Social Design in Digital Simulations: Effects of Single versus Multi-Player Simulations on Efficacy Beliefs and Transfer

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Abstract: Drawing on social cognitive theory, the study tested the effects of single-player versus multi-player simulations on self-efficacy and transfer of learning by psychometrically cumulating 25 years of research with a total sample size of $N=2,274$. Preliminary results indicate no significant difference between conditions. Implications for computer-based instructional design and directions for future research are discussed.

Introduction

Digital simulations can be defined as technology-based programs that contain a model of a system or a process (De Jong & Van Joolingen, 1998). Digital simulations are becoming increasingly popular in adult education for learning complex cognitive skills, largely because the similarity between natural phenomena and their simulated representations promotes transfer of learning (Mayer et al., 2011). Some authors argue that this transfer is further promoted through high levels of self-efficacy (Bandura, 2012; Gegenfurtner et al., 2013). However, other authors argue that simulations, regardless if digital or face to face, need to be carefully designed before they can be expected to promote self-efficacy and transfer (Garris et al., 2002; Knogler & Lewalter, in press). Based on this discussion, it is yet unclear how social design contributes to regulating learners' levels of efficacy beliefs and subsequent transfer of learning (Pineda et al., 2011).

The present study intended to contribute to this discussion by meta-analyzing the available evidence from the past 25 years. The aim was to cumulate previous research in order to correct the size of true score population correlations between transfer and efficacy beliefs. A focus was on the contextual variation between studies that offered different shades of computer-supported individual learning (CSIL) and collaborative learning (CSCL), indicated by the number of players. Single-player simulations indicated individual learning (as in Bell et al., 2008). Multi-player simulations indicated collaborative learning (as in Orvis et al., 2009).

Based on social cognitive theory (Bandura, 2012), we assumed that learners in multi-player simulations, when compared with learners in single-player simulations, had higher population correlation estimates between self-efficacy and transfer of learning, largely because multi-player simulations offer higher degrees of social exchange and co-regulation processes while engaging with the digital simulation tasks (Bandura, 2012; Garris, 2002; Gegenfurtner et al., 2013; Tompson & Dass, 2002).

Method

Literature Searches and Inclusion Criteria

We performed a systematic review of the literature. To be included in the database, a study had to report an effect size r or other effect sizes that could be converted to r (b coefficient; Cohen's d; F, t, or Z statistics). Because the focus of inquiry was on task self-efficacy as an individual capacity (Bandura, 2012), the database included studies that reported data on individuals. Studies reporting group-level data were omitted. We excluded studies on computer self-efficacy, as the focus was on task-related self-efficacy. Studies on non-adult samples were also excluded. We included studies that assessed transfer with objective performance measures while we excluded studies that used self-ratings of transfer. Studies published in peer-reviewed journals over the last 25 years, from January 1986 to December 2011, were located in several ways. First, we searched the PsycINFO, ERIC, and Web of Science databases using relevant keywords. Second, we cross-referenced the retrieved articles as well as recent reviews and special issues on self-efficacy, transfer of learning, and simulation-based training (Garris et al., 2002; Gegenfurtner, 2011; Segers & Gegenfurtner, 2013). A total of 15 journal articles that contributed at least one effect size to the meta-analysis met all inclusion criteria.

Coding of Variables and Computation and Analysis of Effect Sizes

Three independent coders coded a randomly selected subset, 13.33% of the studies from the final sample. Intercoder reliability was generally high (Cohen's $\kappa = .82$). Uncertainty in codability was resolved through collaborative discussions. Each study was coded for psychometric information and the social design element (single-player vs. multi-player). Analysis occurred in two stages. First, a primary meta-analysis aimed to estimate the true score population correlation ρ of the relationship between self-efficacy and transfer of learning. Distributions of Pearson's r were corrected for sampling error and error of measurement using the compiled Cronbach's α reliability estimates (ρ). Second, a meta-analytic moderator analysis aimed to identify moderator

effects. Theory-driven sub-group analyses were used to estimate the effects of single-player versus multi-player simulations on the population correlation estimate between self-efficacy and transfer of learning.

Results and Their Educational Significance

The 15 studies that were included in the meta-analysis had a sample size of 2,274 learners with a mean age of 21.40 (SD = 2.84). 49.24% of the learners were female (SD = 21.88). Participants were students in higher education in 13 studies and military cadets in two studies. The true score population correlation ρ corrected for both sampling error and error of measurement was .38 (SD = .02; 80% CV: .35; .41). Preliminary results of the meta-analytic moderator estimation suggest higher estimates for single-player compared with multi-player simulations. However, although results indicate higher estimates in single-player simulations, the differences between conditions are relatively small, and non-significant, $p > .05$, as the 80% credibility intervals overlap.

Given that digital simulations become increasingly popular environments for teaching complex cognitive skills (De Jong & Van Joolingen, 1998; Mayer et al., 2011; Siewiorek et al., in press; Tompson & Dass, 2002), the aim of the present study was to cumulate previous research in order to correct the size of the true score population correlations between transfer and self-efficacy. In addition, the aim was to estimate the moderating effects of a social design element: single-player versus multi-player simulations. Implications for theory development include a first step toward generating a design-based model of learner efficacy in simulation-based e-learning environments (Pineda et al., 2011). Future research can extend the findings reported here to see whether the present results on self-efficacy can generalize to other motivational dimensions (Garris et al., 2002; Gegenfurtner, in press; Knogler & Lewalter, in press), vary over different digital infrastructures, and are stable across different social design elements. Another direction for future research includes a focus on different samples, such as non-adult populations in K12-education (Knogler & Lewalter, in press).

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