Examination of Effective Information Presentation Using an AR Textbook

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Abstract: In this study, an AR textbook for astronomy education using a tablet device was developed and three of its content elements were evaluated. The results of all the subjective evaluation questions of the AR CG Model Content were assessed as positive. The free description results clarified the content's improvement needs.

Keywords: Augmented Reality, Information presentation, Mobile learning

Introduction

Various fields of education have studied Augmented Reality (AR), which can synthetically present virtual objects in real environments [1]. Research has also examined the practical use of AR equipment such as AR textbooks that overlay the lecture video onto the paper textbook [2] and the effect of information presentation by AR equipment [3]. However, considering the preparation and installation of equipment, AR equipment using a PC connected to a head mounted display and a web camera is not yet practical for use in schools.

In contrast, tablet device usage is increasing, and its practical application in education is expected [4]. AR technology became comparatively easy to use with the attachment of the camera to the tablet device. This facilitates effective learning by viewing and listening to digital content without requiring the students to be aware of computer mediation in contrast to using the AR PC equipment. In this study, an AR textbook using a tablet device was developed for astronomy education and three of its content elements were evaluated to identify improvements needed for useful AR textbooks.

1. Procedure

1.1 AR Textbook for Astronomy Education

The outline of the "AR Textbook for Astronomy Education" is shown in Figure 1. This textbook was developed using an AR browser for a tablet device (junaio) and contains three types of content: Video Content, AR Video Content, and AR Computer Graphics (CG) Model Content. These contents are displayed when the camera attached to the tablet device recognizes each page of a paper textbook.

Video Content displays a lecture video on the tablet's full screen. Once the camera recognizes the image marker on a paper textbook, the lecture video is played to the end. Therefore, the camera need not continuously monitored the paper textbook.

AR Video Content allows the lecture video to be overlaid onto a paper textbook. The lecture video is attached to a 3D virtual object as a video texture and therefore, the paper textbook must always be continuously monitored by the camera.

AR CG Model Content allows CG models to be overlaid onto a paper textbook. The 3D model used in this study displayed the animation of the earth's rotation and the moon's orbit. Sunlight's shadow effect was overlaid on the 3D model of the earth and the moon. The paper textbook must be continuously monitored by the camera as for AR Video Content.

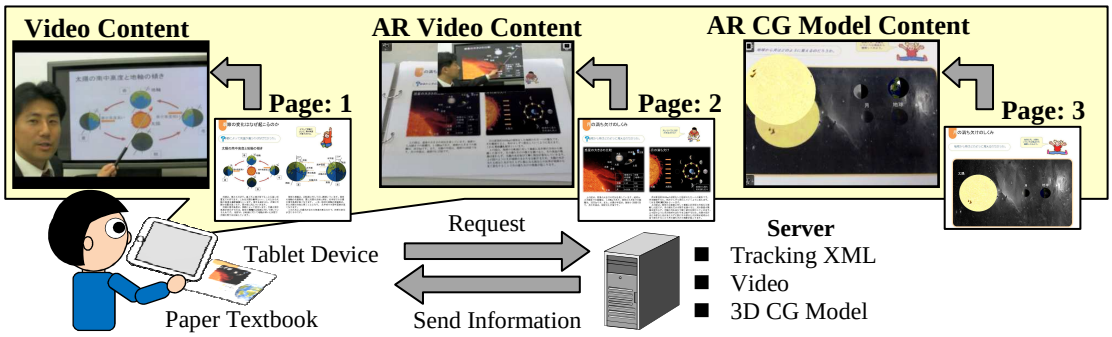

Figure 1: AR Textbook for Astronomy Education

1.2 Subjective Assessment by Survey

85 undergraduate university students participated in the survey. After viewing all three types of content, the students responded to statements in five question categories: Interest, Understanding, Motivation, Usefulness, and Obviousness. The students responded by selecting from the responses: Strongly agree, Agree, Disagree, and Strongly disagree. The positive and negative responses were totaled for each item and were compared using Fisher's exact test. Students also wrote free description responses about the improvement needs of each content type. The free description replies were classified by improvement type within content category and totaled.

2. Results and Discussion

Table 1 provides the analysis results of Fisher's exact test. Table 2 presents the results of the responses suggesting needed content improvements.

For Video Content, the highest number of negative answers were given to the question items on Obviousness. The free description comment analysis in Table 2 indicates the two most frequent responses relating to the negative rating. Of these, the highest number of participants suggested improving the lecture content so that students do not get bored. The next highest number of participants found the lecture video's image quality poor. We assume that students had difficulty reading the characters displayed on the lecture video slides. Other improvement needs noted, in descending order of total comments, are: Additional functions, Sound quality, How to use a tablet device, Download time, and Video play time.

For AR Video Content, the question items on Obviousness also received the most negative evaluations. More than half of the recommendations for improvements were about the "Stability of the display." In AR Video Content, the camera attached to the tablet device needs to continuously monitor the paper textbook, therefore, as compared with Video Content, the display of the lecture video was unstable. The paper textbook's composition needs to be enhanced with an image marker to increase the recognition performance. Other

improvement needs noted, in descending order of total comments, are: Image quality, Additional functions, How to use a tablet device, Instruction, Contents of the lecture, Sound quality, and Video play time.

The results of the subjective evaluation revealed that the AR CG Model Content is the most useful. However, it too needs improvements in the Obviousness category for more useful content in three major areas: Additional functions, 3D model quality, and Stability of the display. Other improvement needs noted, in descending order of total comments, are: How to present the content, How to use a tablet device, and Instruction.

Table 1: Results of subjective assessment

Categories	Video Content			AR Video Content			AR CG Model Content		
	Positive	Negative	Fisher's exact test	Positive	Negative	Fisher's exact test	Positive	Negative	Fisher's exact test
Interest	77	8	**	82	3	**	84	1	**
Understanding	70	15	**	56	29	**	81	4	**
Motivation	72	13	**	72	13	**	83	2	**
Usefulness	75	10	**	65	20	**	81	4	**
Obviousness	52	33	†	19	66	**	77	8	**

**: $p < .01$, *: $p < .05$, †: $.05 < p < .10$

Table 2: Improvement needs for each content type

Video Content		AR Video Content		AR CG Model Content	
Category	Number of answers	Category	Number of answers	Category	Number of answers
Contents of the lecture	15	Stability of the display	34	Additional functions	10
Image quality	13	Video Size	10	3D model quality	10
Additional functions	5	Image quality	5	Stability of the display	9
Sound quality	5	Additional functions	4	How to present the content	4
How to use a tablet device	4	How to use a tablet device	4	How to use a tablet device	2
Download time	2	Instruction	2	Instruction	2
Video play time	1	Contents of the lecture	1	**Total**	**37**
Total	**45**	Sound quality	1		
		Video play time	1		
		Total	**62**		

3. Conclusion

In this study, an AR textbook for astronomy education was developed and three of its content elements were evaluated. Among the content types, the subjective evaluation rated the AR CG Model Content the most highly positive in all the question categories. The free description results clarified the content's improvement needs, suggesting the specific factors of each category that need the greatest improvement.

Future research will focus on improving AR textbooks based on the data obtained in this study. Examining effective practical uses of AR textbooks in elementary schools or junior high schools will be another future focus area.

References

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