APPLICATIONS FOR CLOUD-BASED CAD IN DESIGN EDUCATION AND COLLABORATION

Jeff BARRIE
University of Bath, United Kingdom

ABSTRACT
This paper investigates and evaluates the use of cloud-based CAD in the academic context, comparing it against existing CAD software tools and cloud-based PDM vaults. It aims to guide industry and educators who require insight into the particular needs and issues associated with CAD provision, collaboration and industrial practice in academia.

Keywords: Computer Aided Design, Collaboration, Cloud-based design.

1 INTRODUCTION

Understanding how to use and apply CAD software is a fundamental skill for all engineering and design students. It is important that students not only learn the fundamental basics, but also the new and emerging practices adopted in the industry. This includes increasing integration into PLM/PDM technologies, in-built CAE tools and direct modelling. Engineers and designers rarely work alone, and it is often necessary to work alongside partners and collaborators on a CAD assembly for project work. This often is problematic, when students work remotely (locally or globally), use different CAD files and do not work from a shared digital space. A new trend in CAD is cloud-based interfaces, where most (if not all) 3D part and assembly modelling is performed via a web-browser. Some of the benefits of these systems include enhanced part and assembly creation and editing, as well as cloud-based collaboration with other users.

In general, communication technology now utilises the cloud for enhanced collaboration. For example, Dropbox and Google Docs are used for shared storage for documents and files. Google also offers 'apps for work' such as Google Drive to share files between devices and team members as well as Hangouts for video meetings, screen sharing and presentations. Dropbox Business offers similar collaboration tools for syncing and sharing. Cloud-based CAD also ties into the emerging industry 4.0 research field of cloud-based design and manufacturing (CBDM).

2 TRADITIONAL CAD PROVISION & COLLABORATION

A recent Global Design Exercise between the University of Malta , City University and University of Strathclyde [1] indicated a proficient use of cloud based 'design tools' such as Whatsapp, Google Drive, and Dropbox as well as communication tools such as Facebook and Skype to facilitate aspects of the collaborative design process. This included brainstorming, sketching and concept evaluation between local and global teams. However, the CAD modelling process was conducted by a single person with input from other team members, mostly via Facebook and Skype. It was observed that the use of cloud tools increased in the latter stages of the design process, but the CAD modelling process seemed to be disconnected from the collaborative aims of the study, despite the sharp increase of information and design decision making at that stage.

Perhaps it may have been more efficient for one user to perform all the CAD modelling quickly, possibly due to time constraints and expertise, but overall it can limit a team's overall contribution to the activity and can put a lot of burden on one team member to complete a specialized task.

Product Data Management (PDM) and Product Lifecycle Management (PLM) tools are prevalent within the CAD process. However, only a few tools offer cloud-based storage and collaboration. For example, PTC's Windchill on-demand is a cloud-based PLM software that bypasses the usual restrictive infrastructure setups associated with other tools. Apart from the usual part revisions and Bill of Materials (BoM) management it offers little in the way of collaboration tools. Much of the CAD

review process is handled by viewers (e.g Creo MCAD) for drawing markups and design decisions dictated in a very process driven way.
CAD viewers (for example, Solidworks eDrawings viewer) can offer different levels of enhanced collaboration, visualization and decision making, such as exploded views, cutaway sections and the ability to markup 2D and 3D models on multiple devices (even augmented reality for mobile platforms). However, these models are lightweight versions of their true CAD counterparts and ultimately the design changes are made off-line with the CAD software itself. Viewers offer little capability of modifying CAD collaboratively in real time (see Fig.1).

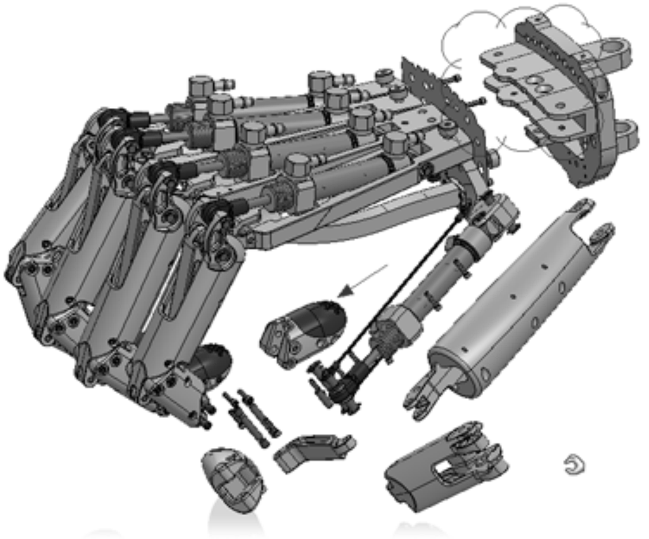

Figure 1. Markup tools in SolidWorks eDrawings

This is similar to many review tools offered by non-cloud PLM packages, for example Siemens XpresReview (for NX and SolidEdge) uses watered down JT files. The closest match to real-time collaboration is the NX modular design tool for part design, where the CAD user can work concurrently with other users on a complex part. Despite being a relatively new venture for NX, the idea of modular design of a CAD model, even over the internet, has been explored for over a decade [2]. There are apparent limitations to the modular design tool in NX, in that more complex parts are more difficult to edit, and that it is more useful in understanding feature hierarchy and dependencies [3]. Another limitation is that the users are making changes in real-time but blindly, in that the part owner and other contributors cannot see what they are all doing until the part is consolidated. Without supporting communication tools (such as Skype or a message based chat system) it would be difficult to collaborate effectively. Another decade old CAD tool that facilitates this feature is CollabCAD [4], which also includes other interesting elements such as ‘para-synchronous’ sharing [5].
One major issue is that collaborative teams may be using different CAD packages, some of which may not be compatible with certain PLM/PDM packages and viewers. A cloud-based PDM system that supports multiple CAD formats (and remains neutral with certain CAD vendors or applications) is GrabCAD, which offers a free collaboration platform to manage and share CAD files. The software offers traditional version control, BoM’s and part management, but with more enhanced collaboration tools for distributed teams and CAD communities, such as chat-based conversations attached to files and visualization over multiple platforms. It also offers mark-up and communications tools, email alerts and the functionality to overlay CAD model versions to view what has changed. GrabCAD has the potential to be a real contender for an easy-to-use, cloud-based CAD collaboration tool for student projects (See Fig 2.)

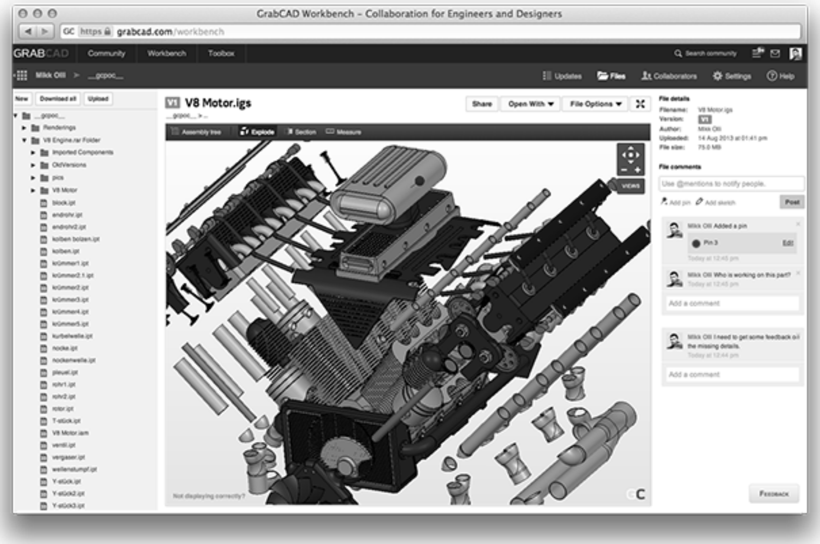

Figure 2. Web-based interface for GrabCAD

Software like Windchill and GrabCAD is distributed as Software as a Service (SaaS) and as such is not tied into node-locked annual licensing or floating licensing for CAD applications. GrabCAD, in particular exists in the same cloud-space as Google Docs and Dropbox and as such is distributed on a membership account basis. In this respect, the software (and its content) is not owned or managed by an institution, as would a traditional set of seats or licenses for CAD applications. This indicates a sea change in how students now utilize technology and drivers in the CAD market. A University could purchase 1000 licenses of a particular CAD software, but the cost of maintaining a license server, as well as 1000 high performance CAD workstations for large cohorts of students, could be problematic. Reflecting on the CAD/PDM challenges discussed by Martin Geier et al [6], a good range of mobile workstations and laptops comfortably support CAD software, and are within the budget of many students. With more students than university PC's in many Universities, there is a growing demand to support CAD and licensing remotely, and the specifications and software use on individual devices are going somewhat outside the institutions control.

SaaS is proving to be popular in the solo-user and small-to-medium enterprise (SME) CAD market; SolidEdge now offers monthly subscriptions and different tiers of specialization. This indicates that CAD provision is becoming more flexible and user-focussed, to meet the demands of a new generation of designers and engineers. Despite provision changes, as well as linking and syncing with cloud-based PDM/PLM and collaboration tools, many CAD applications are still outcasts. Collaborators can review and mark-up 3D models, suggest changes, twist and tweak models on viewers or web-browsers but ultimately the design changes are performed off-line in the CAD software. They can talk to the cloud, but they do not 'live' on the cloud-until now.

3 POTENTIAL OF CLOUD-BASED CAD IN EDUCATION

Cloud-based CAD applications offer functionality where most (if not all) 3D part and assembly modelling is performed via a web-browser. These systems are distributed as SaaS (software as a service), rather than a costly node-locked annual license or infrastructure heavy annual floating licensing. This setup is ideal for single users, consultants and Makerspace/Fablab provision and could have wider implications in student and academic use. There are two current and well know cloud-based CAD packages in the market; Autodesk Fusion 360 and Onshape. Firstly, Autodesk Fusion 360 is a cloud-based CAD product from the Autodesk suite (which also includes AutoCAD, 3D studio Max and Alias). It offers industrial and mechanical design applications in the form of surfacing and solid modelling. The software can also operate on multiple platforms such as PC's, Macs and mobile devices.

Fusion 360 has a similar dashboard platform to GrabCAD's workbench in that collaborators can keep up to date with model and project changes in the cloud using A360. Much of the advantages of having CAD in-built into the cloud is that models and visualizations are supported by browsers enabling display on any device. This satisfies face-to-face meetings but does not facilitate global collaboration where Skype would be utilized. The CAD user interface for Autodesk Fusion 360 is akin to a direct modelling approach-focusing on fast editing and model creation (See Fig. 3)

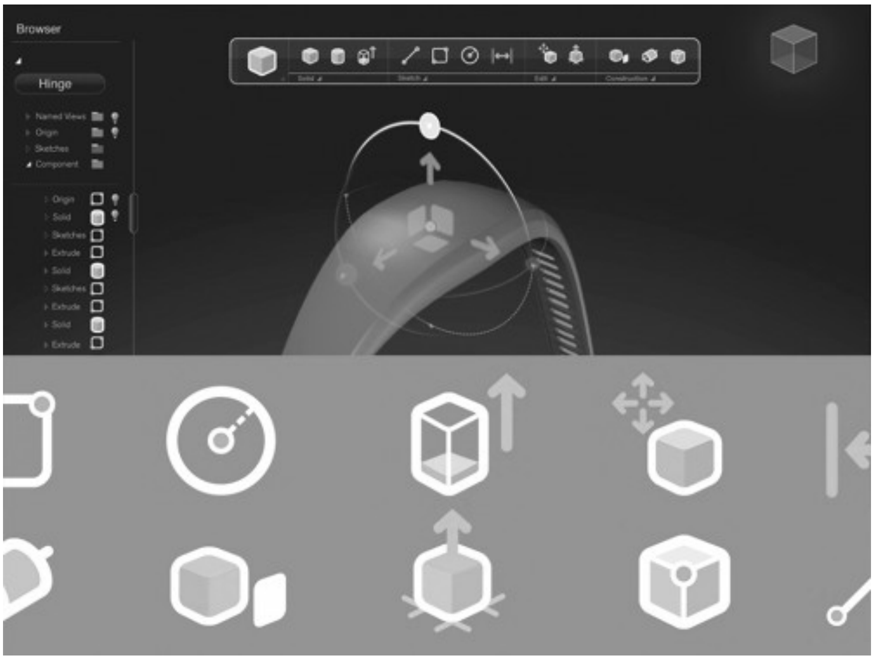

Figure 3. Fast creation and editing tools in Autodesk Fusion 360

The Georgia Tech Manufacturing Institute (GTMI) recently hosted a competition event with Autodesk, where 40 students participated in Fusion 360 workshops and 7 teams competed. Team 'D' won first prize with their "RoboLeg 5000" design (See Fig. 4). The workshop was conducted in a 24hr period and indicates Fusion 360's use in local teams in an academic setting.

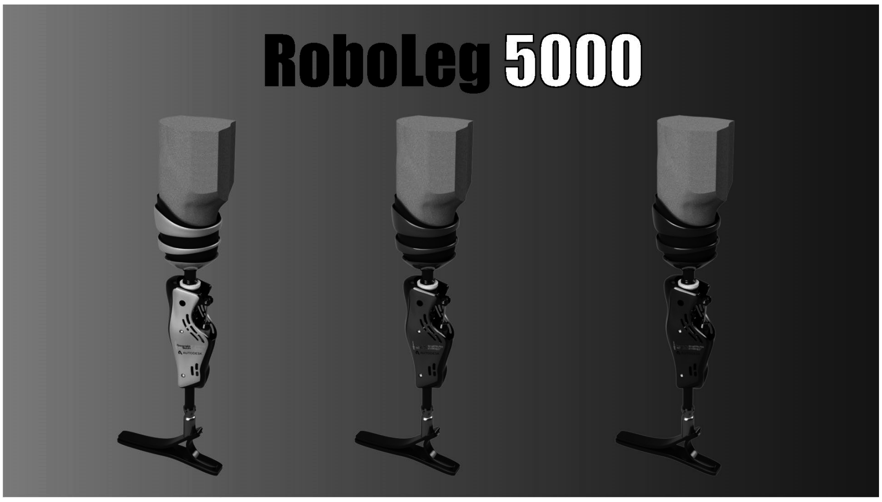

Figure 4. RoboLeg 5000, designed using Autodesk Fusion 360 by a small team of students

Secondly, Onshape is another cloud-based CAD application which claims 'full-cloud' based CAD and collaboration. Instead of traditional 3D part, assembly and draft files, it utilises cloud-native documents (although drafts are dwg/dxf compatible). The part-studio interface is similar to most traditional dimension driven, feature based solid modellers but offers real time editing of features between multiple engineers, with greater visibility of what is being edited in the feature tree. Teams can also build and edit assemblies together in real time.
Onshape has a small collection of industrial customers, but it's utilization in the academic field is yet to be realized. This may be due to many institutions already having a standard, traditional CAD package in place for coursework and projects. A benefit that Onshape has over traditional CAD is that

versions and maintenance are updated automatically in the cloud, meaning that users have the most up to date installations.
Postgraduate students studying ME50348 Advanced Computer Aided Design, as part of their MSc Engineering Design programme were introduced to Onshape and GrabCAD as part of their computer-based tutorials. The students were encouraged to upload their CAD designs to GrabCAD to share with the wider community. A benefit of this is that the teacher can review and keep up to date with the student's ongoing CAD development and revision changes (see Fig.5).

Figure 5. Students getting to grips with GrabCAD and Onshape

This is advisable for students' academic work, but may not be suitable for confidential projects, or class projects where plagiarism may be an issue. The benefits of using cloud-CAD in a collaborative context is yet to be explored, but could open technical barriers to locally and globally distributed teams working together. An example of successful design collaboration between students can be seen in Global Formula Racing, where two educational institutions (Duale Hochschule Baden-Württemberg-Ravensburg, Germany, and Oregon State University, USA) work together, designing two racing cars to compete at the Formula student event. The team currently stand at the top of the league table. Advantages to both Fusion 360 and Onshape packages are that they both operate on cloud-based web interfaces. This means that workstations only need an advanced browser (WebGL for Onshape), fast internet connection and RAM. It is not necessary to have an expensive graphics card or processing power. This gives cloud CAD an opportunity to be utilized on any computer on a campus, without specialist CAD hardware, which offers more flexibility and proliferation of use. Autodesk already has well-established educational licensing and Onshape is free for students. The educational benefit of this flexibility is that CAD can be brought into the lecture hall or classroom; without having to use a mobile workstation or conduct the class in a computer lab.

4 LIMITATIONS OF CLOUD-BASED CAD

As discussed, many institutions already have well-established CAD platforms in place. Changing to a new way of working may be difficult to implement. It may be also difficult to procure bulk memberships for large cohorts of students, as the SaaS packages tend to focus on solo memberships and enterprises. Although Fusion 360 now offers cloud-based rendering and analysis tools, Onshape is yet to offer such capability.
The use of cloud-documents (instead of traditional part and assembly files) may be too much of a workflow change for many traditional CAD users. Also, employers may be aiming to hire engineering and design graduates with relevant surface and solid modelling skills using well-known software. Cloud-based CAD may not yet be a good fit in such a small, emerging market. Nonetheless, traditional CAD can always be used off-line, and effective CAD workflow in the cloud could be disrupted by a faulty network or poor wifi signal.

5 DISCUSSION & OVERVIEW

Cloud-based CAD has some advantages for collaboration work over traditional CAD (Onshape more so than Fusion 360). Cloud-based CAD has the potential to be a good fit for collaborative projects and workshops (as seen in the GTMI/Autodesk collaboration). More evidence is needed to see if cloud-based CAD can effectively improve the 3D modelling stage in global teams. Overall, Onshape seems to have better cloud-based CAD collaboration features, but cloud-document workflow may be too advanced for some traditional users. Autodesk Fusion 360 offers a useful cloud-add on for its more traditional range of software. GrabCAD also provides useful collaboration features and may form the basis of a 'Cloud-CAD vs Cloud-PDM' collaboration study. From a provision perspective, cloud-based CAD in general could provide more flexible and universal access to CAD software across an institution.

6 CONCLUSION

The newly emerging field of cloud-based CAD has the potential to enhance collaboration in local and global student project teams. More evidence, literature and academic case studies are required beyond its use in GTMI. Cloud-based CAD is recommended for collaborative workshops and projects for explorative purposes but still has some way to go to replace traditional CAD workflow and licensing as yet. Onshape seems to offer the most enhanced CAD part and assembly collaboration tools over Fusion 360 and is currently free for student use. Onshape seems to be most appropriate sandpit to explore CAD-based cloud collaboration further-especially global teams. In terms of CAD provision, both applications reduce the need for advanced graphics support and processing power in workstations, which could provide more affordable proliferation of CAD access within academic institutions.

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