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Using business games in engineering courses. UMINHO/Azurém and UNESP/Bauru cases.

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Abstract: This paper presents the results obtained from using the business game Mercado Virtual (Virtual Market) in engineering courses in two different universities: University of Minho (UMINHO), campus of Azurém, Guimarães, Portugal, and at Universidade Estadual Paulista (UNESP) campus of Bauru/Brazil. The paper will present each course main characteristics and, later, discuss the results obtained from the business game Mercado Virtual. Decision-making-related data will be analyzed for these two groups of players during eight rounds focusing on finding a balance regarding: adequacy between production order and installed capacity, financial resources management concerning cash flow, loans payment and investments of surplus funds. For both universities, experiments were conducted separately. In Bauru, the experiment was conducted in the first half of 2009 having 15 teams to compete with

each other and managed by a student whereas in Azurém it was conducted in the second half of 2009 having 35 teams.

Keywords: Virtual Market, Business Game, Simulator, Engineering, Brazil, Portugal

1. INTRODUCTION

The business game Virtual Market was, initially, designed as a tool for teaching Business Administration in Engineering graduate courses. Its setup made it suitable for teaching productive capacity management and studies were conducted to assess the users' perception of the game.

Continuous use of the game made it possible to carry out an overall analysis of the decisions recorded in its database using the game objectives and its features as reference.

Analyses carried out on productive capacity and financial management of the simulated enterprises suggest that these are the contents in which users have the greatest difficulties. From these results, an exploratory and comparative research with two groups of users was proposed. The first group was comprised of Master's students in Production Engineering Program at the Universidade Estadual Paulista - UNESP / Bauru, and the second group consisted of students in the Integrated Master's in Engineering and Industrial Management Program at the University of Minho / Campus Azurém in Guimarães, Portugal.

Data provides only an exploratory assessment of results due to the courses characteristics. The first is a 30-month Master's course in production engineering (UNESP, 2006) admitting newly graduates. The second is a 5-year-integrated Master's course. In this second course the student is admitted to graduate school and can choose to complete the course with a teaching degree in Engineering Science and Industrial

Management at the end of 6 semesters while completing 180 ECTS (European Credit Transfer and Accumulation System). Another alternative would be to complete the course as a Master's in Engineering and Industrial Management after 5 years and 300 ECTS (UMINHO, 2009).

The paper will present each of the courses main characteristics and, later, discuss the results obtained from the business game Virtual Market. Decision-making-related data from two groups of players will be analyzed during eight rounds focusing on finding a balance regarding: Adequacy between production order and installed capacity, financial resources management concerning cash flow, loans payment and investments of surplus funds.

For both universities, experiments were conducted separately. In Bauru, the experiment was conducted in the first half of 2009 having 15 teams to compete with each other and managed by a student whereas in Azurém it was conducted in the second half of 2009 having 35 teams. Two of the enterprises were managed by a team of three students; five were managed by a team of four students and 28 individually. The purpose of this was to divide students into two equal groups (26 and 28) and later conduct an exploratory assessment to verify any differences between enterprises managed by teams and those managed individually.

The reason for studying these differences lies in the characteristics of the Integrated Master's course in Engineering and Industrial Management, which implemented a interdisciplinary project-based methodology six years ago (Project Led Education). This methodology consists of the development of a project during the first semester of the course integrating several disciplines. The first project is developed during the first semester, whereas the second takes place during the seventh semester, and the third during the eighth semester.

2. LITERATURE REVIEW

Business games have been in use in Brazil since at least 1962 (TANABE, 1977, GOLDSCHMIDT, 1997), but research on them seems to have been restricted to research groups and business schools because searching the largest databases used by researchers in Brazil, Lattes Platform, having as criteria "PhD researchers", "business games", "resumés updated in the last 18 months" and searching references "papers", "published books and chapters," "congress papers", "papers in journals and periodicals," other bibliographical publications" and "completed guidelines" showed a total of 1,021 researchers within more than 132,000 (CNPq, 2009). Note that there may be international researchers among this list.

In Brazil the use of business games and researches seem to be concentrated in a few isolated areas. The University of Santa Catarina, for instance, is responsible for 50% of the PhD's in the first 10 researchers listed in the Lattes Platform (CNPq, 2009), considering the number and importance of scientific production in the area. Dugaich (2005) supports this thesis during a survey with Brazilian business schools, revealing that only 38.2% from a total of 34 respondent schools used a simulator.

However, the research highlights an important aspect. The MBA courses represent 60% of the group using simulators. This percentage suggests an association between the use of simulators in Brazil and the idea that those who can most benefit from this teaching resource are those in the labor market. This data is in agreement with Scarelli (2009), Schafranski (2002), and Sauaia (1995) who showed fewer users repeating the experience of using simulators.

According to Ghosh (2003), Dale and Klassen's (1962) survey with 107 schools affiliated to the AACSB (Association to Advance Collegiate Schools of Business) revealed that 71% of them used games. Graham and Gray's (1969) survey presented

91% of schools using games, while Day's (1968) survey showed 94% were game users. Despite these high percentages, they were small samples and the schools surveyed were associated with the AACSB.

In 1975, concerned with the reliability in research, Roberts and Strauss (1975) repeated Dale and Klassen's survey (1962) and achieved an index of 94.5%. On the other hand, a survey conducted in 2003 with 14,497 educators affiliated with ABSEL (Association for Business Simulation and Experiential Learning), IASAGA (International Simulation and Gaming Association) and AACSB, adding a total of 1085 respondents, showed that 30.6% of respondents were users of simulation games (GOSH, 2003, FARIA & WELLINGTON, 2004).

The growing use of simulators in business schools can be observed by comparing data obtained in surveys such as Dale and Klassen (1962), Graham and Gray (1969), Day (1968) and Gosh (2003), suggest that the use of business simulation is growing, indicating that their inclusion in the courses curriculum has been successful, at least in institutions related to the area.

Although it is common to justify the use of simulators based on the competencies and skills they develop, the teaching aspects are extremely relevant because the models they represent usually a) present integrated cross-discipline content, b) have a student-centered teaching-learning process c) allow the learning to occur in accordance with each student's level d) remove the focus from the teacher / tutor as "holder of knowledge by giving him a supporting role in the process, e) are a simplified version of a real situation, allowing students to go through extreme risk and error without facing the same consequences they would have in a real system, f) generate minimal cost when compared to the actual processes and, g) represent little or no risk to users whatsoever.

The business simulations have been used to develop skills and competences in managerial area and they are classified as an experiential learning method (PETRANEK, 1994, THAVIKULWAT, 1999, SNOW, GEHLEN, GREEN, 2007, PETERS & VISSERS, 2009, MORENO-GER, BURGOS, TORRENTE, 2009). Experiential learning meaning the process by which we learn from experience (i.e. "the process whereby knowledge is created through the transformation of experience"). Knowledge results from the combination of grasping and transforming experience" (KOLB, 1984, p.41).

Simulators and business games belong to this context because they facilitate learning through experimentation using a model developed to allow certain "real-world processes" to take place in a simulated environment. Using this logic, they fulfill both the role of a new approach to the teaching-learning process and to provide contact and experience, though simulated, through practical situations for which the academic and / or social lives should prepare the individual.

Chin, Dukes and Gamson (2009) carried out an assessment analysis on games and simulators and state that until Goshen and Washbush`s (2004) study, this topic had not been reported in most published articles on the subject. The proposal for indicators to be introduced in Virtual Market was carried out without attempting to develop an evaluation system. Instead it was proposed in order to make it more efficient and effective as a supporting tool in the teaching-learning process. For the user these indicators are presented as small warnings about the status of some game variables. For instance, there is cash-on-hand not being invested. In this case the user would receive a message warning him about the status of the variable cash as "cash not invested."

The way they are structured in Virtual Market is in agreement with the model presented by Kolb (1984), because it tends to induce the user to a) ponder the meaning

and reason that the information is being received and b) take action regarding the warning with the general contents and learning objectives of the proposed simulation. It is expected that this would speed learning up and that the four basic cycles proposed by Kolb (1984): (1) concrete experience, (2) observation and experience, (3) Forming abstract concepts (forming abstract concepts) and (4) applying concepts to new situations would be traversed more quickly.

During the first round the concrete experience refers to any effort to format the first decision and establish a competition strategy for the game as a whole. From there starts the feedback process composed of the system reports showing the results regarding cash, income statement, balance sheet, stocks, indexes and ranking. Indicators would be an addition to the reports because they would point to details.

It is also during the first round that the observation and experience stage begins because students can communicate freely with others (members of the simulation or not). Moreover, this attitude is seen as a positive and one of the goals of using simulators. Encourage and develop the ability to communicate, to self-study and to search and analyze information. Whereas in stages 3 and 4, both the process in which the simulator is being used as well as the general goals of higher education aim to prepare professionals and citizens. Strategy and competition for instance are broad processes, constantly seen and experienced. The formation of an abstract concept and its application to other situations may be related to the understanding of market competition in terms of professional profile training and personal behaviors.

The teaching-learning process involves teaching (the teacher, the environment, teaching proposal) and learning (the student, his or her motivation and interest in the contents shown). These two elements are contextual. The first refers to the environment

and teaching motivation while the second refers to the student and his or her motivation to learn.

These conditions can change and influence the results obtained by similar processes and, therefore, this research is of interest and importance. Minho University (UMINHO) is in the European context and is part of a process seeking to integrate the countries members into the Common Market (Eurozone) using the Bologna Declaration as its beginning in the educational field. It defines the guidelines for education and establishes the conditions for validating diplomas and allows the flow of students between countries and institutions. According to the document signed by 27 countries (COUNCIL OF EUROPE, 1999, p.1)

A Europe of Knowledge is now widely recognized as an irreplaceable factor for social and human growth and as an indispensable component to consolidate and enrich the European citizenship, capable of giving its citizens the necessary competences to face the challenges of the new millennium, together with an awareness of shared values and belonging to a common social and cultural space.

The Bologna Declaration establishes the European Higher Education System through the a) adoption of a system of easily readable and comparable degrees; b) adoption of a system essentially based on two main cycles, undergraduate and graduate; c) adoption of a system of credits - such as in the ECTS system - as a proper means of promoting the most widespread student mobility; d) the promotion of mobility by overcoming obstacles to the effective exercise of free movement; e) promotion of European co-operation in quality assurance with a view to developing comparable criteria and methodologies; f) promotion of the necessary European dimensions in higher education, particularly with regards to curricular development, inter-institutional

co-operation, mobility schemes and integrated programs of study, training and research (COUNCIL OF EUROPE, 1999, p.3-4).

The Bologna Declaration stimulated the implementation of innovations to the Portuguese higher education system, starting with the establishment of "...bases of the assessment system and institutions of higher education follow-ups" (PORTUGAL, 1994) and ending with the approval of "regulatory principles for the development of a European higher education" in Portugal (PORTUGAL, 2005). Engineering and Industrial Management had their courses reduced from 5 to 3 years becoming an Integrated Masters in Engineering and Industrial Management. Such features differ in structure and duration from the Graduation course in Production Engineering taught at Unesp (Bauru).

The graduation course taught at UNESP has the duration of 5 years and is not attached to the Masters Program in Production Engineering. Therefore the undergraduate has to undergo the same selection process as any other student outside UNESP to participate in the Masters Program. These differences indicate that the results from the two groups may be distinctive. Regarding the courses general objectives in terms of the development of skills and competences and in terms of curriculum, such differences do not stand out.

Both courses aim to prepare its graduates to a) work in challenging environments and with complex projects; b) be able to apply available technology to solutions proposal and implementation; c) possess the competences and skills required to solve engineering problems; d) work in teams, among others.

Based on documents from the two institutions (UMINHO, 2010) and (UNESP, 2005) the distinctive factor of the two courses is the emphasis on technology found at UMINHO. In observing the curriculum of each course, the difference is more

pronounced in the composition of the basic and professional cycles. UNESP has more credit hours in its basic cycle than UMINHO. This is to be expected because although both courses require 5 years to complete, UMINHO puts a greater emphasis on more credit hours being dedicated to specific and technological subjects.

Another noticeable difference between the courses is the time spent by students in extra-curricular activities. It is only observed in UMINHO which, in part, explains the course additional credit hours.

3. STUDY METHOD

The research is exploratory and was carried out through two experiments of 8 rounds. The first was executed with students from the Masters Program in Production Engineering at UNESP in the first half of 2009. The second was executed with students from the Integrated Masters in Engineering and Industrial Management at UMINHO in the second half of the year. This experiment had two modifications when compared to the first.

Students were divided in two groups: enterprises managed by a single student and enterprises managed by teams of three and four students. This modification was designed to analyze whether there were significant differences between enterprises ran by students individually and enterprises ran by teams, because the course at UMINHO applies a project-based methodology.

The indicators were another shift introduced. Based on previous analyses, there was perceived difficulty in managing the enterprise. Therefore, some indicators were developed with the goal of improving student learning in the area of finance and capacity management. Indicators are just a warning. They neither present solutions nor indicate what is to be done. For example, one of the analyses generating an indicator

was cash-on-hand not being invested. If there were an amount exceeding \$ 1,000,000.00 on hand a warning was issued "there is cash not being invested".

Data from the groups' decisions were analyzed separately in terms of financial and capacity management. In order to assess financial management, the groups' ability to carry out capital estimates was analyzed. The analysis assessed the following aspects:

3.1. Capital misestimation

3.1.1. enterprises which did not request a loan in the decision sheet had to receive an emergency loan during the processing round of the game;

3.1.2. enterprises which requested a loan in the decision sheet and had to receive an emergency loan during the processing round of the game;

3.2. Appropriate Capital estimate

3.2.1. enterprises which did not request a loan in the decision sheet and didn't have to receive an emergency loan during the processing round of the game;

3.2.2. enterprises which requested a loan in the decision sheet and didn't have to receive an emergency loan during the processing round of the game;

3.3. Opportunity costs of capital

3.3.1. Enterprises that fail to invest amounts of money exceeding \$ 1.000.000,00.

3.3.2. Enterprises that requested loans and paid upfront.

3.3.3. Enterprises that have failed to pay the loan, despite having cash on hand and/or invested.

3.4. Inconsistency between production quantity and the installed capacity.

3.4.1. Enterprises that arranged to produce more than the installed capacity.

This analysis was observed by comparing the scheduled quantity versus actual production.

3.5. Compare the success rate among enterprises managed individually and in groups.

3.5.1. The comparison was made considering the enterprises accumulated profit round-by-round.

4. DATA ANALYSIS AND RESULTS

The first analysis refers to the origin of students from the masters program at UNESP, because the ones participating in the Integrated Masters at UMINHO, in this fase of the course, have the same origin. The result is presented in Chart 1.

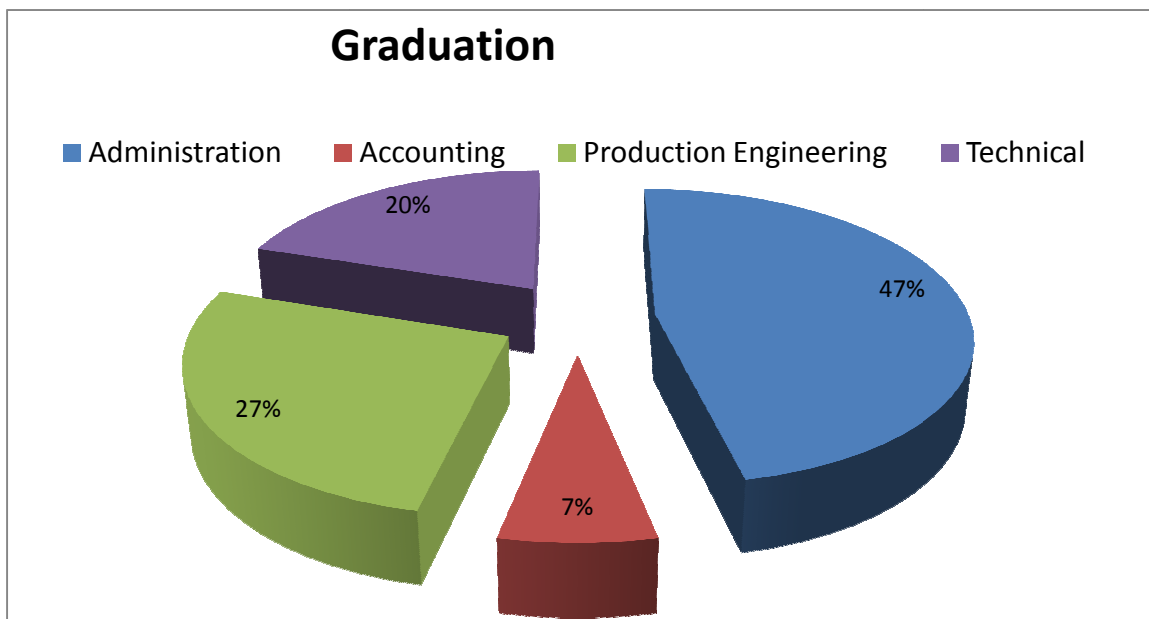


Chart 1. Student Graduations (UNESP)

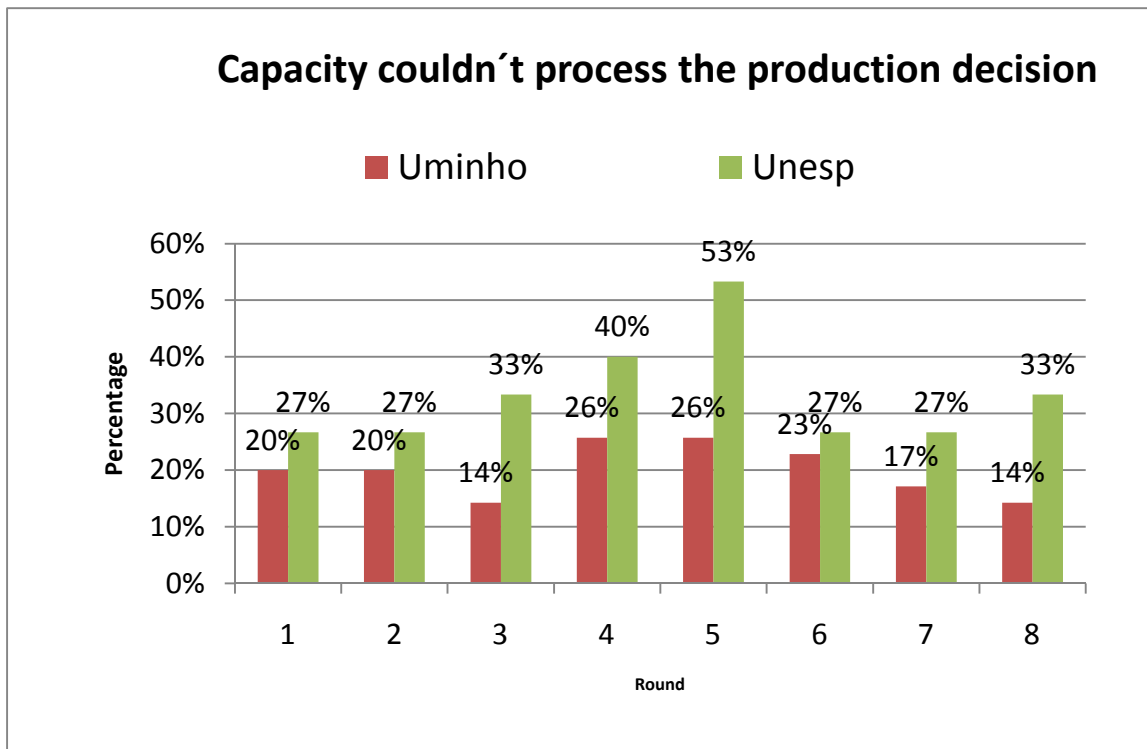


Chart 2. Scheduled Production x Capacity

Then, the players' decisions on quantities to produce and production capacity available were analyzed. Chart 2 represents the results and demonstrates a slightly higher performance of students at UMINHO in the decisions in which there are discrepancies between the production required in the decision sheet and production capacity available are considered. These data suggest that UMINHO students have internal contents related to production capacity planning and control better than the ones at UNESP.

One of the characteristic of the Masters program at UNESP is to admit students who have graduated from a university and have passed the written exam on production engineering content. This admission policy may cause students with a weak theoretical basis in production systems capacity management to enter the program, especially considering that some of them have not graduated with a degree in engineering (76%). On the other hand, most of the students from the Integrated Masters Program in

Engineering and Industrial Management at UMINHO are from the same educational institution, which may ensure a more homogenized training, increased specialization and mastery in this field.

When taking into consideration value creation and differentiation, it is likely that students, who successfully complete their Masters at UNESP, have wider training in contrast to a more specialized training at UMINHO; however, it is not possible to support this argument from data obtained within the game. Concerning professional performance and labor market integration, it is not possible to state that one course has advantages over the other, but they do have characteristics that differentiate them, despite presenting similar purposes. In conclusion, business games can be used for purposes other than developing competences and skills relevant to the model which guided the game construction. They can be used to identify patterns associated with course programs and the history of the student and the educational institution attended. This can be of great relevance when focusing on human development and training aspects, as in the employee selection process and promotion in enterprises.

Charts 3 and 4 represent the decisions to pay in installments or not and the relationship between this decision and the enterprises unforeseen debt. This means that there was a capital misestimation underestimating this need, in which case the enterprise pay for raw materials upfront or in installments and must be rescued with emergency credit.

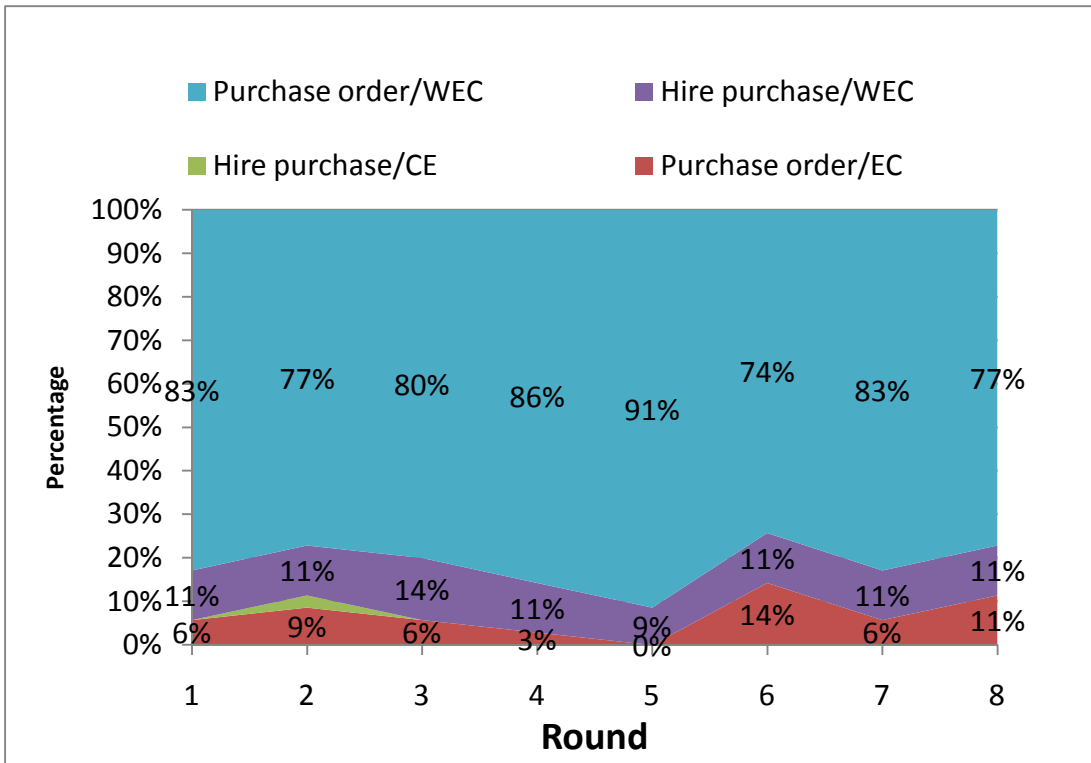


Chart 3. Debt x Purchase (UMINHO)

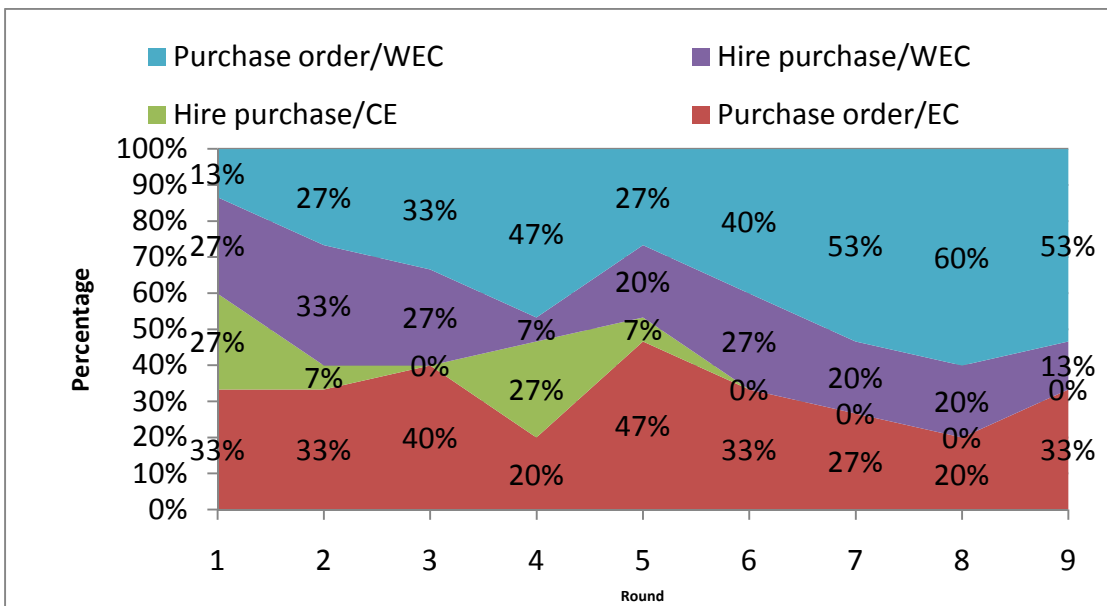


Chart 4. Debt x Purchase (UMINHO)

The charts show that while most UMINHO students chose to pay upfront (Purchase Order / WEC + Purchase order/ EC) a little less than half of the UNESP students chose this option. During the first round of the game percentage values are

89% for UMINHO students versus 46% for UNESP students. The decision consistency of the two groups can be assessed by the occurrence of emergency credit. While the relation at UNESP is 33% / 46%, i.e. 71.7% at UMINHO is 6% / 89%, i.e. 6.7%. These figures are a strong indication that, although more conservative, students at UMINHO may have internalized better the capital estimate techniques, as only 6.7% of enterprises managed by them needed an emergency loan. The convergence to close percentages in the eighth round (88% in the UMINHO experiment and 80% in the UNESP experiment) also shows some learning and internalization of concepts related to financial needs estimated by students at UNESP. This data can be reinforced by additional dynamic features of the experiment in the two institutions. The experiment carried out in Portugal was designed equipment acquisition restrictions. This situation didn't happen in Brazil.

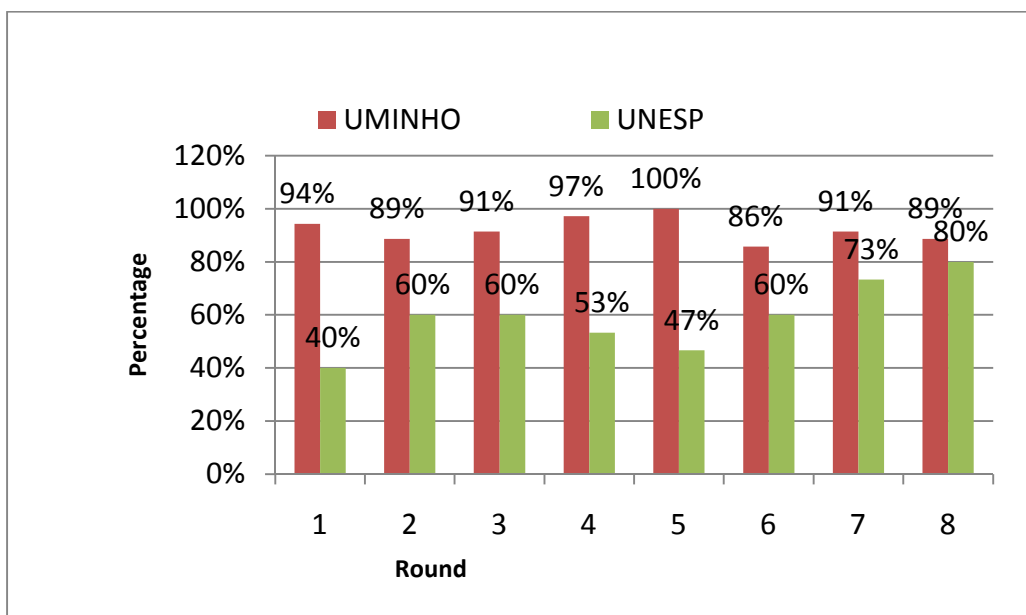


Chart 5 “Invest” indicators

This Chart was designed for the purpose of assessing how cash is managed by the groups and also show the influence of warning signs that notify money not being invested. The experiment with the students at UMINHO was done using a warning

called an indicator which displayed a message in the Balance Sheet report whenever there was a cash asset exceeding \$ 1,000,000.00 not being invested.

Charts 6 and 7 show the two groups' behavior in terms of surplus cash. It was observed that the warning was triggered more often by UMINHO students, probably because this group had investment restrictions in the experiment. In case Chart 7 didn't reveal a high enough degree of warning response, it could be possible students had not mastered the content and the warning would mean nothing to them. Chart 6 only shows the situation in which there was no warning. It may be noted that during the first round 40% (33% + 7%) of teams had available funds that could be invested. However, during the second round only 7% invested such funds. Whereas in the other group, 57% responded to the warning, showing that it was noticed and generated change in behavior. Comparing the two groups, the cash holdings are similar. The number of team with cash that can be invested is very close in both groups, but the percentage of managers who apply the surplus is higher in the UMINHO, although it falls as it rounds occur.

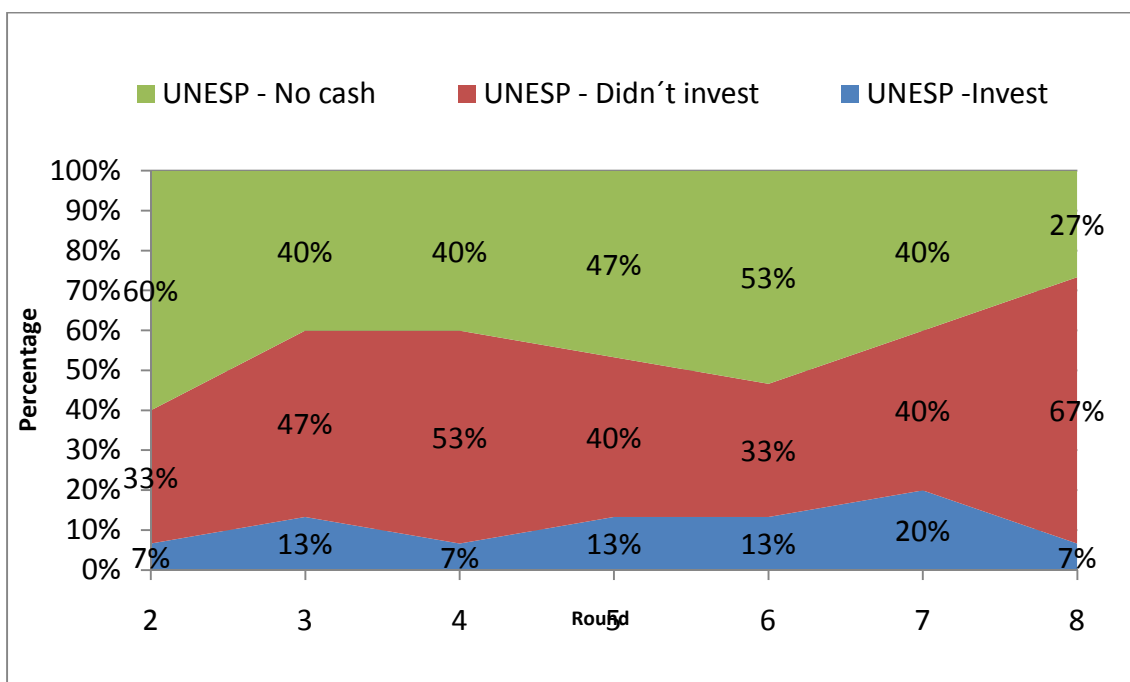


Chart 6 – Decision regarding the cash

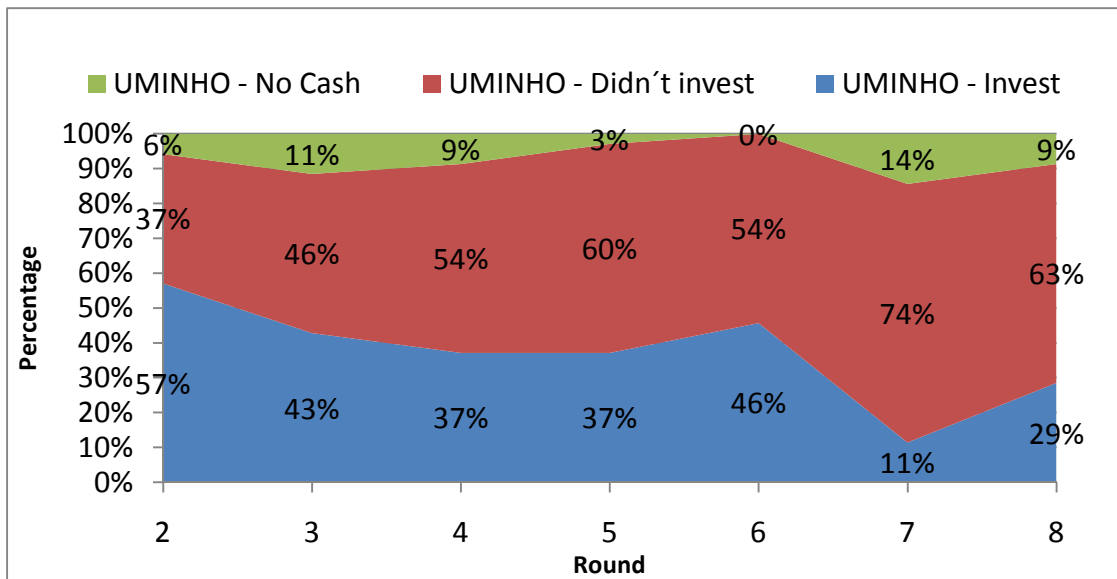


Chart 7 – Decision regarding the cash

The UNESP group showed an increase in the percentage of managers who apply the surplus funds to the round seven, even without the support of the indicators, while the UMINHO group has a percentage that drop from 57% in the first round to 29% in the last round.

Chart 8 is intended to provide an overview of an enterprises behavior when managed by teams or individually. Data are organized in order representing each enterprises ranking (1st, 2nd...5th), the round (1, 2, 3...8) and if the enterprise was managed by a team (light pink) or individually (orange). Data labels identify the enterprise.

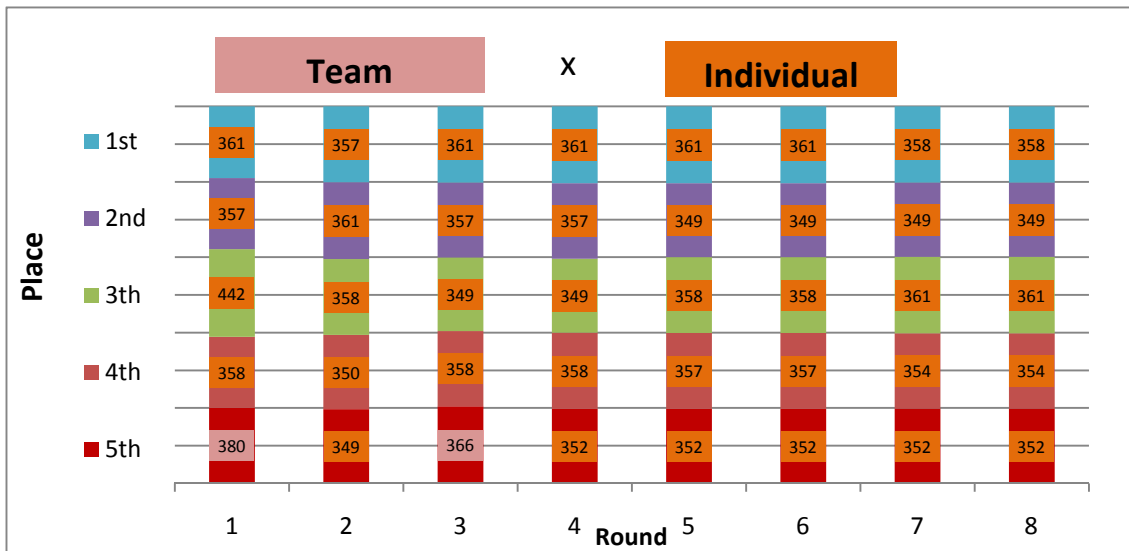


Chart 8. Enterprises managed by individuals versus the ones managed by teams

The enterprises rankings were based on the accumulated profit up to the round in question. Results have showed that enterprises managed individually performed much better than those managed by teams. This is a surprising result because in a course in which students are encouraged to work in teams, it is expected that enterprises run by teams would be more successful, assuming that teamwork is one of the current needs of the market. Part of the explanation for this may be that in simulation the decisions may be best conducted by individuals than by teams, because there is no need to negotiate and discuss what should be done. On the other hand, it may indicate that the course objectives of encouraging teamwork are not being met and that some additional measures must be taken to improve results.

5. CONCLUSIONS

Given the number of variables present in both experiments and the complexity of the relationship between them, the conclusions will be made considering the article proposal: an exploratory comparison of the two groups and also assess the potential of indicators as a strategy for improvement of simulators and business games.

The experiments with the simulator were able to highlight features that are specific to the course projects. In the case of the Integrated Masters at UMINHO, data suggest that the design of the course is to prepare professionals with great expertise in a specific area of production engineering, but at the same time, show that finance is also one of the aspects that can be strengthened in the curriculum proposal.

Concerning the UNESP group, the proposal for a masters program accepting undergraduates from different areas, the simulator was able to highlight gaps in learning expected because the course tends to form a heterogeneous group with respect to graduation. Whereas the identities of all participants are known, the simulator can act as a learning assessment tool of content, and can be used for individualized follow-up.

Data analysis suggests that the indicator can be used to speed up learning, because there was a noticeable change of behavior in the second group. A third experiment is being designed to focus on this aspect, and there will be a larger number of indicators, making possible a more complete assessment of the use of this feature to improve Simulator performance.

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