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I Do and I Understand: Assessing the Utility of Web-Based Management Simulations to Develop Critical Thinking Skills

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Our study assesses the utility of web-based simulations for developing critical thinking skills and analyzes the relationship between critical thinking and simulation performance. We also explore the extent to which students use a collaborative versus competitive problem-solving approach within the simulation context. Pre- and posttest undergraduate student data were collected and used to test critical thinking skills learning. Posttest data were used to assess the relationships among critical thinking, simulation performance, and the problem-solving approach. We found that participation in the simulations was an effective way to develop critical thinking skills. Critical thinking was also related to performance, but only in one of the three simulations. The problem-solving approach did not mediate the relationship between critical thinking and performance; however, a competitive approach to problem solving was predictive of lower performance, and significant relationships were found between critical thinking subcategories and both problem-solving approaches. We discuss the implications of our results and identify web-based simulations as a useful supplemental pedagogy for developing the important skill of critical thinking. Study limitations and suggestions for future research are included.

"I hear and I forget. I see and I remember. I do and I understand."

Confucius, 551–479 B.C.

Developing students' higher order cognitive skills that are characteristic of critical thinking such as analysis, evaluation, reflection, and inference has long been a goal of education in general (e.g., Bloom, 1956), and management education in particular (e.g., Athanassiou, McNett, & Harvey, 2003; Kolb & Kolb, 2005; Rousseau & McCarthy, 2007). To illustrate, Burke and Rau (2010) identify "developing critical thinking skills" (p. 137) as a primary objective of management education. Indeed, critical thinking is an important student learning outcome, both in terms of pedagogy (Whitten & Brahmasrene, 2011) and business school accreditation standards (e.g., Association to Advance Collegiate Schools of Business, AACSB, 2012). Likewise, critical thinking is a crucial skill for managing the complexities of knowledge work (Hilton, 2008), and a key skill assessed during the selection and annual performance review processes (Minton-Eversole, 2013). In fact, a recent survey of 81 large national and multinational firms found that critical thinking was the number-one skill required of future leaders (Brotherton, 2011).

However, recent studies have also noted that employers are not in the practice of teaching critical thinking skills to employees (Paulson, 2011), and critics (e.g., Klimoski & Amos, 2012; Pfeffer & Fong, 2002), argue that business schools have not done a sufficient job of training students for today's workplace. For example, in a large scale study, Baldwin and colleagues found a surprisingly low level of applied management knowledge in both student and managerial populations (Baldwin, Pierce, Joines, & Farouk, 2011). In addition, researchers found that employers tend to value outside experience more highly than classroom experience, suggesting low confidence in the applicability of what students are learning in the classroom (Barr & McNeilly, 2002). Furthermore, Ferreira and Abbad's (2013) review suggests that not enough attention is being paid to training for the emerging competencies that are needed in the workplace. These scholars contend that while great advances have been made in the field in terms of improving methodological rigor, future research should continue to explore how best to train for core competencies (e.g., applied management knowledge, critical thinking) as no consensus presently exists (Ferreira & Abbad, 2013). Therefore, given these points and reflecting on Confucius' words, *I do and I understand*, we seek to better understand what student-centered learning activities best teach critical thinking skills in undergraduate business students.

Critical thinking has been defined many ways (e.g., Abrami et al., 2008; Rousseau, 2012) and is often described in association with problem solving and decision making. In fact, Whitten and Brahmasrene (2011) describe critical thinking as the "cognitive engine which drives problem-solving and decision-making" (p.1). Rousseau (2012) states that "critical thinking involves questioning assumptions, evaluating evidence, and testing the logic of ideas, proposals, and courses of action" (p. 13). Abrami and colleagues define critical thinking as "the ability to engage in purposeful, self-regulatory judgment" (2008: 1102). Furthermore, Carlson (2013) asserts that critical thinking is the application of intellectual values such as accuracy, relevance, and sound reasoning. Similarly, Baldwin and colleagues measured applied management knowledge through participants' ability to identify key issues, describe and evaluate courses of action, and implement a course of action relative to a given scenario (e.g., dealing with poor performance; Baldwin et al., 2011). Incorporating these interrelated aspects of critical thinking and decision making and in conjunction with our AACSB assurance-of-learning goals, we define *critical thinking* as the ability to thoughtfully analyze and evaluate situations and recommend courses of action that consider stakeholders, implications, and consequences.

Further, a substantial body of research supports the claim that skills development (i.e., critical thinking skills development) is best achieved through experiential learning (Bigelow, 1991; Dewey, 1938; Kolb, 1984; Whetten, 2007). Indeed, McKnight (1991) describes management skills development as a form of tacit knowledge (Polanyi, 1966) that can only be developed through experience. Student-centered experiential learning activities, such as management simulations, have received increased attention due to the potential of simulations to motivate student learning and replicate the dynamic and interdependent environments found in the workplace (Bell, Kanar, & Kozlowski, 2008; Salas, Wildman, & Piccolo, 2009; Sitzmann, 2011). In fact, Salas and colleagues call for the further investigation of the utility of simulations in developing relevant management knowledge and skills (Salas et al., 2009). Answering this call, we investigate the extent to which simulation pedagogies can be a positive exemplar of the *I do and I understand* adage, and thus, positively affect critical thinking skills learning.

Simulation pedagogies within the simulation-based training literature encompass a wide range of human- and computer-based experiential learning activities aimed at improving knowledge and skills (Bell et al., 2008; Gosen & Washbush, 2004). Case analyses (e.g., Harvard Business School cases), role-plays (e.g., Keleman, Garcia, & Lovelace, 1995; Robbins & Hunsaker, 2009), and simulating real organizations in the classroom (e.g., The Organization Game; Miles, Randolph, & Kemery, 1993; see also cebm.org) are all examples of human-based activities found in the management classroom. Computer-based activities include a wide range of platforms evolved from programmed instruction (e.g., Pressey, 1926) to virtual reality and web-based simulations. Our research focuses on *web-based management simulations*, which we define as Internet-based, synthetic learning environments where decisions are made within a complex and dynamic setting, and where students experience real-time information and feedback. We suggest that web-based simulations are experiential learning contexts where students can develop skills such as critical thinking through practice and experimentation, feedback on performance, and opportunity for reflection (e.g., Kolb, 1984).

Engaging students in the learning process is certainly essential to the development of critical thinking skills, although, student disengagement caused by a variety of reasons including lack of interest or preparedness can greatly hinder learning success (e.g., Lund, Dean, & Jolly, 2012). Similarly, preferred learning styles of traditional undergraduate millennial students (Tyler, 2008) necessitate pedagogies that can capture and hold their attention, as well as provide dynamic and interdependent contexts for skills learning. Therefore, to address challenges we faced in the classroom in regard to maintaining students' interest and engagement in the learning process, and subsequently, to our concerns over whether learning was occurring, we started using web-based management simulations to stimulate student learning motivation and provide opportunities where course content could be applied in contexts that replicate the complexities of the workplace. Specifically, we use two longer strategy-focused simulations (business strategy and human resource strategy) and one shorter leadership and teamwork-focused simulation to examine critical thinking skills learning. We aim to examine whether these types of learning pedagogies constitute *significant learning experiences*, which Fink (2013) describes as holistic learning experiences that include foundational knowledge, application, integration, caring, the human dimension, and self-directing learning motivation.

In addition, management simulations that require team decision making such as those in this study are also potentially rich environments for developing teamwork skills such as collaborative problem solving (e.g., Fisher & Ury, 1983). Collaboration is a fundamental teamwork competency (Ohland et al., 2012) and a common topic taught within the management curriculum. Given the relevance of collaborative problem solving to team performance (Beersma, Hollenbeck, Humphrey, Moon, Conlon, & Ilgen, 2003) and to critical thinking skills development (Yazici, 2004), we conducted exploratory research to examine the extent to which our students use a collaborative versus competitive approach to decision making within the simulation context and how this practice affects performance in the simulation. Likewise, we seek to understand more about the relationship between critical thinking skills and problem-solving approaches.

In sum, our research questions are as follows (1) Are team-oriented web-based management simulations an effective supplemental pedagogy for developing individual critical thinking skills?, (2) Is critical thinking skills learning positively associated with content knowledge learning (i.e., simulation performance)?, and (3) What are the relationships among critical thinking skills, problem-solving approach, and simulation performance? We contribute to management education by testing the utility of web-based management simulations and identifying simulation-based training as a useful and convenient supplemental pedagogy for developing the important skill of critical thinking. To our knowledge, no previous empirical studies have examined the utility of simulations to develop critical thinking skills. Ultimately, we seek to inspire management educators to include web-based training simulations in their course learning activities.

To investigate these questions, we integrate critical thinking, simulation-based training, and adult learning theories, then explore problem-solving approaches through the lens of the cooperation and competition literature. Our hypotheses are tested by examining data from three simulations allowing for pretest, posttest, and posttest designs. We present our results and discuss the implications of using management simulations as significant learning experiences to train critical thinking skills. We also discuss the relevance of simulations in providing a context for collaboration and competition and provide suggestions for future research directions.

HYPOTHESES DEVELOPMENT

To better understand the utility of management simulations for training critical thinking skills, we first briefly review the effectiveness of simulation-based training. This evaluation is followed by a closer examination of critical thinking. By applying learning theory to our analysis, we link the key instructional design features of web-based decision-making simulations with enhanced student critical thinking skills learning. Following this review, we investigate the potential influence of critical thinking skills and problem-solving approaches on simulation performance. Figure 1 presents our research model with corresponding hypotheses.

Overview of Simulation-Based Training Effectiveness

Over the past decade several conceptual and empirical reviews on simulation-based training have been conducted to evaluate the effectiveness of this

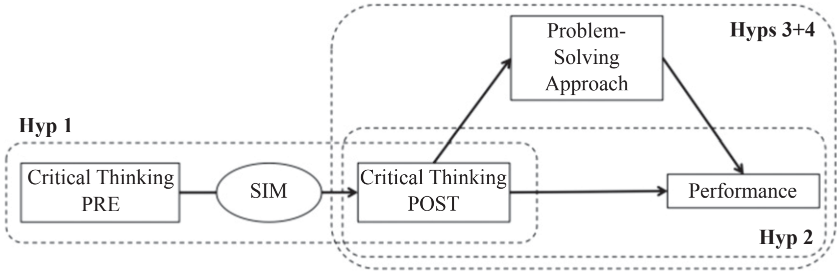

FIGURE 1
Research Model

instructional method (e.g., Bedwell & Salas, 2010; Bell et al., 2008; Gosen & Washbush, 2004; Johnson & Rubin, 2011; Salas et al., 2009; Sitzmann, 2011; Sitzmann et al., 2006). Gosen and Washbush's (2004) review of the validity and methodological soundness of simulation-based training found that, in general, simulations possess both internal validity (i.e., simulation did what was intended) and external validity (i.e., positive transfer to the job). For example, web-based strategy simulations were found to teach strategic management skills, and studies showed that simulation performance was positively correlated with future workplace salaries and promotions, in one case assessed 5 years later (Gosen & Washbush, 2004). In addition, Goodman and O'Brien (2012) contend that pedagogies that provide students with realistic learning experiences result in higher transfer of learning to the workplace.

To provide additional support for the validity of simulations, Sitzmann's (2011) meta-analysis found that simulation-based training resulted in higher levels of declarative and procedural knowledge, self-efficacy, and retention of training objectives than other comparison instructional methods. An earlier meta-analysis by Sitzmann and colleagues indicated that the incorporation of web-based instruction as a supplemental pedagogy produced significantly greater learning gains in both declarative and procedural knowledge than classroom instruction alone (Sitzmann et al., 2006). In Gosen and Washbush's (2004) review of 39 studies that used simulations, only two failed to achieve learning success. Furthermore, Johnson and Rubin (2011) reviewed 71 studies and found support for the positive relationship between simulation pedagogies and objective measures of performance, both when simulations were used alone and as a supplemental pedagogy in conjunction with other instructional methods (e.g., lecture). In addition, reviews of participants' self-report reactions to simulation-based training are positive, with studies reporting positive perceptions of attitude and behavioral change (Bell et al., 2008; Gosen & Washbush, 2004). Given this support for simulations as a supplemental pedagogy, we further analyze the connection between critical thinking and simulation-based training.

Critical Thinking Skills Learning and Simulation-Based Training

As the previous studies indicate, simulations are effective tools for teaching content knowledge and achieving the learning goals set forth by their developers. However, a common attribute of the simulations investigated here is that student teams are tasked with making a series of decisions within a dynamic, complex environment that replicates the workplace. As such, students must use critical thinking skills to analyze and evaluate the situation and make decisions that take into account the consequences and implications of that decision. While not a specific learning goal of the simulations, we contend that the learning experiences simulations can provide are ideal environments for critical thinking skills learning.

Therefore, to evaluate critical thinking skills learning within the simulation context we apply the learning processes of social learning theory (Bandura, 1977), which include (1) gaining student attention and interest; (2) learning retention; (3) practice and reinforcement of learning (behavioral reproduction); and (4) feedback on performance (Bandura, 1977; Gagné, Briggs, & Wager, 1988). In terms of critical thinking skills learning, Kreitzberg and Kreitzberg (2010) articulate that "becoming an effective critical thinker requires a great deal of practice and thoughtful feedback" (p. 25). Whitten and Brahmasrene (2011) suggest increasing students' interest in critical thinking by articulating the applicability and usefulness of the skill. Indeed, instructional methods that gain students' attention and provide feedback on their performance are essential for critical thinking skills development. Likewise, learning retention can be improved through the practice opportunities that simulations offer, especially if this practice is within a dynamic context that students deem interesting and worthy of their efforts.

Further, Abrami and colleagues' meta-analysis of critical thinking instructional interventions found that teaching critical thinking explicitly and then applying the skill to course content (a mixed-method intervention) was associated with the largest instructional gains (Abrami et al., 2008). Posisson de Haro and Turgut (2012) propose that strategy-based simulations targeting the analytical aspects of decision making are an effective way to develop both hard management skills (e.g., content knowledge) and *soft management skills* (e.g., critical thinking), which they define as societal skills (i.e., understanding the impact of decisions on stakeholders, society) and human skills (e.g., collaboration, emotional intelligence). Therefore, due to its high potential for incorporating all four learning processes and thus improving critical thinking skills learning, we examine the mixed-method intervention of web-based management simulations as a supplemental pedagogy to lecture and discussion.

To further analyze the utility of web-based simulation in developing critical thinking skills, we review four instructional features of simulations: content, interactivity, communication, and immersion (Bell et al., 2008) in relation to the learning processes of gaining student attention and interest, enhancing learning retention, providing opportunities for practice, and feedback on performance. The *content* feature relates to how the simulation presents information. Web-based simulations offer a rich multimedia context with such features as informational videos, scenario-planning tools, chat rooms, and comparative data sources. We assert that these interactive features aid in engaging students in the learning process, that is, in gaining students' attention and interest. Likewise, the multimedia context helps to increase recall and improve cognitive organization, thus enhancing retention. Similarly, skill building through multimedia contexts allows for low-risk practice and performance feedback (Salas et al., 2009).

Next, *interactivity,* the degree of "collaborative potential" (Bell et al., 2008: 1421) and the *communication* instructional features describe the parameters of the simulation in terms of the degree of interaction among teammates and within the simulation system itself (e.g., student control over pacing). Again, hands-on decision making, and hence, critical thinking within a team context can increase students' interest in the learning process. In addition, using real-time information for decision making within a collaborative environment adds to the richness of web-based simulations, furthers content knowledge recall and retention, and provides practice and feedback on performance. Moreover, team-oriented simulations offer more opportunities to practice important teamwork competencies that rely on critical thinking skills. In fact, Tyler (2008) notes that millennial students enjoy fast-paced environments where learning is interactive and team-based.

The instructional feature of *immersion* assesses the extent to which a student is involved in the learning process and is also directly related to learning success (Bell et al., 2008; Sitzmann et al., 2006). Indeed, being emotionally involved in the simulation experience has been shown to increase learning (Kilmann, 1975). Salas and colleagues (2009) note that student involvement is an inherent component of simulation-based training, and student learning styles favoring experiential learning do benefit. For example, Mainemelis and colleagues showed that individuals with learning styles preferring experience and conceptualization had greater learning gains in adaptive flexibility skills that rely on critical thinking (Mainemelis, Boyatzis, & Kolb, 2002).

In addition, student control over the learning process, often measured as practice, is also an aspect of immersion. Kilburn and Kilburn (2012) found that active participation in the simulation, measured through frequency of log-ins, related positively to skill learning and overall team performance. Brown (2001) also found that practice was positively related to performance. Simulation benefits such as increased engagement in the learning process and experience with decision making within a realistic context positively affect not only learning and performance but also participants' reactions to the training (Bell et al., 2008; Gosen & Washburn, 2004; Salas et al., 2009). Therefore, as a method of instruction, simulations that incorporate practice, feedback, and play over a period of time have been found to positively affect performance outcomes (Johnson & Rubin, 2011; Sitzmann et al., 2006). Extending this review to developing critical thinking skills through management simulations, we formulate our first hypothesis:

Hypothesis 1: Participation in web-based management strategy simulations is positively associated with critical thinking skills learning.

Critical Thinking and Performance

When it comes to critical thinking skills in undergraduate student populations, more is better. For example, several authors showed the positive effect of critical thinking on performance in college courses (Kealey, Holland, & Watson, 2005; McCammon, Golden, & Wuensch, 1988; Williams, Oliver, Allin, Winn, & Booher, 2003; Williams & Stockdale, 2003; Williams & Worth, 2002). This link between predictor and outcome status is potentially reciprocal, suggesting high critical thinking contributes to success in a course, and success in a course contributes to higher critical thinking. Within this framework, high critical thinkers are more likely than low critical thinkers to achieve good grades in a course, and students achieving high grades are more likely than students achieving low grades to improve their critical thinking skills (Williams et al., 2003; Williams & Stockdale, 2003).

In addition, Gadzella and Wendell (1997) showed that critical thinking is the best predictor when discriminating students with high and low course grades. Their analyses indicated that students who earned As (compared with those who earned Cs) scored higher on critical evaluation, conceptual organization, comparing information, and systematical use of study techniques. The students achieving A grades made more accurate inferences, deductions, and interpretations of the information they studied. In addition, Wertz and Lafayette (2013), using a sample of first-year engineering students, showed that there is a positive association between critical thinking skills and information literacy. This is particularly the case for key critical thinking objectives, such as accurately documenting information, determining what information is needed, and evaluating the reliability of information.

Moreover, a study that examined the critical thinking skills of college freshman and sophomores found that year in school was positively related to deductive reasoning and drawing conclusions (inference) but not related to analysis or evaluation skills (Whitten & Brahmasrene, 2011). Indeed, the lowest levels of critical thinking skills were related to being able to evaluate (28% of total possible) and effectively analyze (44% of total) situations. The highest score was related to inference or drawing conclusions (67% of total). Their finding of an overall critical thinking skills score of 45% was consistent with the normative data provided by the California Critical Thinking Skills test, suggesting room for improvement in students' level of critical thinking. However, SAT scores and high school GPA were positively related to all measures of critical thinking including analysis, evaluation, reasoning, and inference, giving support to the positive relationship between content knowledge (i.e., grades) and critical thinking. Thus, to further examine the relationship between critical thinking skills and performance, we posit:

Hypothesis 2: Critical thinking is positively associated with simulation performance.

Critical Thinking and Problem-Solving Approach

We also explore the extent to which critical thinking relates to one's problem-solving behaviors during the simulation and if these practices have any effect on performance. We chose to use a conflict management framework (Thomas & Kilmann, 1974) to examine two types of problem-solving approaches: collaborative and competitive. Accordingly, a collaborative approach to problem solving, often termed *cooperation*, is both high on cooperation and high on assertiveness. A competitive approach is high on assertiveness, yet low on cooperation. This framework is taught in many introductory management courses, and we were interested in the application of this model within the simulation environment. We focus on the collaborative problem-solving behaviors of direct and open discussion of problem(s), bringing all concerns and issues out into the open, and mutually beneficial solution development (e.g., takes stakeholders interests into account). These behaviors parallel several of the components of critical thinking and further prompted our exploration of the connections. In contrast to collaborative problem solving, competitive problem solving includes being firm in pursuing personal goals, showing the logic and benefits in one's position, and trying to win one's position (Thomas & Kilmann, 1974).

Within the negotiation and conflict management literatures, collaborative problem solving is viewed as an effective problem-solving approach (Fisher et al., 1991). In fact, the negotiation principles set forth in Fisher and Ury's (1983) classic book, *Getting to Yes: Negotiating Agreement Without Giving In,* frequently serve as a training tool for teaching collaborative problem solving (e.g., Booth & McCredie, 2004). Practitioner reports contend that collaborative problem solving is essential in building trust and managing task conflict in a manner that results in performance improvements (Chiocchio, Forgues, Paradis, & Iordanova, 2011). In their meta-analysis, De Dreu and Weingart (2003) reported that task and relationship conflict (e.g., caused by uncooperative problem solving) were related to decreases in team performance and dissatisfaction among team members. On the other hand, drawing on data collected from large corporations, Gratton (2005) found that being able to work cooperatively, particularly within teams, was instrumental to organizational success. Likewise, Beersma and colleagues found that cooperation was related to greater accuracy in team performance (Beersma et al., 2003).

Collaboration and competition have also been investigated in terms of cultural and individual factors and the variability of styles during the problem-solving process. For example, Chatman and Barsade (1995) examined the extent to which cooperative behaviors within a business simulation were affected by individualistic and collectivistic cultural values. Their study found fewer cooperative behaviors were exhibited in the individualistic cultural condition. Chen and colleagues (2012) found that in a sample of 81 Chinese work teams, cooperation within this collectivistic culture was positively associated with team performance, but only when knowledge integration among team members was necessary and resource interdependence was high. In fact, cooperation within teams was found to be higher in interteam competitive situations, but only when the comparison was favorable (Coen, 2006), suggesting that using a collaborative approach may be less likely when your team is performing poorly.

Turning to individual factors impacting decision making, people with extroverted and agreeable personality traits were more successful in cooperative situations, whereas individuals rating low on these traits found more success in competitive environments (Beersma et al., 2003). Volkema and Bergmann (2001) found that individuals tend to vary their behaviors when dealing with interpersonal conflict, initiating problem solving with a more cooperative approach and then relying more on their preferred style (assertive or cooperative) as the interaction progresses. Moreover, females have been found to be more likely to use a collaborative approach to problem solving than males (Brahnam, Margavio, Hignite, Barrier, & Chin, 2005). Certainly, the discussion as to whether a collaborative or competitive approach is best continues to interest researchers (e.g., Schalk & Curşeu, 2010) because while competitive behavior is at the core of capitalism and touted as essential for innovation, cooperation within organizations and teams is vital to success. Therefore, to further explore the relationship among critical thinking, simulation performance, and problem-solving approaches, we offer the following hypotheses:

> *Hypothesis 3: A collaborative problem-solving approach positively mediates the relationship between critical thinking and simulation performance.*

> *Hypothesis 4: A competitive problem-solving approach negatively mediates the relationship between critical thinking and simulation performance.*

METHODS

Participants

Participants were 178 undergraduate students from two different universities. Seventy-eight students (56% male, 44% female), participated in Simulation 1 and were enrolled in a required senior-level business strategy capstone course. Twenty-three students (57% male, 43% female), participated in Simulation 2 and were enrolled in a senior-level human resource management course required of human resource majors. Eighty students (58% male, 42% female) participated in Simulation 3 and were enrolled in a required sophomore-level organizational behavior course. Students participating in Simulations 1 and 3 were from the same university; Simulation 2 students were from the second university. Simulation type was controlled for in our analyses. In total, males consisted of 57% of the participants, and 43% of the participants were female. Simulations are described below.

Procedures

We employed a pretest–posttest design (with no control group) to assess critical thinking skills learning (Hypothesis 1) from the 98 total students who participated in Simulations 1 and 2. Posttest data from all three simulations (including the remaining 80 students who participated in Simulation 3) were used to assess the relationship between critical thinking skill-based learning and simulation performance (Hypothesis 2) and to test the mediating role of the problem-solving approach (Hypotheses 3 and 4).

Team-based simulations were used by the three corresponding instructors as a supplemental instructional method. As part of a graded assignment related to the simulation, students were required to write a 2–3 page analysis of the simulation situation at a given point in time using the critical thinking rubric as a decision-making support tool (see the section **Measures: *Critical Thinking*** for rubric categories). All students were informed that the critical-thinking rubric would be used to grade their assignment, and the rubric was available to all students.

For the pre- and posttest conditions, students completed a written analysis at the beginning of the simulation and again at the end. For the posttest only condition, data in the form of the written analyses were collected at the end of the simulation. For both conditions, survey data assessing the problem-solving approach were collected at the end of the respective simulations. Students had the option of not participating in the study (but were required to complete the class assignment, which included participating in the simulation and writing the analyses but not completing the survey) and only data from those agreeing to participate were analyzed. Student papers were numerically coded to ensure anonymity, and only group data were analyzed.

Simulations

To focus on the utility of management simulations, we collected data from students who played three different web-based simulations that were offered from three publishers. All simulations were web-based, with the publishers' provided instructional and technical support. All instructors had previous experience with their respective simulation. We choose these particular simulations because they are team-based, and in our opinion, require students to apply critical thinking skills. Simulations 1 and 2 are strategy-based, longer in duration, and provide competitive "industry" context. All instructors used a class period each for simulation orientation and debrief. Below we identify the simulation and briefly outline the main learning objectives of each simulation. Table 1 outlines the simulation characteristics with corresponding instructional features and learning processes.

Simulation 1:

Business Management Simulation, Marketplace Live (http://www.marketplace-live.com)

Twenty-six teams of 3–4 students each participated in the simulation, where students start and grow companies that compete in the microcomputer industry. Teams competed in industries of 5–6 teams (companies) for a total of five industries. To successfully run the company and stay ahead of the competition, students are required to make decisions that concern a wide field of business functions, such as marketing, accounting, finance, manufacturing, and human resource management. A subset of the learning objectives for this simulation are (1) to learn to make integrated, holistic decisions that cover several business functions, that is, to learn the interplay of management areas; (2) to work effectively in teams; and (3) to learn to closely monitor markets and competition. The simulation is played in eight decision rounds where each round represents one quarter of the business year. Students spend about 2–3 hours per simulation round. Results were made available after the completion of each quarter.

Simulation 2:

Human Resource Management Simulation, Interpretive Solutions (http://www.interpretive.com)

This simulation gave six teams of four students each the opportunity to assume the role of the newly appointed human resource director for a medium-sized firm (one student did not participate in the study). Learning objectives for this simulation are (1) Describe the issues to consider when making human resource decisions such as selection, promotion, training; (2) Understand and assess the basic factors in determining pay rates; and (3) Explain what a strategy-oriented human resource management system is and why it is important. The simulation is played in eight classes (i.e., decision periods) where each class represents one quarter of the business year. Students spend about 1 hour of class time and about 1 hour of time outside of class to play the simulation and monitor their performance each week. Results were made available after the completion of each quarter.

TABLE 1
Simulation Characteristics, Instructional Features, and Learning Processes

	Simulation 1	Simulation 2	Simulation 3	Features and processes
Simulation's management content focus	Business: marketing, human resources, finance, accounting, operations management	Human Resource (HR) Management and Strategic HR	Leadership and Teamwork	*Content* *Gain Attention, Retention, Practice, Feedback*
Level of critical thinking	High: Requires skills learning over longer period of time	High: Requires skills learning over longer period of time	Moderate: shorter time engaged in simulation	
Target courses	Business strategy or general business	Human resource (HR) management or HR strategy	Management or Organizational Behavior	*Content* *Gain Attention*
Compete against peers	Yes	Yes	No	*Interactivity, Communication, Immersion* *Gain Attention, Retention*
Individuals or teams	Teams	Teams	Teams	*Interactivity, Communication* *Gain Attention, Retention*
Number of decision rounds	8	8	6	*Immersion* *Retention, Practice,*
Total time used as class activity	10–12 weeks	10–12 weeks	2 weeks	*Immersion* *Retention, Practice*
Time spent per decision round	2.5–3 hrs (2 class periods)	1–2 hours (1 hour in class & 1 hour outside of class)	15–20 minutes	*Immersion* *Practice*
Type of feedback	Financial performance, brand, advertising and price ratings, competitor moves	Firm performance, industry metrics, e.g., turnover, morale, grievances	Health, weather, individual and team goal attainment	*Immersion* *Feedback*
Time of feedback	After each decision round	After each decision round	After each decision round	*Content* *Feedback*
External shocks (do unforeseen events challenge the students?)	Yes	Yes	Yes	*Content* *Gain attention, Retention, Practice*

Simulation 3:

Leadership and Teams Simulation: Everest V2, Harvard Business Publishing (http://cb.hbsp.harvard.edu/cb/product/7000-HTM-ENG)

Seventeen teams of five players each participated in this simulation, where teams make decisions based on asymmetrical interests and goals (five students did not participate in the study). The learning objectives from the publisher are to learn how (1) to build, participate in, and lead teams more effectively; (2) to improve the way teams make collective decisions; and (3) to understand how teams can solve problems and make decisions more effectively in situations when members have different information and opposing interests. This simulation runs about an hour and a half and was played over two class periods. Results were made available after the completion of each decision (six decisions total; three each class period). Teams played independent of other teams, thus, the teams did not compete against other teams for performance scores.

Measures

Critical Thinking

We assessed critical thinking through individual written case analyses that were evaluated using a 6-step critical-thinking rubric. These steps are (1) Identify and summarize key problem(s) or issue(s); (2) Identify key assumptions and considers stakeholders; (3) Analyze reasonable alternatives and the consequences of those alternatives; (4) Analyze and present supporting data; (5) Provide clear recommendation with appropriate course(s) of action, and (6) Make conclusions and consider the implications and consequences of action (i.e., justify decision). Each step was evaluated on a 6-point scale with 1 point being "*very poor*," to 6 points at "*excellent*." A total of 36 points were possible. Interrater reliability was determined by grading subsamples of papers (approximately 20%) from the other instructors. Each instructor evaluated the papers on the 6-point rubric. The grading was then compared across instructors. A range of .80 to .87 agreement for scores that matched or were one point different was calculated. This interrater reliability score was in line with previous studies and deemed adequate (Jones, 1981).

Problem-Solving Approach

This variable was measured with the Thomas–Kilmann Conflict Mode Instrument (Thomas & Kilmann, 1974), which was adapted to fit the simulation scenario. At the end of the respective simulation, students responded to an outline survey containing the 30 items. Six items assessing collaborative problem solving were used in our analysis, with a Cronbach α of .57. To ensure the power of the statistics, Hair and colleagues state that alphas .70 and greater are deemed acceptable; however, they note that alphas lower than .70 are acceptable if the research is exploratory as it is here (Hair, Anderson, Tatham, & Black, 1995). Eleven items assessing competitive problem solving were used in our analysis (Cronbach $\alpha = .75$).

Team Performance

Each simulation produced a team performance score, and all team performance scores were standardized within the respective simulation to ensure these scores could be compared across simulations.

RESULTS

Table 2 includes descriptive statistics and correlations of study variables. All data were analyzed using SPSS version 19 (IBM Corp, 2010) unless otherwise noted. All analyses were calculated with standardized variables. Robust standard errors were calculated where indicated.

To test Hypothesis 1 we regressed the pretest critical thinking scores onto the posttest critical thinking scores and found support for our claim that participation in the simulation improved critical thinking skills learning. Only pre- and posttest data from Simulations 1 and 2 were used to test Hypothesis 1, which consisted of 98 data points. Results showed that 7.8% of the variance of the posttest simulation score was explained through the pretest simulation score ($\beta = .279$, $p < .01$). Table 3 presents the paired samples *t* tests for the pretest–posttest composite critical thinking score and the six subcategory scores of critical thinking and provides further support for Hypothesis 1. The average change on the composite critical thinking score was approximately one grade level change, from "fair" to "good" (20.14–24.95, $t(97) = -8.50$, $p < 0.001$. Cohen's *d* of -.70 indicates a moderate effect). In addition, the significant paired samples correlation of .68 indicates that the overall student ranking of critical thinking scores was consistent from pretest to posttest. For example, those students who ranked low in the pretest did improve their scores but still had an overall low ranking in the posttest. In addition, positive and significant changes were found in all of

TABLE 2
Means, Standard Deviations, and Correlations Between Study Variables

	M	*SD*	*n*	1.	2.	3.	4.	5.	6.
1. Gender	.43	.50	178						
2. Collaborative approach	6.75	2.08	178	.01	(.57)				
3. Competitive approach	4.84	2.95	178	-.06	.09	(.75)			
4. CT pretest (Sims 1&2)	20.14	7.55	98	.08	.15	-.09			
5. CT posttest (Sims 1&2)	24.95	6.07	98	-.08	-.11	.05	.28**		
6. CT posttest (Sim 3)	25.67	4.91	78[a]	.30**	-.05	-.22*	NA	NA	
7. Simulation erformance	65.10	82.54	178	-.09	-.03	-.15*	.04	.04	.26*

All variables standardized; Cronbach's α (if applicable) is reported on the diagonal.
Key: CT = Critical Thinking Skills; Gender: Male = 0, Female = 1.
[a] two missing data sets.
* $p < .05$, ** $p < .01$, *** $p < .001$

TABLE 3
Paired Samples *t* Test[a]

Variable	Description	*M*	*SD*	Sig. of group differences	Cohen's *d*	r^2	Paired samples correlations
CT PRE	Critical thinking:	**20.14**	**7.55**	$t(97) = -8.50$***	**-.70**	**-.33**	**.68*** **
CT POST	Sum score	**24.95**	**6.07**				
C1 PRE	"key problems or issues"	3.53	1.40	$t(97) = -7.75$***	-.87	-.40	.39***
C1 POST		4.63	1.11				
C2 PRE	"key assumptions and stakeholders"	3.58	1.06	$t(97) = -7.32$***	-.82	-.38	.38***
C2 POST		4.45	1.05				
C3 PRE	"analysis of alternatives and	3.13	1.75	$t(97) = -.236$	-.02	-.01	.66***
C3 POST	consequences"	3.17	1.87				
C4 PRE	"supporting data"	3.18	1.56	$t(97) = -7.01$***	-.64	-.31	.61***
C4 POST		4.07	1.18				
C5 PRE	"recommendation and course of	3.42	1.44	$t(97) = -6.17$***	-.72	-.37	.36***
C5 POST	action"	4.34	1.11				
C6 PRE	"conclusions, implications and	3.29	1.29	$t(97) = -8.45$***	-.83	-.38	.53***
C6 POST	consequences"	4.30	1.13				

Note. $n = 98$.
Key: CT = critical thinking skills.
[a] Effect sizes were calculated through www.uccs.edu/~lbecker/.
* $p < .05$, ** $p < .01$, *** $p < .001$

the critical thinking subcategory scores except for the category "Analyzes reasonable alternatives and the consequences of those alternatives."

In the following regression analyses, posttest critical thinking data from all three simulations were used, and "gender" and "simulation type" were used as control variables. Simulation effects were accounted for using dummy variable coding (Cohen, Cohen, West, & Aiken, 2003) with Simulation 3 as reference group. To address potential biases in our regression analysis resulting from comparing individual-level (critical thinking and problem-solving approach) with team-level (simulation performance scores) variables, we calculated robust standard errors using the method set forth by Hayes and Cai (2007) for all analyses assessing simulation performance. Robust standard errors or heteroscadasticity- and autocorrelation-consistent standard errors provide a more conservative estimate of the significance level and are a recommended solution for violations to the assumptions of regression analysis (Hayes & Cai, 2007).

Showing the conservative robust standard errors, Table 4 indicates that we found a marginally significant relationship between critical thinking skills and simulation performance when including all simulations. By analyzing the data further, we found a significant effect of critical thinking on performance in Simulation 3 ($\beta = .26$, $p < .05$) that was not found between Simulation 1 and 2 critical thinking posttest data and simulation performance. Therefore, we found only partial support for Hypothesis 2, stemming solely from Simulation 3.

To test the mediating effects of Hypotheses 3 and 4, we used the analysis method specified by Baron and Kenny (1986). For Hypothesis 3 we independently tested the relationship between critical thinking and collaborative problem-solving approach, between collaborative problem-solving approach and simulation performance, and between critical thinking and simulation performance. Given that the composite critical thinking score was not predictive of the collaborative problem-solving approach, no mediated effect was present (Denis, 2010) and Hypothesis 3 was not supported.

TABLE 4
Robust Standard Error Regression Results for Posttest Critical Thinking Skills on Simulation Performance

	Critical thinking on performance
Gender	-.20
Simulation[a]	—
Critical Thinking	.15†
R^2	.03
N	176

Key: Gender: Male = 0, Female = 1
[a] With sim 3 as reference group.
† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

To test Hypothesis 4, the same steps were taken, replacing the collaborative problem-solving approach with a competitive problem-solving approach. Critical thinking was not predictive of a competitive approach to problem solving, again nullifying the mediated effect; therefore, Hypothesis 4 was not supported.

We did, however, find significant relationships between the critical thinking subcategory C5: "clear recommendation with appropriate course(s) of action," and both competitive problem-solving approach (β = -.16, $p < .05$) and simulation performance ($\beta = .18$, $p < .01$). Moreover, with our conservative estimates, a competitive approach to problem solving had a marginally significant negative effect on simulation performance (β = -.15, $p = .08$). Therefore, allowing for the marginally significant results, the conditions for proceeding with mediation testing were met (Denis, 2010) in regard to testing the subcategories of critical thinking skills. Also, when regressing this critical thinking subcategory on simulation performance the standardized regression coefficient changes from $\beta = .18$ ($p < .01$) to $\beta = .16$ ($p < .01$) after the inclusion of the mediator "competitive problem-solving approach." Given the change in β, we ran a Sobel test[1] for partial mediation (Baron & Kenny, 1986; Sobel, 1982). However, the Sobel test revealed that competition does not significantly mediate the link between this critical thinking subcategory and simulation performance ($p = .16$).

Although Hypotheses 3 and 4 were not supported, we did find that two critical thinking subcategories: C1: "identifies key problem" and C3: "analyzes alternatives" had a negative impact on collaborative problem solving. Specifically, the more students analyzed the key problem(s) and solution alternatives, the less they used a collaborative problem-solving approach. When looking at the impact of the critical thinking subcategories on a competitive problem-solving approach, we find that the better students are at formulating clear recommendations, the less they use a competitive approach to problem solving. In addition, the positive effect of C6: "conclusions, implications, and consequences" indicates that the better students are at justifying their actions, the more they use a competitive approach. Table 5 presents the regression results for the critical thinking subcategories on collaborative and competitive problem-solving approaches.

[1] The Sobel test was run through www.quantpsy.org/sobel/sobel.htm.

TABLE 5
Regression Results for Critical Thinking on Collaborative and Competitive Problem-Solving Approach

	Dependent variable	
	Collaborative approach	Competitive approach
Gender	.01	-.04
Simulation[a]	—	—
C1: "key problems or issues"	-.24*	.02
C2: "key assumptions and stakeholders"	.11	.03
C3: "analysis of alternatives and consequences"	-.20*	.13
C4: "supporting data"	.11	-.09
C5: "recommendation and course of action"	.12	-.36**
C6: "conclusions, implications and consequences"	.03	.23*
R^2	.06	.07
N	176	176

Key: Gender: Male = 0, Female = 1
[a] With sim 3 as reference group.
* $p < .05$, ** $p < .01$, *** $p < .001$

Table 6 presents the regression results for the problem-solving approach on simulation performance. Our results showed that using a collaborative approach had no effect on simulation performance, whereas using a competitive approach had a marginally significant negative effect on performance (β = -.16, $p = .059$).

Student Feedback

To better understand how the simulation improved students' critical thinking skills and whether students believed the simulation was useful in developing these skills, we asked students for their feedback regarding the simulation experience. As a post hoc manipulation check we emailed 220 students who had participated in the strategy-focused simulations (Simulation 1 and Simulation 2) over the past year and asked them to complete an on-line survey. These students were surveyed because only the strategy-focused simulations were used to evaluate critical thinking skills learning in Hypothesis 1. Students were informed that participation in the survey was voluntary, and responses were anonymous. In addition, the email was sent to students after all grades had been submitted, and students were reassured that participating or not

TABLE 6
Robust Standard Errors Regression Results: Collaborative and Competitive Problem-Solving Approach on Simulation Performance

	Simulation performance
Gender	-.10
Simulation[a]	—
Collaborative approach	-.01
Competitive approach	-.16†
R^2	.03
N	178

Key: Gender: Male = 0, Female = 1
[a] With sim 3 as reference group.
† $p < .10$

TABLE 7
Student Feedback on Critical Thinking Skills and Simulation Participation

Question: To what extent did:	*M*	*SD*
1. Participating in the simulation help you improve your critical thinking skills from the beginning to the end of the simulation?	4.00	.88
2. Applying your critical thinking skills help your performance in the simulation?	4.21	.76
3. You have the opportunity to apply your critical thinking skills to the simulation?	4.10	.79
4. You feel that after playing the simulation you are now able to use your critical thinking skills to make better decisions?	3.85	.98

participating in the survey would not affect their grades. We sent a reminder email after 1 week. A total of 61 students completed the survey, leading to a 27% response rate, which is considered good in online research (Bonometti & Tuang, 2006; Ilieva, Baron, & Healey, 2002). Thirty-nine percent of respondents were students that participated in this study. The remaining 61% were students who had participated in one of the two simulations subsequent to our study. Table 7 includes the means and standard deviations of responses to four questions we asked relating to critical thinking skills and the simulation. In the survey we provided the same definition of critical thinking that was used in our study to ensure students understood the questions. Questions were rated on a 5-point Likert scale with five equal to "*a very great extent*" and one equal "*to no extent at all*."

In general, student feedback was favorable in regard to the whether they perceived the simulation as beneficial for developing critical thinking (79% answered either "a great extent" or "a very great extent") and whether the simulation provided a context where critical thinking skills could be applied (84% answered either "a great extent" or "a very great extent"). Similarly, students who responded to the survey believed that using their critical thinking skills aided their performance (87% answered either "a great extent" or "a very great extent") and 68% of the respondents agreed either "a great extent" or "a very great extent" that participating in the simulation helped them afterward in applying critical thinking to decision making.

About one third of the students wrote in responses to a question asking "what, if anything, limited your ability to fully apply their critical thinking skills?" Team dynamics and time constraints were identified as hindering critical thinking skills learning. Team size was also mentioned as a limitation to critical thinking skills development, suggesting that smaller teams are preferred to larger ones. However, we also asked students to indicate what aspects of the simulation were the most helpful in developing critical thinking skills and 75% of students indicated that the team environment was the most helpful. This question provided a list of 10 simulation features and an "other" category. The "other" category generated two responses: "business deals with other groups," and "limited time to make choices, serious consequences both good and bad that have long-term effects," indicating that at least for one student, limited time helped with critical thinking skills development. Table 8 provides the percentage of students indicating which feature of the simulation was most helpful in developing critical thinking skills organized within the four social learning theory processes. To provide evidence on how simulations develop critical thinking skills, we also added sample student comments from the final survey question: "Is there anything else that you would like to tell us about your critical thinking skills development and your participation in the simulation?" Thirty-one students commented on this question. Appendix A provides a complete list of student responses.

Furthermore, two thirds of the students indicated that they had not participated in a web-based simulation prior to this class. For those students who had participated in web-based simulations

TABLE 8
Student Feedback: Learning Theory, Simulation Features, and Critical Thinking Skills Development

Learning theory processes	Simulation feature and percentage indicating "most helpful" in developing critical thinking skills	Sample of student comments regarding critical thinking skills development and simulation participation
Gain attention	Team-based environment (75%)	"The simulation let me observe how my decision as well as my teams decisions affected many different areas of the company, as well as how making mistakes or miscalculations affected those areas. Not only that the competition between the other groups pushed me to want to be at the top every week therefore I focused more intensely on my decisions."
	Competition with other teams (75%)	"This was one of my favorite courses and I wish that I could try this game on my own to see if I could do any better."
	Interactive nature of simulation (74%)	"The simulation was a great way to capture students' attention and learn material in a new way. The professor's knowledge of the simulation was very helpful and his feedback was very essential to our team's success."
	Online/web-based versus paper-based format (48%)	
	Captured my attention (46%)	
Retention	Requirement for strategic planning (80%)	"This course was a great way to learn about how you would react to real life situations in a business setting. I loved what I learned and gained from this class."
	Good way to learn course material (49%)	"I thought the simulation was a wonderful way to exercise our critical thinking skills. The way you must adapt to various conditions in the simulation requires careful planning and execution. These are some of the core skills required to have effective critical thinking."
Practice	Duration of the simulation over several weeks (54%)	"The simulation is the most beneficial project I've encountered during my college experience. The impact of your choices can be seen; therefore, you have the ability to adjust and work through your strategy. A traditional assignment does not offer this."
		"Participating in the simulation allowed me to apply my critical thinking skills to understand how my decisions can affect a company and what I need to do to correct my mistakes."
Feedback	Feedback from instructor (67%)	"Having the right teacher make a difference. After this simulation I had another similar simulation at [removed] with a different teacher and the level critical thinking was not the same. It was quite a frustrating experience, unlike the great experience I had with Dr. [name removed]."
	Feedback from simulation (54%)	"The simulation forced you to make a decision whether it was right or wrong. when forced to make a decision it makes you want to genuinely think about the problem and evaluate it."

Note: Student grammar not corrected. Faculty identifying information removed.

before, we asked "in what ways did participating in simulations in other classes influence your critical thinking in this simulation?" Table 9 provides a sample of the responses mapped to specific critical thinking subcategory. Themes that stood out to us were comments related to working as a team and reaching consensus, which we categorized as being able to identify key assumptions and considers stakeholders, and greater awareness of the interconnections among the multiple functions and actions. We categorized this increased awareness of connections as positively affecting students' ability to analyze alternatives and reach conclusions that consider the implications and consequences of the decision.

DISCUSSION

Our goal was to test the utility of management simulations to develop critical thinking skills and better appreciate the *I do and I understand,* axiom. We found that participation in strategy-based simulations was an effective way to develop critical thinking skills in our sample of undergraduate business students. Furthermore, to extrapolate from our student feedback, we can readily apply *I do and I understand* to our study. In particular:

> When I *participate in a team-based, competitive management simulation* (simulation feature), I understand *how to identify key assumptions and consider stakeholders* (critical thinking subcategory).
>
> When I *make multiple decisions over a period of time*, I understand *how to analyze alternatives and consequences of those alternatives*.
>
> When I *receive feedback from my instructors and the simulation*, I understand *the implications and consequence of my decisions*.
>
> When I *apply my experiences from past decisions and simulations*, I better understand *how to identify problems and make recommendations with appropriate courses of action*.

Also, our study showed that critical thinking skills learning was related to simulation performance, but only in the shorter duration simulation where performance was determined solely on the actions of the individual team members versus determined within the competitive "industry" environments indicative of the two longer strategy-focused simulations. We also explored whether critical thinking was related to the problem-solving approach, and subsequently, performance, and we found mixed results. Although the answer to whether students with higher levels of critical thinking skills are more likely to use a collaborative problem-solving approach was inconclusive, significant relationships were found between the critical thinking subcategories and the problem-solving approach.

Fink (2013) states that the goal of teaching is to become a designer of learning experiences. Accordingly, he suggests that significant learning

TABLE 9
Prior Participation in Simulations and Critical Thinking Skills Development

Question: In what ways did participating in simulations in other classes influence your critical thinking in this simulation?

Student comments:	Suggested link with critical thinking subcategory
"It helped me identify problems that I encountered and how to fix them."	C1: Identifies and summarizes key problem(s) or issue(s)
"I knew everyone needs to participate and understand all the given information."	C2: Identify key assumptions and considers stakeholders
"I needed to work closely with my teammates to reach a decision before we moved forward."	
"It made me aware of all the critical aspects of the human resources function and how it is all interrelated."	C3: Analyzes reasonable alternatives and the consequences of those alternatives
"It made me aware of connections."	C6: Conclusions, implications, and consequences
"Experience working with interactive software."	C4: Analyzes and presents supporting data
"Used the skills I learned from previous simulations and applied them to the HRM simulation."	C5: Recommendation with appropriate course(s) of action

experiences affect learning gains in six areas: foundational knowledge, application, integration, caring, human dimension, and the motivation for learning how to learn. Our purpose in using simulations as learning activities was originally to enable skill application and motivation to learn or what Fink (2013) terms, *caring*. By gaining feedback from students and discussing the implications of simulation-based training, we now better understand the implications of management simulations as significant learning experiences. Namely, not only did participation in the simulation improve students' ability to develop and apply critical thinking skills (application), but also it peaked students' interest (caring). Comments included words such as "favorite," "wonderful," and "love." Students also noted that the simulation helped them retain course information (foundation knowledge). Anecdotally, even after graduating, a number of students commented that the simulation was their most memorable learning experience in college.

While our student feedback request was voluntary, and thus, has its limits, we were surprised that only a third of those students responding to our survey had previously participated in simulation-based training. Perhaps incorrectly, we assumed that our millennial students have ample experience with simulation technologies. Previous experience was considered beneficial, particularly in regard to making connections and understanding how functions are interrelated, which maps closely with Fink's (2013) integration category of the significant learning experiences taxonomy. In addition, the interactive nature of the simulation was identified as a key aspect of critical thinking skills learning. We therefore suggest that simulation-based training could be used in multiple business courses, as each experience would be an opportunity to further develop and hone students' critical thinking skills as well as address the six areas of significant learning. Future research is needed to best determine the number of simulations that students can participate in to optimize their critical thinking skills development. In addition, students noted that feedback from their instructor was important to their critical thinking skills development. This point underscores the necessity for effective, attentive teaching versus using simulations as a substitute for good teaching.

The human dimension of learning played a larger role in developing students' critical thinking skills than we had anticipated. The team-based environment and competition with other teams were rated by students as the most helpful in developing critical thinking skills. Both factors replicate the dynamic workplace that many students will be entering. Understanding multiple perspectives of a situation or problem and operating within an environment where the decisions of other people and competitors impact your decisions is a realistic application of critical thinking. We also assert that developing critical thinking skills through simulation pedagogies assists students in becoming self-directing learners. Fink (2013) describes this sixth category of significant learning experiences, learning how to learn, as one of the (attainable) dreams of faculty. For us this includes making sure our students enter the workforce with the ability to apply critical thinking skills to problem solving. Given the statistical results of our study along with student feedback, we contend that management simulations represent significant learning experiences and are useful in developing students' critical thinking skills.

Furthermore, we assessed critical thinking through reflective written reports. Critical thinking is most frequently assessed with multiple choice tests and similar inventories (Abrami et al., 2008; Reid & Anderson, 2012). For example, Reid and Anderson (2012) explicitly taught critical thinking, which was evaluated with chapter quizzes, and then they applied the critical thinking skills component to case analyses within a business strategy course. They found that students with the critical thinking skills training were better able to apply this skill to the case analyses than those students who did not receive the training. Paulson (2011) describes a mergers and acquisitions project where students write an analysis paper that incorporates critical thinking with group communication and consensus-building competencies. However no empirical data were presented to evaluate the success of this project. We required students to write a reflective analysis of the simulation situation at two different points in time (at the beginning [pretest] and at the end of the simulation [posttest]). Being able to communicate critical thinking by way of written analysis takes the skills learning to a higher cognitive level and effective written communication is also an important skill in the workplace. In addition, thoughtful reflective analysis is an essential skill for effective management (Rousseau, 2012). We found no other studies used written analyses and a pretest–posttest design to examine whether web-based simulations are effective in training critical thinking skills.

We also found that critical thinking skills learning went from an average of "fair" to an average of "good," after students participated in the simulations. We suggest that this demonstrates skill acquisition, and with repeat exposure to similar simulation-based training, students can achieve the skill learning levels of compilation and automaticity (e.g., "very good" and "excellent," respectively; Kraiger, Ford, & Salas, 1993). Moreover, learning gains were found in five of the six critical thinking skills subcategories, with only "analyze alternatives and appropriate courses of action" not producing significant learning gains. This finding may be because the simulation parameters artificially constrained students' choices or perception of choices that were available to them. Nevertheless, the significant critical thinking skills learning improvements signal that simulations are a useful supplemental pedagogy for training students in this essential skill and may also be an effective way to assess accreditation assurance-of-learning goals (e.g., AACSB).

Equally important, more faculty are using computer-based simulations in their classrooms, and students do tend to respond favorably to this instructional method. In general, feedback from our students is positive, and the majority of our students are comfortable using the simulation technology. Providing students with practice opportunities, in some cases before the actual simulation starts, and encouraging students to "think positively" or use an emotion-controlled strategy (Bell & Kozlowski, 2008) can help reduce student stress. In addition, guiding students throughout the learning activity with reflective support (Leemkuil & de Jong, 2012; e.g., using prompts to help students clarify their questions and apply their own knowledge) can also help reduce ambiguities that hinder student learning. We suggest that management educators employ a mixed method of instruction when using simulations as a supplemental pedagogy, where critical thinking is explicitly taught and then applied to the simulation experience.

In regard to our second research question, we found mixed results for the connection between critical thinking skills learning and simulation performance. Critical thinking was only positively linked to simulation performance in the shorter Simulation 3. In this case, the analysis of the simulation situation using critical thinking skills revolved on a shorter, more contained learning experience. This focused learning activity may have resulted in a clearer application of critical thinking skills learning to the simulation, which positively influenced simulation team performance. Also, in Simulation 3, team performance was not contingent on the performance of other teams participating in the simulation. Hence, team performance was based primarily on the team decision-making competencies (i.e., critical thinking skills) of the individual team members. Therefore, we can say that in our study with this simulation, critical thinking skills learning had a positive effect on simulation performance. In Simulations 1 and 2, which were the focus of the pre- and posttest results, critical thinking was not related to team performance. While critical thinking skills learning did occur within these two student samples, the longer duration of the strategy-based simulations and the interteam "industry" competition may have affected the correlation between learning and performance. For example, one-time performance errors, occurring any time during the simulation may result in performance decreases that cannot be recovered. Moreover, good or poor performance by the other teams could negatively or positively affect performance. Although critical thinking skills learning was not predictive of team performance, the increase in critical thinking skills from pre- to posttest assessment indicated that students did learn from the experience. Also, performance is not always a proxy for actual learning, and inconsistent findings have been reported between objective measures of learning (assessed through performance) and subjective learning (Bell et al., 2008; Gosen & Washbush, 2004). Ideally, in the future when students participate in simulation-based training or confront a similar situation at work, they will be able to apply the critical thinking skills to the new situation.

Our third research question focused on whether the problem-solving approach used by students was influenced by their critical thinking skills and whether the approach affected simulation performance. The problem-solving approach did not mediate the relationship between critical thinking and performance in our study. However, other significant relationships did emerge that were noteworthy. For example, students who were better at problem diagnosis were less likely to use a collaborative approach to problem solve during the simulation. Perhaps these students believed they knew the "right" answer and were not willing to take the extra time to discuss the problem. We did not find the opposite effect though, that problem diagnosis was positively related to a competitive problem-solving approach. Surprisingly, we also found that students who scored higher on being able to analyze alternatives were less likely to use a collaborative approach. Again, students may have viewed their group members as hindrances versus benefits, or as noted above, simulation parameters may have affected this subcategory. Given these mixed results, future research is needed to understand the relationships between critical thinking and a collaborative problem-solving approach.

Our study also found that students who were strong in incorporating supporting data and providing clear recommendations were much less likely to use a competitive approach to problem solving. This finding is significant as it suggests that those individuals who are better at applying evidence and providing solutions are less likely to be competitive in their approach to decision making. On the other hand, our study found that students who were able to justify their actions, including a summary of the implications of the actions taken, were more likely to use a competitive approach to problem solving. Again, further research is needed to understand how problem-solving approach affects critical thinking and vice versa. Our study showed that the individual subcategories of critical thinking were more predictive of whether a collaborative or competitive approach was used than critical thinking measured as a composite construct. Last, in regard to a problem-solving approach and simulation performance, we found that using a competitive problem-solving approach was negatively related to performance (marginally significant using robust standard error approach). This does lend support to the notion that competitive behavior can hurt performance, which was measured as team performance in this study. Future research should further explore this relationship.

Our study is not without limitations. We employed no control group so we are not completely sure that learning was due to the simulation experience versus other factors such as maturation. Also, we did not control for instructor differences, such as gender or student class standing. However, we were able to show an effect on learning in what Rynes and Brown (2011) refer to as between-classroom research. In addition, our collaborative problem-solving measure was statistically weak, which affected our ability to accurately measure this variable. Using the same measure, Volkema and Bergmann (2001) found that a broader range of responses fell into the assertiveness category (e.g., competitive approach) than the cooperative category (e.g., collaborative approach), indicating that the scale may be more effective in differentiating assertive orientations than cooperative orientations. Moreover, we did not assess demographic variables such as culture and personality, which could have provided additional information about the problem-solving approach. Future research should continue to explore how best to use simulation-based training to teach the essential skill of critical thinking. Furthermore, gathering data from alternative measures of the problem-solving approach and analyzing demographics variables can help us decipher the relationship between competitive and collaborative approaches.

In conclusion, we contribute to management education by testing the utility of management simulations and identifying simulation-based training as a significant learning experience and useful supplemental pedagogy for developing the important skill of critical thinking. Our results provide support for this claim. In addition, we add to the learning-performance debate by showing that learning is linked with performance, but only for the shorter duration, noncompetitive simulation. We suggest that with more simulation-based training opportunities, students can achieve greater skill improvement and stronger learning and performance connections. The relationship between critical thinking and a problem-solving approach is still an area for exploration. Our study did find that competitive approaches to problem solving tend to result in lower team performance. However, we encourage management educators to continue to apply Confucius' words, *I do and I understand*, to management development, and thus, further explore pedagogies that target higher order cognitive skills learning.

APPENDIX A:
Student Feedback
The table below provides student feedback regarding simulation participation and critical thinking skills development organized by the four learning processes of social learning theory.

Question: Is there anything else that you would like to tell us about your critical thinking skills development and your participation in the simulation?

Gain Attention (Motivation to learn)

- This was one of my favorite courses and I wish that I could try this game on my own to see if I could do any better.
- The simulation let me observe how my decision as well as my teams decisions affected many different areas of the company, as well as how making mistakes or miscalculations affected those areas. Not only that the competition between the other groups pushed me to want to be at the top every week therefore I focused more intensely on my decisions.
- I'm curious to know if individual participation in the simulation would have made a greater difference in the development of my critical thinking by giving me a more hands on feel and experience. I am still grateful I was able to participate in this exciting simulation.
- Greatly improved as the stakes got bigger and bigger to win.
- This simulation was a very easy and fun way of learning the material of the course.
- Awesome way to learn course material.
- I enjoyed the simulation. Because the class moves so quickly it's hard to "get it" until the first couple of classes, but it's otherwise a good learning tool.
- It was very fun and educational.
- Overall great class learned a lot.
- I think I learned a lot to help me with my future.
- The simulation was a great way to capture students' attention and learn material in a new way. The professor's knowledge of the simulation was very helpful and his feedback was very essential to our team's success.
- Be part of the simulation, and communicate with group members.

Retention (Activation of memory; Symbolic coding; Cognitive organization; Symbolic rehearsal)

- This course was a great way to learn about how you would react to real life situations in a business setting. I loved what I learned and gained from this class.
- I don't think our group functioned as a whole unit enough to reap all of the benefits of the simulation; however, I do believe that it helped me understand multiple course material in a realistic way. Specifically using information from internet marketing consumer marketing, and international marketing.
- I love Professor [name removed]! [S/he] deserves a raise. [S/he] is a wonderful teacher. The simulation helped apply what I was learning in [his/her] lectures to real-life scenarios.
- Participating in the simulation allowed me to apply my critical thinking skills to understand how my decisions can affect a company and what I need to do to correct my mistakes.
- The simulation forced you to make a decision whether it was right or wrong. When forced to make a decision it makes you want to genuinely think about the problem and evaluate it.
- The simulation is the most beneficial project I've encountered during my college experience. The impact of your choices can be seen; therefore, you have the ability to adjust and work through your strategy. A traditional assignment does not offer this.
- The simulation was the best part of the course because it applies classroom / textbook theories to real life simulation or role playing. In my mind this is the best way to learn by role playing and practicing. Any opportunity for a student to learn in a close to a real life situation as possible the better, i.e. "book smart" vs. "street smart." One might even let the simulation dominate the curriculum and syllabus so that homework involves learning the theories and materials and then you have to instantly apply it. Instead of breaking down the simulation in massive end of course paper and presentation, have weekly breakdowns and explanations to help ingrain the material to memory and thus common practice.
- I think there should be more set backs to people's companies. This will force companies to experience failure and learn to deal with such issues on a more efficient level. My group experience very few set backs giving us little difficulty.
- In retrospect, clear ground rules need to be laid down for business rules in the simulation. This also applies to real life so neither party involved walks away with ill will.
- It became more of how to play the game by anticipating other teams moves. You could not just focus on your own team. You had to think about the other teams and what strategies they were using.
- Bench marking and setting our company goals before the simulation was extremely helpful and made us set the foundation for our company's milestones.
- Had to keep in mind how the employees as a whole would perceive the choices as fair/unfair, or for their benefit and what would best for the company in the long run.
- I learned to examine more of the smaller things and not just focus on the big aspects.
- I think this course is good at getting students to plan ahead and get out of the now. It forces you to analyze your environment and choose wisely or you will be left behind.

(*table continues*)

APPENDIX A: Continued

Question: Is there anything else that you would like to tell us about your critical thinking skills development and your participation in the simulation?
• I thought the simulation was a wonderful way to exercise our critical thinking skills. The way you must adapt to various conditions in the simulation requires careful planning and execution. These are some of the core skills required to have effective critical thinking.
Practice (Behavioral reproduction)
• Having different information allow us to have more different ways to plan our business. Also, having different economic situation would help us to consider more factors that could affect the results.
• The simulation was great. There was definitely a need to think critically about every decision you made, because if you didn't it showed.
Feedback (Reinforcement)
• Having the right teacher make a difference. After this simulation I had another similar simulation at [removed] with a different teacher and the level critical thinking was not the same. It was quite a frustrating experience, unlike the great experience I had with Dr. [name removed].
• It should be used more to apply what you have studied in the class.

Note. Student grammar not corrected. Faculty identification removed.

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