INNOVATIVE METHODS OF TEACHING AND LEARNING

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Science and Engineering in Middle Schools

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Extended Abstract

Interactive learning environments, referred to as *games* in our design due to their unique features, can direct, facilitate, and assess middle-school students learning of specific domain knowledge and concepts in *science, technology, engineering, and mathematics* (STEM). The modular self-contained easily accessible multi-player online games are called *structured-scenario online games* (cited as STRONG) because they use challenging scenarios to engage middle-school students and provide them control over their learning environment. From their review of literature over a period of 28 years, Randel et al. (1992) concluded that gaming could be used effectively to provoke interest, teach domain knowledge, and shore up retention in math, physics, and language arts when specific instructional objectives were targeted. Besides us, the knowledge engineers for STRONG include a small focus group of middle and high school students and teachers. Using developmentally appropriate STEM concepts and standards outlined in the *Benchmarks for Science Literacy* (1993), we develop appropriate scenarios that might interest both resource-deprived and resource-affluent learners in their preparation for active inquiry learning.

Hands-on inquiry learning without domain knowledge merely entertains students and results in their inadequate conceptual understanding. Many resource-deprived students reach schools with limited cognitive skills and are consequently less motivated. Direct instruction to impart domain knowledge in sterilized learning environments leaves learners unenlightened and unable to see its real-world relevance (Wilson, 1997). To cope with this reality, we describe a framework that seeks to immerse all learners in a progression of guided inquiry hands-on activities to facilitate their conceptual STEM understanding, starting with STRONG. McDonald and Hannafin (2003) noted that web-based games promote higher order learning outcomes and understanding because they increase meaningful dialogue among the students and help identify students' misconceptions, both of which are not easily obtained in traditional classrooms without conscious teacher mediation. Likewise, the question prompts in STRONG guide the thinking of players navigating through cliffhangers and chains of events during play.

As the first task for all students, STRONG is designed to increase the domain knowledge and motivation of all learners by stimulating thoughtful conversations in non-threatening low stress high challenge small-group settings. Although STRONG might only succeed in eliciting students' rudimentary and incomplete conceptual understanding, with rekindled intentionality and better domain knowledge afforded to the players, it launches them into active inquiry learning. STRONG requires minimal teacher intervention during play because students' written responses in text box fields are recorded, processed, and assessed continuously during the 15-20 minutes of play. Using a six-step data mining and knowledge discovery process, the underlying STRONG system architecture uses embedded fuzzy logic and machine learning techniques to provide necessary feedback to the learners' based on their text field responses. Such dynamic feedback to players promotes their active learning (Cios et al., 1998).

Students learn because of their active engagement, increased self-efficacy, meaningful dialogue, dynamic feedback, and improved cognitive skills afforded through STRONG. As knowledge engineers, we recognize other considerations that might impact the benefits of using STRONG such as players' limited pre-existing computer skills, teacher bias towards learning methods, and possible conflict between game and learning objectives cited by Mitchell and Savill-Smith (2004). Promoting students' problem-solving and decision-making abilities through STRONG in their critical developmental years of schooling will empower the students and provide them with a solid foundation in STEM, a foundation from which they can develop their lifelong learning goals.

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