Recent studies suggest that the number of students pursuing science, technology, engineering, and mathematics (STEM) degrees has been generally decreasing. An extensive body of research cites the lack of motivation and engagement in the learning process as a major underlying reason of this decline. It has been discussed that if properly implemented, instructional technology can enhance student engagement and the quality of learning. Therefore, the main goal of this research is to implement and assess effectiveness of augmented reality (AR)-based pedagogical tools on student learning. For this purpose, two sets of experiments were designed and implemented in two different construction and civil engineering undergraduate level courses at the University of Central Florida (UCF). The first experiment was designed to systematically assess the effectiveness of a context-aware mobile AR tool (CAM-ART) in real classroom-scale environment. This tool was used to enhance traditional lecture-based instruction and information delivery by augmenting the contents of an ordinary textbook using computer-generated three-dimensional (3D) objects and other virtual multimedia (e.g. sound, video, graphs). The experiment conducted on two separate control and test groups and pre- and post-performance data as well as student perception of using CAM-ART was collected through several feedback questionnaires. In the second experiment, a building design and assembly task competition was designed and conducted using a mobile AR platform. The pedagogical value of mobile AR-based instruction and information delivery to student learning in a large-scale classroom setting was also assessed the investigated. Similar to the first experiment, students in this experiment were divided into two control and test groups. Students' performance data as well as their feedback, suggestions, and workload were systematically collected and analyzed. Data analysis showed that the mobile AR framework had a measurable and positive impact on students' learning. In particular, it was found that students in the test group (who used the AR tool) performed slightly better with respect to certain measures and spent more time on collaboration, communication, and exchanging ideas in both experiments. Overall, students ranked the effectiveness of the AR tool very high and stated that it has a good potential to reform traditional teaching methods.