference in pairs					t	df	Sig. (bilateral)
		Mean value	Standard deviation	Standard error of mean	95% confidence interval for the difference				
					Lower limit	Higher limit			
Pair 1	A1 - A2	-6.72235	6.63688	1.60968	-10.13472	-3.30999	-4.176	16	.001
Pair 2	B1 - B2	-6.72294	11.88809	2.88329	-12.83523	-.61065	-2.332	16	.033
Pair 3	C1 - C2	1.92059	7.48048	1.81428	-1.92552	5.76670	1.059	16	.306
Pair 4	D1 - D2	6.19824	9.55676	2.31785	1.28460	11.11187	2.674	16	.017
Pair 5	E1 - E2	5.35588	4.68460	1.13618	2.94728	7.76448	4.714	16	.000

From table 3, the AB option is significantly increased and the CDE is decreased after the experiment, indicating that the students' learning interest and ability are gradually improved. So let's say that H0 is equal to X1 is equal to X2 (X is equal to A minus E); If the value of Sig.(both sides) in table 3 is less than 0.05, the original hypothesis is accepted; Reject the null hypothesis. The Sig.(bilateral) values of a1-a2 and e1-e2 were all less than 0.05 from the chart. The original hypothesis H0 was accepted, A1=A2 and E1=E2. While Sig.(bilateral) values of B1-B2, C1-C2 and d1-d2 are all greater than 0.05, the original hypothesis H0 is rejected, and B1 does not equal B2, C1 does not equal C2 and D1 does not equal D2. In terms of learning interest and ability, the proportion of students who are very positive and not very positive does not change significantly, while the proportion of students who are positive, general and not positive changes significantly. Combined with other values, the overall level of students can be improved.

Finally, the data were viewed vertically in the same form, so the changes before and after the experiment were compared by comparing the data of the corresponding choices, the results as shown in table 4.

Table 4
Study Interest, Study Ability Questionnaire Comprehensive Statistical Experiment Before and After Control

		Number (person)				
Options		A	B	C	D	E
Before the experiment	Total	198	248	207	170	129
	Average number	11.65	14.59	12.18	10	8.06
After the experiment	Total	262	312	189	111	78
	Average number	15.41	18.35	11.12	6.53	4.88

From figure 9 and figure 10, it can be seen that the sum and average of each option changed significantly before and after the experiment, in which the number of people choosing AB increased significantly, while the number of people choosing CDE decreased significantly. Therefore, the increase of AB and the decrease of CDE mean the improvement of students' learning interest and ability. Most students are satisfied with their teaching experiments and feel that they have made great progress compared with the previous teaching. Some students suggested that teaching could be more lively. Some students felt that the time allocated to teaching was not equal at all levels.

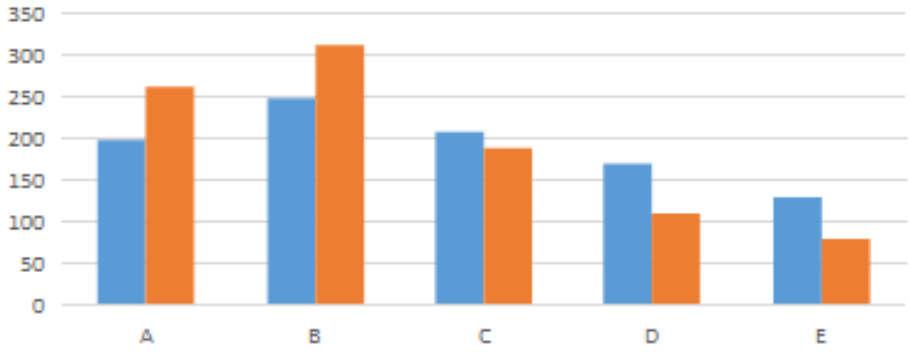

Figure 9. Total number of choices before and after ratio.

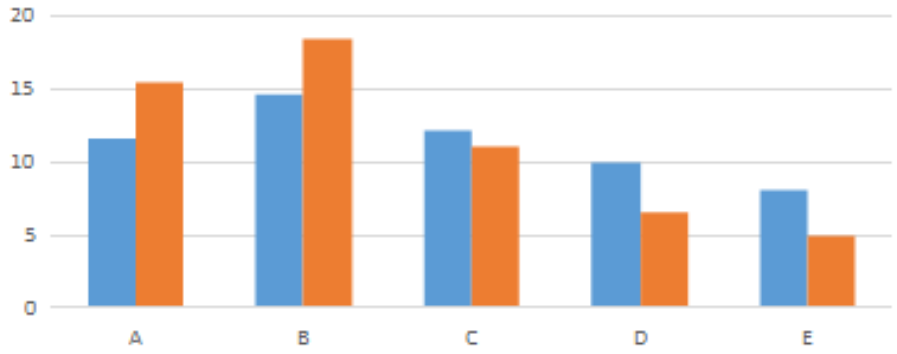

Figure 10. The ratio of the average number of people in each option.

Conclusions

In education field, augmented reality has a significant advantage in facilitating education development and cultivating the students' interests. The application of augmented reality technology in teaching has great potential, which can optimize the presentation effect of teaching materials and promote the interaction between teachers and students in class. The application of augmented reality technology to education is also a meaningful attempt for the reform of teaching mode and the development of education. In this paper, following the analysis of the technical features of augmented reality technology, an AR-based piano teaching system was developed with appropriate tools, which conceive good results in piano teaching practice. However, some certain defects of this system have also been found, proving that it still has a long way to go for improvement. In the future, we will dedicated our efforts to designing and developing better augmented reality teaching tools and teaching resources to be provided and be a high quality technical support for college piano teaching.

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