Integration of Third Party Design Software in a Civil Engineering Design and Graphics Class in Construction Engineering Technology

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Abstract

The current trend of state departments of transportation is to require the utilization of third party design software in the production of design drawings for state funded highway projects. This has led to the need to introduce the use of this type of software in design classes in Construction and Civil Technology programs. The University of Toledo Construction Engineering Technology program integrated GEOPAK into synchronized CAD laboratory projects within a course that included highway geometric design as well as site and utility layout and design. This course was found to foster the ability of students to become sufficiently comfortable with the software, allowing them to take the next step in becoming fully productive with its use. Although it is far from a complete understanding of the workings of the software, students are taught how use GEOPAK to create existing and proposed digital terrain models, cut profiles and produce horizontal and vertical roadway alignments, while producing finished plan sets. Students were found to be appreciative of the delivery system of the class. It offered realistic periodic progress submittals during the development of a semester long project which required the use of GEOPAK to aid in the design. While the students expressed the feeling of being a bit overwhelmed with the additional complexities of GEOPAK, most found that they gained an appreciation for the capabilities of available software technology and its utilization as a time saving tool in the production of construction documents.

Introduction

In order to complete the transition from the quarter to semester academic calendar, The University of Toledo Construction Engineering Technology (CET) program found it necessary to revive a civil graphics class that had not been offered for several years. The reintroduction of Construction Graphics (CET-2030) into the program filled the void left by its quarter-system counterpart. This course was found not to fit into the curriculum when the University converted to a semester-based system beginning with the 1997-1998 academic year. The suspension of this class offering came at a precipice in the history of civil construction document design and preparation. During this time, changes in the way site and roadway plans were produced left the previous offering's methodology of presenting material in this course in need of a review and overhaul. Industry standards were demanding computer-aided drafting (CAD) as the presentation media of choice. Additionally, new software technology which had previously been used by a handful of progressive organizations had now become the norm. State departments of transportation were beginning to require the use of third party design software in the production

of their projects. What had previously been a convenience for time saving and enhanced accuracy was quickly becoming standard industry practice.

A case in point is the process that culminated at The Ohio Department of Transportation (ODOT) in the summer of 1996. Up to this time, ODOT had used several third party software packages to produce in-house designs in conjunction with their CAD platform of choice, Bentley's Microstation. In order to standardize the use of such software and to provide compatibility across the district offices within the state, ODOT evaluated the options that were available and chose GEOPAK as their preferred third party design software. [1]

ODOT does not currently maintain a statewide policy requiring either Microstation or GEOPAK to be utilized on state projects developed outside of the ODOT offices. Mandates can be made by district offices to specify the type of software to be used by consultants in plan preparation on an individual project basis. Nevertheless, the state's consultant population that provides designs under contract to the Department tends to fall in rank behind ODOT's preference and delivers contract documents prepared with matching software in many cases. Additionally, ODOT's goal is to convert to a paperless, electronic plan filing submittal process in three to five years at which time a policy requiring software packages will be adopted. The Florida DOT is now operating with such an electronic filing system. [2] Currently, 19 states as well as the Federal Highway Administration and the Army Corps of Engineers have adopted GEOPAK as their preferred design package. [3]

It was apparent that the acceptance of recent technological improvements in civil plan preparation, such as those shown above, was to be a guiding standard in the redevelopment of the CET-2030 class as it was returned to the program's curriculum.

Course Development, Objectives and Philosophies

After progressing through several academic years under the semester system, the CET program administrators found an area within the project management curriculum focus to combine two classes into one offering. This opened up the space and allowed the return of the Construction Graphics course, paving the way for the revamped approach to the dormant course.

The CET-2030 class is a sophomore year, spring semester offering. The class carries with it the prerequisite of the program's freshman level Architectural Graphics class (CET-1100) in which students learn basic graphical presentation while gaining an understanding of architectural plan preparation and design elements. The resurrected CET-2030 offering maintained the basic course objectives of its previously offered counterpart. Upon completion of the course, students are to have gained an understanding of both site and roadway design procedures as well as a knowledge of civil drafting methods. Specific civil engineering related curricular course elements are listed below in Table 1. Each specific subject would include the development of a drafting exercise in conjunction with the coverage of the lessons related to the specific design elements.

Table 1. Course Objective Elements

Site	Roadway
Site Geometric Layout	Horizontal Alignment Design
Site Surface Grading	Vertical Alignment Design
Site Utility Layout	Superelevation Design
Utility Profile Production	Typical Section Design
Site Details	Cross-section Production

Prior to the course's hiatus, manual drafting methods were utilized in the preparation of drawings within the course. On the recommendation of the program's industrial advisory committee, the CET program had two years prior integrated Microstation into the Architectural Graphics course (using university technology funding) in order to upgrade the program curriculum to the current level of drafting technology. The addition of CAD into the revamped CET-2030 class was the next logical step in that progression. While continuing to pursue the current technological trend, it would also aid in the expansion and reinforcement of CAD skills learned in the CET-1100 course.

It was also an easy decision to include GEOPAK within the class in light of the importance of the use of a third party design software in the industry. The software was easily procured at a reduced rate from the manufacturer by allowing a foothold to be gained in the CET program. However, difficulty arose in attempting to determine the amount of time that should be spent on GEOPAK design related issues. New ODOT design engineers receive two separate intensive training sessions, totaling 56 hours of class time, in which they thoroughly cover all aspects of the software in order to become productive in its use. Entrance into the ODOT training is based upon the assumption that the trainees have a working knowledge of civil engineering design practices and Microstation drafting ability. [4] The CET-2030 class is a 3 semester credit hour course which meets twice per week with a consecutive lecture and lab session. Only 33 contact hours are available during the lab portion of the class. It was readily apparent that the amount of time required for a full understanding of GEOPAK software would not be available to the students in this class. An alternate plan of attack was required to effectively introduce the software.

An additional objective within the design of the course was to not present the material through the use of traditional individual stand-alone lab exercises. To this end, the course was constructed to simulate a real world periodic submittal process by designing and drafting a continuous project over the extent of the semester. A single individual plan sheet pertinent to that week's subject would be submitted for a progress review at the end of each week. A final submittal of a complete plan set (at mid-term for the site project and at the end of the term for the roadway project) would require a compilation of all work to that point. This method would allow students to experience the process that occurs within a consultant's office and help to foster their ability to methodically correct and repair CAD files for their final submittals. Furthermore, the continuous project would focus students on the compilation of all facets of a design that are required in order to complete a set of civil construction documents.

Using the progress submittal approach to the course allowed GEOPAK to be introduced on a limited basis throughout the semester to aid in the production of the site and roadway projects as they progressed. While an additional class revolving entirely around GEOPAK usage would certainly have been advantageous, the introduction of the software in the design process would be viewed as an opportunity to expose students to a state of the art design technique. Due to the limited time available for GEOPAK, it was understood that a complete knowledge of the software would not be gained by students. The realistic objective of the course thus became to make students aware of the capabilities of GEOPAK rather than to attempt to turn them into GEOPAK proficient designers.

Due to the complexity of the software and its instructional manuals which are based on proficiency training, the burden fell on the instructor to summarize the design procedures through lectures and class handouts. During the design and drawing of their projects, students would be led through different GEOPAK procedures to aid in plan production. Within the site design portion of the class, GEOPAK coverage includes:

- Digital terrain model production (both existing and proposed surfaces)
- GEOPAK Site Modeler utilization
- Profile creation for utility profile detail

Coverage within the roadway portion of the class includes the following GEOPAK items:

- Horizontal alignment production
- Existing profile creation
- Vertical alignment design
- Existing cross-section production

With these objectives identified, the class was offered for the first time in its regularly scheduled slot in the spring of 2001 and again in the fall of 2001 to accommodate part-time students out of the normal progression of class flow within the program.

Results, Successes and Tribulations

A detailed questionnaire was given to the students after the final class in each of the first two semesters in which the class was offered. Requests for student opinions ranged from the presentation and delivery methods of the class material, to the grading system that was employed. Specifically, several questions were ideal in attempting to ascertain the success of the integration of GEOPAK and the continuous project delivery method from the student's point of view.

Students were initially asked to reveal their experience with drafting software prior to the beginning of the class. It was revealed that during the first semester offering containing 23 students that nearly 70% of the students had no formal Microstation experience and that 35% of the students had not had any CAD experience at all. This lack of CAD experience was attributed to the recent start of the CET program to include CAD within the CET-1100 prerequisite, in addition to the large number of senior students who registered for the class as an elective. The

second pass through the class (which had an enrollment of 6 students) contained an improved experience level. Half of the class had received previous Microstation experience and only one student had no CAD experience to that point. It was expected that future offerings would have less of a problem due to the progression of students through the program who would have had the prerequisite CAD experience.

Students were asked the following subjective questions within the evaluation questionnaire which produced the accompanying results and comments. The percentages shown have been calculated from the combination of the two class offerings together, with a total sample size of 26 respondents (22 from the spring offering and 4 from the fall).

Question: Did you like the weekly submittal method of the class? (24 responses)

Yes	92%
No	8%

Student comments:

- "The format allowed us to manage time and meet deadlines."
- "This way kept us on track."
- "It allowed us to learn things a bit at a time."
- "The feedback was constructive."
- "Weekly submittals were an integral part of the lab."

Question: Did you like the semester long project format or would you rather have had individual labs stressing certain subjects? (25 responses)

Semester Long Project	96%
Individual Labs	4%

Student comments:

- "A very realistic progression."
- "Just like a real project. It helped to relate it all together."
- "Proud to see a project I completed."
- "Gave us a chance to see what goes into an entire plan set."
- "I liked the continuous project, but a few non-related labs might help."
- "Gave a sense of accomplishment in the end."

Question: Do you feel that you could perform simple GEOPAK tasks if called upon to do so by your boss? (23 responses)

Yes	35%
Maybe	35%
No	30%

Student comments:

- "GEOPAK was very difficult."
- "GEOPAK should be used more in the class."
- "The exposure was good but the software was a bit overwhelming."
- "I think the exposure was good but maybe in another class."
- "The exposure was nice."
- "I don't like GEOPAK."
- "GEOPAK needs its own class."
- "Didn't get enough repetitions with the software."

Students were also asked to rank their level of understanding of both design and drafting subjects from the instruction that they received within the class. Ranking was performed on a zero to five scale with a value of five signifying an expert knowledge of the subject.

Table 2. Student Self-Ranking of Subject Understanding (26 responses)

Subject	Average Ranking
Site Layout	4.1
Site Grading	3.5
Site Utility Design	3.5
Site Drafting Techniques	4.1
Utility Profile Design	3.5
Horizontal Alignment Design	3.5
Vertical Alignment Design	3.4
Roadway Cross-section Design	3.7
Basic Microstation Commands	4.4
Microstation Reference File Work	4.5
Average Ranking of All Subjects except GEOAPK	**3.8**
GEOPAK Commands & Design Process	2.3

These immediate results indicate that the students were not as comfortable with their level of understanding of GEOPAK as they were with the other design subjects. They were nearly twice as comfortable with Microstation operations as they were with GEOPAK. These findings were not entirely unexpected since the goals set for GEOPAK were to provide exposure to the software not proficiency. The results are similar to those exhibited at the United States Air Force Academy when CAD was integrated in several intensities over different courses in order to avoid adding a class to the curriculum. Students were found to adjust better to the full development of CAD software throughout the entire class rather than in an abbreviated or piecemeal fashion. [5]

These results notwithstanding, the students did appear to be appreciative of gaining exposure to GEOPAK. Several other factors may have lead to the low rankings in terms of GEOPAK satisfaction. The software is extremely complex, especially in the roadway design venue. Multiple menus, toggles and a circuitous workflow that winds in and out of two and three dimensional files tended to leave the novice a bit bewildered. When leading a group of students

through any of the GEOPAK work progressions, it was sometimes difficult to determine where a student may have taken a wrong turn in order to produce the discombobulated results on their screen. Coupling the complexity of the program with university network settings resulted in a high probability for problems in any session in which GEOPAK was utilized. Additionally, since GEOPAK subjects were covered only once and were an integral part of the project design process, students who missed labs fell far behind, increasing their exasperation with the software.

On the positive side, the students did look favorably upon the project and progressive submittal methods employed in the class. The semester long workflow led them through a project which gave them the experience in the methods which they may encounter as interns or in permanent positions in later years.

Conclusion

Despite some intricacies in presenting the software, the first two semesters produced favorable amounts of exposure to the students within the class. No plans for discontinuing the use of GEOPAK in the class are currently afoot, in spite of the difficulties that it gives the students. A switch to a less complicated third party design software would be a desirable option, if not for the preferred usage of GEOPAK by ODOT. With the recent acquisition of GEOPAK by Bentley Software Systems, who are also the proprietors of the INROADS three dimensional civil engineering design software, some cross-breeding of future packages might be expected. Thus, a "wait and see" stance may be the most appropriate position in terms of software changes over the near future. Analysis of graduate needs and their level of ability in utilizing the software on the job may also be used to adjust the amount of exposure provided in upcoming offerings.

As technology continues to increase the amount of work performed in an automated method using third-party design software, the necessity for introducing the software at this level will increase. It is evident that students need to be served by exposing them to these technologies. [6] A start in that direction has been gained with this foray into the area. Even though proficiency is not obtained and the students tend to become agitated with the use of the software, the next time they see GEOPAK will not be the first time.

References

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