主論文の要約

論文題目 Smartphone AR Supported Ubiquitous Observation Learning Environment Based on Planetarium Education Method for Astronomy Education
（天文教育におけるプラネタリウム学習法に基づくモバイル学習環境の開発 -AR を用いたユビキタス環境による天体観測の支援-）

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The planetarium is an ideal setting for learning about the astronomy phenomenon. Varieties of the projection learning programs for the astronomy concept have been implemented in the planetarium for the public. However, the learning environment in a planetarium is still limited to simulated learning scenes and lack true interaction with an outdoor astronomical environment. Thus, the knowledge learners gained was still wholly derived from their simulated experiences. When the trip to the planetarium finishes, learners may easily forget the knowledge and skills obtained in the planetarium, which results in difficulties in real world oriented astronomy observation. Further, the planetarium curator indicated that the observation of real celestial bodies is the most important element for learners learning astronomy. The curator anticipates that in the future, the planetarium experience can be applied to actual astronomical observation. However, direct observation of astronomical objects is often restricted by time, place, and weather. One solution is the use of Augmented Reality (AR) technology on smartphones. The current astronomy smartphone AR applications are Google SkyMap and Star Walk. However, these applications are not designed for learning and teaching astronomical concepts and cannot satisfy the learning goal of astronomical observation in science education.

In this study, I utilized smartphone Augmented Reality (AR) and two-dimensional (2D) / three-dimensional (3D) contents to propose Smartphone AR Supported Ubiquitous Observation Learning Environment (SARUOLE) based on a planetarium learning environment for actual astronomical observation. In this study, the planetarium in- terface or contents, and planetarium instruction approaches were used to design and implement the proposed SARUOLE. In the SARUOLE, learners can obtain the

benefits of the planetarium learning experience while also enjoying the benefits of directly observing actual astronomical phenomena. The features of the SARUOLE system are as follows:

(1) Planetarium interfaces/contents-based.

(2) Multi-viewpoint interface.

(3) Across time display model of celestial bodies motion.

(4) Task-based instruction approach.

(5) Ubiquitous observation.

(6) Context-aware contents.

I developed three systems that applied the SARUOLE concept, including the lunar phase, solar movement and season constellation systems. In order to assess the learning effect that the developed systems have, as well as its usability and its effects of getting students motivated in the learning activities, several experiments were designed and conducted.

The experiment results showed that the SARUOLE did improve the students' academic performance in learning astronomical phenomena. The system also made the students more interested in astronomy education. Moreover, the students confirmed that they would like to use the SARUOLE for astronomical observation rather than the traditional classroom method. Thus, the effects of the SARUOLE were proven, and the SARUOLE can be an alternative tool for students doing real world astronomy observation.