Mini-Vehicle Assembly Line (MVAL)

Álvaro P. Graziani*, Antônio José dos Santos +, Eduardo Concepción Batiz +

* Production Engineering Department, Instituto Superior Tupy, Campus Boa Vista, 89221-613 Joinville, Brazil
+ Masters of Production Engineering, Instituto Superior Tupy, Campus Boa Vista, 89221-613 Joinville, Brazil

Email: alvaro.graziani@sociesc.org.br, antoniodos.santos@bol.com.br , eduardo.batiz@ sociesc.org.br

Abstract

This paper describes the plans for a study that proposes to assess whether an assembly line of radio remote controlled model cars can be a teaching resource suitable for simulating a wide range of situations commonly encountered in the assembly lines. These 1:10 scale model cars have a full fledged internal combustion engine and, as with real vehicles, the engines also have a carburetor, air filter, and other subsystems of the internal combustion engine. Production engineering students may have difficulty for understanding the concepts related to industrial management and production systems. The reason for this is that the traditional model of engineering education is supported in the transmission of their knowledge without the necessary contextualization. The laboratory simulation when emulates a real situation from a model developed by an educational game may facilitate understanding of the manufacturing concepts. The study presented here also intends to analyze the use of the MINI-VEHICLE ASSEMBLY LINE (MVAL) as a tool to disseminate the goals of employment of production engineering to attract students who have difficulty for understanding the multidisciplinary approach of the course. It is hoped that the results indicate that gains in learning and training are to be provided to undergraduate students, postgraduate and master's degrees through simulations in a simplified way to represent the behavior of the production environment.

Keywords: simulation techniques and methods; teaching of production engineering; assembly line.

1 Introduction

The term production engineering was initially applied to manufacturing, but was later extended for optimizing the operation of production systems through the application of scientific methods. Frederick Taylor was a precursor to production engineering by publishing the book Principles of Scientific Management in 1911. According to Fleury (2008), Taylor's proposal was put into practice in all its dimensions and nuances by Henry Ford in his effort to build and organize the River Rouge plant in the United States, where the Ford Model T was produced for more than 15 years. Although there were several other car manufacturers at that time, Ford was able to build cars on a large scale and low prices, meeting the expectations of consumers to create the mass production process. According to Fleury (2008), the conception of economic rationality applied to production systems has changed over time and production engineer needs to understand who or what influences the way in which production systems must be designed, implemented and improved.

This paper describes a proposed study that aims to assess whether an assembly line of 1:10 scale model radio-controlled vehicles can be an educational resource suitable for simulating a wide range of situations commonly encountered in manufacturing systems. The simulated situations will meet several academic objectives of the production engineering course and aim to facilitate the contextualization of manufacturing concepts. Different educational games can be created from the initial configuration of the assembly line and, depending on the creativity of the participants, several situations can be simulated and used in a didactic way. However, although there is a very large amount of experiments that can be made in the MINI-VEHICLE ASSEMBLY LINE (MVAL), this study focuses to explore the differences and similarities between just-in-time (JIT) and manufacturing resource planning (MRP II) systems in product assembly. Among the experiments include assembly line balancing, production sequencing and scheduling, production orders versus kanban, and pull production versus push production.

2 Production management systems

According to Corrêa (2001), production management systems are information systems designed to achieve the organizational strategic objectives and to support the tactical and operational decision-making process for the following basic logistical issues:

• What to order;
• How much to order;
• When to order;
• How to order (which resources are needed).

The process management in the repetitive good manufacturing has evolved rapidly since the publication of the work Principles of Scientific Management, written by Taylor in 1911. The rapid evolution of the production management systems in the industry over the last hundred years was mainly caused by the automobile industry by promoting two major changes in the way how consumer goods are produced: the transformation of craft production into mass production, performed by Henry Ford 1913, and the creation of lean production, created by Toyota after World War II.

Fordism was forged from Taylorism and, augmented by information technology, has led to resource planning systems (MRP, MRP II and ERP), strongly supported in information technology. On the other hand, the post-war Japan was the enabling environment for the development of the Toyota system, introduced as an alternative to Fordist methods. The Toyota Production System (TPS), or Lean Manufacturing as is known in the western countries, uses just-in-time (JIT) techniques to manage the production process.

These two approaches of different origin and nature deal with often almost antagonistic ways of managing the repetitive good processes to meeting the organizational strategic objectives.

2.1 Resource planning

Correa (1993) pointed out that the resource planning approach is based on the logic of the requirements calculation in order to deliver the customer orders with minimal inventory levels, planning purchase and production in order to occur only on time (not before nor after) and in the quantities needed (no more, no less). The material requirements planning (MRP) systems were initially developed in the 1970s. They are computer-based management information systems designed to manage dependent demand inventory items such as raw materials or components. These systems provide timely and useful information to establish the exact order quantities and timing for each component part from a bill of materials (BOM) file to satisfy the production needs without lack or surplus of any item.

The evolution of the MRP to manufacturing resource planning (MRP II) systems in the 1980s was made possible by technological innovation. An improved computer processing capability and communication between the organization departments allowed the to expand MRP concept to include other manufacturing resources allocated to production. In other words, the MRP II differs from the MRP as far as the type of planning decision: while the MRP decisions are concerned to what, how much and when to order, MRP II also includes decisions about how to produce, considering the resources needed and available (Corrêa, 2004).

The enterprise resources planning (ERP) system emerged in the 1990s as the final and most significant unfolding of the basic philosophy of the MRP. As Krajewski (2009) pointed out, ERP is a management information system using a comprehensive and centralized database that ensures the integrity and uniqueness of the data and allow to integrate the various departments of an organization. The integration of functional business areas allows the ERP to view their operations as a whole, instead of having to try to bring together the different pieces of information generated by its various activities and sectors. However, according to Slack (2007), perhaps the real value of ERP systems will only be fully exploited when e-commerce is widely deployed. Figure 1 illustrates the modular structure of the ERP.

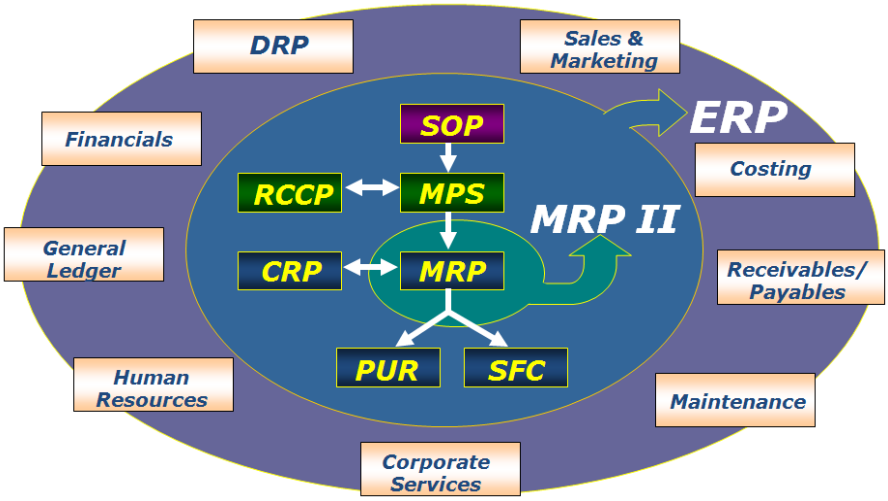

Figure 1: Modular structure of ERP systems. Source: Corrêa 2001

2.2 Manufacturing resource planning (MRP II)

In fact, according to Corrêa (2001), MRP II is more than just MRP with capacity calculation since the structured planning logic implicit in the use of MRP II provides a hierarchical sequence of calculations, checks and decisions aiming to achieve a feasible production plan in terms of availability of materials and production capacity. MRP systems do not consider the capacity constraints of its resources at the time of loading and scheduling activities on the date as late as possible, discounting back in time the activities lead times to get their start dates. For this reason, according to Corrêa (2004), MRP is a infinity backward scheduling system.

The MRP II system consists of a series of planning procedures grouped into functions normally associated with the modules of commercial software packages (Corrêa, 2001). In addition to MRP module, generally MRP II systems have the following modules: S&OP (Sales & Operations Planning), MPS (Master Production Scheduling), RCCP (Rough-Cut Capacity Planning), CRP (Capacity Resource Planning), PUR (Purchasing) and SFC (Shop-Floor Control).

The aggregate production plan generated by the S&OP is broken down in the MPS to obtain the master production schedule, a statement of what the company intends to produce, product by product, bucket by bucket, from the generation time of the plan to the end of the planning horizon. The RCCP module attempts to match the order load to the capacity available using a number of simplifying assumptions to calculate the load per resource, enabling the production schedule of final products to be approximately feasible.

The MRP module, as claimed by Chase (2008), is based on dependent demand caused by the demand for the higher level item in the bill of materials in a direct multiplication process. The MRP explodes the MPS to obtain the gross requirements of materials and, after considering the scheduled receipts and the number of components in inventory, MRP can compute the net requiremts, creating a comprehensive production and purchasing schedule by time bucket (what, how much and when to produce and buy). The CRP program identifies the overloads and orders that can be moved to achieve a balance. Finally, among other duties, the PUR and SFC modules respectively generate purchase and production orders, "pushing" the production, from purchasing raw materials and components to the inventory of finished products.

MRP II is a system with great potential for higher level planning, with longer maturities and aggregation levels of information, and materials planning. According to Corrêa (2001), the treatment capacity does not meet the more complex problems of the organization, such as different levels of productivity for different combinations of machines/ tools/ operators, split and overlapping of orders and operations, matrix set-up, resource allocation, among others. There are also limitations in the operations control and treatment of short-term decisions.

By their nature, MRP II systems are most valuable in assembly operations and for companies in which the same equipment is used in different production batches, not working very well in companies that produce annually a low number of units (Chase, 2008). Corrêa (2004) pointed out that the key point for successful implantation of an MRP II system is not its logic or the chosen application. A robust and software quality is necessary but this is not sufficient condition for a successful implantation. There are three other essential conditions for success: the top management commitment to the implantation objectives, intensive and sustained training at all levels and sound implantation process management.

MRP II users must continually train in conceptual and computational tools to know well the system logic and making more effective the decision making process. The MRP II parameters such as lot sizing policy, lead times and safety stocks need to be updated constantly to allow the system to model reality in a manner compliant with its characteristics, without jeopardizing the decision quality. As computer systems rely on an accurate and updated database, Corrêa (1993) pointed out that a data accuracy level of 98% at least is needed to prevent the system is discredited among the MRP II users. In research conducted by Mesquita (2008) with 46 suppliers of the automotive chain in Brazil, most providers surveyed did not reach this index, suggesting a low accuracy of inventory records requiring frequent review of inventories to alleviate the problem.

The formalities required by MRP requires strict adherence to its rules for these systems to work properly. Davis (2001) stated that often users develop informal systems claiming that MRP II is too rigid or inappropriate to deal with real problems of production planning and control. As these rules are not included in the formal system, incorrect data are often reported, generating low accuracy in the database.

2.3 Lean Manufacturing

Lean manufacturing is a multi-dimensional approach originally developed at Toyota Motor Company which includes a wide variety of management practices, including just-in-time, total quality management (TQM), total productive maintenance (TPM), quick changeover techniques, cross-functional work force, PDCA, cellular manufacturing, supply chain management (SCM) and several others, in one integrated system. Lean manufacturing is not based on a computer program, but requires a profound change in organizational culture where people's participation is the key requirement for the success of this system. Thus, according to the point of view, lean manufacturing can be perceived as a business strategy, a philosophy or a set of manufacturing techniques.

Implementation of lean tools without a strong organizational culture will just jump off the performance measures of a company, not sustainable in the long run (Liker, 2005). Specific improvements in specific activities should be sought only after understanding the process in its entirety. According to Santos (2007), the production system used by Toyota prioritizes the improvements based on understanding of the process through a operation and process network in which a set of losses is connected more to the process as a whole than a single operation. The complexity of this holistic approach, often hidden behind the simple application of its tools, can hinder the understanding of the whole scope and potential outcomes that can be achieved through its implementation. This is one of the reasons why the results achieved by companies in the implementation of lean manufacturing are often below the expected potential.

2.4 Just-in-Time (JIT)

Just-in-time (JIT) was initially conceived as a system to prevent waste, reduce inventories and maintain production efficiency. JIT subsequently evolved into a production management philosophy, put into practice through a diverse set of techniques. The philosophy behind this production management was that customers should and could be met with the highest quality in the shortest time of production. It is a consumer oriented manufacturing strategy, which seeks to respond quickly and flexibly to market fluctuations.

According to Chase (2008), JIT is a philosophy that takes into consideration comprehensive product design, process design, equipment and facility design, supply chain coordination, work design and

productivity improvement . It is much more than just a pull production system from the demand that in each stage produces only the necessary items in the required quantities just when necessary. While traditional systems like MRP seek to solve the problem of coordination between demand and production, accepting the uncertainties associated with the demand of manufactured items (in terms of quantities and dates) and the purchasing or production processes of these items, the JIT system aims to solve these uncertainties firstly and after the problems of coordination.

Corrêa (1993) pointed out that the just-in-time aims to continuously improve (kaizen) the production process through a mechanism to reduce inventories of raw materials, materials in process and finished products. The stocks are used to avoid discontinuities in the production process due to quality problems, problems of breaking machine and problems preparation machine, generating independence between the stages of production. The reduction of inventories, and provide a greater movement of capital, enables problems to be viewed. As problems become visible, prioritized and focused efforts can be made to eliminate them and smooth the production flow, continuously improving the production process.

A company can increase productivity and, consequently, margins, and also its global competitiveness in a systematic way to tackle the causes of low competitiveness. Many organizations, however, who think they are using the concept of just-in-time wisely, do not realize that the JIT should be integrated into the company's philosophy, going beyond the implementation of only one set of techniques or practices. The programming logic drawn from the JIT is normally operated with the kanban system, the name given to the cards used to authorize the production and handling of items throughout the production process (Corrêa, 1993). The kanban system operates based on the philosophy that each process in a productive system pulls the type and quantity of components required by the process at the right time. The basic premise is that the material is not being produced or is not being moved until a client sends the signal to make it happen. The client part can be a consumer of a finished product (external customer) or the next production station in the manufacturing process (internal customer). Similarly, the supplier would be the the preceding production station in the manufacturing process (internal supplier), or a supplier of actual inputs (external supplier).

The mechanism used to authorize production or movement of an item is generally based on a physical card. In some cases, computer systems (electronic kanban), light signals and electronic systems can also be used. Four devices are employed in the physical card system: kanban card, kanban panel or frame, container and supermarket. In a "pull" production process, the process item warehouses are replaced by small "supermarkets" close to local consumption. As the kanban cards are exchanged for pieces in the supermarkets, its replacement begins sequentially by the productive sectors, using containers with standardized amounts to store and move items from one production batch.

The kanban system is used for various purposes and functions as a request for production, delivery system of requisitions and production orders. In practice, it is a tool for visual communication and a communication device from the point of use prior to operation. The kanbans, thus, replace the purchase orders to suppliers and production orders for the manufacturing departments, eliminating the documentation that would be required in traditional manufacturing. However, the kanbans should not be used when required batch production or significant safety stocks, given the difficulties that the kanban system will have to meet these requirements.

2.5 Comparison between MRP II and JIT

The production planning and control conducted by MRP push a set of orders for the production system generated from the master production scheduling (MPS). There is a high potential for error between the scheduling production and what is effectively implemented due to time difference between the production schedulling system and actual customer demand. Both overestimation and underestimation of customer demand forecasting can lead to inefficiencies stemming from, respectively, of the excess or shortage of inventory.

On the other hand, the production planning and control under JIT prepare the master production scheduling with the objective to evaluate the stocks (proportional to the number of kanbans) and

calculate cycle times that set the pace of work. As customers are confirming their orders, production is pulled through the kanban system without the need for large inventories (Tubino, 1999).

Since no specific approach or system offers a perfect solution to all problems, many organizations have opted to use hybrid systems that include two or more different approaches in subunits with specific characteristics. The ERP environment favors the planning framework for medium and long term, more aggregated levels of information and materials management, genesis of the MRP system.

On the other hand, the factory management is the primary purpose of Lean Manufacturing tools and programming and control of production (kanban or visual management) of just-in-time (JIT) provide detailed activitiy management by decentralizing the short-term decisions. The JIT and MRP can work together, pointed out Chase (2008), since the the MRP is part of the global system (simply finding a schedule), and not the overall system (running the company).

Correa (2001) claim that integrate MRP and JIT II is not always a trivial thing, as often the different logics that can be used in a hybrid solution have very different or even conflicting aspects. Companies working in an ERP environment need to consider the logic of the system JIT to adopt lean practices in managing their production systems. For example, while working with MRP II production lots, the JIT logic is based mostly on production rates.

3 The engineering education

The functions developed by the engineer are increasingly interfacing with other areas both within and outside the company. This new professional profile requires better communication skills, work team ability, a broader range of knowledge and an ability to analyze more deeply the social, legal, environmental and economic issues. Studies carried out by the Institute Euvaldo Lodi (2006) point out that the engineer has a new reality of rapid technological change:

- Solid knowledge in basic areas;
- Ability to take ownership of new knowledge in an autonomous and independent way;
- Spirit of research to monitor and contribute to the scientific and technological development of the country;
- Ability to design and operate complex systems, with competence in using modern equipment, particularly computer resources, workstations and communication networks;
- Ability to develop original and creative solutions to the design, production and administration problems;
- Full control over such concepts as total quality, productivity, safety and environmental managemnet;
  Ability to work as a team to coordinate multidisciplinary groups and to conceive, design, implement and manage engineering projects;
- Knowledge of legal and regulatory issues and understanding of administrative, economic, political and social issues, in order to understand and intervene in society as full citizens, especially with regard to the ethical implications, and work environmental policies;
- Strong knowledge of foreign languages, necessary for direct access to information generated in the advanced countries, where there are major innovations;
- Perception of the market and the ability to formalize new problems and find a solution.

According to Belhot (2001), the traditional engineering education model adopted in Brazil is still supported in the knowledge transmission without its necessary context, focusing on the conceptual aspects of the various theories. The reproduction of knowledge is valued by repetitive practice of the mechanisms and the operating logic of the conceptual models, by encouraging the memorization and application of techniques and methods as the sole and optimizing troubleshooting. The application of simulation and modeling, Belhot (2001) pointed out, aims to support the development of a systemic view, the practice of strategic thinking, the ability to work together, share knowledge and learn together. As emphasized Rentes (2008), designing processes and systems to manage these

processes is a typical activity of the production engineer and is a great responsibility, since these systems are among the main elements of differentiation between companies. Educational simulations that require students solving exercises and practical tasks from direct involvement with the laboratory work can facilitate the assimilation and understanding of these concepts.

Belhot (2001) defined simulation as a process of experimenting with a detailed model of a real system that aims to determine how the system responds to changes in its structure, environment and boundary conditions. The simulation can be a useful and powerful technique for solving problems through a well-built model to help find answers to important questions. However, care must be taken that the simulation is not been applied as an insulated tool. The simplification of the environment may restrict the scope of the problem and limit the people commitment.

The educational games can be classified in the teaching-learning as a simulated method in which training is conducted in a certain environment that comes close to reality as possible. Kirby (1995) stated that training through games is possible for participants to learn better than reading. According to him, the games as a structured training activity have many advantages:

- Anonymity: the participants have an active involvement by itself, less extraverted members of a group have the opportunity to actively participate.
- Development: the games are means of development for participants and instructors, an instructor has a wide repertoire of games and choose the most appropriate for the group allows the instructor to develop skills.
- Experimental: the games are action-based learning, the learning source of the participants is that they do, not what they hear from the instructor.
- Experimentation: the games allow participants to experience various options without the risk of consequences of doing in the real world. Participants can put their skills into practice in a relatively safe environment.
- Flexibility: the instructor has the opportunity to vary the activity conditions according to the group needs, which on single training can sometimes be difficult.
- Participation of everyone: The games require the participation of all participants, the involvement of all participants is the norm in games.
- Group responsibility: the group will have to establish their principles and ways to obey them and the game gives the group the opportunity to make their own decisions.

4 Mini-Vehicle Assembly Line (MVAL)

The problem contextualization in laboratory practice can help students to better understand the dynamics of simulated exercises and application of acquired knowledge in real situations. The construction of an mini-vehicle assembly line can be a valuable teaching tool that emphasizes the experience in the learning process. The proposal provides for the possibility of setting up sixty vehicles with combustion engines, fueled with methyl alcohol. The 1:10 scale radio-controlled model cars are divided into three models, distinguished by body color. Figure 2 depicts the model with blue body.

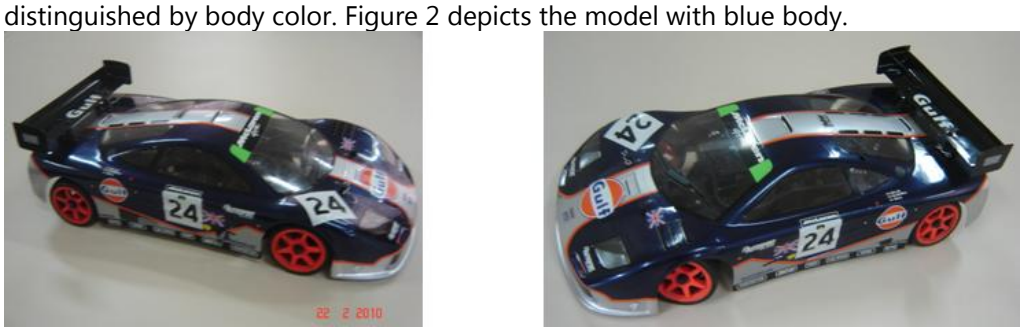

Figure 1: Radio-controlled vehicle in 1:10 scale with blue body. Source: Author 2012

The Project MVAL has six assembly stations, two transfer stations and supermarkets to stock parts and assembled products. The benches were designed taking account of the ergonomic height, no sharp edges, use of lightweight materials and collapsible legs to allow transport. In case of any problem arises, each bank has a safety button that allows to paralyze the entire assembly line.

The assembly line has a U-shaped layout to optimize the use of space and allow its installation into classrooms. The project includes two assembly lines working in parallel, one running inside the "U" and another running out, each with six workstations. Thus, twelve students could participate directly in the assembling, six students could act as suppliers of line and two more students could pack the assembled cars in racks. Obviously, depending on the number of students enrolled in a course, these numbers may vary up or down. Figure 3 illustrates the U-shaped layout.

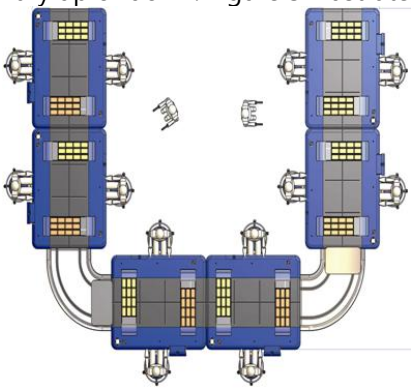

Figure 3: U-shaped layout. Source: Author 2012

The design of the assembly stations and transfer stations was completed and is detailed in 3D. After approval of the proposed budget will be possible to begin the construction of workstations and storage shelves. Figure 4 shows the MVAL configuration designed to be installed in the classroom.

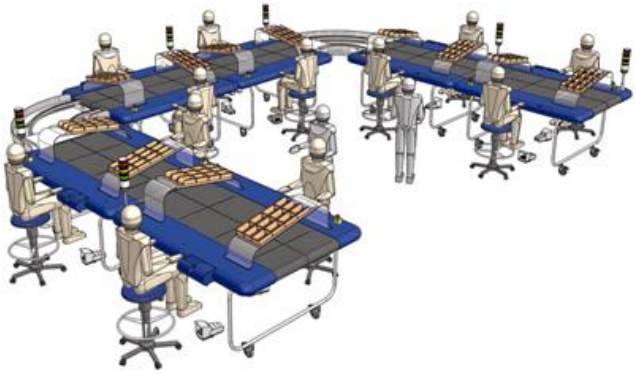

Figure 4: MVAL Laboratory. Source: Author 2012

The vehicles can be disassembled into several parts and components, but as the assembly line has only six workstations were considered some assemblies, including: lower chassis, front wheel drive shaft, rear drive axle, front suspension, rear suspension, engine and fuel tank. For teaching purposes, however, may consider other mounting configurations to allow any problems to arise and enable the development of specific solutions.

More important than the creation of the assembly line itself, however, is the development of simulated situations related to the production management that supports the learning and absorption of complex concepts by means of contextualization. Therefore, it is necessary to evaluate the possibilities the Project MVAL offers with respect to gains in production engineering learning through simulations of the production and operation environment. The simulations should include the application of theoretical knowledge in solving practical problems through simulated exercises. The mini-vehicle assembly plant will

instrumentalise the production engineering course and provide tools and laboratory practices that help students understand concepts and techniques in a practical way.

Several assembling options for defining operations to be performed on each of the six workstations have been considered. The best option found is summarized in Table 1, where the following information is given for each workstation: the number of operations and the time required in minutes to perform the task, parts and assemblies (the tools needed and the amount and type of necessary fasteners have also been specified, but were not included in this table). The cycle time in this situation is of 3.30 minutes (2.89 minutes with an slack of approximately 15%).

Table 1: Workstations

Workstation	Number of operations	Time (min)	Assemblies / parts
1	3	2.76	lower chassis (base) rear drive axle rear suspension fuel tank
2	8	2.,76	engine tank hose safety key + power cord plug throttle server channel 2 throttle server channel 1 battery receptor
3	2	2.51	front drive axle front suspension / pivot screw
4	1	2.76	upper housing
5	3	2.41	battery cover stop crash acceleration stick
6	3	2.89	upper protection escapement/ return hose wheel shaft

Source: Author 2012

Several sets can be created from the initial situation that simulates problems or difficulties to encourage students to develop their own solutions, accompanied and supervised by the teacher or trainer. It is also possible to deliberately unbalance the assembly line by altering the number of operations or the number of workstations. Experiments are being conducted on this project with a selected group of undergraduate production engineering student, comparing learning achieved through purely theoretical lessons with that obtained through a teaching methodology based on learning games using play techniques to simulate the production environment using LEGO® bricks. Some examples of concepts that can be contextualized in laboratory practice include:

- Balancing: students may try different assembly alternatives to define the best cycle time;
- Production sequencing and scheduling: students may try several alternative assembly sequences to define the best option;
- Pull production (kanban cards) versus push production (production orders): students may assemble the cars following the production orders originating from a sales forecast, or assemble according to customer request through the kanban system.

5 Conclusion

This paper describes the plans for a study that proposes to assess whether an assembly line of 1:10 scale model cars can be a teaching resource suitable for simulating a wide range of situations commonly encountered in the assembly lines. The simulated situations will meet several academic objectives of the production engineering course and aim to facilitate the contextualization of manufacturing concepts.

Several educational games can be created for this purpose and, depending on the creativity of the participants, many situations can be simulated and used in a didactic way. Games could play a constructive and interesting role in the classroom when developed on sound learning theories. Students can make comparisons and analogies between simulations and real situations encountered in the production environment, identifying failures, successes, advantages and difficulties.

Although there is the possibility of performing experiments through a dynamic education based on the use of LEGO® bricks, the use of 1:10 scale model cars has some potential additional advantages: has greater complexity and allows a closer approximation of reality, since the products to be assembled emit sounds and smells coming from their internal combustion engines that arouse curiosity and interest of students. On the other hand, nothing prevents some simple experiments are conducted in MVAL with LEGO® bricks. The strength and durability of these parts justify its use in various situations as a more economical simulation.

A secondary objective of the Project is attractive and making known the production engineering course at Instituto Superior Tupy (IST) of the Educational Society of Santa Catarina (SOCIESC). Therefore, it is important to consider the use of the MVAL to promote events that serve as a call to the production engineering course. Being modular, MMV could be assembled in events and fairs, exhibitions, shopping centres and other spaces available for dissemination. The visual impact of the assembly line can not only attract new students to the production engineering course, but also be very important in obtaining scholarships from manufacturing companies.

References

Belhot, R. V.; Figueiredo, R. S.; Malavé, C. O. (2001). *O uso da simulação no ensino de engenharia.* XXIX Congresso Brasileiro de Ensino de Engenharia (Cobenge). Obtido em 30/08/2011: http://www.pp.ufu.br/Cobenge2001/trabalhos/NTM093.pdf .

Chase, R. B.; Jacobs, F. R.; Aquilano, N. J. (2008). *Administração da produção para a vantagem competitiva* (10th ed.). Porto Alegre: Bookman.

Corrêa, H. L.; Corrêa, C. A. (2004). *Administração de produção e operações. manufatura e serviços: uma abordagem estratégica.* São Paulo: Atlas.

Corrêa, H. L.; Gianesi, I. G. N. (1993). *Just In Time, MRP II e OPT: um enfoque estratégico.* São Paulo: Atlas.

Corrêa, H. L. Gianesi, I. G. N. Caon, M. (2001). *Planejamento, programação e controle da produção*. São Paulo: Atlas.

Davis, M.M.; Chase, R. B.; Aquilano, N. J. (2001). *Fundamentos da administração da produção* (3rd ed.). Porto Alegre: Bookman.

Fleury, A. In: Batalha, M. O. (org). et al. (2008). *Introdução à engenharia de produção.* Rio de Janeiro: Elsevier.

Institute Euvaldo Lodi. Núcleo Nacional. (2006). *Inova engenharia propostas para a modernização da educação em engenharia no Brasil.* IEL.NC, SENAI.DN. Brasília: IEL.NC/SENAI.DN.

Kirby, Andy. (1995). *150 jogos de treinamento*. São Paulo: T e D.

Krajewski, L.; Ritzman, L.; Malhotra, M. (2009). *Administração de produção e operações* (8th ed.). São Paulo: Pearson / Prentice Hall.

Liker, J. K. (2005). *O Modelo Toyota: 14 princípios de gestão do maior fabricante do mundo.* Porto Alegre: Bookman.

Mesquita, M. A.; Castro, R. L. (January-April 2008). *Análise das práticas de planejamento e controle da produção em fornecedores da cadeia automotiva brasileira.* Gestão da Produção, São Carlos, v. 15, n. 1, p. 33-42. Obtido em14/11/2011: http://www.scielo.br/pdf/gp/v15n1/a05v15n1.pdf.

Rentes, A. F. In: Batalha, M. O. (org). et al. (2008). *Introdução à engenharia de produção.* Rio de Janeiro: Elsevier.

Santos, R. P. C. (2007). *As tarefas para gestão de processos.* Thesis (PhD. in Production Engineering) – Universidade Federal do Rio de Janeiro.

Slack, N.; Chambers, S.; Harland, C.; Harrison, A.; Johnston, R. (1997). *Administração da Produção.* São Paulo: Atlas.

Tubino, D. F. (1999). *Sistemas de produção: a produtividade no chão-de-fábrica*. São Paulo: Atlas.