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Business Simulation Validity Across Course Delivery Formats

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Abstract

Web-based simulations expose business students to complex and dynamic real-world decision-making scenarios. Simulations increase decision-making speed, lengthen information retention times (Bolt, 1993; Chernikova et al., 2020), and foster positive learning reinforcement (Dweck, 1986). As a proven pedagogical tool, simulations enable greater classroom flexibility and adaptability potential across higher-education delivery platforms. Layering a team-based competition onto the simulation tool can provide a means to improve critical thinking skills and improve cognition skills (Deitz, Fox, & Fox, 2022; Laverie, Hass, & Mitchell, 2022). Interestingly, limited research exists on longitudinal group/team performance trends in simulation performance across class delivery formats. This longitudinal (12-year) quantitative study examines student group simulation performance across three classroom formats (e.g., face-to-face, online, and hybrid learning). Findings expound on the external validity of sim-based education. Results from 42 team simulations (186 groups of 924 students) across 12 years suggest no significant difference in simulation group performance across delivery formats. Group simulation performance is not dependent on the medium of class delivery, whether live, online, or a combination of the two (hybrid).

Student Group Simulations

Computer simulations are renowned for enriching the classroom experience for students in higher education (Singh et al. 2022; Cantor, 1995). Online computer simulations deliver authentic learning experiences to students. Simulations increase student engagement, teamwork, problem-solving, and critical thinking, often more so than pure theory or case studies (DiMeglio, 2008; Henry, McCormack & Saeed, 2019). Computer simulations exist across essentially every discipline: marketing (Deitz, Fox, & Fox, 2022; Laverie, Hass, & Mitchell, 2022), accounting (Polimeni, Burke, & Benyaminy, 2009), organizational science (Hill et al., 2009), political science and international relations (Meleshevich & Tamashiro, 2008). The use of computer simulations as learning tools has been mainstream since the mid-late 1970s (Sprouls, 1962) due to the ability of students to learn through practice as opposed to the traditional hands-off approach.

Research examining the impact of simulations is pervasive (Vermunt, 2023). Positive outcomes from team-based competitions include learning reinforcement (Dweck, 1986), exposure to real-world decision-making scenarios, increased decision-making speed, longer information retention times (Bolt, 1993), and the integration of complex problem-solving (Heitzmann et al., 2020). Combining team-based competitions with simulations can improve student confidence and make learning fun (Peters & Stamp, 2021), provide a safe place to experience mistakes (Peters & Stamp, 2021) while offering timely feedback to support learning (Deitz, Fox, & Fox, 2022; Laverie, Hass, & Mitchell, 2022; Peters & Stamp, 2021). Academic research has also recognized the ability of students to evaluate information, weigh alternatives, and make decisions in a virtual environment (Deitz, Fox, & Fox, 2022; Di Meglio, 2008).

Kilburn, Kilburn, and Faught (2010) previously examined pre-competition student assessment scores, group size, and average group GPA to assess their predictability of final group rankings within the simulation. Gamification in online classes can improve engagement and encourage other interactions within an online course (Chapman & Rich, 2018). Various authors stress the engagement enhancement realized in classrooms using simulations (Deitz, Fox, & Fox, 2022; Laverie, Hass, & Mitchell, 2022; Peters & Stamp, 2021; Zhen, Luo & Chen 2023; Zych, 1997).

A study by Laughlin et al. (2006) found groups of three to five people to have performed better than individuals when attempting to solve complex problems. Group performance is often better than the average group member's (Rue and Byars, 2007); however, "much" leaves the door open for criticism. Using a group to make decisions has several advantages and disadvantages. Two benefits of groups are an increased pool of knowledge and different perspectives. Disadvantages include group domination by one or more persons, groupthink (Maier, 1967), and dissension among the group (Gentry, 1980).

A more thorough understanding of group evolvement can indicate a group's expected performance outcomes. For example, Lemberger and Clemens (2012) examine changes across time that impact student performance. Schumann et al. (2008) also noted the importance of improving a student's simulation learning experience over time. In addition, the authors cite improved social/communication and organizational skills as outcomes of student groups over time. Further, Vij and Sharma (2013) find that the relationship among college-aged business student groups increases student entrepreneurial drive over time. The college student age and life stage was further linked to simulation success by Kulkami, Banerjee & Raghunathan (2022).

Student group changes through learning have been studied exhaustively (Lewis and Grosser, 2012; Naudé, 2012; Spencer et al., 2008) and overwhelmingly support the idea of intergroup communication, time, and shared experiences as drivers of group success. Naudé (2012) thoroughly examines the role of social learning theory in service-learning groups. Naudé (2012) explicitly proposes that student-group interrelationships are affected by prior knowledge but can be altered based on new experiences within the group. Likewise, Lewis and Grosser (2012) highlight the role of resistance to change in student group failure. The authors also emphasize the importance of intergroup communication, trust, and motivation in overcoming resistance to change and increasing group performance and effectiveness.

Capturing Student Group Simulation Performance. While the benefits of web-based business simulations are infinite, the parameters within which some simulations operate can create drawbacks. Business simulations are of particular interest within which results are strictly internal, relative to the class administered, and individuals or teams compete with one another within a single simulation.

As addressed above, many web-based simulations measure success relative to firm performance within a single administration. Thus, the outcome data typically provides the instructor with substantial performance indicators amongst the simulation players (individuals or teams). In these simulations, the instructor can accurately gauge player performance relative to the administration; however, understanding of student knowledge/learning, in general, can be limited or non-existent. Thus, when a primary goal of higher education is to establish an overall benchmark of student knowledge and mastery of subject matter, simulations that use internal relative scoring systems fall short as there is typically no means of comparison across administrations. Alstete (2023) suggests using a graduated weighted method for simulation performance grading in order to allow for learning and performance responsiveness.

Business simulations typically use financial measures to gauge competitors' performance and success. Indicators such as cumulative profit, return ratios, market share, etc., are reviewed, and scores are assigned accordingly. Thus, high returns receive high scores and indicate success. Most often, the assessment ends there. The student or group gets a grade, the semester ends, and the cycle restarts the following semester. Ultimately, a relative internal scoring system does not truly demonstrate business knowledge. Simulations that use comparative internal scoring systems have built-in situationally derived variance. Each administration comprises a unique pool of students with individual knowledge bases, decision-making processes, work ethics, learning techniques, competitive drive, risk propensity, and when using groups, chemistry.

Thus, when using a relative internal scoring system, hundreds of situational variables may combine to form one unique score. Without assessing the distinctive situational variables of a given simulation, the instructor cannot assign external meaning to scores from a given simulation. Thus, due to unaccounted-for variation between administrations, if the winner of a business simulation finishes with a profit of $100 million, it can be unclear whether this group or person has any greater understanding of business than a group or person who finishes with a negative earnings in another administration. Likewise, it could be possible that a rerun of the simulation with identical participant scores could net an entirely different result. It could also be highly probable that the winner of one simulation would likely finish last in an industry with increased competition and knowledge. For example, the winner of a simulation comprised of all C-students would be less likely to win in a simulation of all A+ students, regardless of their relative internal score. This situation is neither a positive nor negative reflection on the groups. It merely demonstrates the lack of generalizability of a comparable scoring system among other administrations of the same simulation.

With situational variables limiting the generalizability of simulation results, assessing the true proficiency of groups involved in simulations becomes difficult. Therefore, creating a framework upon which we make our comparisons across groups is necessary. To create a comparative framework, one should assess generalizable commonalities that are key to determining whether something is favorable or unfavorable within the simulation. To assess understanding of subject matter in simulations that utilize relative internal scoring, instructors should identify commonalities linked to success regardless of the situational environment. Likewise, instructors should understand that typical success factors do not always lead to success or failure. In the case of business simulations, if every competitor makes a wise business decision, there will still be a winner and a loser.

Attempting to develop generalizable metrics should be approached with relative subjectivity and avoid absolute scales. Developing generalizable metrics may not provide conclusive data and should be addressed in close ranges. The ultimate goal of the simulation is to assess knowledge of the subject matter. Since a competitor takes appropriate measures and makes logical decisions, this would place them in a high range regardless of the relative internal score earned in the simulation. Likewise, if a competitor is not taking appropriate measures and not making logical decisions, then this would place them in a low range regardless of the relative internal score earned in the simulation. Because each simulation operates in its unique situational environment, one could have a simulation with all teams scoring in a low range or all teams scoring in a high degree, demonstrating the irrelevance of the relative internal score.

While developing ranges for the metrics is a more appropriate means of categorizing competitors, developing multiple criteria upon which to “grade” competitors will allow for more significant quantifiable metrics and resulting delineation between competitors. Furthermore, identifying the relative importance and weighted differences amongst criteria, if any, will enable instructors to accurately assess differences between competitors and demonstrate variation in levels of competence in the exercise.

Variance among different format groups can be measured using multiple indicators. Here, we examine group performance in the CAPSIM© simulation using critical error analysis: essential error counts and profit variance are assumed to be directly correlated. For this study, the number of critical errors is the standard point of comparison among all student groups within simulated industries. A critical error in this research is a unit of measurement developed independently of the actual simulation. Critical errors are business decisions that are more common in the early rounds. Therefore, Round 1 of CAPSIM © is the most critical assessment point and provides the data from which these flaws are tallied. In this research, common critical errors concern inappropriate manipulation of products across four markets and poor budgeting of marketing in any market. Critical errors are decisions made within the simulation which demonstrate irrational business decision-making despite the availability and validity of relevant information. Common-occurring examples include the following: (1) marketing budgets within the CAPSIM© Simulation have a break-even point for customer awareness, as well as a saturation point, both of which are provided to the student groups—when groups stray outside the minimum and maximum budgets, they are either forfeiting customer awareness, or over-spending for no additional awareness above saturation, and (2) research and development within the CAPSIM© Simulation provides information to allow groups to alter products in accordance with customer purchase preference. Setting product metrics outside that R&D data will mean loss of sales and excess inventory.

Classroom Delivery Format. Increased flexibility for classroom design, often referred to in the literature as “place,” allows multiple degrees of integration of online content into traditional, face-to-face classrooms. Allen et al. (2007) define modern classroom designs across four categories: traditional (zero integration of online tools), web-facilitated (1-29% of online delivery proportion), blended learning (30-79% of online delivery proportion, and online learning (80% or greater of online delivery proportion. Today, two main drivers have catapulted higher education towards web-facilitated, blended, or online learning: (1) the integration of and reliance on the LMS across college campuses and (2) the 2019-2020 COVID pandemic (Cellini, 2021). Simply put, today’s classroom can be anywhere.

Impacts on learning outcomes resulting from more dynamic learning formats are mixed. Some research finds lower performance outcomes for online learning (Hart, Fieldmann & Hill, 2018), where students repeat courses more often after taking them online, with lessened interest in future content-related courses. Alpert, Couch & Harmon (2016) find a 5-10% score decrease from the face-to-face to the online learner in a Microeconomics course. Post-COVID research has explored the type of learner and their success rates in online courses. One study by Kofoed et al. (2021) examined the performance of West Point students along a range of academic risk levels and found that those who were more at-risk performed lower in virtual classes conducted over Zoom© due primarily to lack of understanding of instruction, lack of concentration, and a decreased connection with peers and instructors.

One significant study published in 2023 acknowledges the variance in online/hybrid learning environments across learner types and finds that the key to providing a consistent learning environment, despite the format, is through instructional design and communication (Müller, Mildenberger, & Steingruber). The authors find that learning is not as dependent upon delivery format as the course’s structure and interpersonal engagement. They emphasize course structure, clarity in instruction and communication with student guidance, active learning tasks, stimulating interaction with instructors and peers, social interaction, and timely feedback through structured intervals and channels as requisite for student success across dynamic classroom formats (Müller, Mildenberger, & Steingruber, 2023).

Umble, Umble & Artz (2008) describe the benefits of team-based competitions as learning tools and their positive effects on the student learning process, student motivation to learn, excellent retention of knowledge, and a more comprehensive and integrative understanding of course material, among other benefits. Team-based competition simulations can provide a means to improve critical thinking skills and cognition skills (Deitz, Fox, & Fox, 2022; Laverie, Hass, & Mitchell, 2022). As Peters & Stamp (2021) highlighted, web-based sims also engage learners. Students have more fun. Feedback through simulations is structured, accessible, and easily shared amongst group members. Essentially, the web-based group simulation aids instructional effectiveness in any learning environment. It automatically provides the social engagement, interaction, and instructional clarity necessary for learning across dynamic environments by Müller, Mildenberger, & Steingruber (2023).

Do student groups commit a statistically significant number of these or critical errors in their simulation depending on what type of instructional delivery they receive? Should instructors estimate a variable group performance depending on the delivery format? This research attempts to confirm that simulation groups do not necessarily make a statistically different number of critical errors whether they enroll in a live, online, or hybrid course. Thus, the following hypothesis is presented:

> *H0: There is no statistically significant difference between delivery formats (Live, Online, and Hybrid) regarding the number of critical errors.*

Research Study

Data Collection

The computer simulation used in this study is CAPSIM©. CAPSIM© is a cross-functional team-based competitive computer simulation wherein students manage a $100 million company over a simulated period of up to 8 years (Saulnier, 2009). Over 500 business colleges and universities across the globe utilize the CAPSIM© Capstone Business Simulation (Saulnier, 2009). Within their simulated company, student groups are responsible for decision-making in 4 interrelated functional areas: research and development, marketing, production, and finance. The simulation design prohibits using outcome variables (e.g., profitability, ROI, ROA, etc.) as a unit of analysis for comparison between industries due to the uniqueness of each industry.

A weighted relative score calculation determines group performance within the simulation generated automatically by the simulation (ranging from 0-100). The following variables and corresponding weights determine this weighted score: Market Share 12%; Stock Price 12%; Market Capacity 16%; Return on Equity 12%; Return on Sales 12%; Return on Assets 12%; Asset Returns 12%.

The researchers collected CAPSIM© student group performance data from graduating College of Business senior teams at a Southeast university across 27 spring, summer, and fall college semesters over 12 years (2013-2022). Majors (e.g., accounting, marketing, management, economics, and information systems) were randomly distributed across groups. Also, gender and race were assigned randomly to the groups to allow for additional diversity. Teams had four, five, or six members. Results of CAPSIM© consider the financial performance of each group with multiple dimensions of business decision-making: R&D, Marketing, Production, HR, and Finance, relative to their competitors (CAPSIM, 2023). After approximately three weeks of rigorous training, the CAPSIM© competition simulation typically spans seven weeks during a semester. Therefore, the data used for this study included semesters with seven and 8-week simulation competitions.

Multiple simulations ran across numerous sections of the same course each semester. Across these twelve years, 42 completed CAPSIM© simulations were available for data collection. Within each simulation, 5- 6 groups were competing against each other. These 42 simulations of 924 students yielded results for 186 student teams (approximately five students per group) who completed the simulation across live, online, or hybrid classes. Format 1 (Live) committed an average of 0.5 critical errors per group, while Format 2 (Online) averaged 1.1 critical errors per group, followed by Format 3 (Hybrid) averaging .73 critical errors per group.

Results

The number of administrations of the simulation varied across the three formats, rendering uneven sample sizes across groups [Format 1 (Live) n=15, Format 2 (Online) n=19, Format 3 (Hybrid) n=9]. As a result of uneven group sizes, additional tests ensure the appropriateness of one-way ANOVA using SPSS. Bartlett's test was used to assess equivalent variance across the three formats. The Bartlett's Test results allowed us to assume that the variances are equal (p-value: .878) (Table 1).

Table 1. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.5
Bartlett's Test of Sphericity	Approx. Chi-^{2}	0.024
	df	1
	Sig.	0.878

Next, each delivery format group was tested for normal distribution using the Shapiro-Wilk statistical test, which is appropriate for small sample sizes (n<50). The results from the Shapiro-Wilk test indicated that we could not assume a normal distribution of the data for each group (sig.=.05) (Table 2).

Table 2. Shapiro-Wilk Test of Normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
indavgflaws	0.148	42	0	1	42	0.05

a Lilliefors Significance Correction

Consequently, we used a non-parametric one-way ANOVA (Kruskal-Wallis) for this analysis. The Kruskal-Wallis test reports whether the medians across groups are equal. Results indicate that we failed to reject our null hypothesis (P-value: .839, df=2, Test Statistic=.351), and the distribution of critical errors is the same across delivery formats (Table 3). We conclude there is no difference in committing critical errors among live, online, or hybrid delivery formats.

Table 3. Independent-Samples Kruskal-Wallis Test Summary

Total N	42
Test Statistic	.351a,b
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	0.839

a. The test statistic is adjusted for ties.

b. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Discussion and Implications for Future Research

This study serves to emphasize the flexibility of web-based simulations. Despite the delivery method, results enhance the attractiveness of an instructional tool that allows for adaptability and seamless application across diverse educational settings: web-based business simulations. The web-based nature of the simulation allows for flexibility and increased opportunities for student interaction. Web-based simulation flexibility enables participants to function in face-to-face, online, or hybrid settings while engaging in the same learning environment.

Promoting flexibility and adaptability allows instructors to convert from one delivery method to another if an environmental shift occurs. The benefits of simulations have been decisively established (Alpert, 1995; Bolt, 1993; Dweck, 1986), previously leaving the question of validity across delivery methods unanswered. This research assesses the validity of utilizing a business simulation across course delivery formats to determine whether learning occurs equally across different learning environments. It shows no statistically significant difference between delivery formats on group commitment to critical errors in their web-based simulation.

Brooks, Burson, and Rudd (2006) call for further research on how supplemental assignments to computer simulations can benefit student learning. Assessing student groups participating in online simulations can be more helpful if multi-faceted and not solely reliant on the simulation-generated ranking. The investigation into student group learning provides insight into the pedagogical strategy of utilizing student groups and online simulations in the classroom. Student groups are more productive than individuals in introducing diversity in thought and understanding of the material. Using simulations in the classroom has also proved positive: learning reinforcement (Dweck, 1986), exposure to real-world decision-making scenarios, increased decision-making speed, and extended information retention times (Bolt, 1993). Students learn through a computer simulation's ability to make real-time decisions (Di Meglio, 2008).

This study's limitations include using performance data from one university, thus limiting the generalizability. Next, we have used a non-parametric one-way ANOVA for analysis. Although ANOVA does not assume same-sized groups, there are two main possible limitations regarding the interpretation of the data: (1) reduced statistical power and (2) reduced robustness of unequal variance. Ideally, future studies would examine data where the number of classes across delivery formats would be equal. However, our study examined team performance across several years, wherein the relative distribution of delivery formats varied in number. While it is ideal for performing ANOVA on similarly-sized groups to optimize statistical power, the capture of delivery formats across time and the benefit of controlling equality over situational and circumstantial elements override the possible limitations unequal groups introduce. Likewise, for testing, normal distribution within groups would need to be examined in future studies, along with all other ANOVA assumptions. Future studies should, however, further test performance across delivery formats that are normally distributed.

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