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Evaluation of Cloud-based CAD software in teaching experiments for engineering education: 3D Experience

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Abstract. Today Industry 4.0 mark the fourth industrial revolution. That's why, engineering Schools currently face the challenge to train their students for the forthcoming this new industry, which is based on the use of the internet technology. The Software-as-a- Service (SaaS) mode, a form of cloud computing, become widely used by industrials. New developed CAD solutions which are distributed as (SaaS), present a part of the evolution new generation software. Concerned about the quality of its engineering students training, Université de Technologie de Compiègne (UTC) aims to implement 3DEXPERIENCE the "Business Experience Platform» which is one of the proposed solutions in the market, instead of Catia, in order to prepare future engineers integrating industry4.0. Hence, in this paper we present a study aiming at identifying, analyzing and evaluating the capacities of Cloud-based CAD software, with an especial focus on 3D Experience. From literature review, presented in the second section, we extract criteria considered for the evaluation. After the presentation of 3DEXPERIENCE, in the third section, we experiment it in the fourth section, on the basis of extracted criteria, and we discuss the evaluation results that allow us to compare 3DEXPERIENCE to OnShape and Fusion360 already evaluated in our previous work.

Keywords: Computer Aided Design (CAD), Education, Design engineering, 3D Experience.

1 Introduction

In the context of the industry4.0, the mechanical computer-aided design (CAD) software keeps growing. The use of cloud-based CAD software offers a solution

to its users, a service that requires no software installation, no conflict in versions and license because they are used as Software-as-a-Service (SAAS). The SAAS mode consists of installing the software on remote servers. The software in SAAS mode therefore requires a good internet connection, but, since the operating “efforts” are made on the cloud, the user does not need to have a computer with very high specifications for the software to work. Thus, the publisher offers a service with very little (if at all) maintenance, a short deployment time if the software corresponds to the customer's request. The software in SAAS mode may have certain drawbacks on the data since it is stored on the servers of the provider offering the solution. In order to get an overview of what CAD software in SAAS mode can offer, we realized a comparison of two software in SAAS mode, Fusion 360 (published by Autodesk), and Onshape (published by PTC) (Gaha et al., 2021). In this paper we are focused on 3DEXperience, which is launched in 2012 by Dassault Systems. It is described as a "Business Experience Platform" and can be "available on premise and in public or private cloud" (DS, 2021).

For the software analysis we consider functionalities founded in the literature review as well as those transmitted in the geometric modelling value unit (TN20, 2021). Hence, we start by presenting the platform 3D experience, then we conduct a literature review to extract some criteria taken into consideration in our analysis. Then, an UTC pedagogical experimentation is applied on 3D experience based on extracted criteria. A discussion of the obtained results with comparison to our previous work is realized in the fourth section.

2 Literature review and evaluation criteria

Experimenting scientifically, a cloud-based software was an important step for implementing these technologies in several engineering universities ((Maranzana et al., 2012), (Fielding et al., 2014), (Bedolla et al., 2017), (Eiden and Apostolov, 2017) and (Barrie, J. 2016)). From literature review we have identified some relevant criteria considered to evaluate this type of software. Junk and Kuen, (2016), consider in their literature review work the criteria “ease of use” and “scope of functions” where a weighting factor is additionally implemented to compare between existing open source and freeware CAD systems.

The criterion "Software familiarisation", is considered by Also, Le (2018) to examine Solid-Works and Onshape based on SWOT analysis and AHP model in order to have a rational comparison.

The comparison, realized by Rassoavytska and Striuk (2018), on various cloud-based CAD software (e.g. Onshape, Fusion 360, etc.), services and mobile applications, is based the main following criteria: functionality, availability, easy access from different devices, ability to integrate with other software, support for

collaboration. The collaboration is an important criterion required for students when realizing a common project. Barrie, (2016) and Wu et al. (2017), confirmed this importance in their works.

Today, facing the use of numerous CAD software, the conversion ability presents an important criterion considered in TN20 as well as the criteria of the design modelling and some additional functionalities considered also by Junk and Spannbauer (2018) in their technical comparison realized between Onshape and Fusion 360.

Based on the literature review from one side and the TN20 from the other side, we extract the following criteria (Table 1) to consider for the evaluation of 3D experience, in order to consider it or not for the mechanical engineering training at UTC. In order to have concrete results, we attributed marks based on the importance of the functionalities required in TN20 (table 1).

Table 1. Comparison criteria extracted from literature review

<i>Criteria</i>	<i>Coefficient /10</i>
Intuitive Interface (Junk and Kuen, (2016))	6
Accessibility (TN20, Rassovytska and Striuk (2018))	9
Design Shape, Volume, Assembly (Skeleton method) (TN20, Junk and Spannbauer (2018))	10
Software familiarization (Junk and Kuen, (2016), Le (2018))	7
Collaboration (Tn20, Rassovytska and Striuk (2018), Barrie (2016), (Wu et al., 2017))	8
Conversion (TN20)	8
Additional functionalities (TN20, Junk and Spannbauer (2018))	3

3 Presentation of 3D Experience

3DEXPERIENCE is a commercial platform that hosts applications relevant to 3D modelling, simulation, collaboration and information intelligence, as seen in Figure 1. The software can be launched on a web page of a browser and includes a multitude of apps, which can be Web apps (work directly on the web browser) or native apps (require heavy installation on the computer). In the future, Dassault Systems wishes to integrate all of its apps (native and web) into the browser. 3DEXPERIENCE.



Fig. 1 3D EXPERIENCE compass tool for navigating the interface

4 Experimentation, results and discussion

4.1 Experimentation and results

Based on the aims of TN20, a student in fifth year under the supervision of three teacher-researchers, a Professor and two lecturers, who teach TN20, with collaboration of three teachers, tested the 3D experience functionalities extracted above on a project semester have been already done on Catia, Creo in TN20 and on Onshape and fusion360 in our previous work (Gaha et al., 2021). The case study considered is an automotive spring damper (Figure 2). Each extracted criterion is scored when using 3D experience to attempt the final design of the considered case study by comparing it to its design on Catia V5 and Creo Each experiment team member mentioned above give a score for each criterion. The final attributed score for this criterion is the average.



Fig.2 Product case study (Spring Damper)

The marks, shown in Table 1 for the evaluation of the functionalities of 3D Experience, were given keeping in view the fact that the software would be used by novice.

For the first criterion “the intuitiveness” we find that the first use is tricky. Indeed, in order to use Catia via the 3D Experience, it is necessary to install Catia workshops on the computer, via "apps". These are cumbersome installations, and the point of cloud-based software is lost, so it will require a student to have a computer with high specifications. Installation is done workshop by workshop, which can take time. In addition, the installation settings of the apps are not clear: a simple window opens with very few options for installation. Other features are harder to use. Indeed, the general ergonomics of the platform is quite difficult to understand at first, if the user wants to launch Catia for example, it will take some time to understand where to find the launcher app. Hence, despite the easy use of Catia once it is operational in the 3D Experience, where we find the same workshops (Part design, volume, Generative Shape Design, or even Assembly Design) and navigating through these workshops is rather easy, we attribute the score 4/10 because it is not intuitive for a novice user.

The conditions of use of the software has an impact on its accessibility. 3D Experience requires the installation of on-premises apps, and the use of software in the cloud. Installing on-premises software requires a personal computer certified and compatible with good performances. It is also necessary to have a good internet connection since the installation of the various apps is done by download. It is functional on many browsers such as Google Chrome, Mozilla Firefox, and Opera. The ease accessibility to a software, for a student from his personal computer, is an important criterion. Which seems not to be the case of 3D experience, especially when updates are done. Moreover, the most encountered problem is the lost of some data when DS make updates and it is necessary to wait minutes to re-access, sometimes we are able to reconnect on our account if it was not disconnected from another computer. As a result, 3D Experience is rated 3/10. This criterion is important from the point of view of time between collaborative groups working on a common project in TN20.

Once previous problems are overcome, the classic functionalities required for the UTC mechanical engineering training are affordable. Indeed, solid modeling is affordable for a CAD novice because the user is not overwhelmed with features on the screen (figure 3). The feature drawings are more visible and it is therefore easier to find the desired features. The modeling is done in the part design workshop, which is the same as on Catia V5. The main difference is on the organization of the features. Where Catia features in the 3D Experience are classified and it is not the case on Catia V5. However, this classification is not very useful. Indeed, the features are not necessarily arranged in a logical way, we can find the fillet and chamfer features in the “refine” sub-section while the “basic function” sub-section would lend itself better. You can also find the revolution feature in the "model" sub-part and in the "basic functions" sub-part, which may raise questions about what "model" really is, because most of the features of this sub-part are also present in the “transform” sub-part.



Fig. 3 Solid modeling of some components of the Spring Damper

The shape design is done in the Generative Shape design workshop. Figure 4 present the shape design of a car shock cap. In order to design it, we integrate an image as a sketch support for the cap profiles. Like any CAD software allowing to work in surface, the curves guides made it possible to make a sweep, then the surfaces were thickened.

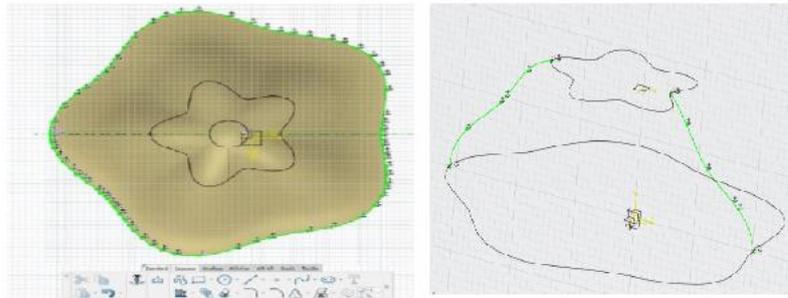


Fig. 4 A shape design case study (Spring damper cap)

A product assembly takes place in the Assembly Design workshop (figure 5). We can note some differences, in particular at the level of the connections between the various parts, which are made by mechanical connections (spherical, cylindrical, pivot, ect.).

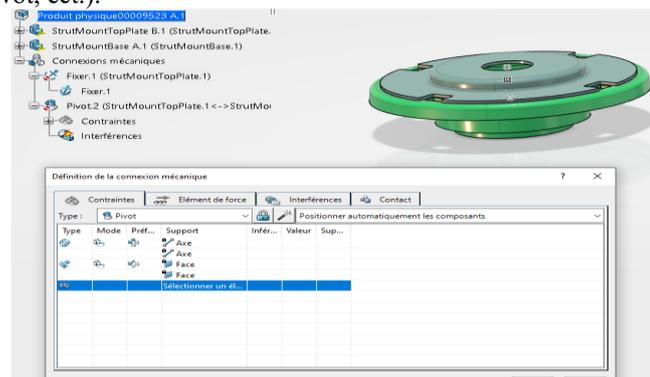


Fig. 5 The assembly operation of the spring damper components

A feature specific to the assembly of parts has therefore been added, which greatly facilitates assemblies between parts. The operation of the workshop remains the same as on Catia V5 (product, component, publications, ...). The rating given to 3D experience for the “design” criterion after experimentation, is 8.3/10.

The criteria "software familiarisation" considers the required time for a novice user to adapt to the software. In 3D Experience, the multidisciplinary makes the platform difficult to learn. Thus, the adaptation time is rather long. Indeed, understanding the search for apps or for shared content (or even our own content) takes long time. In addition, some features are difficult to learn, such as upgrading. However, due to its similarity to Catia V5, users will not be lost, although the interface changes a bit. This version of Catia is more accessible than the old one for a CAD novice due to the more intuitive ergonomics. However, it will still require some adaptation time, especially for the launch of Catia. For this criterion the platform received a score of 7/10.

3D Experience collaborative system is not very intuitive, compared to traditional CAD software. It can be explained by its multi-domain side. There is a system of directories, in which we can save our various contents. These directories are called “Collaboration Space” and are accessible via the 3D Space. Due to issues with the 3D Experience, UTC has few collaboration spaces, and students using the 3D Experience must save their content in the same space. A collaboration space can be private, protected or public. The user in a collaboration space can have different roles. He is able to be a contributor, author, or leader. These notions are theoretical and could not be used in this study due to the problems associated with creating collaboration space on UTC's 3D Experience. Hence, where the criterion of collaboration is important in TN20, leads us to rate the platform 5/10 for the collaboration criterion.

The conversion refers to the possible export and import formats. These formats allow interoperability between different software. In addition, in the context of an evolving digitization in an industry 4.0, it seems to be a fairly important criterion as well as collaboration. In 3D Experience, the parts can be exported in numerous standard format (3DXML, STEP, STEPZ, 3MF, AMF, XCGM, ICEM, IFC, IGS, MODEL, STL, VRML) and, also, the various extensions specific to Catia (SMG, SMGXML, SMGPROJ).

By default, the STEP file is STEP AP242 edition 1. The definition drawings (drafting) can be exported with different extensions (3DXML, DWG, DXF, IG2, CGM, GL2, JPG, PDF, PS, SVG, TIF) and the various extensions specific to Catia (SMG, SMGXML, SMGPROJ). The assemblies can be exported in the following extensions (ICEM, IFC, IGES3D, STEP, STEPZ, STL, WRL, CGM, AMF, 3MF, 3DXML) and the various extensions specific to Catia (SMG, SMGXML, SMGPROJ). Due to these large lists of formats we attribute the rate of 8/10.

The additional functionalities, for students in TN20, are just a plus. As it is a multidisciplinary platform, 3D Experience offers many features. We can list a some apps. It should be noted that the 3D Experience aims to take into account the

entire product life cycle. We will therefore find CAD software (Catia, Solidworks, or even XDesign), CAM (Prismatic Machining), or even simulation (apps linked to Simulia, Abaqus CAE is not integrated into platform, you can use it via a converter integrated into the 3D Experience only). You can add apps linked to the entire production process (apps integrated into Delmia, the production management software), or apps allowing you to manage projects (in Enovia). This list is not exhaustive and many possibilities are offered by the platform. It is constantly evolving platform. That's why we attribute the rate of 8/10 for added functionalities criterion.

Table 2 summarize the criteria rating of 3D experience, where the calculated average is 5.7 according to criteria coefficient importance related to the functionalities required in TN20 (table 1). The Average is calculated based on equation 1.

$$\text{Average} = \frac{\sum (\text{criterion score} * \text{criterion Coefficient})}{\sum \text{coefficient}} \quad (\text{eq.1})$$

Table 2 Technical Evaluation of 3D Experience

Criteria	Software	3D Experience mark	Coefficient (/10)
Intuitive Interface		4	6
Accessibility		3	9
Design Shape, Volume, Assembly (Skeleton method)		8.3	10
Software familiarization		7	7
Collaboration		5	8
Conversion		8	8
Additional functionalities		8	3
Average		5.7	

4.2 Results discussion

The criteria used above to evaluate 3D Experience were used also to evaluate and compare between Onshape and Fusion360. Based on the results extracted from (Gaha et al., 2021), we established the comparison graph presented in figure 4.

We note that the ratings of the 3D Experience are relatively low compared to those of Fusion 360 and OnShape (which scored 7.5 and 7.2 respectively). It should be kept in mind that, despite the efforts made to maintain a certain objectivity, the marks awarded may contain an element of subjectivity. In addition, the marks awarded are oriented in the case of educational use, directed towards learning CAD. However, it offers features that we might find in a PLM, such as check-in / check-out, versioning, tracea-

bility and part maturity they are not very intuitive. While the version upgrades of parts are automatically taken into account in an assembly on Onshape and Fusion 360 (just go and update the assembly). Those of the 3D Experience require a certain number of manipulations that call into question the traceability within the platform. Also, the export is more complicated than on Fusion 360 and OnShape.

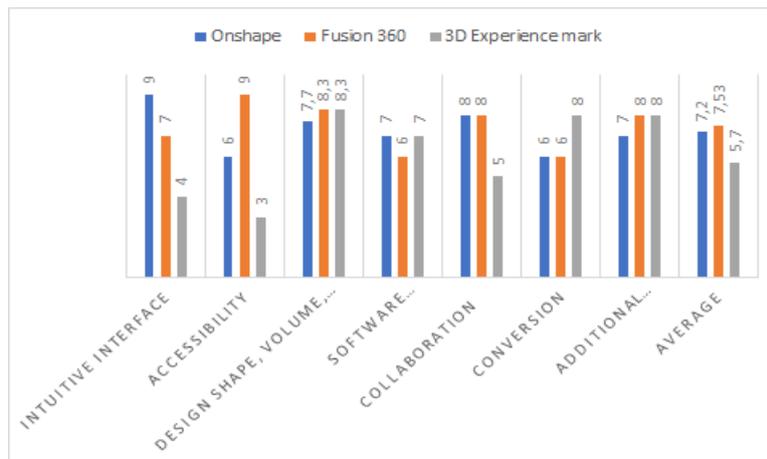


Fig. 4 A SAAS based-TN20 criteria comparison

The integration of Catia into the 3D Experience is rather well done. Catia's interface in the 3D Experience is more intuitive for a CAD novice than Catia V5, but some features are poorly organized.

5 Conclusion

To be coherent with the advanced technological evolution, we are trying at UTC to follow the industry demand. More precisely TN20 teaching unit. The widely spread using of 3D experience leads us to perform a technical experimentation on the platform in order to integrate it at the mechanical engineering training. The study object is to evaluate its capacities to be used by students in a design project. The following criteria (intuitiveness, handling, accessibility, collaboration, design and conversion) are considered in the experimentation process. These criteria are essentially extracted from the literature review as well as the aims of TN20 unit, in the first section. This study showed that 3D Experience is less attractive than Fusion 360 and Onshape. The software is low-rated on the criteria of intuitive interface, accessibility and collaboration, especially when internet connection is unstable. Like all CAD software in SAAS mode, 3D Experience is not a subject to

heavy maintenance, because software updates in SAAS mode are done directly from the software publisher's servers. It requires a heavy installation on the local performant which can potentially present a problem for students. However, it has various advantages, starting with storage. The amount of storage will depend on an agreement between a software publisher and the institution.

The result of the comparison allows us to approve the use of Fusion 360 which obtained the highest average among Onshape and 3D Experience from one hand, and considering the condition of connection stability from the other hand. TN 20 session can be ensured without worry by using Fusion 360.

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