Web-based Tools for Engineering Graphics Education

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Abstract

Two web-based computing software tools for use in the engineering graphics and CAD course at California State University, Sacramento are introduced and presented. One is a cloud-based commercial CAD tool that runs on web browsers, and the other is on the development of an in-house web-based software tool for practicing spatial visualization skills. The advantages of the web-based software over the traditional installation-based software are discussed, especially as a CAD educational tool. Also, new web-based educational software is being developed for improving engineering graphics and spatial skills. A few different types of problems can be automatically generated instead of retrieving from a pool of pre-made questions. The software is based on 3D models so that students can visualize interactively, improving understanding of the 2D and 3D mappings.

Introduction

With the developments of new computing technologies during the past decades, engineering graphics and CAD courses, once considered to be traditional courses, have recently been updated and redesigned in many universities. Adopting parametric 3D CAD tools instead of 2D drafting systems was a big step forward in the engineering graphics education. However, the sophisticated 3D CAD systems are expensive in keeping licenses as well as maintaining both the software and hardware in the lab -- especially for budget-conscious institutions providing STEM education. Another important change in engineering graphics education was utilizing the spatial visualization skills for measuring students’ 3D skills, which are essential in their engineering careers as discussed in Branoff et. al. (2012).

Recently, new technologies have driven yet another change in the computing platforms; from the local PC platform with software installed on the local hard drives, to the internet platform with web-based software remotely running in the cloud. This platform change gives users these four major advantages:

- No need for software installation as the software runs on web browsers. There is minimum maintenance in software and hardware.
- A possibility of high performance computing even with a low computer hardware specification.
Software runs on multiple platforms (Mac, Windows, Chromebook, smart phones, tablets, etc.) and students can use their own device.

Students can run Software anytime, anywhere.

These advantages are significant in an educational software tool for schools and universities. Previously, expensive CAD software was a hurdle in offering online CAD courses, but the web-based software makes it economical and accessible, even if students are remotely located using their own home computers.

In this digest, two web-based tools will be described for use in the engineering graphics course. One is a cloud-based CAD, and the other is a web-based software tool for practicing and developing the spatial visualization skills. They will be described in the following sections.

Cloud-based CAD

In the spring 2016 semester, two sections of the Engineering Graphics (ENGR6) course at California State University, Sacramento used Onshape from Onshape, Inc. (2016) as the CAD tool in the course instead of SolidWorks from SolidWorks Corp. (2016). Onshape is a full cloud-based commercial CAD system developed by Onshape, Inc. It is a feature-based, parametric solid modeling system much like other widely used CAD systems such as SolidWorks. The advantages of Onshape (cloud-based CAD) over SolidWorks (traditional CAD systems) include:

1. The software runs on multiple platforms (Windows PC, Mac, Linux systems, iPad, Android tablets, smart phones), and the hardware requirement is minimal.
2. The license is free for students and educators. No installation is needed, and new features are updated automatically simply by refreshing the web browser.
3. All data is stored in the cloud automatically and there is no save button. No local hard drive is used for storing data or files. This means that students can use different computers continuously without transferring the files. The data is not lost even when a computer is crashed or the power is out while using the software.
4. The software has a built-in data management and version control system. Users’ interactions with the software are all recorded.
5. It has a unique feature of supporting collaboration among multiple team members.

The collaboration design capability (Item 5) is a unique feature of Onshape. Multiple users can work on the same parts, assemblies, and drawings simultaneously. Each user can individually make a branch (different version) to work on, and then the individual design changes can be merged with the works of others. One user can virtually watch what other team members are working - even if they are remotely located. These features give an excellent tool for practicing team-based learning (Michaelsen, et. al. 1982, Howard 2001) or peer-teaching method (Goto & Schneider 2010, Whitman & Fife 1988, Cuseo 1997) in the class. During the spring 2016
semester, designing and modeling of a Stirling engine is assigned as a team project. Each team was composed of 3 or 4 students. Students were required to study the principles of different types of Stirling engines. They needed to design their own Stirling engine and build a virtual CAD model (using Onshape assembly). When traditional file-based CAD systems (SolidWorks) were used in the previous semesters, one or two champion students did most of the CAD modeling. Using Onshape, however, it is observed that more students were participating in CAD modeling and actively communicating with each other. Figure 1 shows a few examples of the students’ designs. Although one semester will not give any meaningful data, Figure 2 shows a small amount of improvement in the spring 2016 semester in the grade scores on the CAD part of the courses comparing with the previous 4 semesters.

Figure 1. Engineering graphics students’ designs of Stirling engines
<table>
<thead>
<tr>
<th>Semester</th>
<th>Spring 2014</th>
<th>Fall 2014</th>
<th>Spring 2015</th>
<th>Fall 2015</th>
<th>Spring 2016</th>
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<td>SolidWorks</td>
<td>SolidWorks</td>
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<td>Onshape</td>
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<td>5.8</td>
<td>5.9</td>
<td>6.4</td>
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</tbody>
</table>

**Figure 2. CAD scores in five semesters**

**Development of web-based software for spatial visualization skills**

The Revised Purdue Rotational Test (RSVT:R) (Guay 1977, Maeda et. al. 2012) is one of the popular tools for measuring students’ spatial visualization skills. But there are only a limited number of resources (practice questions) available for students to practice. Students may exercise the 30 test questions multiple times and memorize the answers by repetition. It may be desirable to have a rich pool of questions so that the students will solve a set of unique problems each time. But creating a lot of new questions for the pool is time-consuming as it involves sketching the graphics.

**Figure 3. A screen shot of a coded-plan problem**

To this end, the author is developing an online web-based tool for practicing the spatial visualization skills. Focusing on the multiview drawings, rotation test, and coded plan problems (Sorby 2011, Sorby et. al. 2003), new questions (and corresponding answers) are automatically generated dynamically each time a student attempts to practice. They are full three-dimensional models, so students can manipulate the 3D objects interactively to confirm the results, which is not possible in the 2D media such as paper drawings or pictures. Since it is a web-based tool, it shares
the same advantages of the web-based software tools as discussed in the previous sections. It is being implemented using the Three.js (a cross-browser JavaScript library/API using WebGL), written in JavaScript. Figure 3 and 4 shows screenshots of the tools.

Figure 4. Construction of multi-view drawing from an isometric view

Conclusion

The engineering graphics course at California State University, Sacramento, has been under revision since the spring 2016 semester. As a part of redesigning the course, the pilot classes used a cloud-based CAD system instead of a traditional CAD system. The low maintenance cost of the web-based CAD is suitable for entry-level college engineering courses and K-12 STEM courses. The unique collaboration tool of the CAD system enables applying the peer teaching and the team-based learning methods to CAD and engineering graphics education. Realizing the advantages of the cloud-based software, a web-based tool for practicing spatial visualization skills is currently under development. A unique feature of the tool is that questions are dynamically and randomly generated so that students will rarely encounter the same problems in their multiple trials. Unlike most of the available test questions that are sketched on 2D media, the software is based on 3D models so that students can check the 3D results interactively, providing better understanding of 2D-3D mappings.
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References


Cuseo, J.B. (1997). Tips for students when forming learning teams: How to collaborate with peers to improve your academic performance, Cooperative Learning and College Teaching, 7(3), 11-16.


Software
