Business simulation games: impact on SOLO taxonomy learning outcomes, learning performance and teamwork competency

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Abstract. Despite the increasing use of simulation games in business education, only few studies have explored the cognitive processes that learners employ while playing the game, with quite controversial results about the students' learning outcomes. The current study analyses the impact of a Business Simulation Game (BSG) on the cognitive processes related to the "Structure of the Observed Learning Outcome" (SOLO) taxonomy. Moreover, overall learning performance and perceived teamwork competency have been investigated. A quasi-experimental pre and post-test design was applied. Eighty (80) university students played a marketing simulation game to practise a business marketing plan. The results showed a significant improvement in the unistructural and extended abstract levels of the taxonomy after playing the game. There was no significant difference in the multi-structural level while the effect on the relational level was negative. Also, a strong, positive correlation between perceived teamwork competency and learning performance was found. Implications for instructional designers and educators are discussed.

Keywords: Business Simulation Games, Game Based Learning, Marketing Simulation Game, SOLO taxonomy, Team Competency.

1 Introduction

Business simulation games are learner-centred educational approaches where learners are required to apply their theoretical knowledge to solve real-world tasks in risk-free virtual business environments often collaboratively. They are simplified and dynamic models of real or hypothetical systems where players, following a set of rules, compete or cooperate in order to achieve a specific goal. They provide a structured environment, abstracted from real life action, with stated goals and allow participants to exercise real world skills providing them all the necessary feedback in order to learn from their mistakes in a risk-free environment [1]. Business students can understand complex relationships and develop practical skills and competencies [2].

A business simulation game includes several branched scenarios which, according to the player's actions, determine the final result. Through this process learners attain the necessary feedback, and the educational subjects are learnt [3]. BSGs, by placing the learner in the position of a decision-maker, enables them to understand the complexity and the different issues of such a decision-making process. BSGs are also suitable for raising awareness of various types of risks [4]. BSGs are suitable to support business students since it is expected that business students should have the opportunity to become more experienced and astute decision makers in uncertain situations [5]. While traditional lectures are ideal to provide definitions, concepts and theory, decision making is an empirical process [6]. According to [7], the main reasons that BSGs have been adopted are the following: i) they provide a decision-making experience, ii) they allow practicing and iii) they help students familiarise with functional business areas.

BSGs' most important learning feature is the experience gained through practice. This effective teaching and learning approach facilitate students' engagement in decision support systems [8]. Engagement and collaboration are achieved through practice and new skills are attained through the knowledge gained from learning from one's own trial and error [9], reinforcing both skill and knowledge [10]. Simulations also can contribute to experiential learning, an important component to developing emotional intelligence [11].

While there is an ongoing usage of busines simulation games, research in the area is quite scarce [12] and, empirical findings about their effectiveness are quite often controversial [13, 14]. The current study aims to add some more empirical evidence related to the development of cognitive processes, teamwork skills and learning outcomes.

The next section discusses the impact that BSG have on student learning outcomes and cognitive processes. We also discuss the importance of teamwork competencies and skills in relation to learning performance. The section ends by introducing our research questions. The methodology section describes our research: participants and procedures. The data analysis section presents the statistical analysis to assess the impact of BSG on the different levels of SOLO taxonomy and the correlation between overall student performance and teamwork competency. In the final discussion and conclusion section we discuss the results and their implications.

2 Background

2.1 Business Simulations Games (BSGs) and learning outcomes

Current research finds quite controversial results concerning the learning outcomes that BSGs' players attain. Previous studies showed that the use of simulations in education causes a positive outcome in knowledge acquisition [15, 16, 17]. Research provides some evidence that gaming strategies have a positive effect on students' learning achievements and motivation [18]. The use of business simulation games can have a positive impact on engagement, learning achievement and higher order thinking skills [19]. It is also recorded that educational games have a positive effect on the quality of learning for people with learning difficulties [20].

However, other studies did not show similar positive outcomes [21] and this is an area that needs further investigation. There is mixed evidence regarding the positive effects simulation games cause, in relation to instructional contexts [14, 22]. Different outcomes accrued form different gaming strategies and gaming environments [23]; e.g., students show a significant preference for games and interactive simulations when they have the control of the game's navigation while no significant preference is recorded when teachers control the navigation [24]. Research has found that game practice increased students' motivation [25], without having any positive effect on learning outcomes and cognitive skills [23]. There is a lack of studies concerning the cognitive processes and learning strategies that students employ when playing a game [13, 26]. Although lectures are important elements in the teaching process, they do not always foster higher cognitive levels. Active experimentation is one way to achieve higher levels of understanding. Simulations reinforce students to apply knowledge that they have learned in class to another, virtual environment. Simulations integrating more complex skills of analysis, synthesis, and evaluation is a promising tool. Players develop and identify semantic patterns which help them through their cognitive strategies [27]. Simulations facilitate this sort of progressively learning procedure as they enable students to repeatedly practice and eventually move towards higher levels of mental abstraction [28]. The positive cognitive and affective learning outcomes associated with simulation and gaming can affect students' development of critical thinking skills [29].

Learning processes can become very complex including various levels of understanding described by various taxonomies of learning outcomes [30]. Related research reports various game development efforts directly addressing levels of cognitive processes [31]. Most research addresses the six progressive levels of cognitive learning: knowledge, comprehension, application, analysis, synthesis, and evaluation as described in Bloom's Taxonomy [32]. In the context of simulations, [33] discusses the hierarchy of experiential learning with regard to the stages of Bloom's learning hierarchy. Researchers agree that only certain types of simulations are better suited to certain learning objectives of the Bloom's taxonomy [31].

Another broadly accepted hierarchical model is the SOLO taxonomy (Structure of the Observed Learning Outcomes) that classifies learning outcomes in terms of their complexity [34]. Learning progression starts from basic knowledge and gradually evolves to deeper constructs, a procedure which is sufficiently captured by SOLO taxonomy's levels [34], providing a more comprehensive hierarchical model which can be easily supported by objective criteria and applied in a vast area of assignments [35]. SOLO taxonomy, developed specifically for university teaching, is suitable for measuring different kinds of learning outcomes focusing particularly on observable learning outcomes [30]. The SOLO taxonomy distinguishes five levels according to the cognitive processes that students are involved in order to obtain them [36 pp. 34-35, 37 pp. 76-80].

Level 1 is "the pre-structural level": the student does not understand the task and uses unrelated pieces of information to solve it. Level 2 is "the unistructural level": the student focuses on one single aspect of the task and starts making obvious connections. Level 3 is "the multistructural level": the student focuses on several aspects but independently without making any connections. Level 4 is “the relational level”: the student integrates several aspects of the task understanding the relations between them. Level 5 is “the extended abstract”: this is the highest level where the student can perceive the task form multiple perspectives and is able to transfer knowledge in new untaught areas. Table 1 displays the five levels with example verbs that can be used to describe the learning outcomes within each level of the SOLO taxonomy. SOLO taxonomy has not been extensively studied in the context of simulation games.

Table 1. Examples of verbs within SOLO 2–5 based on Biggs (2003), p. 48

SOLO Level	Description	Verbs indicating level of understanding
uninstructural	One relevant aspect	‘define’, ‘identify’, ‘name’, ‘draw’, ‘find’, ‘label’)
multistructural	Several relevant independent aspects	‘describe’, ‘list’, ‘outline’, ‘complete’, ‘combine’
relational	Integrated into a structure	‘sequence’, ‘classify’, ‘compare’, ‘contrast’, ‘analyse’, ‘organise’, ‘distinguish’, ‘relate’, ‘apply’
Extended abstract	Generalised to a new domain	‘generalise’, ‘predict’, ‘evaluate’, ‘reflect’, ‘hypothesise’, ‘theorise’, ‘create’, ‘prove’, ‘justify’, ‘argue’, ‘compose’, ‘prioritise’, ‘design’, ‘construct’ and ‘perform’)

The current study exploits the SOLO taxonomy to evaluate the cognitive processes and to what extend different levels of understanding have been achieved assessing therefore students’ performance.

2.2 Business Simulations Games (BSGs) and teamwork competency

Teamwork is the collaborative effort of a group to achieve a common goal or to complete a task in the most effective and efficient way. It is a significant success factor for any context where a group of people are working together to achieve a common objective. It can increase productivity and efficiency and maximize performance [38]. Teamwork competency refers to an “individual’s knowledge, skills, and abilities to contribute more productively and effectively to a team” [39]. Teamwork competency is an essential skill that students must develop in order to function sufficiently in labour market [40]. Evaluating teamwork competency is important to better understand how individual teamwork dynamics can contribute to the effectiveness of a group working towards a common goal and improve practices. The same holds for educational contexts in order to improve learning activities, lessons plans or curricula to help further develop skills related to teamwork.

Teamwork skills has been studied in various organisational contexts (e.g., after-school programs and community centres) [41].

Teamwork competency is essential in business communities as well; there is a strong need for graduates with collaboration skills and therefore undergraduate business education needs to integrate this into the coursework. Business simulation games students can offer an experience-based learning environment where students can play in teams and collaboratively solve authentic problems. Studies in team-based multiround business simulation games explored the process of learning of individual students [42]. Collaboration in simulation-based learning helps students to increasing their understanding of the content [43]. However, other studies provide evidence that using teaching methods that help group dynamics does not have a significant impact on the overall learning outcomes [44]. Team structure and cohesiveness have been found to have a significant influence on team performance [45]. While simulation game studies have widely discussed the development of social skills [13], teamwork competency is an area that needs to be further explored in the context of BSG environments and in relation to the various levels of cognitive understanding and actual learning performance. The current study explores teamwork skills alongside a business simulation game to highlight the dynamics associated with learning performance.

The research questions that the study is aiming to answer are:

1. What is the impact of practising a Business Simulation Game on students' SOLO taxonomy levels of understanding and on students learning performance overall?
2. How does students' learning performance relate to their perceived teamwork competency in the context of a Business Simulation Game?

3 Methodology

3.1 Participants and Procedure

The participants in the study were 80 students enrolled in a marketing course, randomly selected from the Department of Economics (N=38) and the Department of Business Administration (N=42) at a European University. Ethical approval for the participation requested and approved; students were informed in advance about the research procedure; their participation was voluntarily, and all the data were collected anonymously.

The whole procedure lasted four weeks. During the first week, students studied basic key concepts regarding strategic marketing theory and took a pre-test with multiple choice questions based on SOLO Taxonomy to test learning performance before the BSG intervention. During the second week, students were randomly assigned in two groups. The first group consisted of 40 students (24 students from the Department of Economics and 16 students from the Department of Business Administration). The second group consisted of 40 students (14 students from the Department of Economics and 26 students from the Department of Business Administration). Students from both groups practiced the "Practice Marketing" simulation game [46] applying marketing strategies they have learned in class. “Practice Marketing” is a 3D multiplayer business strategy game based on the framework of the "4 Ps" of marketing: Product, Price, Placement, and Promotion. Students, as marketing managers, could practice various marketing strategies, in order to successfully launch a new product (a backpack of their own design) to market. Students are involved in all processes of a business plan (e.g., market research, new product development and cost analysis, pricing strategy, distribution channels selection, promotion strategy coordination, market share and sales results analysis to refine the product, price, promotion strategies in order to maximise profits). The game has a 3D interactive interface that connects, using an animated approach, principles and practices of marketing: Market Segments, Product, Price, Place, Positioning, and Competitors. Learning is supported through this interactive approach. Players can travel along the elements around the business conceptual map, click and zoom in on different elements to further practice.

The first group practiced the simulation game individually for two hours. The second group practiced the simulation game individually for one hour and then the students were gathered in teams to practice the game for one more hour. Each team had three members and competed the other teams in order to achieve the best game score.

During the fourth week students from both groups took the post-test with multiple choice questions based on SOLO Taxonomy to test learning performance after the BSG intervention. Students from the second group were also given a questionnaire to evaluate the level of perceived team competencies and skills. Figure 1 depicts the experimental procedure.

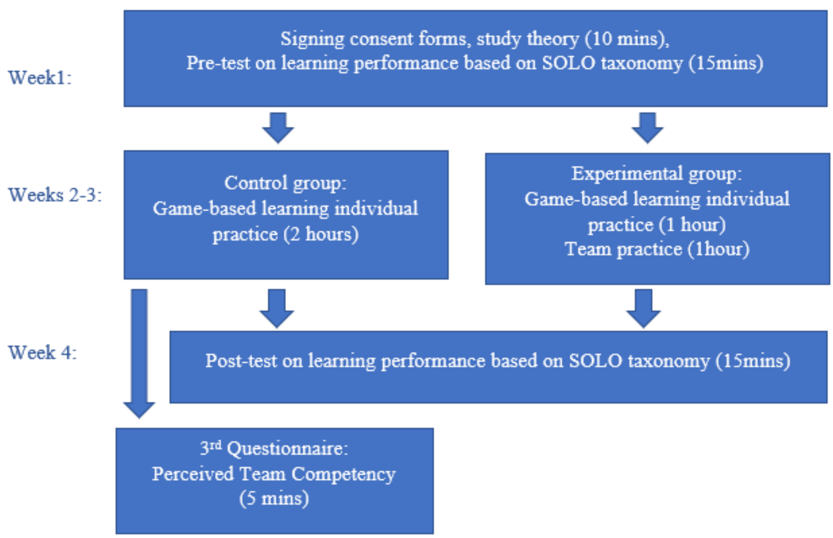

Fig. 1.. The experimental procedure

3.2 Instruments

In order to evaluate students' learning performance before and after the BSG intervention, researchers used a set of 35 questions randomly chosen from a multiple-choice questions pool [47]. The selected approach was the SOLO taxonomy that focuses particularly on observable learning outcomes unlike other taxonomies, such as Bloom's, that consider a rather cognitive perspective [32]. Questions were assigned to the different levels of the SOLO taxonomy: 9 questions at the uninstructural level, 10 questions at the multistructural level, 10 questions at the relational level and 6 questions at the extended abstract level. The tests did not include a section for the first SOLO taxonomy's level, "pre-structural". This level refers to a state where the student has not formed yet a relevant idea of the thematic point, thus a pre- and post-test comparison would serve no use.

The questions in levels 1 to 4 of the taxonomy were related to strategic marketing theory that was taught during the previous weeks. A brief document including basic key concepts regarding marketing theory was also given to them to study before the beginning of the research. The assessment was designed based on the SOLO taxonomy which focuses on observable learning outcomes while other taxonomies (e.g., Bloom's taxonomy) follow a more cognitive approach [32].

In order to evaluate students' perceptions about their teamwork competencies and skills the teamwork scale for youth has been used. It is a tool developed to assess a youths' perceived ability to collaborate and work with others to achieve a common goal in the group or team context [48]. It consists of a brief 8 item questionnaire assessed on a 5-point Likert-type scale ranging from 1 ("Completely disagree) to 5 ("Completely agree"). It was developed to assess a youth's perceived skills of teamwork and collaboration in order to achieve a common goal. Items reveal self-perceived attitudes toward teamwork (e.g., "People who work in teams can learn more than if they work by themselves") and teamwork behaviours e.g. "I feel confident in my ability to work in a team" [41].

4 Data Analysis and Results

Learning performance. Two tailed paired samples t-tests were conducted in order to compare scores before and after practicing the game, for each level of SOLO Taxonomy, in order to evaluate if there is a significant change on student's learning performance. Categorical independent variable is time, with two different time levels – before and after the game practice, while the continuous, dependent variable is test scores of the same people, as measured before and after the game. Table 2 shows the descriptive statistics for each SOLO taxonomy levels and table 3 shows the pair-sample t-tests results.

Level 1: Unistructural level. Results showed that there was a significant increase in the test scores at the unistructural level after the intervention. Students' learning performance at the unistructural level after the BSG experience (post: $M = 0.654$, $SD = 0.175$) outperformed their performance before the BSG experience (pre: $M = 0.477$, SD = 0.186), t(79) = -6.915, $p < 0.001$ (two-tailed). The eta squared statistics (0.376) indicated a large effect size [49].

Level 2: Multistructural level. At the multistructural level there was not a statistically significant increase in test scores after the intervention. Students' learning performance at the multistructural level after the BSG intervention (post: M = 0.591, SD = 0.163) was not significantly different form their performance before the BSG intervention (pre: M = 0.550, SD = 0.162), t(79) = -1.908, $p < 0.06$ (two-tailed). The eta squared statistics (0.044) indicated a moderate effect size.

Level 3: Relational level. For the relational level there was a statistically significant decrease in test scores after the BSG intervention. Students' learning performance at the relational level after the BSG intervention (post: M = 0.551, SD = 0.163) was significantly lower from their performance before the BSG intervention (pre: M = 0.608, SD = 0.184), t(79) = 2.473, $p < 0.016$ (two-tailed). The eta squared statistics (0.072) indicated a moderate effect size.

Level 4: Extended abstract level. A significant increase in the test scores after the intervention was reported for the extended abstract level as well. Students' learning performance at the extended abstract level after the BSG intervention (post: M = 0.573, SD = 0.185) outperformed their performance before the BSG intervention (pre: M = 0.379, SD = 0.198), t(79) = -7.252, $p < 0.001$ (two-tailed). The eta squared statistics (0.394) indicated a large effect size.

Overall test scores. For the total test scores there was a statistically significant increase after the BSG intervention. Students' learning performance after the BSG intervention (post: M = 0.569, SD = 0.114) was significantly higher from their performance before the BSG intervention (pre: M = 0.518, SD = 0.108), t(79) = -3.496, $p = 0.001$ (two-tailed). The eta squared statistics (0.134) indicated a large effect size.

Table 2. Descriptive statistics for each SOLO taxonomy level

	Pre-test			Post-test		
SOLO taxonomy level	N	M	SD	N	M	SD
Level 1 Unistructural	80	0.477	0.186	80	0.654	0.175
Level 2 Multistructural	80	0.550	0.162	80	0.591	0.163
Level 3 Relational	80	0.608	0.184	80	0.551	0.163
Level 4 Extended abstract	80	0.379	0.198	80	0.573	0.185
Overall performance	80	0.518	0.108	80	0.569	0.114

Table 3. Paired sample t-test results for students' SOLO taxonomy levels

SOLO taxonomy level	t value	df	Sig. (two-tailed)
Level 1 Unistructural	-6.915	79	0.001*
Level 2 Multistructural	-1.908	79	0.06
Level 3 Relational	2.473	79	0.016*
Level 4 Extended abstract	-7.252	79	0.001*

Learning performance vs teamwork competencies and skills. A Pearson product-moment correlation coefficient was computed to assess the relationship between perceived teamwork competencies and learning performance (as measured from the scores teams achieved while playing the Practice Marketing simulation game). Preliminary analysis was performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. There was a strong, positive correlation between the two variables, $r = 0.54$, $n = 40$, $p < 0.001$, with high levels of perceived team skills associated with higher levels of game scores.

5 Discussion and Conclusions

Despite the widespread use of simulation games in business and marketing courses, there is a long -standing debate about whether participation in such simulations provides a meaningful educational experience [6]. While game-based simulations have been extensively studied [13] and various efforts have been made so far to improve game design elements and how to make learning fun, more focus should be given on integrating pedagogical concepts such as learning taxonomies or learning objectives [50]. Simulation games design should improve skills as a result of the gaming experience. Learning outcomes should be aligned with specific cognitive processes and levels of understanding. Learning taxonomies have not been adequately studied in the context of Business simulation games [51]. To the best of our knowledge, this is the first article that explores SOLO taxonomy in the context of a Business Simulation Game. It addresses the learning progression through the different levels of SOLO taxonomy (unistructural, multistructural, relational and extended abstract levels) evaluating the impact that the integration of the BSG in the instructional practice has on each level and overall student performance. It also investigates the relation between learning performance and perceived teamwork competency.

Study findings revealed a statistically significant increase of the scores at both the uninstructural level and the extended abstract level; no significant change was noticed of the scores at the multistructural level while a statistically significant decrease was found of the scores at the relational level. Regarding the total score from all SOLO levels, a statistically significant increase was found after the students practicing the game. Moreover, a positive relation between learning performance and perceived teamwork competencies was found.

Recent research results on simulation games have contributed towards our understanding of the benefits that educational games provide and the requirements needed for their efficient use. This work's findings agree with current research [23, 52, 53, 54, 16] regarding simulation games providing a deep and sustained learning, improving understanding ability of content and leading to a significant increase in learning achievement. The advancement of the extended abstract level found in our research is in-line with previous research about the positive cognitive and affective learning outcomes associated with simulation and gaming resulting in students' development of critical thinking skills [29].

What is interesting though is that this score's increase was not recorder for each level of SOLO taxonomy. In particular, a statistically significant increase of the scores was found only at two levels: the uninstructural level that concerns to basic knowledge, and the extended abstract level which concerns to the higher cognition levels of generalization and synthesis. This finding may be easily justified regarding the positive impact the game caused on students' scores at the unistructural level, as it refers to basic knowledge. There must have been a familiarisation of the students with theory's key concepts through the game's practice. There was however a significant decrease of the scores at the relational level, which refers to the ability to relate and integrate theories. This is in contradiction with research in simulations [28] facilitating a progressively learning procedure as they enable students to repeatedly practice and eventually move up SOLO taxonomy to higher levels of mental abstraction. However, at the next cognitive level – the extended abstract one, which refers to generalisation and reflection, there was again a significant increase in test scores. A possible explanation could be that BSGs tend to focus on practising the decision-making skills – this mostly requires good understanding of the theory and the ability to evaluate each situation in order to proceed to the proper actions. Relational level's integration of different theories does not seem to have the most important role in this procedure.

Results also showed a strong, positive correlation between perceived team skills and game scores in the experimental group of students who practiced the game in teams. This may be justified as this correlation refers to game scores and not the final test scores; it is quite possible students who performed better as a team during the game to help each other and cover each other's weaknesses. Other research [55, 56] also provides evidence that curricula can be more effective when they address more teamwork principles, and by supporting certain team structure and quality factors make a team more cohesive and help avoiding mistakes in the game, resulting to a better task quality [45]. Facilitating the collaborative knowledge construction mechanisms, improves student learning [57].

The study finding can be of interest to instructional designers and educators. Designing and applying simulation games to teaching is a challenging task since it requires appropriate technical infrastructures and pedagogic integration [12]. On the basis of assessing each level of the SOLO taxonomy, the article provides recommendations to integrate learning outcomes in the game design and assess student performance as suggested by constructive alignment [58]. SOLO can not only be used for assessment purposes but also for simulation game design. As previous research suggests, by understanding the group and learning dynamics within simulations we can better align course goals and assessments and provide teaching recommendations [42].

Future research will benefit from more detailed experimental studies that systematically explore cognitive outcomes at each level of mental abstraction. Moreover, the strong positive correlation found between perceived teamwork competencies and learning performance indicates that curricula have proved to be more effective when they address more teamwork principles, which is in-line with previous research [59, 56].

The generalizability of the study results can be limited by the use of the particular simulation game, the use of self-perceived instruments (despite their validity and reliability), and the small sample size. Future work may aim to monitor student progression in the different taxonomy levels providing more detailed findings regarding the cognitive processes required to obtain the desired learning outcomes.

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