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Didactic Game in the Teaching of Lean Concepts in Construction Management Discipline: Experience Report*

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ABSTRACT

Lean Thinking aims to reduce or eliminate activities that do not add value to the product, using continuous improvement and waste reduction. This philosophy was created in the 90s and was incorporated into the courses in Production and Civil Engineering. This research understands that the use of educational games can be efficient, as it stimulates participation and motivates people. Then, this article investigated the use of this pedagogical source to disseminate lean concepts among professionals of the future of the sector. Thus, the method was an experiment with the application of the game Pen factory in the undergraduate class in Civil Engineering. For that, simulations were carried out to use the concepts of Lean production and production management. After application, the researchers asked for a report on learning. Finishing the simulations, it was possible to verify the group's participation in the activities. The examples were about positive aspects and suggestions. In conclusion, games can help with the theory that needs to be taught in addition to classroom knowledge.

KEYWORDS

University education. Teaching and training. Simulation games

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Jogo Didático no Ensino de Conceitos *Lean* na Disciplina de Administração de Obras: Relato de Experiência

RESUMO

A mentalidade enxuta visa reduzir ou eliminar as atividades que não agregam valor ao produto através de melhorias contínuas e da redução de perdas. Trata-se de uma filosofia originada na década de 1990 e que, aos poucos, foi incorporada aos currículos dos cursos de Engenharia de Produção e Civil. Sob esse aspecto, por entender que a utilização de jogos didáticos pode ser eficiente, ao passo que estimula a participação e motiva os envolvidos, buscou-se investigar a utilização desse recurso pedagógico na difusão dos conceitos *Lean* entre futuros profissionais do setor. Diante do exposto, o presente trabalho originou-se de uma experiência com a aplicação do jogo Fábrica de Canetas em uma turma da graduação em Engenharia Civil. Para tal, foram realizadas simulações que permitiram abordar conceitos relativos à Produção Enxuta e ao gerenciamento da produção e, ao final, foi solicitado, aos integrantes dos grupos, a elaboração de um relatório sobre o que foi aprendido. Após a aplicação do jogo, foi possível observar maior participação dos discentes ao desenvolverem as atividades e ao comentar sobre os aspectos positivos e o que poderiam ser melhorados. Conclui-se, portanto, que os jogos podem auxiliar no ensino de teorias, sendo complementar ao que outrora fora visto em sala de aula.

PALAVRAS-CHAVE

Ensino superior. Técnicas de ensino-aprendizagem. Jogo de simulação

Juego Didáctico en la Enseñanza de Conceptos *Lean* en la Disciplina de Gestión de la Construcción: Informe de Experiencia

RESUMEN

La mentalidad Lean tiene como objetivo reducir o eliminar actividades que no agregan valor al producto a través de la mejora continua y la reducción de pérdidas. Es una filosofía que se originó en la década de 1990 y que, poco a poco, se incorporó a los planes de estudio de los cursos de Ingeniería de Producción y Civil. En este sentido, entendiendo que el uso de juegos educativos puede ser eficiente, estimulando la participación y motivando a los involucrados, es posible investigar el uso de ese recurso pedagógico en la difusión de conceptos Lean entre los futuros profesionales del sector. Dado lo anterior, este trabajo se originó a partir de la experiencia con la aplicación de la Pen Factory en un grupo de estudiantes de pregrado en Ingeniería Civil. Para esto, se llevaron a cabo simulaciones para abordar conceptos relacionados con la producción Lean y la gestión de la producción y, al final, se pidió a los miembros del grupo un informe sobre lo que aprendieron. Después de aplicar el juego, fue posible observar una mayor participación de los estudiantes en el desarrollo de actividades, comentando aspectos positivos y lo que podría mejorarse. Se concluye, por lo tanto, que los juegos pueden ayudar en la enseñanza de teorías, complementando lo que ya se ha visto en el aula.

PALABRAS CLAVE

Enseñanza superior. Enseñanza y formación. Juego de simulación.

Introduction

According to Moraes and Cardoso (2018), the traditional teaching is grounded in the theoretical exposition of contents through lectures, and this might lead the students not to develop the required skills in the labor market, since, nowadays professionals are expected to have management competencies and to be able of making decisions, features which are overlooked in traditional teaching. Moreover, as stressed by Lima and Lopes (2021), another important aspect to be observed when reflecting on traditional teaching methods is the students' motivation. The dissemination of digital technologies hinders getting students' attention, and as such imposes on the teachers the need to rethink the arrangement of their educational practices in order to involve the students in the development of their learning process.

The production of modern apprentices is different from that in which the traditional techniques and methods of teaching were based. The language and culture have changed since then, and these changes are reflected in distractible, unmotivated, and indifferent students. According to Evangelista (2020), these factors play an important role in students' performance, influencing higher failure and dropout rates in courses. It might be a challenge for the teachers who were educated in traditional teaching to overcome this scenario since they need to restructure the teaching and learning process through the adoption of teaching practices following the students' language and interests. Accordingly, as stated by Tori (2010), the educator needs to know his listener profile and respect his culture, in order to provide effective and productive communication.

In consonance with Peretti, Yared and Bitencourt (2021), overcoming the traditional teaching practices is necessary and urgent, in order to provide spaces for dialogue that contribute to the formation of critical thinking and an effective teaching-learning relationship between teachers and students. As stated by those authors, "it is, therefore, necessary to create educational spaces which foster collaboration and problematization, and in which theory and practice are in permanent relation through academic and professional development" (p. 3).

When considering didactics in higher education, Almeida (2015) stated that the approach most frequently used by the teachers is the traditional one. Even though they might use gadgets, their form of evaluation still aims at measuring knowledge. In addition, Fernandes, Freitas and Carneiro (2019) attributed this fact due to the little attention paid by the professors concerning didactics, since most of them are bachelors and did not have any pedagogical formation. Thus, these authors emphasize that the application of innovative methods and interdisciplinary approaches in higher education will foster the students' reflexive and critical view on the subjects studied by them.

As stressed by Kenski (2003), the modern technological moment is defined by the expansion of the possibilities of information and communication, therefore, one of the main challenges of modern schools is the deployment of technological assets in order to promote

critical teaching. Taking into account the uncountable possibilities of such assets, it is up to the teachers, then, to decide and seize those which are the best in accordance with the students' daily practices and experiences.

In this regard, using games for teaching, especially in engineering, might be an important pedagogical tool. Its use is widespread in different areas and it aims at playfully teaching specific contents, motivating the students, alleviating the learning process, stimulating management skills. These are the following examples of the use of such methodology, according to Moraes and Cardoso (2017, p.27): applying lean production concepts, managing projects, simulating construction environments e logistics, and production programming. Especially when dealing with courses related to production management, it is necessary to resort to a practical application in order to foster comprehension of the given concepts, since such subjects usually spring from direct observation in construction sites. Thus, using games and other kinds of simulations might be an important pedagogical tool.

According to Tsao *et al*. (2013), using simulations as a didactic tool is effective, for it helps students to develop a much more consistent understanding of lean concepts and their applications in the construction industry. Taking this into account, games might be used to spread lean concepts among professionals and students in the construction industry.

However, in order to adopt games as a didactic tool, the teacher must consider which subject of a given course is relevant and capable of being simulated, according to the teacher's theoretical repertoire. Once its theme has been defined, according to Leite *et al*. (2017), it is necessary to investigate the concepts related to it, in order to trace strategies that could be further used in a simulation activity.

Thereby, the objective of this study is to report the application experience of a game as an alternative practice for the teaching of lean concepts to undergraduate students in Civil Engineering.

The following topics of this report of experience are discussed: (a) the teaching of lean concepts in Engineering; (b) the use of games as a didactic tool; (c) the methodological procedure adopted in the making of this paper; (d) the analysis of the collected data; (e) and the conclusion.

The Teaching of Lean Philosophy

The publication of "The machine that changed the world" (1992), by Womack *et al*., sets the standard for Lean Production. This study considers the methods employed in the automotive industry, especially those in Toyota Motor Corporation, in order to set a theoretical basis for the dissemination of lean concepts. According to these authors, the lean product is a mix of the advantages of craft production and mass production. Thus, Lean Production requires fewer quantities of necessary input (workers' effort, tool investment, planning hours, supplies), reduces product defects, and improves the quality and quantity of the production process.

Accordingly, Womack e Jones (1996) identified five lean principles which might be adopted by company managers of different branches. These principles are: defining value, mapping the value stream, creating continuous flow, using pull production, and pursuing perfection. Companies that have adopted lean logic in their production processes to reduce and eliminate wastes are said to be Lean Thinking. Thus, the employment of lean concepts into civil construction is called Lean Construction (LC), according to Koskela (1992).

Aware of the benefits provided by the application of lean concepts, Ramos (2013) sustains that the training of all organizational levels on this philosophy is a must if its employment is to be successful. In this way, universities should actively take part in this process through the integration of lean thinking and related assets in their curriculums, so their students might employ subjects previously matured in their academic life in the labor market.

Therefore, it is observed the employment of lean construction concepts as a didactic tool in universities, since this philosophy corresponds, on the one hand, to the students' matter of interest and, on the other hand, to increasing market demand. Alves *et al*. (2016) noticed that the teachers, besides offering graduate and undergraduate courses on this subject, seek to use interactive methods as a way to encourage critical thinking and foster discussion on the applicability of such concepts.

In a study on different teaching approaches for LC, Tsao *et al*. (2012) analyzed three experiences: one from the Lean Construction Institute (LCI), one from the Associated General Contractors of America (AGC), and, lastly, the other from the community in general. As for the first experience, it has been reported the creation of an academic forum, the implementation of annual meetings on this theme, but also data provision, such as manuals and papers on LC, through the LCI internet portal. As for the second experience, the AGC has developed its training program on Lean Construction for its workers. This program involved nine short duration courses available online which were followed by an exam. At last, the third experience revealed that Lean Construction only courses are rare. In general, this subject is treated in some courses in which the analysis of case study was one of the teaching practices employed.

Following this early study, Tsao *et al*. (2013) gathered teaching methods used in seven LC courses of American universities. These methods were: discussion forums (online and onsite), technical visits, guest lectures, case study analysis, seminars, group projects, application of simulations, and paper preparation. These were some of the approaches employed by the teachers, besides traditional didactic assets such as exercises and exams. It has been observed that online resources not only are important assets but there has been a growth in their use in classroom teaching. Moreover, Tsao *et al*. stressed the importance of LC educators using a great variety of teaching methods, in order to fit the different learning styles and reduce one-way, or teacher-centered, explications.

Another initiative was proposed by Rybkowski *et al*. (2012) in Texas, where professors developed a three days long workshop that involved group simulations and discussion to teach lean concepts to professionals. This study revealed that the audience who took part in the activities became more confident in applying such techniques. Following this idea, Hyatt (2011) developed a multidisciplinary course, in a Californian college, in which lean principles, sustainability, and building information modelling were integrated. On this occasion, the *Last Planner*™ was used and it encouraged students to learn more about lean construction.

Pellicer and Ponz-Tienda (2014) reported a forerunner experience in Spanish academy with the implementation of the Lean Construction course in the Civil Engineering master's program in Planning and Management. Such course adopted a methodology that merged readings, discussion, games, and a project made with the *Last Planner*™ system. Overall, the course was well evaluated and its students expressed contentment with their learning, consequently, this experience shows that the approach employed was effective for the transmission of concepts, even reaching out to students who had never had previous contact with this subject.

According to these studies, Nofera *et al*. (2015) have also employed different methods which encouraged students to solve problems autonomously and criticize solutions that were given to them. This way, the students' feedback enabled the improvement of the pedagogical practices. Among the employed strategies, the previous reading of texts which dealt with LC stood out, for it not only helped to develop students' critical thinking but also enabled the educator to concentrate on the most difficult topics.

Forbes *et al*. (2018) e Rybkowski *et al*. (2018) studied the evolution of LC teaching between American companies and colleges. On the one hand, under the organizational aspect, it has been observed frequent efforts for the implementation of training in the organizations, since they perceived lean thinking as a competitive advantage. At times, these training programs used assets found in academic programs as their references, but it has also been observed that some companies stressed the leadership role in lean transformation. On the other hand, under the academic aspect, a substantial increase in the suggested readings and played simulations was observed, together with the emergence of extension courses or pieces of training on LC, due to an increase in undergraduates whose demand was to improve their qualifications.

Tsao *et al*. (2012) stated that integration between Lean Construction courses offered by the academic community and the pieces of training offered to the professionals enables the correct matching of their contents in such a way that they complement each other. This strategy fosters the communication between students and future employees on the knowledge that they have already learned in college.

In Brazilian literature, a variety of examples on the use of simulation to teach principles and other specific assets of lean philosophy is found. One such example is the study by Moura *et al*. (2012), in which three different simulations were performed in the undergraduate discipline of Architecture, in the course of Construction Management and Economics, of the Federal University of Rio Grande do Sul (UFRGS) and were later analyzed. Following the application of these simulations, not only the students felt more encouraged to solve the activities which were proposed to them, but they were also more capable of retaining the given contents.

Lastly, Alves *et al*. (2016) emphasize that the activities which involve its participants more actively foster greater learning, since the students memorize its concepts at the same time that they see their practical application, further strengthening their understanding of lean thinking. In such a way, the efforts put into the learning of lean concepts become more efficient.

Hence, according to Libâneo (2011), the teacher needs to keep on adjusting his didactics to the new reality which is constantly presented to him, developing communicative skills, mastering the informational language, and putting new gadgets into use his classes. Following these guidelines, the methods used in the teaching of lean philosophy have become much more diversified, including the adoption of games of simulations, in order to answer the different students' needs and promote greater participation during the learning process.

Using Games in the Classroom

Games, given their interactive nature, can be used as a didactic tool. As stated by Leite and Lopes (2021), teachers can reach students' imagination and promote their engagement through the emotional bond which is inherent to the act of playing. Therefore, games present pedagogical effectiveness which can be used by the teachers as a teaching tool.

Hence, Romanel (2009) states that the games have been used as an alternative learning method in classrooms and organizations since the late 1950s, and have gained more space in Brazil from 1998 onwards. For that matter, Mesquita (2014) claims that the use of games enables the exchange of experiences and pieces of information, besides promoting the dissemination of knowledge, since their players will unconsciously assimilate and use the concepts in that given situation.

Gamification, according to Boller and Kapp (2018), consists in using typical game features for learning, in other words, it resides in the employment of parts of game designs in institutional environments. This approach is effective for sustaining the students' involvement with the content over long periods, besides being a useful tool to refresh already taught concepts and other pieces of information.

According to Cruz *et al*. (2017), games are composed of the following features: characters, context, levels, objectives, rules, conflicts, interactivity, and feedback. Through these features, games set up a competitive environment in such a way that it becomes an opportunity to involve the players with subjects taught in the classroom. As stated by Boller and Kapp (2018), when speaking about games with didactic ends, the feedback step, that in which the discussion about the overall results of the game is made, is of utmost importance, since it is both in this step that the sharing of what was learned happens and that the concepts which were used throughout the game are brought to awareness.

As claimed by Tori (2010), some learning principles are found in good games, so the educators have much to learn with this tool. Endorsing such view, Oliveira (2009) states that there are many benefits of using games for teaching, such as: making the participants more involved and, thus, the learning process more dynamic, focusing on making decisions, enabling learning through experimentation, stimulating leadership and teamwork, developing skills, integrating theory and practice and, lastly, creating a systemic view.

According to Braghirolli *et al*. (2016), the interviewed teachers perceive that the benefits of games to the learning process are due to their inclusive, interactive, and motivational character since they enable the widespread use of concepts in a controlled environment and stimulate the dialogue between teachers and students.

A simulated game intends to reproduce a certain reality in a controlled environment. This scenario stimulates ingenuity for the resolution of challenges in an experience in which mistakes become an opportunity to learn. Simulations and games share the same inherent features. Thus, as claimed by Braghirolli *et al*. (2016) and Gramigna (2007), simulations might be effective as introductory activities in higher education, developing a basic knowledge on that specific field among students and encouraging their participation.

As stated by Gramigna (2007), when speaking of simulated games, another aspect that must be considered is the fear of venturing. In simulations, players are trained to make decisions without being concerned about the possible wastes caused by their wrong choices. Therefore, it is the opposite of what happens in real situations, in which one typically restrains from learning due to his fear of failing.

Games with didactic ends have evolved with the incorporation of new technologies. According to Moraes and Cardoso (2018), even with the growing popularity of digital games, analogical ones remain being broadly used for the teaching of Engineering. Such a view sustains Lopes (2011) claims that the quality of games cannot be resumed to their incorporation of technological novelties, but to their capacity to fulfill the proposed objectives.

As for the teaching of lean philosophy using games and through an extensive account of the related literature, it has been shown that the games, in general, addressed many lean concepts. There is a significant variety of materials and features used in these games, ranging

from simple resources (such as paper, pen and cards) to digital resources (such as computers). For instance, Poget and Granja (2015) addressed the concepts of line of balance (LoB) and critical path method (CPM) by constructing scale model houses using mounting blocks. Rocha and Miron (2018) used illustrations of houses as an object in a game for the teaching of standardization. Pollesch *et al*. (2017) created a card game for the teaching of different lean concepts. In such a manner, Leite *et al*. (2017) developed a memory game in which the students were required to match the name of the principles and their definitions. The variety of games driven to the teaching of lean philosophy broadens the possibilities of their future applications, besides contributing to the dissemination of the concepts which underlie these practices.

Methodological Aspects

The following experience report was developed from exploratory research using a qualitative approach and the method of non-participant observation of students' daily routine. The non-participant observer watched the group but remained a neutral spectator. As claimed by Marconi and Lakatos (2003), these observations were made in a real environment, so the data that sprung from them correspond to real-life practices.

The first step corresponded to the selection of the game to be used. Based on the curriculum of the Construction Management course in the undergraduate discipline of Civil Engineering of the Federal University of Sergipe (UFS), research was made in order to find games that could be employed in the teaching of lean concepts. Consequently, the pen factory game, referenced in the studies of Silveira *et al*. (2005), Souza and Silva *et al*. (2003), and Costa *et al*. (2006), was chosen.

Based on the description of this game found in these papers, the required adjustments were made so the game could fit the course curriculum. Following this, a game manual was made, describing its features, steps, and main topics (Appendix A) in order to help students during its application.

This research was made during the first term of 2019 and the class that took part in it was composed of 21 students which were divided into three teams. The performance lasted two hours divided into two moments: game and discussion, respectively. The students had already had previous contact with this subject before its performance, so the game was used to wrap up the concepts learned through traditional teaching.

Following its performance, a report that involved its evaluation was requested. The groups were asked to make a report about that experience which covered the decisions and strategies they had made, their perception and discussion about the concepts, an analysis of the game as a didactic tool, and, finally, their suggestions for its improvement. Using the data drawn from these reports, a content analysis was performed, following the methodological aspects outlined by Bardin (2011), in other words, a floating reading of the reports was

performed, and then the unity of analysis was set, and this was followed by the categorization of the data, so interpretations could be drawn from them. As claimed by Bardin, categorization is the classification of the elements of a set performed through differentiation and genus regrouping based on preset criteria. In the present study, the following categories were preset: identification of the systems of production; mentioned concepts; description of the simulation steps; strategies used by the group and, lastly, analysis of the experience.

Game Instructions

During the game performance, 70 pens of the same model were used (50 black and 20 red ones). They were disassembled and divided into four components: end cap, ink chamber, barrel, and cap (Figure 1).

Figure 1. Pen factory game components.

Source: the authors

The teams were asked to get split up into the production, quality, and coordination sectors (Table 1). No rule was set regarding the internal disposition of their activities since this was completely up to the students to decide the labor division in each team, the indoor factory layout, and time management. The rules regarding the sequencing of the operations should be obeyed when asked.

Table 1. Factory sectors and their functions

Sector	Function
Quality	To analyze both the executive process and the product and operation quality
Coordination	To analyze productivity, relocate the team, coordinate its activities and observe overall performance
Production	Pen assembly

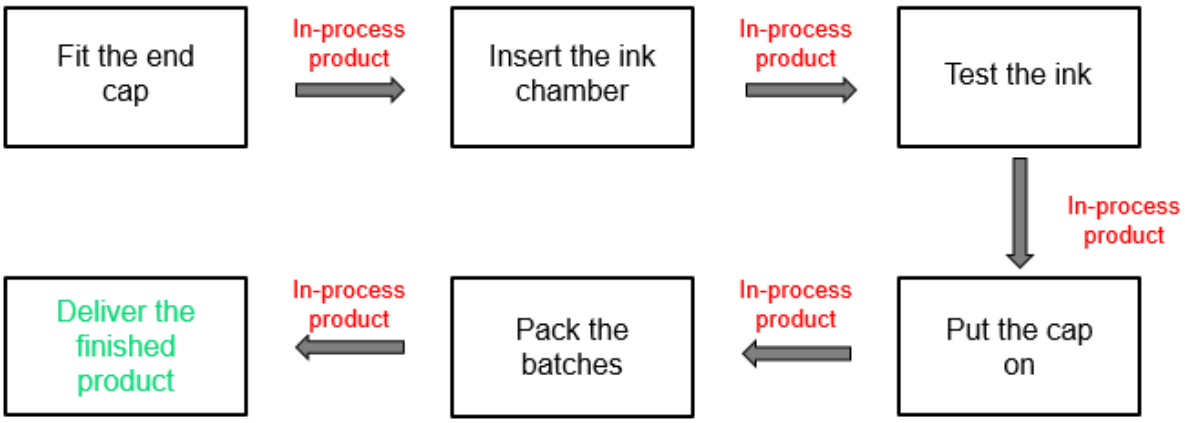
Source: the authors

Three rounds were played in order to simulate different situations regarding the workplace layout, raw material transportation, and labor division. Each simulation involved the assembly of 70 pens divided into batches of 10 units.

Uncontrolled production – without sequencing rules and stock indoor the workplace. The only demand was that production should be made in the shortest time possible;
Push production – labor division and stock outdoor the workplace. The assembly should obey operations sequencing (Figure 2). Moreover, there was no preset demand, so the batches colors order was random;
Pull production – Akin to the rules in the second simulation, but variable demand and external customers' demands were added. The teams should produce, according to the tutors' demand, using the production card with the customers' orders as a guideline. Five different orders were made, changing the batch composition and pen colors (black or red). The time between orders was standardized in 90 seconds for production.

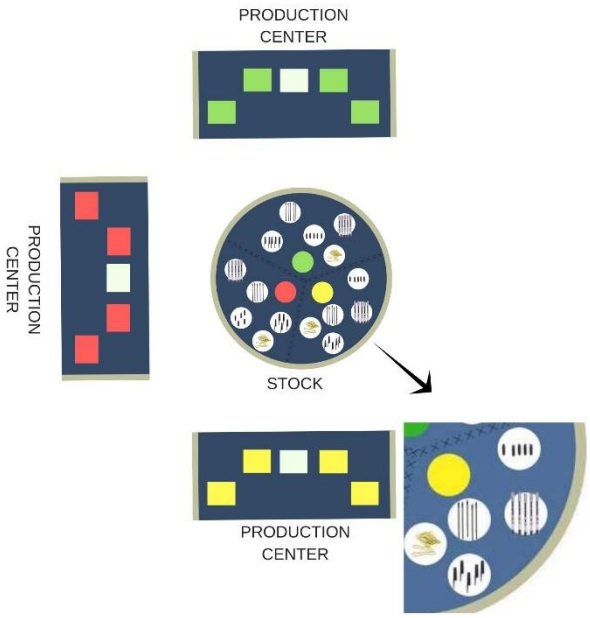
The finished product, referenced in Figure 2, corresponds to the formation of seven batches. Each batch was made of 10 pens wrapped in a rubber band. Moreover, according to the instructions, during the second and third simulations, the stock was placed outdoor the workplace (Figure 3).

Figure 2. Operation sequencing in the pen factory.



Source: the authors

Figure 3. Pen game: simulation *layout* rounds 2 e 3.



Source: the authors

The performance of the game lasted the three rounds previously described and their finished product was the same (seven pen batches). This way, the students' awareness of the production process was brought into light, fostering their understanding that a certain production might be arranged in different ways in order to obtain the same product, but each arrangement will differently affect the pace of the activities. By the end of these simulations, there was a moment for discussion and sharing of their views on the experience.

Results and Discussion

In previous classes, the students who composed the three teams in the game had learned about pull and push production, the former concept being part of Lean Production and Construction. Through the simulations, the students were encouraged to think about the systems of production, the customers' demands *versus* the product standardization, production line bottlenecks, and the learning effect.

The first content analysis category, the identification of the systems of production, sought to determine whether the participants were able to describe the systems of production portrayed in the simulations, being the first two rounds based on a push system and the last one based on a pull system. As a result, it is to be observed that Group 1 (G1) was not able to distinguish the different systems of production, establishing the connection between the concepts of systems of production and the simulations performed in the activity. The second group (G2) correctly established these relations, and the third group (G3), although having used the concepts of pull and push production in its report, did not relate them to the game rounds. Even if some groups did not use the proper words, the three groups realized that the activity allowed the observation of different systems of production and their implications in productivity.

The next analysis category is that of the concepts mentioned in the students' report. For that matter, the most mentioned concepts in all groups were that of production line, workplace, and labor division. The groups also stressed the influence of outdoor workplace stocking and the influence played by the transportation of the raw materials in increasing the time spent in production. Such as the studies of Silveira *et al*. (2005), the present study also found concepts related to the variable demand, workplace layout, and bottleneck activity in the students' reports, in other words, the production failures were mentioned. Furthermore, it is worth mentioning that G2 referenced concepts that surpassed those expected to be developed during the game. From this fact, it is implied that the game aroused these participants' interests in lean thinking.

The third analysis category consists of the description of the simulation steps by the students. Overall, the three groups described the game in accordance with what had happened, being able to relate each round of the simulation with the production time variation. In turn, the fourth analysis category deals with the strategies used by the group during the game. The participants were granted free choice regarding these strategies,

therefore, each group created different strategies depending on their performance during the first simulations. The G1 chose the transportation demand to be sectorized in the third simulation, so they could better organize and reduce raw material delivery failures. On the other hand, G2 rearranged the functions among their participants, for some of them did not fit their assigned operation, and this hindered production. G3 also adopted this strategy. Moreover, this latter group also tried to adopt two parallel assembly lines in the first simulation, an idea which was dropped in the following two simulations since it required more human resources than what they had at their disposal. These different strategies highlight one of the main features of games, that of stimulating the players' creativity and this supports Falkembach's (2006) claims that: "games encourage an active, critic and creative reaction among students, socializing the knowledge. The student is distinguished and valued as a person" (p.4), and he adds that "games promote an atmosphere of spontaneity and creativity" (p.7).

At last, the final category corresponds to that of analysis of the experience. Overall, the groups agreed that the game application was positive since it mingled theory and practice, as stated by participants of Groups 1 and 2:

> The comparison of pros and cons of each manner enabled the theory studied in class to be merged with the reality, even if simulated, of a mean of production such as the factory floor and aroused the debate among the group participants about what kind of distribution would be the most productive and efficient (G1).
>
> In front of the performance of the simulations, it was possible to perceive the concepts of production engineering and put them into practice, seeking to improve the manner ballpoint pens were being produced (G2).

Yet, another point worth mentioning is related to the value of individual work for the team progress, as highlighted by participants of Groups 2 e 3.

> Through the simulations of the production of ballpoint pens, it was possible to verify the occupations in factory sites, the challenges faced by the employees, their interaction, the institutional needs to fulfill the demand, and in order to meet this latter requirement, it is necessary good individual work as well as good teamwork (G2).
>
> Overall, all participants were able to express their opinions and decide on the best way to produce. As a result, the team was content, competitive, and able to work in harmony (G3).

From these testimonials, altogether with the results collected from the reports and class observation during the game performance, it is worth mentioning that the students were excited about developing and organizing themselves during such activity. Thus, all students participated intensely during the performance of the simulations, bringing about questionings and suggestions about the employed strategies. Furthermore, the experience encouraged the dialogue about lean concepts and promoted interaction among students, since they had to debate about their actions in order to carry out the activities in a playful way. However, some concepts, even some of which had already been theoretically studied, passed unnoticed in the

students' reports. This finding supports Flemming's (2004) claims concerning the teachers' intervention, during the consideration about the results of the performance, as being of utmost importance.

> The use of didactic games does not discharge the teacher's mediation during game activities and the integration of this activity in the more broad class context. It is necessary to make the connections between "before" and "after" the game performance, so the playful activity can achieve its didactic objectives (FLEMMING, 2004, p. 6).

In accordance with this, classroom games, when well guided, appear to be an efficient tool in the teaching-learning process. They can be used both during the introduction of a new subject and its consolidation. Even though in the present study some groups presented some kind of difficulty when naming the concepts, it was possible to perceive, based on the students' testimonials, that the game employed can simulate the differences among the systems of production, as well as some lean principles. This way, this activity preset objectives have been fulfilled. Thus, the teacher has a key role in organizing the post-game discussion, in order to highlight and clarify some aspects which might not have been properly understood in the game, further polishing students' knowledge.

Therefore, games come out as an enabler through encouraging students to take part in playful activity with an educational bias. This emotional experience featured in games might even arouse students' interest to investigate more pieces of content on that subject. In this scenario, the teacher becomes a mediator so the insights produced during the activity get properly discussed and transformed into knowledge. For that matter, the discussion moment was of utmost importance to notice students' perception of the used didactic tool. The students reported that they had got involved and enjoyed that kind of class, which is not usual, expressed their doubts about the subject at hand, and finally made suggestions which are to be observed in future applications. These observations mainly referred to the classroom, in which the activity took place, layout, and dimensions. Overall, they suggested that a larger room would provide a better distribution of the groups throughout the space and thus the distances between the production centers and the common stock would be fairer.

Conclusion

This study tried to reflect on the application of didactic games as an alternative practice for the teaching of lean concepts. For that matter, a pen assembly factory was simulated using different systems of production in its production process. The objective of this game was to enable students to make decisions on production planning and management, in such a way they should reduce wastes.

Based on the analysis of the report, it has been observed that the students were able to establish relations between the theory and the practice of a factory production line through dialogue and experience exchange among peers. Furthermore, the students turned out to be excited and creative during the performance of what had been asked and this reassures the positive aspects of using games as a pedagogical tool, as claimed by Oliveira (2009).

It is worth mentioning the teacher's need to intervene during the application of such games, be it whether during the subject introduction or its consolidation, making sure that the concepts at hand are properly treated by students in the simulation.

This study was restricted to an experience report with undergraduate students of Civil Engineering who were attending the Construction Management course at the Federal University of Sergipe (UFS). However, it is worth mentioning that this game could also be applied to similar courses, such as Project Planning and Scheduling, Construction Planning and Scheduling, and Construction Productivity. Therefore, it outlines as the next step in such researches the analysis of other teaching practices used for the teaching of lean concepts among other Civil Engineering undergraduate courses in Brazilian federal universities, as well as teachers' and students' views about the effectiveness of these learning methods.

At last, it is expected that this work serves as a stimulus, so the teachers might rethink their pedagogical practices in such a way that they can apply new tools in their work environment, further contributing to the students' learning and their future professional career in this field.

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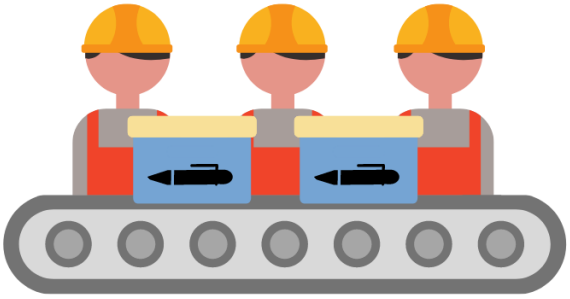
APPENDIX A

INSTRUCTION MANUAL

PEN FACTORY

GAME • PUSH PRODUCTION X PULL PRODUCTION



You were hired to work in a pen assembly factory. The first step is the team distribution among production, quality and coordination sectors. You have to assemble 70 pens divided into batches of 10 units. Pay attention to the rules and... 1,2,3, go!

COMPONENTS

The game features:

50 black pens;

20 red pens;

7 rubber bands;

5 rugs (workplace);

1 container for transportation.

OPERATIONS SEQUENCING

Fit the end cap

Insert the ink chamber

Test the ink

Pack the batches

Put the cap on

Deliver the finished product

Let's start the simulations ->

0 PLANEJAMENTO

Use this time to think about the production strategies. You can simulate operations, train collaborators and organize workplaces.

MEASURE THE TIME SPENT IN THE PRODUCTION OF EACH BATCH AND THE TOTAL TIME OF EACH SIMULATION

1 SIMULATION

Without production rules, undetermined demand and stock indoor the workplace. The only goal is to produce the 7 batches as fast as possible.

IN SIMULATIONS 2 AND 3 YOU CAN ONLY TRANSPORT 10 COMPONENTS FOR EACH RIDE.

2 SIMULATION

Labor division, that is to say, each player plays a role. Undetermined demand, the order of the batches does not matter and the stock is outdoor the workplace.

3 SIMULATION

Labor division, that is to say, each player plays a role. Demands are determined by external customers and the stock is outdoor the workplace. The production starts only when ordered.

TOPICS FOR DISCUSSION:

- Labor division in each round (mainly among the first and other rounds);
- Learning effect observation;
- Identification of the systems of production in each round;
- Identification of production bottleneck and its solutions;
- Transportation influence in productivity;
- Product standardization x customers needs.