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IMPLEMENTING PDM SYSTEMS IN DESIGN EDUCATION TO ENHANCE DESIGN COLLABORATION

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ABSTRACT
Product Data Management (PDM) systems are inevitable when it comes to design collaboration. In industry, the use of PDM systems as a means to support data management and engineering cooperation is an integrative part of the design process. It is thus surprising that in design education, the focus lies on the handling of different CAD systems rather than the management of CAD data along the design process. This is particularly true for technical and vocational schools in Austria. The consequence of this educational system is that almost no design collaboration is taking place and the raise of individual designers is favoured. However, technical design processes in industry are taking place in project teams; data exchange between different parties with different responsibilities in the design process is daily business. To facilitate and strengthen collaborative design, the authors of this paper have conducted a project to implement a PDM system into the design education syllabus of different national technical schools. In a follow up project a specific Ecodesign case serves as a basis for implementing collaborative design among involved schools. Therefore, the implemented PDM platform is enhanced with functionalities to allow for environmental evaluation of the design concepts. This paper gives an overview of the enhanced PDM functionality, discusses the experiences gained during the project so far, and presents a survey that shows how much the system was accepted by students. It concludes for further adaptations and best practices of the platform for Austrian vocational schools and technical universities.

Keywords: CAD, ecodesign, PDM, product development, vocational school

1 INTRODUCTION

Product design in industry is usually taking place in teams. The complexity of a product or economical considerations during product development sometimes requires the collaboration of geographically distributed, intercultural and interdisciplinary teams. The use of PDM systems is inevitable during this process, as multiple parties are involved representing different competences and performing specific tasks. Any change of a particular part or component in the product can be communicated via a PDM system, may it involve communication to the supplier, the development engineer or the purchase department.

Technical and vocational schools play an important role in the education of technically skilled employees in Austria. While these employees usually have profound design skills, skills for design collaboration are shortcoming. To provide an environment where capabilities for design collaboration can be trained, our research group at Vienna University of Technology has created and maintains a PDM platform for national vocational schools [1]. In this project, the feasibility to establish such a platform for schools was investigated and confirmed. Emphasize was put on configuration and customization with respect to CAD data management capabilities. While the students used the PDM system for data storage, in the current project advanced functionality of the system is trained and facilitating design collaboration between students is given special attention in order to support team oriented work. Currently, five schools in Austria are cooperating to introduce and implement this PDM platform into their design syllabus. The PDM platform is optimized for the different types of design education courses at schools and is adapted to the schools' specific needs. In particular,

students in their final year of school shall take advantage of this platform to prepare their final design projects which are commonly conducted in cooperation with partners from industry.
The constellation of the cooperating schools was carefully chosen. Each school is specialized on a particular topic, e.g. materials, production technologies or electronics. Three of the schools are using PTC Creo as their favourite CAD system, one is using Autodesk Inventor, one is not involved in design but shall provide data about material specifications. All collaborating parties use the PDM platform for the exchange of data and to communicate tasks and issues.

2 PDM-UP CASE STUDY

The current project PDM-UP (UP in German "Umweltgerechte Produktentwicklung" means Design for Environment – DfE, also referred to as Ecodesign or green design) focuses on the adaptation of the platform for successful design collaboration in schools spanning design projects with special respect on DfE. This topic was chosen to leverage further advantages of the PDM system usage and thereby convince students of the added value. Developing products in regard to their environmental performance is becoming more and more important in industry [2]. A particular goal of the project is to provide students with add-on functionalities for environmental evaluation of their design concepts which the CAD environment (different CAD-systems are in use) is not capable of. The existing databases in the PDM system are complemented with environmental databases containing environmental impact indicators such as indicator for global warming expressed in gram-CO_2-equivalents or Cumulative Energy Demand (CED), expressed in MJ. Experiences gained by the authors in previous projects with teenagers aged between 15 and 18 indicated that these two impact categories are most tangible for these ages. The platform itself is optimized to allow the consideration of the processes in the products' life cycle, from use of raw materials to end of life processes, to attach metadata to CAD files and ease file sharing and communication between design collaborators. Four important steps are followed in the project:

1. Systematic analysis of products in regard to their environmental performance: To help the students in evaluating the environmental impacts of their concepts, an abridged Life Cycle Assessment (LCA) methodology was incorporated into the PDM system.
2. Integration of environmental database into the PDM system: To access environmental impact indicator values and life cycle inventory data, the database Ecoinvent [3] is integrated into the PDM system. Students are only confronted with the indicator values for materials and processes. Life Cycle Inventory (LCI) data is used for the development of the system's internal algorithms for environmental evaluation.
3. Design collaboration between schools: A real product has to be designed through collaboration of students distributed in different schools. Each school is assigned a particular component based on the competencies they have.
4. Analysis of the acceptance of the PDM system: It is important to understand how much the system is accepted in design lectures (intra-school application) and/or inter-school design projects.

Since most students were not familiar with the concept of ecodesign, an introductory workshop was organized in the schools to give insight into the topic. Through the project, students are continuously supervised to help them to accomplish step 1 for their design task. By integrating LCA into PDM, students are provided a powerful tool to analyze the environmental impacts of their design [4]. As a real design task, the collaborative design of a new cordless drill driver is considered in step 3 of the project. It is divided into its four main components: 1. Housing, 2. Drill chuck, 3. Gear, and 4. Power unit. Each school is responsible for the design of one main component; one school provided material specifications for the new design of the drill driver. In this step, the PDM platform is continuously improved based on the requirements for efficient collaboration. Usability, functionality and acceptance of the PDM platform are investigated in step 4 to conclude for a platform concept that has the potential to be an integrative part of the design lectures.

3 ADAPTED SYSTEM ENVIRONMENT

To ease the handling of the PDM system and to provide capabilities needed for the case study, an easy process to extract, visualize and communicate analysis information is needed. Business Intelligence (BI) and reporting tools are capable of fulfilling these requirements. BI systems usually have three main purposes: 1. Providing data, 2. Analyzing data, and 3. Presenting data. The open source application Pentaho [5] provides all necessary features relevant in the scope of this project.

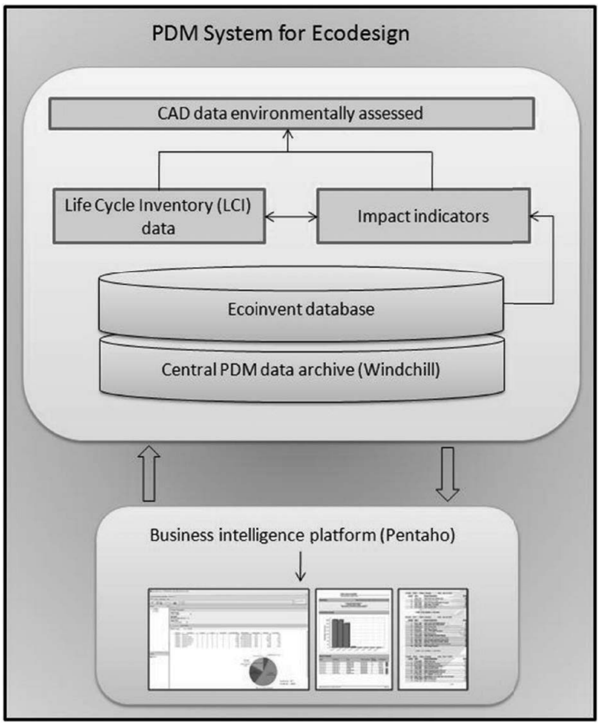

Figure 1. Final architecture of PDM system [4]

For the purpose of this project it is important to conclude to an architecture that can be implemented in any of the participating schools; a concept that fits into the design lectures and at the same time would allow for an efficient collaboration between the schools. Additionally, the concept should account the schools for bringing in their competencies and communicating between the collaborating parties. It is important to provide a tool that can be used by any of the schools, regardless whether they are contributing to the project by designing in CAD or not. Even the fact that different CAD systems are used should not hinder students to properly share their results and outcomes. The final architecture of the adapted PDM system is shown in Figure 1.

In order to facilitate easy file sharing among different CAD systems, to retrieve data for environmental evaluation and to generate reports, it is necessary to track were relevant data (coming from the CAD systems and containing information such as material or mass) is stored in the central data archive of the PDM system. By applying reverse engineering methods this problem has finally solved been [4]. A number of reports have been created in Pentaho to deliver the relevant environmental data which can be analyzed by students in order to improve their design concepts. Due to the web-based architecture of the system, users have access no matter in which location they are working.

Providing a proper tool environment that satisfies the different cooperating schools is a very delicate task. On the one hand the tool should be a specific one to fulfil the requirements set by the schools and the project (easy handling, environmental evaluation, proper reporting). On the other hand, it has to be general enough to actuate each school to bring in its competency.

4 EXPERIENCES

In a first workshop both topics, PDM systems and the concept of Ecodesign, were introduced. Most students had some background regarding these topics, but had no practical experience. To make environmental evaluation more tangible for them, a practical example of an electronic toothbrush was exercised. By providing CED indicator values for the relevant life cycle data of the toothbrush, the students were able to calculate the life cycle impacts of the product. Based on the result, improvement strategies to reduce the environmental impacts for the toothbrush were developed. Analogies for the cordless drill driver were pointed out. Further workshops were carried out in order to address problems and to get insight in the design progress of the cordless drill driver. In addition, regular meetings with the involved school staff allow the direct integration of feedback from both, students and staff, into the PDM system.

During the supervision of the students, it was found out that they were willing and motivated to design the given tasks by using a CAD system. However, when asked to use the PDM system, many of the students were overwhelmed with the rather complex handling of the system. At some point of the project, the PDM system degenerated to a simple data exchange tool. With this picture in mind, some students favoured to use data exchange tools such as Dropbox® to shift their data. The other advantages of the PDM system were sometimes even neglected. A first survey was conducted among 76 participating students to find out about the acceptance of the PDM system in the design education. They were asked about usability of the system, the added value of integrating such a system into the design lectures and about the time effort to use such a system amongst others.

A particular aim of the questionnaire was to find out whether the acceptance of the PDM system solely depends on the system itself or the way it was taught and introduced in the lectures.

The students surveyed were aged between 17 and 19, where 46% were aged 19. These were students in their final year of school and were particularly interested to evaluate whether the PDM system is of any advantage for their final design projects. When asked about the usefulness of implementing PDM systems into the design lectures, some 28% considered it as less useful or even not useful whereas when asked for the usefulness for final design projects, 65% considered it as very useful or useful.

The optimization of the virgin PDM platform through integrating the reporting tool helped the students to better handle the platform. Figure 2 shows the interface of the reporting tool. Some 73% rated the usability of the platform as very good or good. However, almost 50% indicated that by adding a PDM system to the design lectures and the obligation to use it has raised their workload considerably.

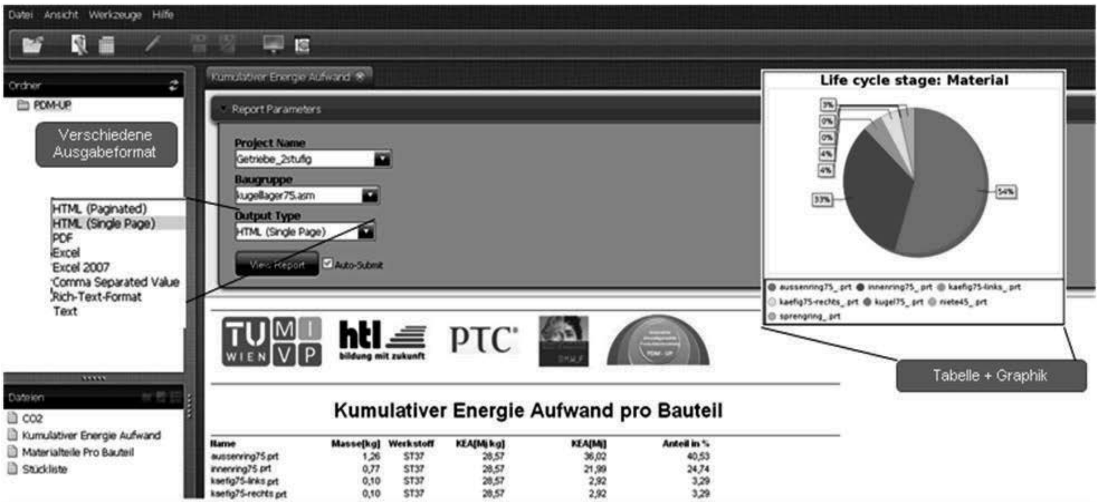

Figure 2. Interface of the integrated reporting tool – The figure shows life cycle analysis results for the life cycle materials

On the other side, the willingness to use the PDM system is also high, since some 80% agreed on the fact that by using the system, they have gained more competencies in the design process and 90% were stating that the use of PDM should be part of the design lectures already in the third school year after the basics of design and technical drawing have been educated in the first and second year.

In general, the use of the PDM system in design lecture was perceived quite positively, although some comments indicated that more time should be allocated to the teaching of the system.

5 CONCLUSION AND OUTLOOK

The experiences we have gained through the project so far, in particular regarding the acceptance of PDM systems among the students, were confirming our previous findings in projects conducted with students in university and engineering designers in industry. In all cases, the involved parties were asking for supporting tools to optimize their design process but were barely willing to take additional workload. Engineering design is already a complex process; any additional supporting tool has to be intuitive, provide rigorous results, and has to ease the work right away; although learning mechanisms positively affects the handling of a tool over time, most users do not appreciate tools that require long learning periods. In another project for an international crane manufacturer, where the integration of an environmental evaluation methodology into the design process was investigated, the requirements for any methodology were set very tight by the design department: only a very limited set of additional parameters shall be considered and analyzed. This requirement led to the development of a parametric model, where the definition of a set of parameters would give the environmental performance of a crane [6]. It seems that the trend is to have a very complex and rigorous methodology presented in a very simple and intuitive way.

This was also the findings in a study conducted by Collado-Ruiz and Ostad-Ahmad-Ghorabi among students in university, showing that for environmental design, information regarding environmental issues should be based on rigorous analysis, but be communicated in a simple manner to allow for creative ideas during design and re-design processes of products [7]. Findings in the project discussed in this paper confirm that for students in schools this assumption also holds true. The students, in particular those in their final year, were seeking for a professional tool for design collaboration but the original virgin PDM platform seemed too complex to handle and added too much to their workload.

For any tool or methodology to be successfully integrated into design, the effort clearly lies on the developer's side. Complex tools requiring long learning periods are outdated. Those tools will either be completely declined or their full features will barely be used efficiently. As much as consumers are demanding easy to handle and intuitive products, engineering designers require processes and tools that are as much intuitive as the products that are the result of these processes.

For the case of PDM systems, our research group has started further efforts to ease data exchange processes, ease environmental analysis for engineering designers and to provide a clear structure for communication between design team members. The motto is not to provide all information or any information that might be of any use sometime in the design process, but rather provide only that particular information which is needed in a particular process step in the most efficient way. A second survey will be conducted after the aforementioned improvements have been implemented. By then, the design of the cordless drill driver will be finished and a feedback from the students regarding the use of the PDM system will be most insightful.

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