A Short Portable PLM Course

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Abstract

This paper presents the modern education principles of a short PLM course designed to be deployed all over the world in universities that do not have a PDM software. The main objective of this course is to present the advantages of using a PLM strategy during the Product Development Process. A case study is used to present and explore different process areas of a product lifecycle within a collaborative environment. Students are required to perform tasks and develop a technical solution. Special attention is devoted to the information exchange using an open source PDM system.

1. Introduction

The new economy demands that today's engineers are able to work in a distributed, interdisciplinary, problem-based, and technology-enhanced environment [1]. The growing interest in PLM in the industries has demanded college education to impart engineering students the necessary skills for collaborative design in a distributed environment [2]. In other terms, industry is requiring a new profile of students able to understand the PLM principles and to be trained in the tools that industry uses.

The purpose of engineering education is to provide the learning required by students to become successful engineers—technical expertise, social awareness, and oriented towards innovation [3]. The big issue for universities is which topics to include and how to teach them.

In the last years, Politecnico di Torino has been asked to assist other universities and technical institutes in the deployment of PLM courses. Specially, it was explicitly required to use the PDM software during the lectures. This situation had lead us to search for a PLM course that could be deployed all over the world using a PDM instrument.

Nowadays, there is no standard for defining the necessary skills and capabilities for a PLM expert and therefore it is impossible to define the educational path for new engineers. In this chaos, every university has decided to apply its own strategy: IT oriented, CAD oriented, PLM Project Management, user (data creators, reviewers or consumers) or super user (administrator). The first challenge was to define an original PLM course that covers different areas of a product lifecycle without being partial to one area.

Usually, the PDM software requires a server and client installation that requires time and technical skills. This condition makes almost impossible to use the tool outside the network where the installation was made. In literature there are some examples of curriculum development of PLM courses or PLM projects with information exchange between different teams [4-6]. In these examples, the university which organizes the course is the owner of the PDM system and the course was executed with groups that work inside the network of the university. Instead, Segonds et al [7] develop a project using Dropbox as PDM for a collaborative project between two universities. This solution solves the installation problem but Dropbox cannot manage the configuration and change management process necessary to work in a PLM environment. The second challenge was to find a PDM solution that could be easily installed, managed and reachable from the outside of the university network.

This article presents an original short PLM course focused in the development of a new product (section 2). The exercise covers different process areas (section 3) and its integration (section 4) using an open source PDM. The course deployment and results are discussed in section 4 and 5 respectively. Finally, conclusions are stated in section 6.

2. Case Study

The sliding door trolley (Fig. 1) is a key component of commercial and garage doors and gates since it links the gate framework to the surrounding structure. The trolley runs on a monorail which is fixed to the wall. It should be designed and constructed in such a way as to prevent it from falling down, collapsing or derailment during normal operation or in case of contact with stationary obstacles.

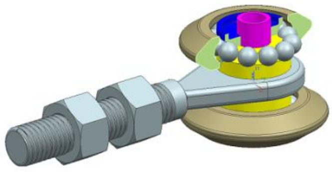

Fig. 1 – Sliding door trolley

3. Process Areas

During the development of the exercise there are a series of processes with similar goals which are grouped in Process Areas (PA). A PA is a cluster of related practices in an area that, when implemented collectively, satisfies a set of goals considered important for making improvement in that area [8].

Requirements Management (RM)
The purpose of this PA is to manage the requirements of the project's products and product components and to identify inconsistencies between those requirements and the project's plans and work products [9].

Project Management (PM)
Project Management is the application of knowledge, skills, tools and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project [10].

Quality Planning (QP)
Quality planning is part of quality management focused on setting quality objectives and specifying necessary operational processes and related resources to fulfil the quality objectives[11]. One of the most significant methods to assure quality is the Failure Mode and Effects Analysis (FMEA). FMEA is an analytical methodology used to ensure that potential problems have been considered and addressed throughout the product and process development phases [12].

Product Design (PD)
Product design is to conceive the idea for some artifact or system and to express that idea in an embodiable form [13].

Process Design (PrD)
Process design is to conceive the looks, arrangement and workings of something before it is constructed [14].

Configuration and Change Management (CCM)
Configuration is a management activity that applies technical and administrative direction over the life cycle of a product, its configuration items, and related product configuration information [15]. It is composed by four basic functions: identification, configuration control, status accounting and audit. The Institute of Configuration Management [16] has defined a closed-loop change process used to release new information and to change information already released. This loop is formed by a Problem Report (PR), Engineering Change Request (ECR) and Engineering Change Notice (ECN). A PR form is used to report a problem, where it occurred and the steps which led to its occurrence. An ECR form is used to request changes and initiate reviews that will result in a proper disposition. An ECN form is used to implement approved ECRs and provide the authority to upgrade and release associated documents.

4. Integration

Information technology, by the way of collecting, sharing and gathering data, exchanging information, optimising process through package software, is becoming one of the key developments and success for collaboration strategies [17]. The integration of the process areas was achieved by using the open source PDM software Aras Innovator [18]. Aras has been successfully used in different universities [19,20]

Innovator's solution suite constitutes of a full-featured engineering business solution supporting engineering and manufacturing processes throughout the plant and the extended supply chain [21]. Aras takes advantage of HTTP/HTTPS, XML, and SOAP protocols to deliver its functionality through a standard web browser (Internet explorer).

The server installation resides at Politecnico di Torino and is reachable from the outside. Even though Aras does not need a client installation, a small client configuration is mandatory. It consists of setting up some browser security issues.

All modules used in the development of the exercise come along with the standard version of Aras Innovator 9.3. The only exception is the Requirements Management module that was developed by a third party and delivered as an add-on to the software.

The only customizations made to the software were:

- Requirements classification
- Requirements sequence number
- Part sequence number
- Document sequence number

Fig. 2 presents an overview of the exercise. It covers the Imagination and Definition phases of a product lifecycle and includes the PAs described previously. PM and the CCM play in parallel to the other process areas. Further description of the graph will be given in the next sections.

Before starting, a training on the PDM software is essential. It is supposed that the attendees are new in the use of this instrument so in the first part of the course, the students receive the credentials to enter the system and a general overview of the most used applications.

The collaboration is achieved by using a project structure that permits information access to all team members. Projects inside Aras Innovator use a Work Breakdown Structures (WBS), which allows users to break down the project into manageable phases, activities and tasks. Each activity is identified uniquely and it can be associated to a deliverable, start and due date, assignee, and role. It is also possible to define predecessors or other constraints.

A project template (see Fig. 3) has been used to develop the new product. The template was previously prepared and filled with the information and dates of the course.

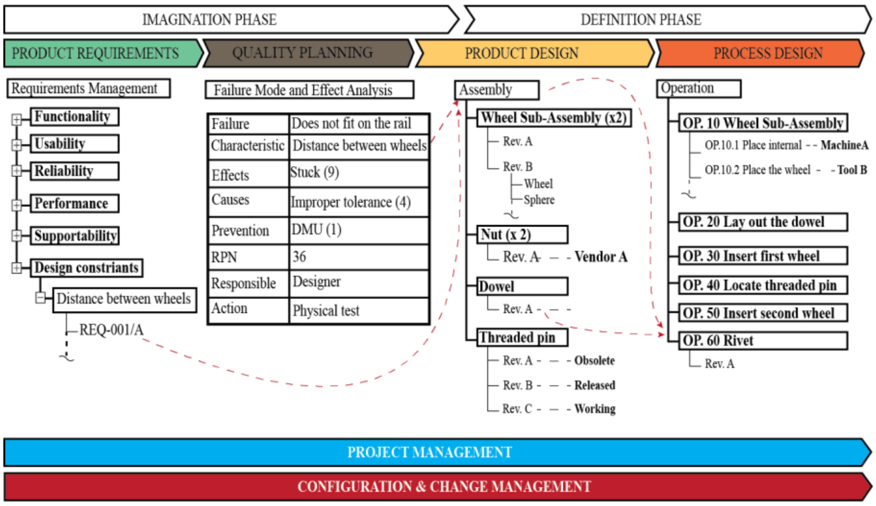

Fig. 2 – Exercise overview

N	Project Tree	Predecessor	Plan Duration	Plan Hours	Attach Required	Attach Type	Lead Role	Required
	New Product				☐			
	Phase 0 - Requirements				☐			
1	Understand customer needs		1		☑	Document	Manager	☑
2	Define Product Requirements	1	1		☑	Document	Manager	☑
3	Validate Product Requirements	2	1		☑	Document	Manager	☑
4	Requirements end		0		☐			☐
	Phase 1 - Quality Planning				☐			
5	Select DFMEA team	4	1		☑	Document	Quality	☑
6	Perform DFMEA analysis	5	1		☑	Document	Quality	☑
7	Follow-up actions	6	1		☑	Document	Quality	☑
8	Quality end		0		☐			☐
	Phase 2 - Product Development				☐			
9	Create BOM	6	1		☑	Document	Design	☑
10	CAD Modelling	9	1		☑	Document	Design	☑
11	Material Specification	10,9	1		☑	Document	Quality	☑
12	Technical drawings	9,10,11	1		☑	Document	Design	☑
13	Product Assembly	10,12	1		☑	Document	Design	☑
14	Product development end	10,13,12,11,9	0		☐			☐
	Phase 3 - Process Development				☐			
15	Define component operations	14,8	1		☑	Document	Process	☑
16	Define assembly sequence	15	1		☑	Document	Process	☑
17	Process end		0		☐			☐

Fig. 3 – Project Template

During the development of the exercise students use and learn almost all functions of PLM systems: versioning, vaulting, searching strategies, multi BOM management (eBOM and mBOM), concurrent engineering, workflow management and part reusing.

Phase 0

The kick off for the exercise is the list of requirements for the product. The requirement list was established by the role of Requirement Analyst (RA) which is an expert of the product. The RA has to understand customer needs and to translate this into product requirements. Finally, he has to validate them. Students are not involved in the requirements definition, instead they are asked to consider these requirements and to satisfy them. Requirements were classified according to FURPS+ [22].

For the sake of brevity, only one requirement is presented here that is going to continue for the rest of the phases as an example. Referring to the design constraint (Fig. 2) “the distance between the wheels”, it can be deduce that it is a critical requirement since the distance assures the correct assembly between the trolley and the monorail. This requirement is identified and managed by the CCM.

Phase 1

The Quality Manager is asked to form a group and to perform a Design FMEA (DFMEA) using the integrated FMEA matrix. In Fig. 2, the failure mode “Trolley does not fit on the rail” is analysed. As a consequence, the trolley may impair the sliding operation. The cause of such failure could be an improper tolerancing of the parts. A Digital Mock-Up (DMU) is planned to prevent the failure. Then, the Risk Priority Number (RPN) is calculated according to the effect severity (9), the cause probability of occurrence (4) and the probability to detect the failure (1). The RPN helps to classify and rank the failure modes.

The most important thing is that once the FMEA is performed, an action is assigned to a role. The designer who has been commissioned will receive a notification and will be asked to give evidence of completing the task.

A product characteristic (distance between wheels) is created. This characteristic is managed by the CCM and must be considered during the product design. Aras links the FMEA characteristic to the product configuration by adding a tab in the BOM. Links can be made at assembly or part level.

The DFMEA lifecycle has a particular way of being conducted. It is created as draft and it remains in that state until the phase of product design is closed. The DFMEA can be released only after receiving the completion of all taken actions.

Phase 2

During the product Design, the Design leader creates the BOM of the product and assigns the design of the parts to other team members. Team members create the 3D models of the parts and deliver the technical drawings. The material selection is a task assigned to the quality team. Finally, the team leader performs the product assembly.

While performing this tasks, designers must take into account the product requirements and characteristics that have been established in previous phases. For example, the distance between the wheels requirement and characteristic are linked to the assembly level of the product. This distance can be obtained after all parts are assembled. Also, the designer must answer to the task assigned in the DFMEA.

By linking requirements, characteristics and DFMEA actions, the designer is lowering the risk level of committing a mistake. After completing the required actions, the DFMEA table will be updated adding two more rows, the action taken and a new RPN (which is expected to be lower).

During the product design, the single part is responsibility of the designer in charge and he performs a manual releasing. Instead, the assembly, due to its importance, is submitted to an ECN for its releasing.

Phase 3

The Process leader assigns the analysis of a part to different team members. Every team member develops the necessary operations to produce the part. During this development, the process designer has to link the part to the process and to consider all necessary resources (tools, machines, work areas, etc.).

Process leader is responsible of the operations definitions of the final assembly. He is also responsible for taking into account the product requirements and characteristics that are influenced by the process. For example, Op. 60 (see Fig. 2) is the final operation made to the assembly; by riveting a dowel, the trolley gets its final shape. This operations is the one that produces the desired distance between wheels. It is also possible to perform a Process FMEA and to establish a quality control plan of the operations.

All items of the process development must be managed according to CCM. Single part production are manual released while the final assembly is controlled by an ECN. Phase 3 ends up the project. The products is considered to be successfully produced and it reaches the market.

Phase 4

A client complaint is reported and managed with a PR automatic workflow. The change specialist evaluates the problem and asks for technical expert opinion. If the problem is accepted, it is then taken to an ECR.

The change board team evaluates the problem and looks for a technical solution. For example (Fig. 4), a change in the dimensions of the client's rail will cause a change to the requirement associated to the distance between the wheels. In the same way, the new requirement version will produce a change to the product, and the it will cause a process change. Finally, an ECN must be performed to inform all stakeholders that the change has been achieved.

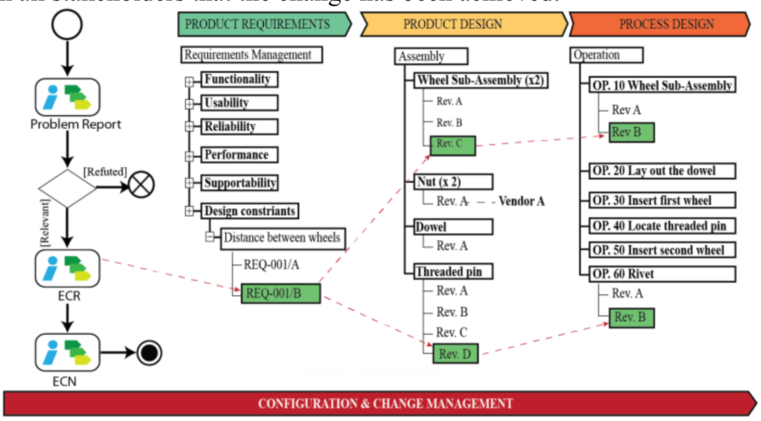

Fig. 4 – Change Management

5. Deployment

The course has been deployed several times in different universities (Ss. Cyril and Methodius University in Skopje, FYROM; University of Novi Sad, Serbia; Arts et Mètiers ParisTech, France) and technical institutes (ITIS OMAR Novara, Italy). The course can be limited to a demonstration of the tool or expanded to a practical exercise. The number of hours employed vary according to this constraint.

The most complete experience (in terms of project achievement, number of students involved and number of hours dedicated) has been reached in June 2013 at University Federico II of Naples. Results and conclusions refer to this last experience.18 professional master level students from different backgrounds (electrical, mechanical, industrial and system engineering) participated in the 27 hours course. Students were assigned to different teams according to their preferences: 2 Project Managers, 4 Quality Engineers, 4 Product Designers, 4 Process Designers and 2 Change Specialists. The course was given in 6 days in sessions of 3 and 6 hours.

The connection to the PDM worked correctly and students accessed without problems. The performed activities were fairly clear and team leaders gave evidence of the completion of the tasks on time.

6. Results

At the end of the course an anonymous questionnaire (Likert scale) was used for measuring student perception. The more relevant (positive and negative) aspects are listed below.

Positive Aspects
Overall, the course achieved its objectives satisfactorily (Fig. 5a) and the contents of the course were considered original by the majority of students (Fig. 5b). The teaching method and material given were highly appreciated.

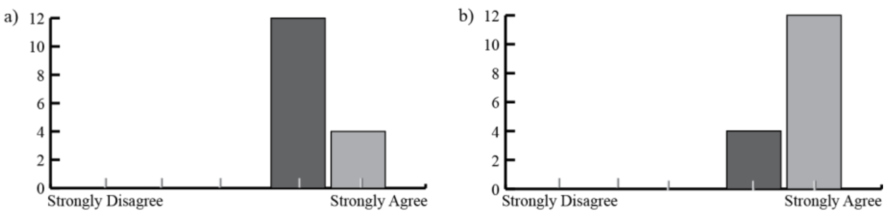

Fig. 5. a)Course contents are original. b) The course achieved its objectives.

Negative Aspects
Up to version 9.3, Aras worked exclusively on Internet Explorer (IE) using a .NET security framework. This situation limited the use of computers with Windows

operating system. However, version 10 of Aras has been recently released and it does not require the .NET security framework and therefore it will be possible to connect also with Firefox on Windows and OSx.

During the days before the course, IE passed from version 9 to 10. This update caused a delay during client configuration. Though, from 17 computers, only one presented problems that were solved in the same day.

Moreover, Aras presents some usability errors (i.e. the insert row tab is missing while creating an FMEA) that made impossible some operations and influenced negatively student perception (see Fig. 6). In order to connect to the server, a non-restricted WIFI or LAN is compulsory. Other software (i.e CAD software) needed during the development of the course must be installed and licensed in the students computers.

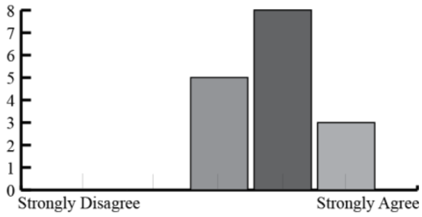

Fig. 6 – I used the system (Aras innovator) without difficulty.

7. Conclusions

This paper presents an original PLM course that covers different phases of a product lifecycle integrated in an open source PDM. This course includes the development of a new product within a collaborative environment.

Students are exposed to the complexity of managing product information through different process areas (product requirements, quality management, product and process design, project management, and configuration and change management). The course encourages the integration of product information, processes and people, and it is not oriented to a single technological area. A project structure is used to consent information access to all team members while they develop a technical solution.

The use of a web based open source PDM eliminates the need of a client/server installation and facilitates its use outside the network where the tool was installed. Despite some technological and usability problems, the system performs well.

From experience gained by organizing the course in different institutions, it is found that this course can be deployed all over the world. It is our belief that other universities can take this paper as a model to develop PLM courses exploiting the advantages of open source PDM or similar solutions.

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