## Abstract

In recent years, game-based learning has attracted attention. Young children play all the time, and they learn while playing. Play provides opportunities for children to explore ideas, experiment with materials, and express new understandings. However, can middle school children play games during science lessons and actually learn that way? This study investigated the effects of game-based learning in science classrooms in terms of students' achievements, motivation to succeed, learning preferences and attitudes towards game-based learning. We used the Multi-Faceted Holistic Approach (MuFHA) for science instruction in heterogeneous, inclusive classrooms. Game-based learning is a component of the MuFHA. This study took place in Israel with 107 eighth-grade students who attended a regular school. The participants were assigned to three study groups. Thirty-five students (19 girls) were assigned to the intervention group and experienced game-based learning. These students studied in Sports Class 1. They majored in sports and were reported by their teachers as having an average scientific knowledge level. The second group, Sports Class 2, was a control group comprising 35 students (15 girls). These students also majored in sports and were reported as having an average scientific knowledge level. The control group studied science according to the curriculum without game-based learning. The third group comprised 36 students (15 girls). These students majored in Science and Technology Advanced (S&TA) and served as a reference group for the intervention group. These students were reported as high achievers in science studies. All participants answered the Students' Adaptive Learning Engagement in Science (SALES) and Learning Preferences Questionnaire and pre-post Scientific Knowledge Questionnaire. Focus group interviews took place with 21 intervention group students.

Data analysis at Time Point 1 (i.e., pre-intervention) showed: a) The three study groups did not differ in gender distribution. b) The students from the reference group performed in

achievements better than students from the intervention group. c) The intervention group scored higher on the learning goal orientation than the control group. d) The intervention group did not differ significantly from the reference group. e) The intervention group exhibited greater preferences for learning science via sensorimotor and scaffolding and adjustments than the reference group.

At Time Point 2 (post-intervention), a significant interaction of time and group was found, meaning that the intervention group scored higher in the scientific knowledge questionnaire than the control group. The results demonstrated that the average students in the intervention group (Sports Class 1) significantly improved their academic achievements compared to those who majored in science and technology advanced (S&TA; reference group).

This outcome indicates the powerful impact of game-based learning that provides equal opportunities for students with varying levels of abilities in science. The study found that game-based learning can bridge the achievement gap between students with different aptitudes.

The qualitative results offered additional insights regarding game-based learning in science studies in the context of learning experience and students' attitudes. We recommend the use of game-based learning methods to improve average students' achievements and their motivation to succeed in science education.