A CASE STUDY OF THE IMPLEMENTATION OF SMART MANUFACTURING IN THE MAUÁ 4.0 CELL

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Abstract. *Due to the rapid evolution of Internet of Things (IoT), the advantage of having smart manufacturing has been quickly recognized by the industry. Manufacturing companies are facing challenges of organizing an unprecedented technical integration of systems and factories across hierarchy, domain boundaries and life cycle phases. Many reference models and use-case are available in national and international smart manufacturing related studies. However, gaps between study and actual factory environment exist due to the less care of interconnecting of process steps toward smart manufacturing implementation. To make over the transformation of implementation effectively, methodology to identify the gaps and address appropriate solutions in practice is needed.*

Keywords. *GCSP, Internet of Things, Industry 4.0, 3D Experience*

Introduction

The evolution of Industry 4.0 brings a lot of challenges to overcome the organizational factor inside the industries. This problem can be solved using virtual reality in order to improve the factory processes. One of the biggest challenges in automotive production is dealing with endless prototypes. With each change made by engineers, a new part must be built and tested in practice, checking the performance of the new design, safety items or engine parts. It is a time-consuming and costly process that is being revolutionized by virtual reality. It allows you to simulate a new vehicle prototype, conduct tests without destroying a newly built model, and make changes in real time (NOMUS, 2021).

From the period in which the research was developed, several aspects were analyzed and allowed a better understanding of the problem that was verified previously, as well as its consequences. Industry 4.0-related research is important as it have several challenges that are faced today and those are lined with the objectives of the GCSP program. These challenges consist of a lack of staff with the necessary skills to reap the full benefits of Industry 4.0. To successfully implement new technologies and optimize operations, the company must have a workforce that has people who understand how digital tools can help manufacturing processes become more fluid, reducing waste and bottlenecks, preventing failures with predictive measures and increasing the plant's operational efficiency (HAYASHI, 2020).

As the main premise of Industry 4.0 is to create an increasingly autonomous and highly cognitive ecosystem, we need to rely on technologies such as Artificial

Intelligence to further accelerate efficiency and create new business models, products and services based on data collected and analyzed throughout the production chain.

The knowledge acquired during the research is related to some competencies proposed by the GCSP, such as Technical, Multidisciplinary, Economic Feasibility and Entrepreneurship. In view of the results obtained, the next steps involve a greater deepening of the theme and work within the IMT campus.

Objectives

A case study of the implementation of smart manufacturing addresses several aspects that are discussed in the program. Industry 4.0 contains the main technological innovations in the fields of automation, control and information technology, applied to manufacturing processes. From Cyber Systems, Internet of Things (IoT) and Internet of Services, production processes become increasingly efficient, autonomous and manageable. There are some principles for the development of industry 4.0, which are the ability to operate in real time, virtualization, service orientation and production according to demand.

The priority of the GCSP great challenges that fits the research was the enhance of virtual reality (ENGINEERING, 2021). Moreover, the main global challenges the study approaches are “decent work and economic growth”, “Industry, innovation and infrastructure”, “Sustainable cities and communities” and “Responsible consumption and production”.

Development

Preliminary study

The topics that the research will cover includes a study analysis over a Mitsubishi Electric Corporation study (SHI et al., 2019), such as “Practice issue toward smart manufacturing”, “Maturity assessment and sustainable implementation” and “Case study in factory productivity”.

Today, the Internet of Things optimization need to meet the costumers personalized demand. This affects directly into smart manufacturing systems, requiring them to become adaptive. This leads to a study on how to implement this smart manufacturing in industry. Finally, this demand of a flexible industry increases the competitive edge, and each industry needs a clear roadmap for that.

Depending on functions, organizational management objectives and industry sectors, the complexity and pace of smart manufacturing leads to different points of implementation efforts across manufacturing companies. This situation creates gaps of standard terminology and improvement opportunities.

To overcome the challenges of across implementations toward smart manufacturing, was developed the Smart Manufacturing Kaizen Level (trademark of Mitsubishi Electric Corporation Filed in April 28 2017) conducted with the Key Performance Indicator (KPI) to achieve sustainable implementation (Figure 1). The vertical axis is defined as the maturity level, describing the different levels of information transparency. The horizontal axis is defined as the management level, specifying the range of system implementation.

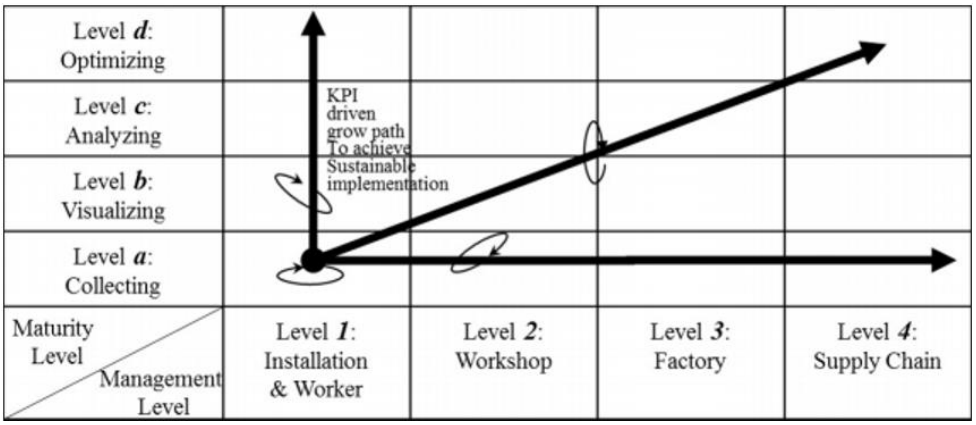

Figure 1 - Smart Manufacturing Kaizen Level (SHI et al, 2019)

As a result of the organizational method showed in the chart, a manufacturing company can draw a clear vision, strategy and systematic roadmap matches its own situation efficiently and effectively in its system application, where greater investment and more manufacturing will take place.

Productivity improvement starts from the factory owner located at the factory management level. Production Manager and Service Provider are responsible for the productivity in general. The production operator, installation and machine vendor take place in installation and worker level.

A maturity level chart of this study shows the improvement of the factory after the use of Smart Manufacturing Kaizen Level (Figure 2). Some of the productivity aspects have improved, such as process capability index, utilization efficiency and allocation efficiency.

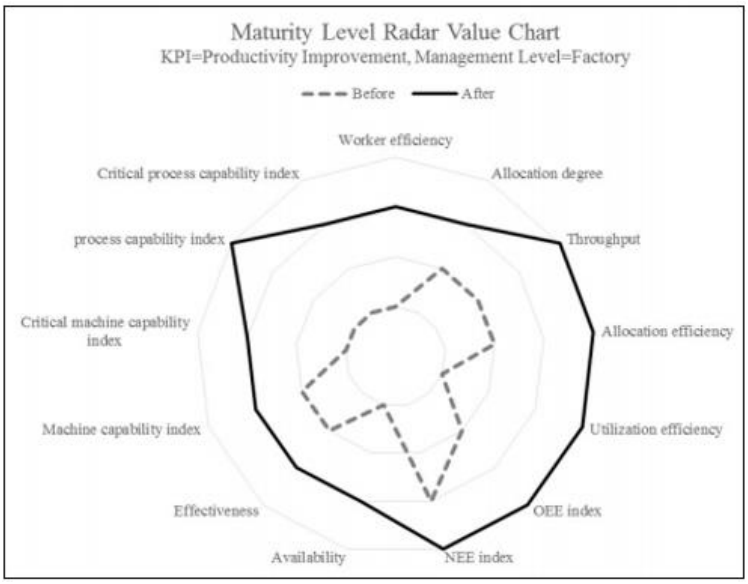

Figure 2 - Maturity level chart (SHI et al, 2019)

3d Experience platform

After the analysis of the Mitsubishi Electric Corporation Study, the second step of the project involves the 3d Experience Platform. At the start, the learning at 3d Experience began through the "Learn 3DEXPERIENCE" Module. In this module, the basic knowledge of the platform is available. The first steps show what is the platform and first connections with it. During the learning, it was possible to learn how to create a dashboard and how to open apps. Then, was explained what a collaborative space is and how to create one. In a third part, the module teaches how to install the native client of the 3DEXPERIENCE platform and how to create an engineering assembly (Figure 3).

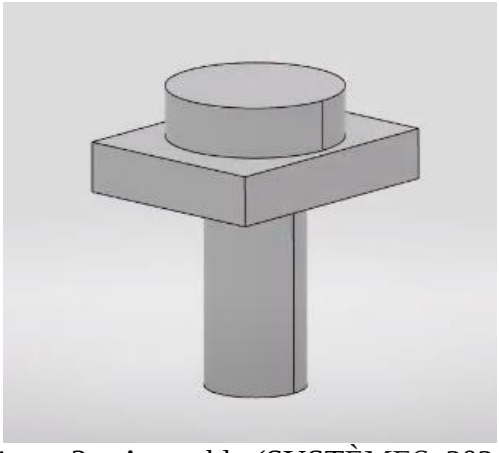

Figure 3 – Assembly (SYSTÈMES, 2021)

Inside the program, it was possible to learn how to create a community and how it can facilitate social interactions and collaboration. Then, how to use the student community in order to get help with the world community.

After learning the basics, the next lessons talked about 3D Design in 3DEXPERIENCE. It was possible to learn Part-Design, Assembly-Design, Generative Shape Design and Kinematics and Dynamics Simulation (Figure 4 and 5).

Figure 4 – Shock Absorber Assembly from "Getting Started with Assembly Design" lesson (SYSTÈMES, 2021)

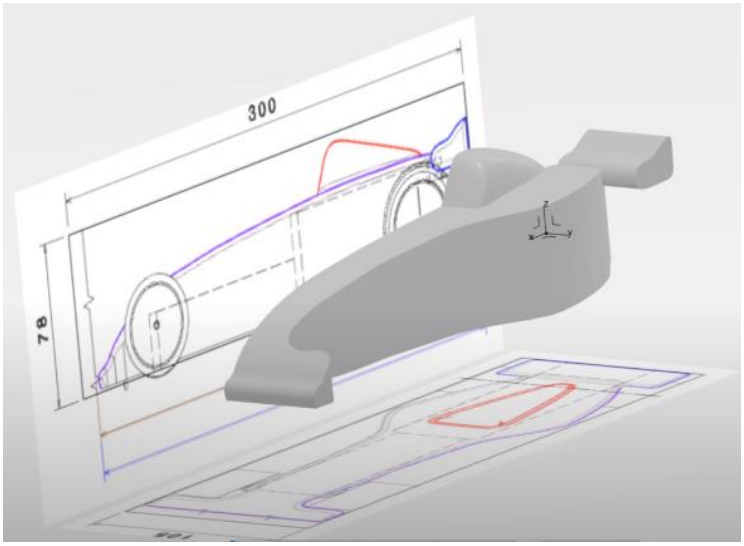

Figure 5 – Car Body developed from "Getting Started with Imagine & Shape" lesson (SYSTÈMES, 2021)

Further learning at the 3d Experience involved 3D designing, where the students can get started with manipulating surfaces to achieve a unique design.

In addition, other important lessons from the learning module were Advanced Design, System Engineering and Physics Simulation. The knowledge from these classes must have a greater study to be fully comprehended.

Competencies

Several activities improved some knowledge that were proposed in the pre-definition of the GCSP-IMT program, and they helped developing the competences that the program has as a priority. Those competences developed were Technical, Multidisciplinary, Economic Viability and Entrepreneurship as presented at Table 1. The skills that still need to be developed mainly involve the improvement of technical aspects.

Table 1 – GCSP Skills chart

	Skills Developed				
Activities	Technical	Multidisciplinarity	Economic Viability and Entrepreneurship	Multiculturality	Social Consciousness
PM4010	X				
AD3019			X		X
CM3033	X	X			
PM4008			X		
Mauá Jr.	X		X	X	X
3D Experience	X	X			

Power BI (PM4010 – Power BI Básico)

The extracurricular activity involving Power Bi helped in the development of activities that involve more of the Technical part required by GCSP.

Entrepreneurship (AD3019 Empreendedorismo: Análise de Viabilidade Financeira em Startups utilizando Simulador em Excel)

The analysis of financial viability of startups was extremely important to understand the aspects of economic viability and entrepreneurship.

Introduction to Data Science (CM3033 – Introdução à Ciência de Dados)

When performing the Introduction to Data Science SPA, several skills were acquired that enable a better understanding of how data can be treated in order to apply what was learned in the research. During the classes, the +RStudio Cloud work environment was used.

The skills acquired from carrying out the activity that involve Technical and Multidisciplinary skills.

Negotiation Techniques (PM4008 – Técnicas de Negociação – Muito Além de Preço e Prazo)

The activity comprising Negotiation Techniques was carried out, where various methods involving the business area were learned. In addition, the competence of the GCSP program that had a greater development were Economic Viability and Entrepreneurship.

Mauá Jr.

Speaking about other activities, two years were concluded within Mauá Jr. Aspects such as entrepreneurship, economic viability, social and technical awareness were developed. Within the junior company, projects involving technology were carried out. Finally, the aspect of entrepreneurship was observed in the leadership of the Sales team, where it was possible to understand how the negotiations and sales of a common company works.

3D Experience platform

The software 3D Experience used to develop the virtual reality space is very important to improve GCSP Technical and Multidisciplinary competences.

Results and Discussion

Further steps involving the implementation of the skills learned in the 3D Experience platform will take place in the IMT campus, where the supply of virtual reality glasses is a meaningful part of the research. Consequently, practical results will be provided to support the importance of virtual reality inside the industry organizational system.

Conclusion

In conclusion, the activities carried out so far will provide the basis for further research development. The competencies of the GCSP program are being acquired and will be contemplated along with the success of it. The next steps in the research involve using the 3d Experience platform to create a virtual reality environment. Other activities

will also be carried out aimed at developing the skills required by GCSP. Furthermore, the practical implementation will involve the use of virtual reality glasses.

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