

The Role of PLM Academic Platforms in Education of the „Engineers of the Future“

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Abstract: *The growing importance of Product Lifecycle Management (PLM) as a key business strategy for achieving success demands that the workforce understands PLM and how to use PLM systems to support the increasingly complex reality. Beside technical knowledge, the engineers of future must be familiar with the PLM philosophy and use PLM solutions effectively in collaborative environment. However, the lack of engineers with these competencies makes it difficult to implement and execute PLM concept in companies. So engineer's education must take a step forward using advanced educational models based on student's working in a real PLM environment. The paper discusses how PLM academic platforms provided by PLM software vendors can contribute to establishing of such models, indicating the educational potential of some of the most commonly used academic platforms in practice.*

Keywords: *Product Lifecycle Management; academic platforms; engineers of the future*

1. INTRODUCTION

Product Lifecycle management (PLM) is an integrated, information-based approach consisting of people, processes and technologies covering all aspects of the product life cycle, from its design through production, implementation and maintenance, to final disposal [1].

According to CIMdata, a global leader in PLM consulting, PLM is a strategic business approach that applies a consistent set of business solutions to support the collaborative creation, management, dissemination and use of product information across companies, integrating people, processes, business systems and information. [2].

PLM is an information system aimed at integration the company's functions by connecting and controlling various business processes through product data, using advanced IT technologies [3].

PLM systems include a multitude of applications covering different processes and disciplines during the product lifecycle, such as:

- Product Data Management (PDM);
- Computer Aided Design (CAD);
- Computer Aided Engineering (CAE);
- Simulation and Analysis (S&A);
- Computer Aided Manufacturing (CAM);
- Reporting and analytics;
- Portfolio Management;
- Requirements management;
- Compliance Management;
- Project Management;

- Configuration Management;
- Document Management and others.

In last decades, PLM has grown into a key paradigm for product management due to the increasingly intense process of globalization, shorter product lifecycles and increasing demand for a wide range of complex, sophisticated and customized goods and services.

The growing importance of PLM systems has also been influenced by new engineering trends that companies follow to achieve innovative leadership in their fields and as a consequence of striving to achieve excellence at all stages of the life cycle from idea, through development and production to service delivery.

On the other hand, globalization and technological progress are driving markets and highlighting the need for PLM strategies to help turn emerging markets into emerging economies, and mature markets into innovator markets—but this demands that the workforce understands PLM and how to use it to support the rapidly evolving realities [4].

In accordance with the importance of the PLM concept for prosperity and strengthening the competitiveness of companies in today's business conditions, the development of PLM competencies should be an integral part of educational strategies in the education of next generation of engineers with competencies that are in line with the requirements of contemporary industry, the so-called engineers of the future.

Since PLM is IT-based paradigm-based paradigm, preparing students for real-world professional challenges in PLM environment requires the use of a wide range of IT solutions in teaching processes. Since PLM systems include a wide range of applications that span the entire product lifecycle, from requirements management to technical documentation, which commercial price is quite high and unaffordable for most of educational institutions, PLM education is quite limited.

Engineers of the future must possess skills such as innovation, entrepreneurial vision, problem solving, critical thinking, teamwork and digital competences, which is difficult to achieve with traditional educational models.

The application of PLM academic platforms in education processes is a way to overcome all these challenges in the education of future engineers. Those platforms provide integrated software solutions that cover entire product lifecycle, which is aimed at supporting of education and preparing students to work in a PLM environment, understanding of PLM concept, and acquisition digital experience as well as competencies inherent to the engineers of the future.

2. PLM SYSTEM AS IT SUPPORT TO IMPLEMENTATION OF PLM CONCEPT

PLM systems combine different tools and technologies into a single solution that enables collaborative creation, management, exchange and use of information, data and product knowledge. In order to present in more detail the possibilities provided by the PLM concept, some of the modules and functionalities of the PLM system will be presented. Given the rather heterogeneous conceptualizations of PLM, there is no single perspective on what exactly PLM contains [10], and therefore no unique classification of the modules and functionalities provided by PLM systems.

Below are given some of the standard PLM functionalities, which are supported by most PLM systems, this list is derived from the analysis of PLM solutions currently available on the market.

Bill of Material (BOM) Management module serves product designers to create and manage a part-centric digital product, it enables product visualization, part classification, easy editing, tracking part history...

Change and Configuration Management module provides delivering a real-time view of the most accurate data about change and product configurations from single source.

Manufacturing Management module provides an unimpeded information flow between engineering and manufacturing by ensuring automation and unique source of data about product traceability, change control and security.

Product data management (PDM) module provides reliable and fast access, manipulation, tracking and control of CAD data and related documents generated during design and other engineering processes.

Systems Engineering module supports collaborative work of multiple engineering disciplines during the designing and building of complex products.

Requirements Management module helps teams, during developing complex products, to specify, verify and validate every product aspect; also, it enables automation of traceability and sharing of data about requirements and product validation, between different functions and teams.

Idea Management module enables generation, evaluation and selection of ideas for new product development in a structured way.

Process Definition and Management module relates to the functionalities enabling efficient development and management of processes and workflows including product development workflow management, engineering change management...

Compliance Management module functionality relates to the management of regulations and standards related to product compliance management.

3. PLM ACADEMIC PLATFORMS

Since PLM is not just an engineering discipline, PLM education should be extended well beyond engineering techniques, on business and operations strategies, marketing, purchasing, product support, project management, costing, manufacturing... On the other hand, researches show that PLM related curriculums are mainly based on topics such as CAD, CAE and Digital Manufacturing [4], which limits the engineers training exclusively to the product design or production phase.

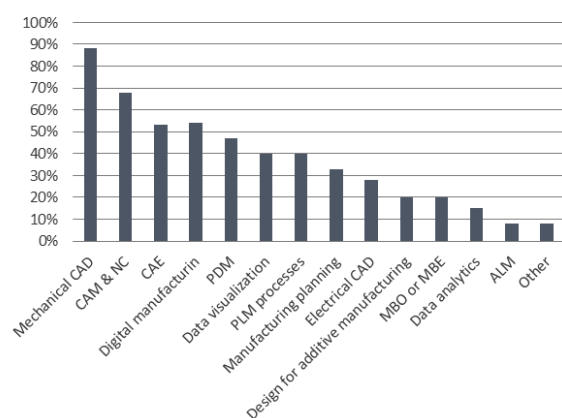


Figure 1. Topics covered in PLM related curriculums [4]

Such programs do not cover the entire range from planning to engineering design to manufacturing

and cannot prepare students for PLM roles beyond engineering or to understand PLM concept and how to use it to support the company growth.

PLM academic platforms provide integrated software solutions for the needs of educational processes that cover entire product lifecycle, from idea, through development and production to service delivery, and product disposal. This enables the preparation of future engineers for PLM roles beyond engineering leading to comprehensive understanding of PLM concept and how it could be used to establish an integrated management of product data throughout the entire product lifecycle or to drive company growth.

By introducing the PLM academic platform into classrooms, students are enabled to acquire skills, knowledge and advanced digital competencies by working in a real PLM environment.

It is also important to note that the use of the PLM academic platform during the educational process supports the implementation of Project and Problem-based educational learning models. These pedagogical strategies are widely accepted in various fields in educational contexts to promote critical thinking and problem-solving skills, so they play an important role in educating engineers in line with contemporary industry requirements. The concept and key benefits of these educational models are discussed below.

3.1. Project-based learning as a main pedagogical strategy for education of "engineers of the future"

Project-Based Learning is one of the increasingly used educations teaching which occupies an increasingly important place in modern education strategies, especially in the education of so-called „engineers of the future“. Project-based learning is an education method in which students acquire knowledge and skills by exploring an authentic, interesting and complex question, problem or challenge over a long period of time. During the learning process, students are focusing on achieving the common goals through collaboration.

According to Hârtescu [5], the concept of Project-based learning organizes learning around projects and involves the students in authentic situations where they can explore and apply the subject matter to problems that are complex and relevant to the professional practice for which they are preparing.

The project-based learning is considered to be a particular type of inquiry-based learning where the context of learning is provided through authentic questions and problems within real-world practices that lead to meaningful learning experiences [6].

According to [7, 8, 9] the key benefits of project-based learning relate to:

- stimulation of self-motivation and student ownership of the problem, solution and learning;
- development of self-regulation, agency, commitment and competence;
- experience and development of teamwork;
- experience of authentic problems and professional practices;
- development of reflective skills;
- significant influence of creative thinking on students' learning outcomes;
- development of written, oral and other communication skills;
- experience of problem solving and the design process;
- exposure to the multi-disciplinary and systems nature of problems and
- coping with incomplete and imprecise information;
- improving students' problem-solving skill, critical and creative skill, communication skill, team work;
- lifetime learning, adaptation to changes, and self-evaluation.

What is more important, the authors of the study [11] find that project-based learning as related to STEM (science, technology, engineering and mathematics) curriculum led to gains in terms of enjoyment, engagement with the project and the ability to combine theory and practice effectively.

3.2. Problem-based learning as an education model for promotion of critical thinking and problem-solving skills

The Problem-based learning is one of the often-used education strategies leading to developing 21st century skills. Although this concept has been in use for more than thirty years, providing good results in various fields, its importance is especially evident in educational processes aimed at educating engineers with conceptual knowledge, practical skills and critical thinking and problem-solving skills in accordance with the needs of modern industrial trends.

Today the use of problem-based learning in engineering programs has been widespread, especially within the field of STEM education.

Yew & Goh [12] define Problem-based learning as a pedagogical approach that enables students to learn while engaging actively with meaningful problems, whereby the students are given the opportunities to problem-solving in a collaborative setting and creating mental models for learning.

Also, they indicate that Problem-based learning as a pedagogical strategy is premised on the belief that effective learning takes place when students both construct and co-construct ideas through social interactions and self-directed learning [12].

According to Arend [13], Problem-based learning consists of some basic elements, including 1) problem orientation; 2) organizing students to conduct research; 3) assisting independent and group investigations; 4) developing and presenting artifacts; and 5) analyzing and evaluating problem solving process.

As authors [12, 14, 15, 16] point out, problem-based learning benefits relate to:

- promotes self-directed learning habits;
- enables developing problem-solving skills and deep disciplinary knowledge;
- supports active and group learning;
- developing students’ reflective, critical and collaborative skills;
- it is aimed at training competent and skilled practitioners and to promote long-term retention of knowledge and skills acquired during the learning experience;
- empowers students to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem
- provides opportunity for students to work cooperatively, to demonstrate effective communication skills, and to use content knowledge and intellectual skills to become continual learners.

4. PLM ACADEMIC PLATFORMS REVIEW

In this chapter, some of the most commonly used PLM academic platforms in educational institutions with PLM related courses will be reviewed. Namely,

the educational potential of the academic platforms provided by Aras, Siemens and Dassault System companies will be presented.

4.1. Siemens PLM academic platform

Siemens PLM platform offers IT support for main PLM components, integrated into 350 commercial applications that addresses the full product lifecycle enabling: transforming of product development to accelerate innovation; connecting people and processes with knowledge; optimizing manufacturing for greater confidence and deploying standardized solutions with open software tools.

Siemens PLM Software also provides a global academic program that is focused on empowering the next generation of digital talent [17].

Siemens PLM Software delivers a multitude of PLM capabilities in support of education as an integrated solution that covers the gamut from planning to engineering design to manufacturing within one platform, making data more accessible for roles beyond engineering. This academic platform is aimed at preparing the next generation of engineers for the digital experience [17].

As a part of its academic program Siemens established e-Learning portal so called Learning Advantage that enables users to gain skills and knowledge in Siemens Digital Industries Software products. Learning Advantage contains on-line learning resources, such as courses and assessments that are updated whenever new PLM software versions are released.

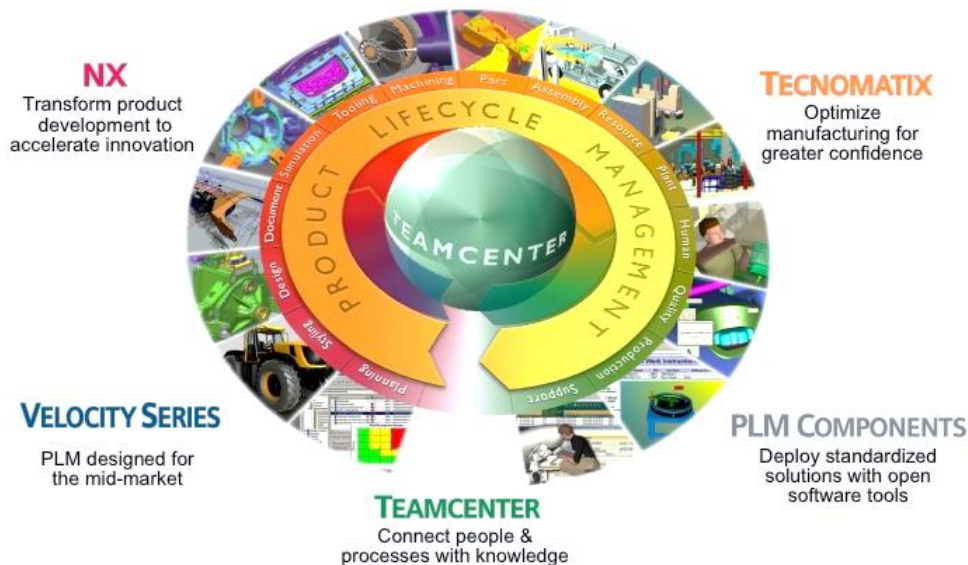


Figure 2. Siemens PLM Platform [18]

As in Siemens point out, the key benefits of this e-Learning portal are [17]:

- Free to any institution that has active academic licenses access to learning content and assessment tools;
- Helps students to improve their Siemens PLM Software solutions skills;
- Helps students to improve their marketability with Siemens PLM Software industry partners;

- Provides complete access to training updates and new content and
- Allows students to track course completion dates and assessment scores.

The Siemens academic partner program empowers future engineers and technologists with advance digital skills at academic institutions through different student’s projects, for example:

- Student from the Katholieke Universiteit Leuven in Belgium build electric racecars using Siemens Digital Industries Software solutions such as NX, Simcenter and Teamcenter to cover the entire product creation process chain.
- Team Bath Racing from the University of Bath designs and builds a single-seat race car to compete in Formula Student competitions around the world. During this research project they use Siemens software Simcenter Flomaster as part of the design process.

These are just some of examples of successfully implemented student projects by using the Siemens academic platform that Siemens Corporation is proud of.

4.2. Aras PLM academic platform

As Aras Corporation states, Aras academic program is aimed at providing subscriber licenses of Aras Innovator PLM platform to educational institutions so that educators and students can advance their PLM education [19].

There are many academic institutions around the world which are members of the ARAS academic

community, providing future business and technology leaders with advanced training in one of most important areas for modern industry - PLM. There are more than fifty prestigious academic institutions in the program, some of them are: OHIO University, Technische Universität Dresden, PRUDE University, Politecnico di Milano, Hamburg University of Technology...

Aras academic platform provides to institutions access to Aras Innovator Platform, Aras Applications, Aras Community, Customer Support, Aras Training and access to the subscriber portal.

Aras PLM Platform is built by applications that span the entire product lifecycle, from requirements management to technical documentation.

Most of those applications are available as a part of Aras Academic package, including: Product Engineering; Program Management; Process Quality Binding; Manufacturing Process Planning; Technical Documentation; Quality Management System; Component Engineering; Requirements Management /Engineering; Aras Impresa MRO and Aras Comet SPDM. Most of those applications are of an "Open-access" type.

Having in mind the above, it can be concluded that the application of Aras academic platform in the educational process enables a comprehensive PLM education for students, offering them the opportunity to train to work with all applications that span the entire product lifecycle, in that way students can transition to the professional workforce which will be competent to implement and enforce PLM concept within companies.

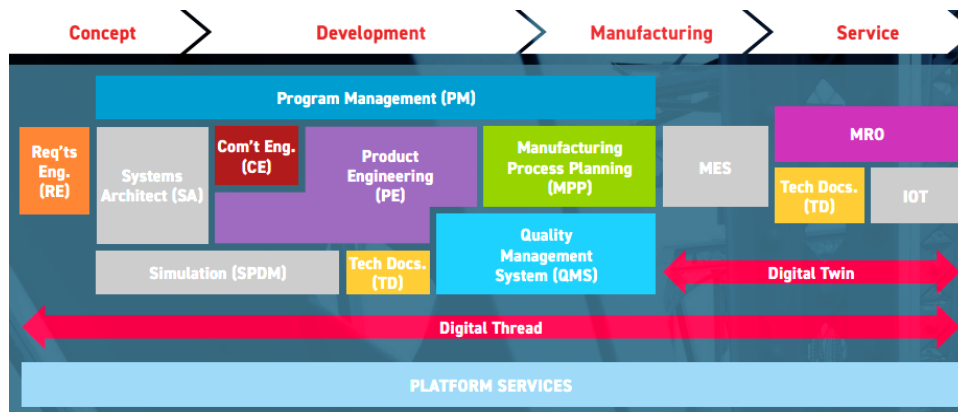


Figure 3. Aras PLM Platform [20]

According to [19] the major benefits of Aras PLM academic platform relate to:

Benefits for Students

- Unlimited access to flexible, scalable and upgradable PLM software
- Access to the Aras Community for project collaboration and custom curriculum
- Hands-on exposure to PLM so students can transition to the professional workforce

Benefits for Academic Institutions

- Instructional aid for teaching PLM, product development and model-based SOA programming concepts
- Development of add-ons, enhancements, new solutions and projects with the Aras Community
- Use Aras PLM to streamline institution’s document management and other internal business processes

As part of its education program, Aras Academic also offers online learning courses in the hottest PLM topics, including:

- Component Engineering
- Manufacturing Process Planning
- Quality Planning Essentials
- Product Engineering Essentials
- Program Management Essentials
- Visual Collaboration
- Self Service Reporting
- Technical Documentation

4.3. 3DEXPERIENCE platform for academia

3DEXPERIENCE PLM platform offers comprehensive PLM solutions supporting wide range of processes during the product lifecycle. As integrated solutions 3DEXPERIENCE covers different areas such as Design and Engineering, Systems Engineering, Advanced Simulations, Marketing Experience, Manufacturing and Production, and Governance and Project Management within one platform.

Specialized IT solutions included in the 3DEXPERIENCE platform cover all activities and engineering disciplines related to product design and simulation, manufacturing planning, digital manufacturing, governance and project management, business and industrial innovations. This includes solutions:

- CATIA – product design;
- DELMIA – digital manufacturing;

- SIMULIA – realistic simulation;
- ENOVIA – collaborative innovation and
- 3DEXCITE - high-precision rendering and interactive immersion.

All these solutions are available within the academic platform, so-called 3DEXPERIENCE platform for academia which is aimed at supporting of education of the engineers with the comprehensive PLM experience and advanced digital competencies. By providing students with those tools in education process, they are enabled to acquire knowledge that will prepare them for real-world professional challenges in PLM environment and help them to improve their employability.

Dassault System Company describes its academic platform as advanced platform designed for a variety of industries, enabling the new practices of industry renaissance. They also state that it offers the ideal infrastructure for bringing industry practices into learning, since it encompassing comprehensive CAD, CAM and CAE capabilities, also it provides powerful solutions for managing collaborative work and joint innovation [21]. As they point out an advantage of this academic platform is that it enables the learning practices required by the future industry such as Project-based learning, (Digital) Problem-based learning, Peer learning, Experiential learning...



Figure 4. 3DEXPERIENCE PLM platform [21]

Also, there are various services that are available for institutions, educators and students to increase learning efficiency and improve education process including:

- 3DS academy website
- Peer Learning EXPERIENCE
- Project-centric learning
- Dassault Systèmes Certification Program

In addition, Dassault Systemes Company is constantly striving to contribute to the creation of educational innovation. As a result of these aspirations, it arises Edu Hub, which conducts educational research by global collaboration to envision future trends in engineering education.

5. CONCLUSION

The paper discussed how PLM academic platforms can contribute to establishing of education models capable of creating a workforce which understands PLM philosophy and how to use PLM systems effectively to support the increasingly complex reality, as well as workforce able to work in collaborative PLM environment. In additional, the educational potential of some of the most commonly used PLM academic platforms in practice such as Aras, Siemens and 3DEXPERIENCE academic platforms are presented. Also, it is emphasized that the main benefit of PLM academic platform is that it enables the learning practices such as Project-based learning, (Digital) Problem-based learning and Experiential learning that play an important role in educating engineers in line with contemporary industries' requirements.

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