Developing Understanding of Basic Astronomical Concepts By Using a Virtual Solar System

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This study describes high-school students' conceptual development of the basic astronomical phenomena during real-time interaction with a virtual solar system (VSS). The solar system is a highly complex abstract scientific concept. Its dynamic nature, vast spatial dimensions and different time scales cannot be perceived directly by the senses. In order to understand the basic astronomical concepts such as the day-night cycle, the seasonal changes or the moon's phases, one must visualize the relative motions of the planetary objects in 3D space from different perspectives simultaneously (Barnett *et al*., 2001). Previous studies have reported that students hold intuitive misconceptions of the basic astronomical phenomena such as the day-night cycle, the generation of seasons, lunar phases, and solar and lunar eclipses (Vosniadou & Brewer, 1994; Baxter, 1989). The VSS is a non-immersive 3D virtual environment based on high-resolution spacecraft images of the solar system's planetary objects (i.e. planets, moons, asteroids etc.). The objects revolve in their orbits against the constant background of the Milky Way and the stars) Yair *et al*., 2001). The learner uses the computer mouse to change his/her viewpoint while "flying" in 3D space. For example, the learner can zoom-in or zoom-out, roll below or above while accompanying the plants' revolution around the Sun, or he can "spin" together with the planet as a geo-centric satellite. This offers a new visual learning experience, which has not been systematically studied yet. Nine high school students participated in the study. Each student was given two tasks containing a set of observe-explain questions about the Earth-Moon-Sun system without mentoring. Based on the microdevelopment approach we designed a systematic examination of the learner's real-time interactions and the subsequent qualitative and quantitative changes in the learner's behaviors and thinking, in order to reveal the hidden patterns of learning processes (Gazit & Chen, 2003). The results suggest that high interactive performance does not necessarily contribute to the development of scientific conceptual understanding. Alternative dynamic misconceptions of the basic astronomical phenomena emerged as a result of: (1) Cognitive difficulty in coordinating visual information form different frames of references; (2) Misinterpreting salient features of the VSS visual representation; (3) Ignoring the 3D nature of the Moon's relative motion, together with incorrect perception of the Moons' and the Earth's relative size and distance, and (4) The inability to mentally shift away from the Earth's frame of reference. The participants used the VSS as a visual thinking tool by drawing on screen the trajectories of the planets and gravitational forces. For example, Student E.L builds a new frame of reference to show the Moon-Sun relative motion. By imagining the Earth as the Sun, and the Moon as the Earth, he was able to draw on screen with his mouse the apparent motion of the imaginary moon. These findings have significant bearing on our understanding of the potential and pitfalls of learning via virtual reality environments. This study demonstrates that the conceptual development within the VSS has an emergent nature, as the learner controls his/her own learning process. However, interacting with a dynamic representation might cause the emergence of alternative conceptions of astronomical concepts. Indeed, one may infer the emergence of misconceptions as a direct consequence of the lack of planned mentoring. A well-thought interaction with a teacher or a smart agent during the session would undoubtedly reduce them. Hence, this kind of learning should be accompanied with suitable scaffolding and guided reflection. Moreover, the design of virtual environments should include navigation tools to empower the learners' perceptual and cognitive system.

References

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