

# **CROWD ENGINEERING - BRINGING FULL CLOUD CAD INTO THE LAB**

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## **ABSTRACT**

Engineering and design of products is changing rapidly. Products become more complex and interconnected, engineers need to work in interdisciplinary, globally distributed, multinational teams. Many tools and services have been moved into the cloud, in private life but also at the workspace. Another probable game changer is the crowd sourcing approach to outsource work to a group of people.

At universities students are taught to design products with conventional CAD tools and attend lectures about project management, use of product lifecycle management (PLM) or challenges and obstacles of distributed product development.

With this in mind, the University of Kaiserslautern together with a partner university and an automobile company initiated a pilot project, where students have to organise the development process by themselves using a full cloud CAD software.

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

## **1 INTRODUCTION**

Engineering and design of products is changing rapidly. Products become more complex and interconnected, engineers need to work in interdisciplinary, globally distributed, multinational teams. Design Education however, still has a very traditional character. It is mainly focused on two things: Teaching design methodologies and engineering tools such as authoring design and simulation tools. In the last years, design education has started changing a bit into interdisciplinary education [1]. The integration of product data management (PDM) and product lifecycle management (PLM) into design education is also emerging. A big challenge is teamwork. Students learn how to use engineering tools, but they don't learn how to use them in distributed teams [2].

But globally distributed teams and rapidly changing tasks, which are provided to a crowd of people, are integrated into companies and their product development process. How do students use cloud tools in the product development process and how do they interact with other students? For this purpose, a pilot project was initiated at the University of Kaiserslautern together with another university of applied sciences and a major automobile company.

## **2 CROWDSOURCING**

In 2006 Jeff Howe coined the term "Crowdsourcing" [3]. He wrote "Crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but is also often undertaken by sole individuals. The crucial prerequisite is the use of the open call format and the large network of potential labourers" [4]. But why do people contribute to crowdsourcing tasks? Tran et. al. found six different motivations for crowd workers: Financial rewards, reputation and recognition, opportunities, joy and fun, contribution willingness and the "prosumer" trend, where people do not just want to use a product, but to define it [5]. Very quickly some crowd based services started to become a threat to established market players by offering cheaper prices for content. Starting at creating pictures up to research activities worth tens of thousands of dollars, many things were offered by the crowd workers [4]

Crowdsourcing is also used in a variety of industries like software development [6]. It can be found on every step of the Software Engineering process from requirements analysis, software design, coding, testing, up to verification and maintenance [7]. In recent years crowdsourcing was also used in (mechanical) engineering and product development [5], [8], [9], [10], [11].

The overall finding is that crowdsourcing engineering tasks is possible but limited. Most engineering tasks are either broken into small pieces of work before given out to the crowd or are simple to solve. With these conditions, crowdsourcing engineering tasks can be a success [10], in other cases, crowdsourcing failed because of too many workers that constantly produced wrong results [11]. The use cases showed that crowdsourcing could be used best for generating ideas or design concepts but the detailed engineering or prototyping should be done in the company itself [5], [8].

Most crowdsourcing tasks are given to single persons, but how can several people work together in a groups via internet? In 2001, Hammond, Koubek and Harvey [12] gave a good overview in the topic of distributed collaboration. The IT tools at time cannot be compared to those available today, but some findings can be applied today. Working together from distributed locations changes very much the way of communicating and decision making. A group that works together can achieve better decisions and success than one person because individual contributions are adding up, errors can be identified and corrected, the most competent group member has high influence, a focused work-approach due to a group membership and the increased amount of information, but working in groups can also has some difficulties, if errors are accepted or poor choices aren't criticized to avoid disagreement. The good thing is, the positive aspects outnumber the negative ones. [12]

### 3 ONSHAP

Unlike traditional CAD software like Siemens NX, Dassault Systemes CATIA or PTC Creo, Onshape is a full cloud and browser based CAD solution. This means no need to install a software on a computer or working with different software versions. Also it is possible to work on the same project at the same time. [13]

In the traditional approach using a CAD/PLM integration a document is locked by an author until changes are implemented and the document is again uploaded into the PLM solution. In Onshape there is no need for this since everything is server based and several people can work simultaneously, i.e. in real time, on the same data. In the context of crowdsourcing complex tasks another feature of Onshape is important: CAD data can be split up into branches, which can be changed independently. After the aimed changes are implemented, the different branches can be merged together to obtain a combination of both results (see Figure 1). This concept – originally known from software development – is a very powerful tool for collaborative CAD working.

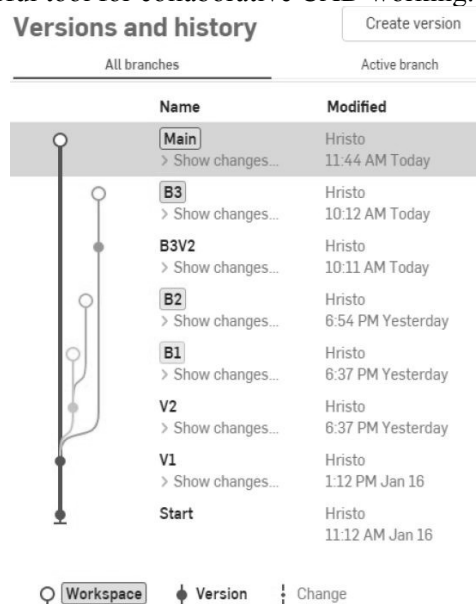


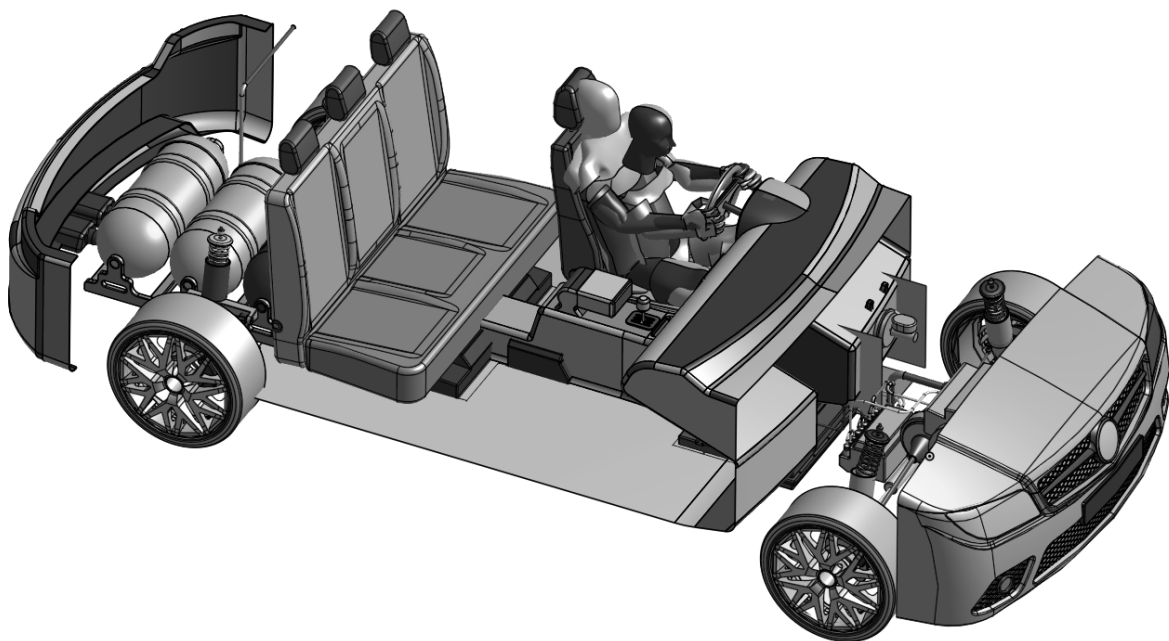
Figure 1. Versions and History in Onshape

Because Onshape is server based and completely used in a browser, every user has access to the same version of the software at any time. There are no issues of compatibility or outdated versions. Since

the computing-intensive work is performed by the server, Onshape can be accessed from everywhere on a laptop or mobile device so that the students can work at the university but also from home or on the go at all times.

#### **4 TASK & STRUCTURE**

A task was set up with two questions: First, is Onshape a suitable tool for distributed working groups, and second, is it possible for a company to get new ideas for their product development process by crowdsourcing tasks to a group of external people. A CAD model of a vehicle was provided, which consisted of several subassemblies like the motor, chassis and the trunk (see Figure 2). In this model, the students had to design a longitudinal and a cross beam in the front of the car, attach everything to the engine and chassis. In the rear section, the students also had to design a longitudinal and a cross beam, which should be attached to the hydrogen tanks and the chassis of the car. Another task was packaging: The car model needed some design changes to implement fuel cells and the hydrogen tanks. A concept where to place these modules had to be made. The fourth task was the overall data management, exporting the CAD data from a traditional authoring tool and importing it to Onshape, checking constraints, creating branches, merging the results and supporting the design tasks.



*Figure 2. CAD model used for the task*

The CAD model was provided by the partner university, but to create a crowdsourcing situation the automobile company acted as the “contractor” for the teams. In total there were 12 students involved in the project. Six from the University of Kaiserslautern and six from the partner university of applied sciences. According to the tasks four teams were formed, two at each university. Data management and trunk design teams were located in Kaiserslautern, packaging and design of the motor compartment teams were located at the partner university. This distribution was chosen to reproduce realistic crowdsourcing conditions to force the students to communicate as much as possible. A project lead team was formed consisting of company representatives, professors and research fellows to support the teams. The project duration was set to three months with first objective to see how the students establish communication, work together and handle the new situation.

All students had some CAD experience, but had never used Onshape before, so some training possibilities were offered. First the project lead team was trained on-site by an Onshape educator, to determine the possibilities of the software and some best practice examples for collaborative work. At the project start, two webinars were organized by Onshape to train the students in the basic CAD functionalities of Onshape and especially in the collaborative methods the software provides. During the webinars, the students could ask questions via a chat tool and could use this opportunity to get to know each other better. Onshape offers a lot of video tutorials on their webpage for an individual

training and the webinar was recorded and also provided to the students. This way of training was well accepted by the students and turned out to be useful for them.

Support was provided on different levels. First there is a built in support in Onshape, where parts and features can be highlighted, commented and sent to Onshape. These questions are responded by the Onshape support in the CAD model. Also the project lead team was trained and could assist the students. Because of the company support during the project time there were also some Onshape experts in a Slack channel, which was used as a communication tool. Questions asked and answered in Slack could be seen by everybody to prevent similar problems.

## **5 COMMUNICATION**

By creating four different groups at two locations we tried to enforce communication to its maximum. To support this, a Slack team was created as a collaboration platform and Onshape support channel. Slack is an instant messaging collaboration service that is specialized on companies. It can be used for a direct communication between two persons or communication in channels, which have special topics. The main advantage over consumer tools like WhatsApp is the searchable log that can be accessed by everybody. Also document sharing is easy because of integrations to e.g. Dropbox.

However, right from the beginning it became clear that communication was the biggest challenge in the project. Only few students used Slack and a WhatsApp groups was created by the students themselves as a substitute. Also, communication was established via mail and face to face within the groups and between groups at the same location.

During the project, communication was mostly on a low level between the groups from different locations. That lead to problems regarding the collaborative tasks and to students bypassing other groups. The two groups at Kaiserslautern communicated much more but mostly face to face and met when doing work.

After the project duration there was a feedback event, where the project and communication was discussed with all participants, the company representatives and professors. It turned out that the lack of communication was mostly caused by two topics: First, the poor performance of Onshape at the one location led to frustration and to a lack of communication. The biggest point was the inhomogeneous group that never had a face to face meeting and therefore were a bit reserved to talk to “strangers”. An initial “ice-breaker” would have helped a lot to get a basic understanding of each other and the task itself. Also it was clear that most students like to use communication software that they already had like WhatsApp.

## **6 DISCUSSION & OUTLOOK**

To bring the new concepts of crowdsourcing and full cloud CAD into design education a pilot project was initiated and conducted. The teams were able to fulfil their tasks to a sufficient level for this pilot project, as the main focus was to study communication between the students and the usefulness of Onshape as a collaboration tool. The biggest challenge and problem turned out to be communication between the participants at different locations. The offering of collaboration platforms like Slack or WhatsApp was not enough to strengthen communication. Also technical problems at the university of applied sciences were a big challenge. The students could not use Onshape on the university’s computers for a reason that could not be determined.

The project showed that a tool like Onshape is very powerful for collaborative work or “crowd engineering”. But self-organized groups need a well formed structure to fulfil complex tasks and generate value to companies. Face-to-face meetings offer a chance to facilitate communication strengthen the binding of all groups and clarify the tasks.

For companies Onshape is a great tool to give out tasks just to see how people outside the company generate solutions and solve tasks. As the experiment showed most of them are not ready to implement in the engineering process, but “crowd engineering” can be used as a creative process to strengthen industrial–academic exchange.

As a next step, Onshape is going to be used in a design laboratory at the University of Kaiserslautern. In this laboratory groups of 10 to 15 students have to develop and design a non-complex product from scratch. This project has a stricter time schedule with more oversight from the supervisors and a lot of face-to-face meetings. Also all students are at one location, for that reason communication and reservation against “strangers” should not be a problem.

A big challenge in the past was data management, concurrent engineering and sharing of CAD data. Often, the results of the students were not complete, sometimes more than 50% of all the part data was missing in an assembly because of poor data management. In Onshape this is not possible since all the data is already at the database. "Copying errors" are not possible. Another big issue in the past years was the different workload of the students. Some of them were doing all the work, others didn't work at all. One reason for that was the availability of the construction data, which was mostly stores on one PC and not shared with all of the group members. Full cloud CAD allows access to all the data from everywhere and allows all students to participate. With Onshape the students do not need to come to the university for further work on their CAD models and don't need to fit into the strict time table of computer labs.

A further research topic is data management for collaboration. Onshape has some powerful data management functions like branching, versioning or merging of CAD models. But in the industrial environment CAD data is organized with PDM or PLM solutions [14]. How can both concepts be connected?

## 7 CONCLUSION

Full cloud CAD is evolving and is available for industrial and academic use. It has the potential to help engineers to collaborate and work in distributed teams on one project. It can also be used for companies to generate new ideas and to strengthen academic-industrial relationship. To use full cloud CAD communication is crucial and has to be ensured in a way that is accepted by all users. A major advantage in the academic environment is the ease to share CAD data without using an oversized PLM solution, which makes full cloud CAD a perfect tool for design projects of small student groups. Also licensing is a huge advantage for universities since Onshape has a free education plan, which can be used by every student and it helps to go easy on campus resources like computer labs since it can be accessed on every (personal) device.

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