The Use of Product Data Management (PDM) Software to Support Student Design Projects

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Abstract

Industry recognizes the central importance of managing and sharing CAD data within the organization, and powerful Product Data Management (PDM) systems have been developed to address this need However, engineering schools have been slow to adopt PDM technology, and student design teams typically rely on a variety of ad hoc approaches to manage shared CAD data. To address the PDM requirements of student projects, the University of Western Ontario acquired and deployed PDMWorks in January 2006. PDMWorks is a midrange PDM system for SolidWorks. Installation and administration of this midrange product are very straightforward, and its tight integration with SolidWorks makes PDMWorks easy to use. However, PDMWorks is best suited to relatively small workgroups, and does not scale easily to large numbers of users.

1. Introduction and Background

In recent years, engineering design has shifted to a collaborative approach, often involving geographically distributed teams. Engineers now use a host of CAD tools to design, manufacture, and support products from "cradle to grave". Traditional paper-based engineering documentation systems are inadequate to manage the exponentially growing amount of complex data and information that must be managed and shared. Product Data Management (PDM) software systems have emerged to help address this growing problem.

Changes in engineering education are mirroring these trends. Many introductory engineering graphics and design courses now emphasize team-based projects incorporating: parametric modeling of complex parts and assemblies, managing and sharing CAD data, and preparing engineering documentation and reports. Wiebe [1] recommends team design projects to expose students to the problems of managing shared CAD data. He identifies the need for PDM software, but the requirements he identifies are quite basic and can be addressed using ad hoc methods described later in this paper. Frame et al. [2] present strategies for integrating Product Lifecycle Management (PLM) processes into the classroom. They also emphasize team design projects, and recommend the use of PDM software to manage shared CAD data. However, they have not implemented PDM at their institution.

A few engineering schools are beginning to incorporate commercial PDM systems into their curriculum. Rensselaer Polytechnic Institute introduced PDMWorks into their introductory Engineering Graphics and CAD course in 2000 [3]. However, it was used primarily as an on-line file repository. The Department of Computer Graphics Technology at Purdue University introduces students to several commercial PDM systems [4]. In 2003, Georgia Tech used ProjectLink PDM Software from Parametric Technologies Corp. to support an experiment in multi-school design collaboration [5].

Like most engineering schools, the University of Western Ontario has been using modern CAD software for team design projects for many years. We have recently adopted SolidWorks as our standard CAD software in the Department of Mechanical and Materials Engineering. Other available software includes I-DEAS, Unigraphics NX and Pro/Engineer. We recognize the need for PDM software, and have

recently acquired PDMWorks. This paper discusses the functions and benefits of PDM, surveys existing methods for sharing files, and describes our initial experience with deploying and using PDMWorks.

2. Functions and Benefits of PDM

Many papers can be found describing the functions and benefits of a PDM system [6, 7, 8]. PDM systems are still evolving, but the following are considered minimal requirements for PDM :

1. Data vault and document management
2. Workflow and process management
3. Product structure management
4. Internet-enabled

Data vault and document management
PDM systems incorporate a "vault", which is a secure repository of CAD data and other product information. The vault is typically implemented using a relational database. Access is strictly controlled, and authorized users must "check out" files to work on them, and then check them back in. Other users cannot make changes to data that has been checked out. The PDM system manages relationships between files. When a user checks out an assembly, the assembly model and all of the associated part models are checked out and downloaded to the user's computer. When the assembly is checked back in, the new versions are created in the vault for any files that have been modified. A complete version history is maintained, and previous versions are still accessible.

Workflow and process management
In a team project, responsibility for different subassemblies and parts is typically assigned to different team members. Changes made to one model will affect other models, so all team members must be notified of design changes.

CAD models typically move thorough stages such as "in-work", "for review", "approved", "released", etc. Workflow systems support these processes by notifying people of changing status, implementing electronic approval, routing files as needed, modifying access rights, etc.

Product structure management
A product structure is typically represented in the form of a bill of materials (BOM). This corresponds to a CAD assembly model consisting of multiple parts. Complex relationships or references exist between different files in a CAD model. CAD software and PDM systems are aware of these relationships, and can manage the project structure. PDM systems allow data of all kinds to be linked or associated. In a parametric CAD model, a change to a dimension on one part will propagate changes through the rest of the product structure. When an engineer opens an assembly or drawing model, all of the links to the associated files must be maintained.

Students are unaware of the complexity of CAD file management, and this is exacerbated by the fact that CAD software does a good job of hiding this complexity from them. Most CAD software creates a product structure by recording the location of referenced files as the model is constructed. These files are usually located in a user directory on a local or network drive. Students naturally assume that an assembly or drawing file is self-contained, whereas it actually contains complex references to other files. If any of these files are moved or renamed, the references are lost and the file cannot be opened. This is a source of confusion and considerable difficulty for students attempting to share CAD data.

A typical scenario involves a student transferring an assembly or drawing file to another user. When the recipient tries to open the file, it cannot open because it cannot find the referenced files. The same file opens perfectly for the sender, who is unaware there is a problem.

Internet-enabled
For geographically distributed teams, it must be possible to access shared CAD data over an Internet connection. For practical purposes, we can consider a PDM system to be Internet-enabled if it supports a connection to a vault server over a TCP/IP connection. It is not strictly necessary that access be through a web browser, and often proprietary client software is used. Virtually all modern PDM systems are Internet-enabled.

3. Ad Hoc Approaches to File Management

In the absence of a true PDM system, students find many alternative methods for managing and sharing files within a design team. People tend to choose the approach they are most familiar with, rather than the best approach. When limitations are discovered, users develop ad hoc "work arounds" rather than abandoning

the method. Ad hoc methods of file management work reasonably well for self-contained files like Word documents and Excel spreadsheets, but break down quickly for more complex CAD file management. Some of the most common methods are discussed below.

Email file attachments
This is perhaps the most common way to distribute and share files. It is simple and widely understood, but has many drawbacks. Distributing a file to multiple recipients immediately creates multiple instances of a file, with no mechanism for version control or reconciliation. If an assembly or drawing file is sent, it cannot be opened because it cannot find the referenced files. In some instances it is possible to zip the necessary collection of files, which are unzipped on the recipient's machine. The required procedure is complex, and is rarely described in the CAD software documentation.

Peer-to-peer file sharing
Many students also like to send files using peer-to-peer messenging systems like Windows Messenger. The same problems exist as with email.

FTP
FTP is an internet protocol allowing the sharing of files over a network. FTP provides access control, but has no versioning or check-in/check-out facility. Files must be downloaded for editing, and then uploaded.

The Western Formula SAE and Mini Baja teams store their shared CAD files on an FTP server. The files are organized into directories corresponding to subsystems (chassis, suspension, brakes, etc.) Team members download copies of required files, edit them locally, and upload the modified files. By default, the revised files overwrite the previous versions unless different file names are manually created. Notification and coordination between different designers is informal and ad hoc.

Assemblies and drawings are managed by duplicating the directory structure on the server and on the local drive. To work on an assembly, the assembly file and all of the associated part files are downloaded from the server.

Removable media
Files are frequently shared using the modern variant of "sneakernet". Students save the files on a CD-R or USB drive, and share the files with their teammates. In some cases, the USB drive itself becomes the file repository. Often, a single student assumes responsibility for all CAD modeling for the team.

Shared network folders
Shared network drives or folders provide a simple way to share files within a team [9]. Shared network folders provide access control, and basic check-in/check-out. If a user has a file open for editing, it becomes available as read-only to other team members. Access is restricted to computers connected to a Windows LAN domain, so students with laptops or home computers cannot access the shared folder. Furthermore, much of the desired PDM functionality is missing.

Web folders
Web folders are a Microsoft technology that allows directories or folders located on a web server to be accessed as if they were normal network folders. The main advantage is that anyone with an Internet connection and user account can access these folders. Web folders provide access control, and allow editing in place without downloading and uploading. Figure 1 shows the SolidWorks Open from Web Folder dialog box. The assembly file and related part files are all located on the web server, and are accessed using a URL rather than a drive letter and network path.

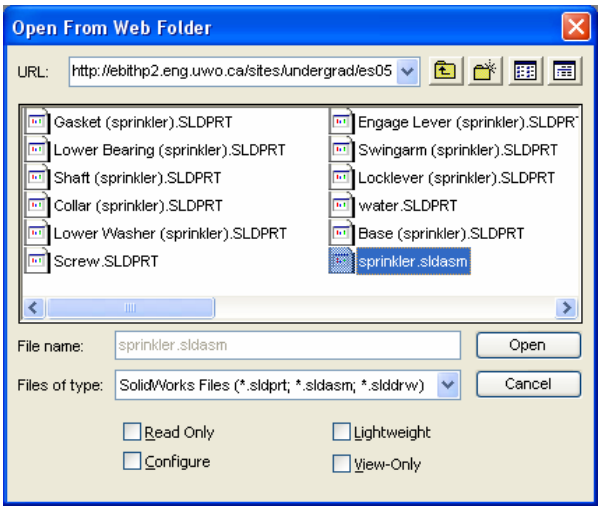

Figure 1 Opening an assembly from a web folder

SolidWorks has the option to save local files to web folders. If an assembly model is saved to a web folder, the user has the option of copying the referenced files to the server as well. A sample dialog box is shown in Figure 2.

SolidWorks web folders maintain product structure, but offer no version management or check-in/check-out facilities.

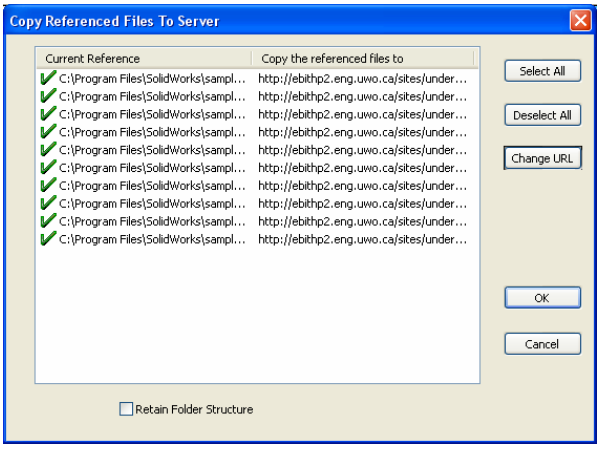

Figure 2 Copying referenced files in an assembly to a web folder

Microsoft Sharepoint

Sharepoint is a web-based shared workspace with many collaboration tools, including shared document libraries [10, 11]. Sharepoint provides access control, check-in/check-out, revision management, and many other collaboration facilities. Sharepoint is not designed to manage product structure, so files are can only be opened or downloaded individually. Figure 3 shows a view of a SharePoint document library containing SolidWorks part and assembly files.

The Sharepoint document libraries can be accessed as Web Folders from SolidWorks, but Sharepoint version management and check-in/check-out are not integrated with SolidWorks. If version management is enabled, a new version is created every time files are a saved to the web folder whether they have changed or not.

Proprietary file viewers

Another approach is to allow team members to view CAD models, without the ability to change them or to incorporate them into other models. Some viewers can open and view CAD files in native formats. Others use a proprietary format. File viewers often support only one CAD package.

Figure 4 shows a screenshot of the iSeries Professional visualization client from UGS. It uses a proprietary JT file format, which must be saved from the originating CAD software. The JT format is intended for visualization rather than CAD data sharing. JT is being promoted as an open standard, but vendor support is still limited.

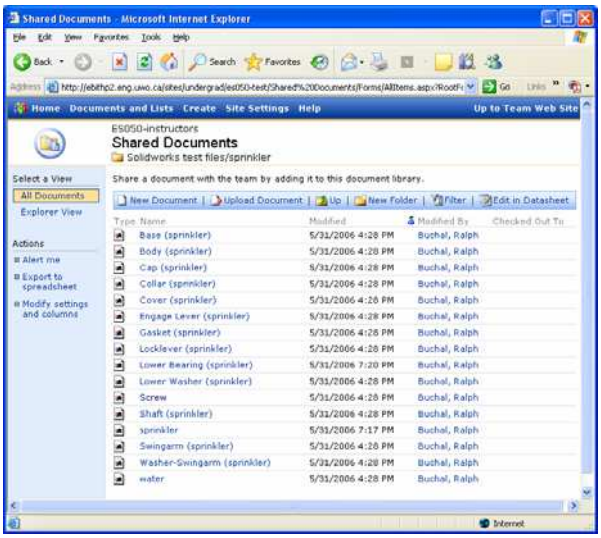

Figure 3 Document library view in SharePoint

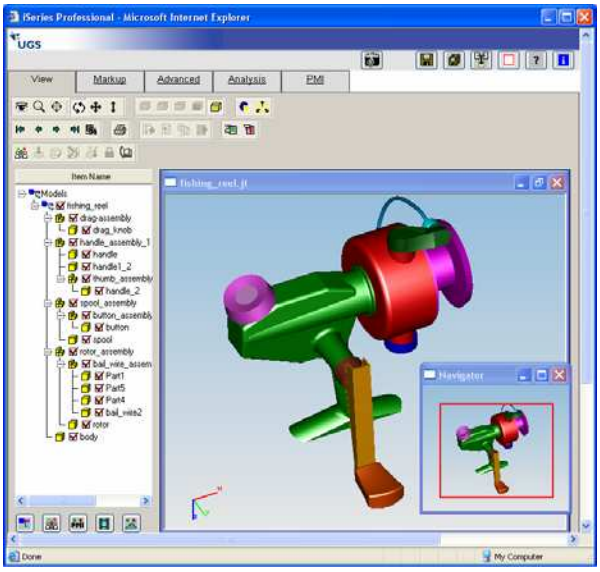

Figure 4 iSeries Professional CAD viewer

4. CAD Data Exchange Standards

A CAD model contains much more than just raw geometry. A part model contains additional information including a feature tree or history, parametric relationships, geometric constraints, etc.

Assembly models contain mate or assembly relationships between constituent parts.

All mainstream CAD tools use proprietary data formats. If members of a design team are using different CAD software, they cannot share native files. The solution adopted by industry is to save and share files in an industry-standard neutral format. The most common formats are IGES and STEP. IGES is an older standard that is being replaced by the newer and more robust STEP. Some vendor-specific formats like DXF, STL, ACIS and Parasolid are also widely used for data exchange.

While these formats are widely supported, they typically encode only model geometry. Important model intelligence, including parametric, constraints, feature trees, and assembly relations, are lost.

5. PDM Adoption and Implementation Issues

While PDM systems address many of the CAD data management problems facing student design teams, they are rarely found in academic environments. There seem to be several reasons for the slow adoption of PDM in engineering schools.

PDM software is expensive, and complex to install and administer. Many PDM products are targeted at large companies, with vendors offering extensive (and expensive) consultation, configuration, customization and installation services. Many PDM systems are complex and difficult to learn. For student use, the software must be easy to use.

Vendors have been slow to recognize the need for PDM software in engineering education. Often PDM is not a part of their academic software bundles, and vendors do not actively promote PDM to educational institutions.

Educators and students manage without PDM, and do not fully appreciate the concepts, functionality and benefits of PDM. CAD data management requires a new way of thinking about and working with files. The process of check-out and check-in is not immediately intuitive, and experience is needed. It is very difficult to gain this experience and understanding without using a PDM system.

There is little if any teaching material or textbooks covering the concepts and use of PDM. Vendor websites are vague, and little third-party information exists.

6. PDMWorks – a Case Study

To address the PDM requirements of student projects, the University of Western Ontario acquired and deployed PDMWorks Workgroup in January 2006. PDMWorks is a midrange PDM system for SolidWorks [12]. PDMWorks is intended for small engineering workgroups.

Installation
PDMWorks is very simple to install, and installation can be completed in a few minutes by a non-expert. During installation, a "vault" location is defined. The vault can be on a local drive, or on a network server. In addition to the vault, user and administrator client software is also installed.

The PDMWorks license is managed by the SolidWorks license server, so no additional license configuration is required provided that SolidWorks is already installed. PDMWorks is not included as part of the standard SolidWorks academic license, but the additional cost for PDMWorks is very reasonable.

PDMWorks is included as part of the SolidWorks educational software bundle, and it can be installed during SolidWorks installation. Students may install a local vault and the administrator client on their own computers if they wish. However, they have administrative access to only their local vault.

To deploy PDMWorks, we installed a global vault on a network server, with carefully restricted administrative rights. Only one vault can be installed on a given computer.

Administration
Users with administrative privileges can perform the following tasks:

- Create user accounts. These accounts are separate from existing Windows domain accounts.
- Define user groups and access rights (read only or read/write).
- Define projects. These are repositories for specific team projects.
- Assign users to projects.

- Define lifecycle workflow rules.
- Set various options.

The vault settings dialog box of the Vault Administrator client is shown in Figure 5. Other administrative functions have their own tabbed dialog boxes.

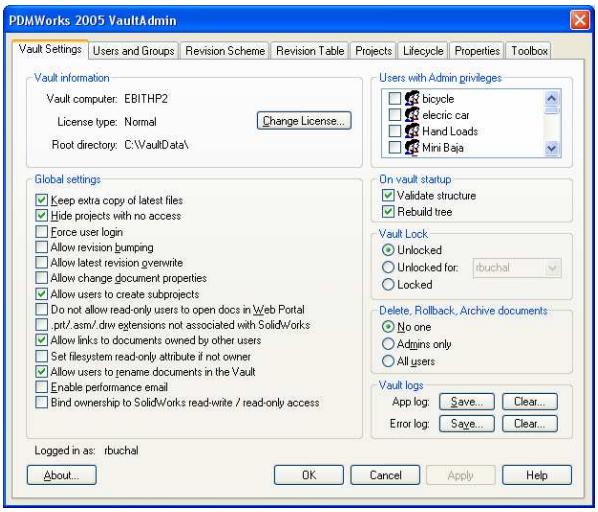

Figure 5. PDMWorks Vault settings dialog box.

Using PDMWorks

PDMWorks can be run using either a stand-alone client, or from within SolidWorks. SolidWorks provides a step-by-step tutorial on both administering and using PDMWorks.

When launching PDMWorks, the user is prompted for a login name, password, and vault host name. The vault host name is a standard Internet host name. While this capability is not advertised by PDMWorks, the software works over an Internet connection and is not blocked by most firewalls. This means that students can access the vault from off-campus and from wireless laptops, and are not restricted to computers on the LAN.

PDMWorks associates metadata with CAD documents, including: document name, document location, document owner, document revision, date last modified, document file type, notes, references, where used, configurations, and name of the project. PDMWorks allows management and viewing of metadata associated with both local documents and documents in the vault. Figure 61 shows how metadata is displayed in the stand-alone client. Figure 72 shows the PDMWorks vault view within SolidWorks.

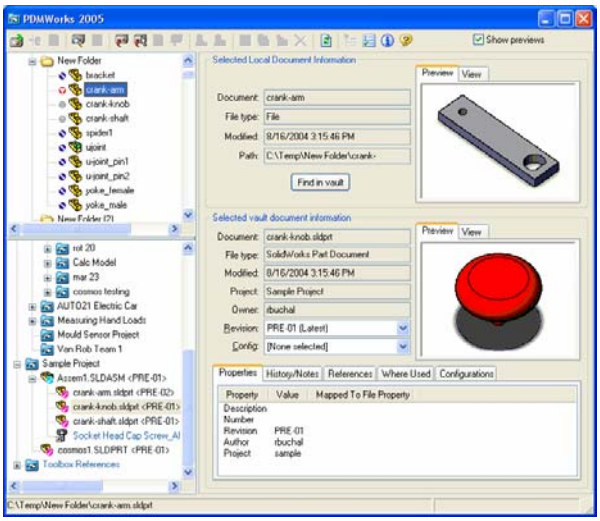

Figure 6. PDMWorks stand alone client

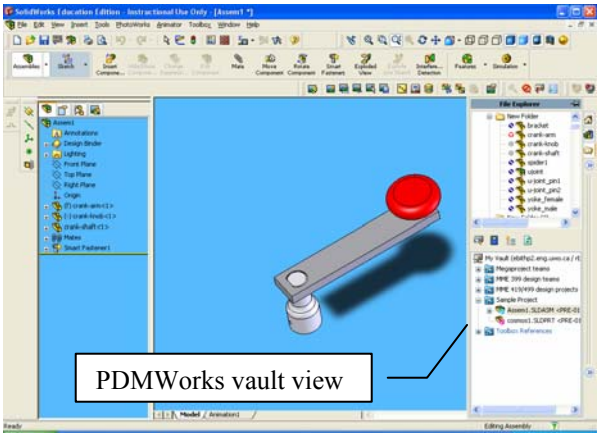

Figure 7. PDMWorks client within SolidWorks

When a file in the vault is opened and checked out, the file is downloaded from the vault to a local folder. If an assembly or drawing is opened, all of the referenced files are downloaded as well. PDMWorks compares the documents on the local drive to the documents in the vault, and gives the user the option to overwrite previous versions with the latest versions from the vault. The Open Document dialog box is shown in Figure 8.

A file can be opened only by its owner. If the owner wishes to release a file for someone else to work on, he or she releases ownership. This file can then be

checked out by someone else, who then assumes ownership.

A user works on a local copy of the CAD model. When a user wishes to update the vault, the file is checked in. The modified file is uploaded, and a new version is automatically created. All previous versions are automatically saved, and the user can roll back to a previous version at any time.

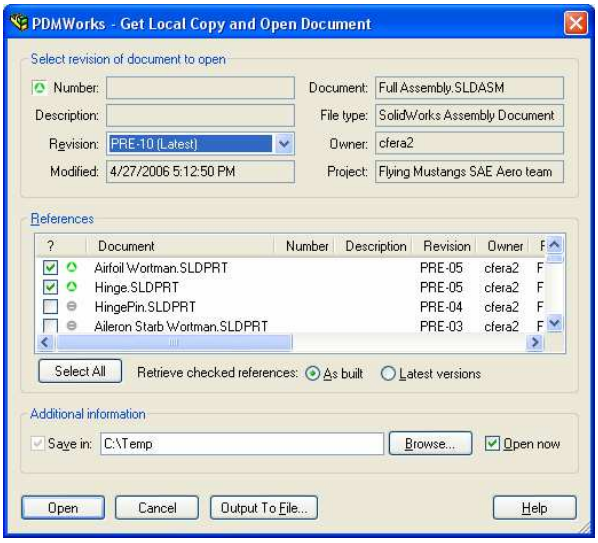

Figure 8. PDMWorks open document dialog box

Limitations

PDMWorks is compatible only with SolidWorks, and cannot manage native CAD data from other CAD packages. This makes it unsuitable for project collaboration involving different CAD packages.

PDMWorks is a midrange PDM system best suited to small workgroups. It is easy to administer and use, but has some serious limitations when the number of users and projects increase. The vault has a single global user list, which is difficult to manage for a large number of users. There are no facilities for filtering or sorting the user list. Adding users to projects is achieved by selecting the project name, then scrolling through the global user list and assigning checkmarks to the desired members. In a large class with hundreds of students and dozens of projects, this would be unworkable.

All user accounts must be added manually through a dialog box. User names and passwords must be created for each user. The current version of PDMWorks cannot make use of existing Windows network accounts. This is not a significant issue if there are only a few users, but becomes a serious limitation if accounts must be created for hundreds of students.

PDMWorks administrators have global control of the vault. There is no way to assign administrators to specific projects. As a result, administrator privileges are very powerful, and it is risky to grant these privileges to more than a few trusted individuals. This increases the administrative load.

PDMWorks is intended for small workgroups, so it is not clear how its performance will scale up to large numbers of users and projects.

Our experience so far

So far, our experience with PDMWorks is limited. It has been used for several third-year and fourth-year design projects. The Western SAE Aero team has adopted PDMWorks to manage their CAD data (Figure 9). The Formula SAE and Mini Baja teams will evaluate it over the summer, and will likely migrate their existing and new CAD data to PDMWorks by Fall 2006.

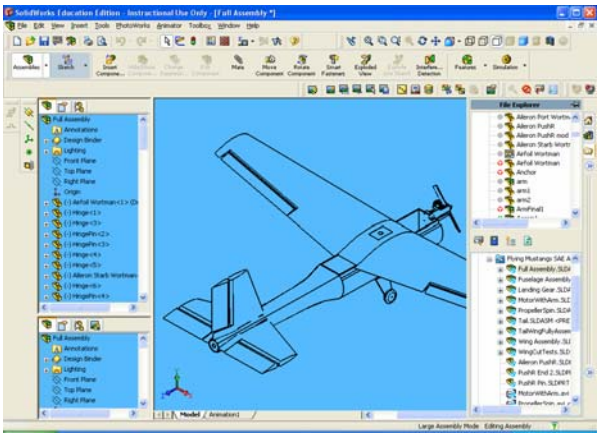

Figure 9. The full assembly model of the Western SAE Aero plane

7. Conclusions

PDM has become an essential complement to today's CAD tools, and it is important that engineering students gain experience with this technology. Ad hoc methods are inadequate for managing the CAD data of a student design team. PDM tools are becoming easier

to install, administer and use in an educational setting. Our experience with PDMWorks shows that it is easy to install and use, but has important limitations when scaled up to a large number of users. It is well suited to the needs of small student design teams, but would become difficult to administer for larger undergraduate classes.

8. References

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