Training Civil Engineering Faculty on the use of AutoCAD Civil 3-D

Alborz, Nakisa$^1$ and Das, Gautham$^1$

$^1$Department of Interdisciplinary Engineering
$^1$Department of Civil Engineering and Technology
Wentworth Institute of Technology

AutoCAD Civil 3-D is the most commonly used design software package in the civil engineering industry. The need to incorporate this software into various courses in the civil engineering curriculum is essential to ensure students are equipped with software design skills. The industry demand and need to incorporate it into academic coursework led to the training of faculty teaching courses such as highway engineering, geomatics, structural analysis, municipal planning, project management for engineers, and senior design capstone. The training modules were designed to address the discipline specific needs reliant on the course content and method of delivery. Training modules highlighted the software’s automated features to enable faster design processes and allow students a multitude of iterations given the parametric nature of individual projects. The training modules consisted of showing the faculty the automated features in the software such as creating topographic surfaces from survey data, using the assembly feature to generate cross-sections and further determine the volume of earthwork. The objective of this paper is to discuss the structure of the training sessions, the material covered in the different modules, the challenges in condensing various courses into individual training modules, the different assignments, the challenges that were overcome and lessons learned.

Corresponding Author: Nakisa Alborz, Alborzn@wit.edu & Gautham Das, dasg@wit.edu

Introduction

Civil 3D is an engineering software package used by civil engineers and other professionals to plan, design, and manage civil engineering projects. These projects may fall under the three main categories of land development, water, and transportation projects; and can include construction area development, roadway engineering, river development, port construction, canals, dams, embankments, heavy civil applications etc (Autodesk, 2016). Civil 3D is used to create three-dimensional (3D) models of land, water, or transportation features while maintaining dynamic relationships to source data such as grading objects, contours, and corridors. As an industry-leading building information modeling (BIM) solution, Civil 3D is well known in the civil engineering community and widely used on a variety of infrastructure projects both large and small. (Edulearn, 2016). Due to the maturity and reliability of this commercial software the current industry, consulting and government agencies are actively using this software package. As a result of this increased use, students graduating from colleges and universities are expected to be proficient in the use of Civil 3D (ABET, 2014).
In 2013, the Civil Engineering Program at Wentworth Institute of Technology (WIT) in Boston, MA became a fully accredited civil engineering program as the department transitioned from a Technology to an Engineering program. In order to meet the Accreditation Board for Engineering and Technology (ABET) criteria and to meet industry demands, numerous courses where identified and the decision was made to integrate Civil 3D into these courses. Courses such as Introduction to Geomatics, Soil Mechanics, Highway Engineering, Municipal planning, Design Studio Lab, and Land Use Management were identified. To effectively incorporate Civil 3D, it was required to train the faculty in using the software application. The objectives of this paper are to illustrate the development, implementation and results of the various training modules which were conducted for the faculty over a fourteen-week semester.

Method of Implementing Training Modules

Prior to implementing topic specific training modules for the faculty, an overview of the software was provided outlining the general uses. This was achieved by the creation of how-to guides for the faculty which outlined a step-by-step approach to using the many basic tools of Civil 3D. Once the basics of the use of the software were introduced the topic specific modules were introduced which would be applicable in specific courses. The sections below indicate the course specific approach taken in the development and implementation of the training modules.

Introduction to Geomatics

The geomatics course at WIT uses modern surveying equipment such as robotic levels, total stations and GPS units. The data may be obtained manually from field books or using data collectors and with this data traverses, contours and other terrain models are generated. The lab portion of this course was generally taught by adjunct faculty. To make full time faculty familiar with Civil 3D, faculty were shown how to download information from the data collectors to their laptops. The data was then transferred to either text (txt) or comma separated value (csv) files, which are common methods of importing data into Civil 3D. Faculty were then shown how to create traverses, generate contours and 3D surfaces using the Import Survey Data wizard in Civil 3D. Figure 1 shows an example of a contour surface created during the training session. With the Mapcheck Analysis command, faculty were shown how to survey figures and parcels for closure, based on label direction and distance values. The Mapcheck Analysis command was used to check manually inputted data for closure errors, and to subsequently adjust and create AutoCAD polyline objects. Additional information such as state mandated nomenclature for the utilities were also shown to the faculty.
Figure 1: Example of contours created during training session

Soil Mechanics

In soil mechanics one of the course objectives is to classify the soil obtained from boring logs and generate soil profiles. To create soil profiles Civil 3D has a borehole utility tool, this application in Civil 3D helps to automatically generate soil profiles, wherein users can input the boring log information directly into the software package either as AGS, .TXT, .CSV or GEF format at each of the borehole locations. To conduct the training module, the existing boring log information was inputted directly into the software and soil profiles were created as shown in Figure 2. To further emphasize the borehole utility feature numerous videos were shown to the faculty.
If the soil boring data is not available in a file format where the borehole utility can be used, an alternate method of creating the profile would be by the use of surfaces, alignment and vertical profile creation tools. Although this method is not desirable it is an alternate method which allows for easier automatic iterations versus manual drawing in Civil3D. In such a case point groups are created from which surfaces are generated from the manually entered points. The soil profile is later produced through the use of the vertical profile creation tool.

**Highway Engineering**

The goal of the training module for the Highway Engineering course was to outline the features of Civil 3D to design fundamentals such as the geometric design horizontal and vertical curves, super elevation and mass haul. The faculty were shown how to use and create the corridor feature in Civil 3D. To create a corridor, an alignment, profile, and assembly were combined to form a 3-dimensional representation of a road (Figure 3). The alignment tool was used to create the roadway, horizontal curves and super elevation parameters were generated by the software based on the design speed and length of the horizontal curves. Existing roadway profile was produced based on the location of the roadway alignment on the terrain created in earlier modules (Figure 4). To generate the mass haul, an assembly (cross-section of road along with curbs and gutters) was created and attached to the roadway alignment. The faculty teaching highway engineering course stated the use of this software reduced the class project time by 60% and allowed students a multitude of modeling iterations of their designs.
Figure 3: Corridor of roadway alignment during training module

Figure 4: Split Profile of the Roadway Profile
Faculty teaching courses related to Municipal Planning, Land Use Management and DSL used all the discipline specific training modules. WIT focuses on experiential learning hence many of the courses incorporate real life projects with short design turn around durations and real life applications. Given the time sensitivity to these projects and to ensure students are spending their time designing versus drafting the use of Civil3D automation features proved invaluable. All projects included elements such as the design of proposed topography, generation of soil profiles, roadway design, building development footprints, and watershed analysis and drainage design. The faculty of the courses indicated the use of software allowed for faster generation of design drawings as the automation allowed students to question and test their designs versus spend their time drafting using a non-parametric software.

As compared to traditional AutoCAD the faculty noted the ability of Civil 3D to generate a dynamic model of any road, rail, or corridor project by using design elements such as alignments, profiles, super elevation, and other design criteria was extremely useful as it reduced the project time by 60% of the overall time required. Furthermore, it was noted AutoCAD Civil 3D provides real-time editing of individual stations or station ranges along the road. AutoCAD Civil 3D also has an intersection creation wizard, that allows users to create three-way and four-way intersections, with dynamic offsets, and dynamic curb returns, in just minutes. Such features allow students to focus on design versus drafting hence adding value to the design process by examining their design decisions more closely through the real-time feedback from their design model.

**Results of Civil 3D Faculty Training Modules**

The use of parametric software is becoming more important in industry due to the need to provide a multitude of design iterations for various purposes including value engineering, sustainability analysis, life cycle project controls requirements such as cost and schedule and above all sound design. Hence it is critical Civil Engineering students are proficient in the use of software packages such as Civil3D. The faculty incorporated the use of Civil 3D in their courses and noted it is scalable, comprehensive multi-user project management system providing students better organization of files, distribution of files over a network, version control, check-in and check-out, rollbacks, and generation of design iterations. These features allowed students to focus on design versus drafting. AutoCAD Civil 3D includes a range of file management features that suit varying levels of project management needs—from drawing-based shortcuts and xrefs to the full-scale project management solution features. Students also welcomed the use of the parametric software as it reduced their iteration time by more than 60%.

One of the main advantages faculty noted was in the features of building surfaces. The ability to build surfaces from a variety of 3D source data through numerous data collection devices was very valuable in creating many design iterations. Analyses of contours, slope, elevation, watershed areas, volumes, and surfaces while making surface edits was greatly appreciated. AutoCAD Civil 3D updates surfaces when data is added or edited, and rebuilds the surface when data is removed. These features allow students to instantly see the results of their design
decisions giving them a better understanding of how design decisions have global impacts on their projects.

The faculty discipline specific and general training modules resulted in the immersion of the use of Civil3D in their courses. Courses such as Introduction to Geomatics, Soil Mechanics, Highway Engineering, Municipal planning, Design Studio Lab, Land Use Management and Project Management for Engineers implemented the use of Civil3D. Both faculty and students indicated the use of parametric software allowed them to truly explore design and increased their knowledge on how their design decisions impact overall project outcomes. As WIT has embraced experiential learning across its curricula, it has become ever more important to use software which is dynamic, design oriented, and allows a multitude of iterations to address various areas of concern such as sustainability in design, life cycle analysis of design features, value engineering, cost and schedule concerns and industry applicable approaches to design.

Conclusions

As WIT has increased its experiential learning endeavors across all years of study from Freshman to Senior years. The curriculum has included means and methods to address industry needs including the use of parametric modeling software to facilitate increased design iterations and for students to immerse themselves in real world projects from early on in their course of study. The Externally collaborative experiential Project based Interdisciplinary Culture (EPIC) at the institute has further highlighted the interaction of various disciplines and the impact of decisions made by discipline specific designs on other disciplines within projects. The use of dynamic software packages allows students to see these impacts quickly, hence focusing on design instead of drafting (EPIC, 2016). The results of the implementation showed that a 60% reduction was seen in the time needed to develop an alternate design given the dynamic nature of the software. Proficiency in such a program is critical for industry competitiveness and the ability of students to verify their designs in real time.

Given the results the Civil 3D discipline specific faculty training modules were a success and a critical component in students’ education. It enhanced the theory through application and modeling of design assumptions. Design is an iterative process hence students must be accustomed to providing multiple iterations and alternatives to their designs to meet industry needs and project requirements. These powerful tools provided students with dynamic real time review of the outcomes of their design decisions giving them an appreciation for the theory. The cohesion of theory and practice makes it evident students need a holistic understanding of their design decisions to address issues of sustainability, value engineering, life cycle analyses, project controls functions and sound engineering and design. Software packages such as Civil3D enhance this understanding and application as it allows for the modeling of theoretical design parameters in real time and in a short duration.

References

Autodesk (2016) “AutoCAD Civil 3 D: Model in 3D Civil Engineering Software” Website: http://www.autodesk.com/products/autocad-civil-3d/overview
Website: www.abet.org


Website: http://wit.edu/epic-learning/