

## **Editorial: Special Issue - Collaborating and Learning in Shared Virtual Environments**

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Virtual environments, as found in computer games for entertainment as well as serious purposes, are an excellent tool for the provision of training and education applications. Additional benefits can be gained if multiple users can interact in these, providing opportunities for collaborative learning in shared virtual environments. This Special Issue is a companion to the Special Issue on Graphics and Virtual Environments for Serious Games and consists of five articles that examine techniques and technologies for education and training in virtual environments, spanning both solo and collaborative approaches. These articles include original submissions as well as extended and revised versions of selected best papers presented at the VS-Games 2019 conference.

The first article, “Cloud-based Dynamic GI for Shared VR Experiences”, addresses the trade-off between rendering quality and computation time on graphics capable consumer-level computing devices, baking irradiance onto a network-based, voxelized scene representation and progressively streaming lighting updates to clients. There this indirect illumination data is then merged with locally computed direct illumination information. The article “Developing Children’s Regulation of Learning in Problem-Solving with a Serious Game” bridges research concerned with collaborative learning, educational games and the emerging topic of shared regulation. It examines the educational impact of the mathematics education game “Festarola that was developed as a research instrument for the investigation of the problem-solving capabilities of 8 to 11 year old school children. The results of their experiments to verify the effectiveness of their approach to leverage educational games in collaborative learning and supporting the development of the learners’ self-regulatory skills can potentially serve as guidance for serious game developers from other subject domains.

The focus of the article “Effectiveness of Virtual vs. Physical Training: The Case of Assembly Tasks, Trainer’s Verbal Assistance and Task Complexity” lies on a study comparing the effectiveness of virtual training and physical training for learning transfer of a bimanual assembly task. The study compares two virtual and two physical training conditions and experimental results from 100 participants show that although the system can be utilized to train assembly workers, this is less effective when physical objects are not incorporated in the training. The article “Two is Better than One. Improved Attention Guiding in AR by Combining Techniques” presents a laboratory study using a stereoscopic head-mounted display that examines whether an additional arrow guiding technique for coarse navigation has the potential to improve both search time as well as the efficiency of existing techniques. The results show objectively superior performance for one of the combined techniques trialed in the study.

The final article, “Spatialised Audio in a Custom-Built OpenGL-based Ear Training Virtual Environment” demonstrates a VR ear training system for interval recognition. Two experiments with 46 participants investigate the usability, user experience and the effect of multimodal integration through addition of a perceptual cue. The results show that the system is highly acceptable and provides a very good experience

for users, while the added spatial auditory cues provided in the VR application give users significantly more information for judging the musical intervals, which would not be possible in a non-VR environment.

The guest editors wish to extend their thanks to Pak Chung Wong for guiding the production of this Special Issue. We are also grateful to both authors and reviewers for their efforts. We hope you enjoy reading these articles and learn more about collaborating and learning in shared virtual environments.