

Exploring the Potential of Blended Learning in Mechanical Engineering Education

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ABSTRACT

Computer-aided design (CAD) is a known tool for all mechanical and civil engineers, and it has been utilized for decades to help carry out everyday engineering design tasks. The evolution of CAD software and various information technology tools, e.g. virtual/augmented reality or 3D printing, has broadened the amount of engineers utilizing CAD. While learning CAD is an essential part in the curriculum of mechanical or civil engineering, there is a growing interest for learning CAD in other engineering disciplines also. To extend our teaching to students from other disciplines, our teaching has to be freed from the scheduled classrooms. The development of learning management systems, with help of auto-assessment systems, allows creation of semiautonomous courses. In traditional classroom teaching, the teacher can see the progress and the challenges in the learning during the contact sessions. In online teaching, more emphasis has to be put on the feedback and assessment methods.

This paper presents the findings from the development of a place and time independent CAD course. The course teaches the basic tools and methods in the mechanical CAD education, starting from the creation of simple parts and ending with parametric design automatons. During the course, various tools are used to evaluate the student's learning and to exchange feedback.

1 INTRODUCTION

Teaching feature-based parametric modelling with Computer Aided Design (CAD) tools is a central part of mechanical engineering education [1]. 3D printing, virtual and augmented reality and digitalization have become a part of everyday life that has caused a growing interest to learn CAD in other disciplines as well. Typically, the CAD courses are heavily utilising computer classes and students' learning is assessed mostly with weekly practical exercises, small exam-kind-of-tasks or by broader final work (individually or in groups) [2]. The focus of CAD courses can vary from learning how to use the tools to how to choose the most suitable modelling technique [3]. The number of students participating in CAD courses can be quite high. For example, in our university the intermediate level CAD course has annually more than 300 students.

To better respond to the increased amount of students, more flexibility and online tools in the CAD course are preferred. The increasing capabilities of application virtualisation provide an interesting opportunity to run computationally heavy CAD software online [4]. This allows students with lower end computers or unsupported operation systems to access CAD programs. The Learning Management System (LMS) contains tools related to sharing (i.e. attachments) and to receiving information (i.e. returning box). Besides these tools, LMS allows automatic assessment in the form of quizzes as well as discussion boards for collaborative learning. [5] When LMS and automatic assessment tools are combined, an online CAD course can be created.

In this paper, an online CAD course is presented. The tools and methods utilized are tested in the traditional CAD course to collect students' feedback. The research questions are:

- What are students' perceptions for time and place independent mechanical CAD learning?
- How can time and place independent mechanical CAD course be implemented?

2 COURSE DESIGN

The online course is created on the basis of an existing CAD course (parent course). Elements of online course have been tested on this course in the previous year. The student feedback is collected with two online surveys during the course. In this chapter, the parent course, and the developed online course, are presented.

2.1 The Parent Course

Computer-aided Tools in Engineering is a 5 ECTS, 13 week long course aimed for the first year students in the fields of mechanical and civil engineering, energy and environmental engineering, and built environment. Annually, about 350 students take this course, including students from other disciplines. The intended learning outcomes of the course are:

- understanding the basics of computer aided tools
- ability to use computer aided tools.

Because the course teaches students from different disciplines, the course is divided into several modules with different aims (Fig. 1). All students learn 2D and 3D CAD during the first seven weeks of the course, and in the second part of the course, they select one of the three offered modules based on their major or interest.

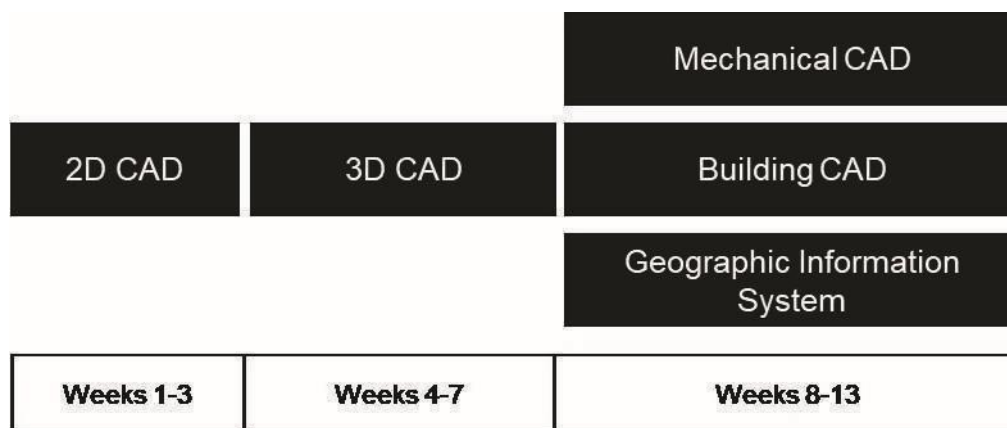


Fig. 1. The modules of the parent course.

The course contains weekly lectures and voluntary computer exercise sessions at the campus. The students are able to install various software utilised during the course on their own computers and thus complete exercises on their own. Most of the exercises are submitted thru Moodle-based LMS or auto-assessment systems, besides a couple of exercises that are demonstrated to the teaching staff. All of the course material is available at LMS. [6]

The course utilises two experimental auto-assessment systems. For the 3D CAD module, a geometry assessment tool is utilised to check that student's model's shape corresponded with targeted output geometry. In the Mechanical CAD module,

an autoassessment tool checks that the student's actual CAD model (not just geometry) behaves as designed when input parameters are changed.

2.2 The Online Course

To create an online course for mechanical engineering students, selected modules from the parent course are included. The CAD tools utilised in mechanical industry are mostly 3D, so "3D CAD" and "Mechanical CAD" modules are selected. To provide the same course length, the 3D CAD module is redefined and expanded to 7 weeks. The online course is divided into 14 weeks, each week having one main topic (Table 1).

Table 1. Weekly schedule and themes.

Week	Main topic	Week	Main topic
1	Turned parts	8	Family table
2	Milled parts	9	Sheet metal
3	Engineering drawings	10	Model Based Definition
4	Complex shapes	11	Parametrisation
5	Assemblies	12	Simulations
6-7	Project	13-14	Project

The online course is divided into two parts. The first part teaches the basics of featurebased CAD (how the tools work, how to create shapes, how to draft drawings, how to utilize assembly tools etc.) and ends with a project work, where all the previously learned tools are applied. The second part teaches efficient use of CAD (creating product families, parametrisation of models, basics of strength and mechanism simulations etc.) and ends with a project work where learned skills are utilized.

Siemens Solid Edge ST8 is software in the first part and PTC Creo 3.0 in the second part.

To trace the students learning and to receive feedback on how the exercises and tasks has been understood, is challenging. During a traditional course, the exercise sessions and lectures provide a good opportunity for this. To ensure that the student is well instructed during the weekly tasks, a weekly exercise structure is defined (Fig. 2).

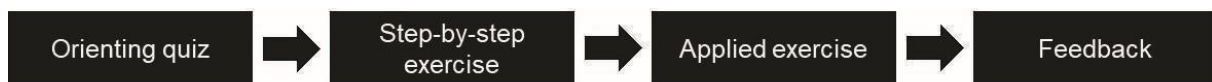


Fig. 2. Weekly exercise structure.

The week (topic) starts with an automatically assessed orienting quiz checking that the student has gone through the pre-assigned material. This can be for ex. a series of questions about engineering drawings projection rules (Fig. 3). When the student has passed the quiz, the CAD exercises are automatically opened. The exercises are submitted using automatic assessment tool or through LMS. When the exercises are done, a short feedback survey in the LMS opens. When this survey is completed, the next week is opened and the process repeated.

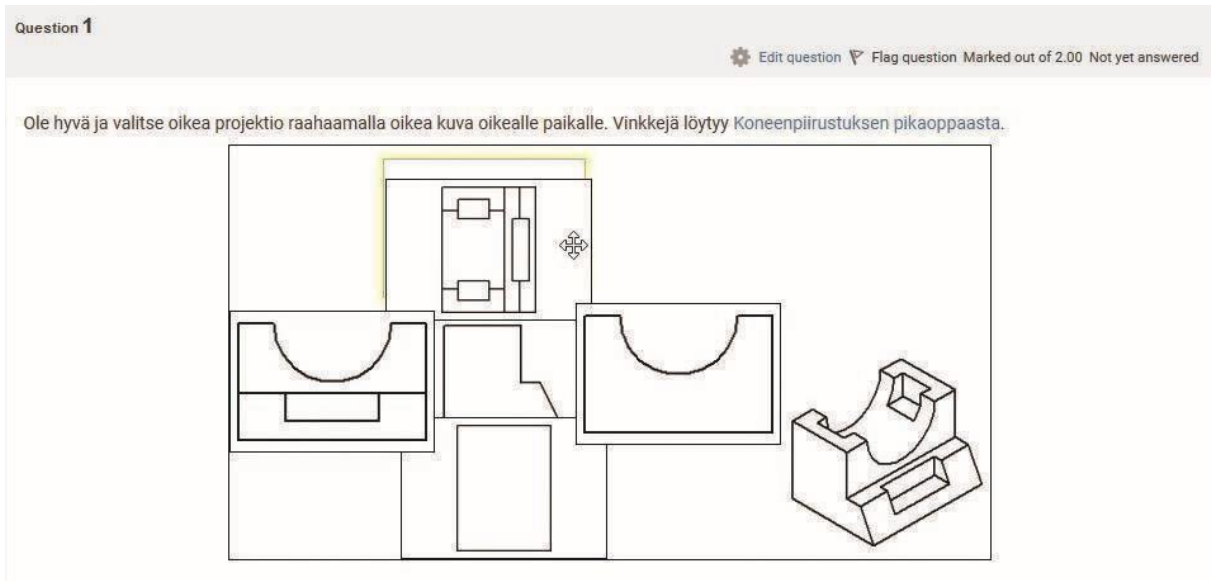


Fig. 3. An exercise about projection rules in the engineering drawings.

Assessing students' learning takes time and requires resources. The automatic assessment tools can check that the exercises with predefined outcomes are done correctly (i.e. the model has the right shape). Exercises with varying outcomes (i.e. engineering drawings can be modelled in different ways) and project works (i.e. the same devise can be modelled with many of ways) need still to be assessed manually. To help both the teaching staff to assess and the students to receive feedback, assessing rubrics are defined.

3 RESULTS

Students' attitude and capability towards online teaching was studied by two online Webropol surveys in 2018. The first (N=253), where student's possibilities to online teaching was surveyed, was carried out during the first weeks of the course. The second survey (N=236), where student's perceptions towards automatic assessment and working online was studied, was carried out in the middle of the course.

3.1 Starting survey

The students are well equipped for distance learning. 95.3% of students own a laptop computer and 96.4% a smart phone. Almost half of the students (43.1%) owned a desktop computer. Students are motivated to learn CAD and see the importance of CAD related skills (Fig. 4).

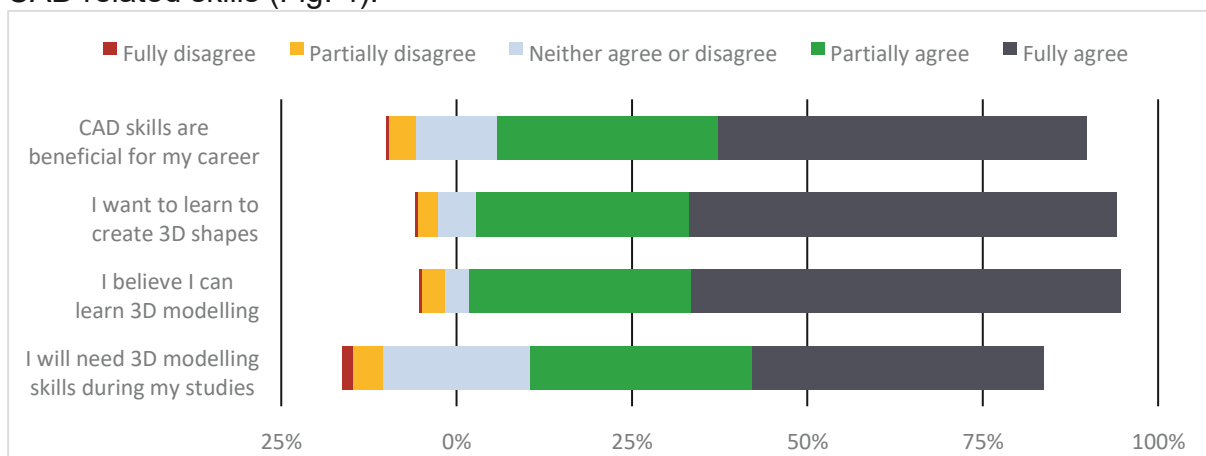


Fig. 4. Students' opinions related to 3D CAD.

3.2 Midterm survey

The majority of the students installed provided 3D CAD software on their own computers (Table 2). The major reasons not to install were related both attitude (wanted no extra software) and hardware (insufficient performance or incompatible operation system).

Table 2. Answers to survey questions related to software usage

Did you install 3D CAD software on your home computer?	%
Yes	61%
No	31%
If No, mention max three reasons	
Wanted no extra software	35.2%
Insufficient performance	33.0%
Incompatible operating software	28.6%
Did not want to use own computer	13.2%
Found hard to install	7.7%
Incompatible hardware	4.4%

When asked about submitting exercises time and place independent, two students out of total 236 didn't like this possibility. Students' preferred feedback types can be seen in Table 3. The automatic assessment system in the first half of the course gave both illustrated and verbal feedback. When asked about tolerable waiting time for the automatic assessments, students preferred a median of two minutes response time.

Table 3. Preferred automatic assessment feedback types. Scale from 1 (not preferred) to 10 (preferred)

Feedback type	Average	Standard deviation
Right/wrong	7.8	2.7
Verbal feedback	9.0	1.4
Illustrated feedback	9.3	1.1
Pointing to the wrong feature	8.9	1.6
Tells how the model can be fixed	8.0	2.2

4 DISCUSSION

Most of the students are prepared for an online course and they see the importance of learning CAD. The majority of students utilised the provided design

software on their own devices. However, there are still some attitude, hardware, and software related challenges to fully get rid of computer physical classes (i.e. transfer all teaching to online environments). With the help of LMS and automatic assessment tools, an online course for mechanical CAD education can be implemented. Students value the time and place independent teaching that an online course can provide.

Future work will contain incremental improvement of an online CAD course based both on the experiences of the teaching staff as well as on the feedback of the students. It is planned to release the online course during the summer 2019. It will be beneficial to have some peer-assessed exercises to show students different ways to model the same geometry. To achieve this, a critical mass of students is required. This can be tested when the online course has been run for some time.

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