

Utilization of AGTEK in Construction Management Classes

Ryan Dougher

California Polytechnic State University
San Luis Obispo, California

AGTEK Sitework 4D is a building information modeling program designed to conduct takeoff and estimating procedures for earthwork purposes. This program provides an opportunity for the construction management department to implement a building information modeling (BIM) program related to heavy civil construction. Nearly seventy percent of construction management students agree that the BIM programs that they have learned during their time at Cal Poly have been directed toward residential and commercial construction. AGTEK can provide students an opportunity to learn site planning, earthwork estimating, as well as cut and fill diagrams all through a new BIM experience geared toward heavy civil construction. This program can be implemented into either CM-239 construction surveying or CM-314 heavy civil construction management as both curricula involve topics that are included in AGTEK. Students showed a stronger interest in having the program implemented in CM-314 rather than CM-239. Interviews with the current lecturers of both classes yielded two potential learning strategies for learning AGTEK: synchronous and asynchronous. Each option has its own advantages and disadvantages but after review of the AGTEK license agreement the synchronous version would be the more optimal option.

Key Words: AGTEK, Building Information Modeling, Education, Earthwork, Heavy Civil, Topography

Introduction

AGTEK Sitework 4D is a product by Hexagon that provides construction managers with a useful tool to takeoff, estimate and manage earthwork quantities for any type of project. This is a very useful tool for any type of earthwork construction. It can be used for underground utility trenches, excavations, cut and fill, highway roadwork, grading, and site work. Many construction projects that AGTEK can use with are heavy civil construction but can be utilized for commercial and residential site work. This building information modeling program can be an opportunity for the Cal Poly construction management department to present students with an opportunity to get involved with building information modeling regarding heavy civil construction. Currently earthwork topics in construction management classes are done with Microsoft Excel and with paper.

This paper has a general aim to find the potential ways that the building information modeling program AGTEK can be implemented into multiple construction management classes. Through research, the following information will be extracted: students' thoughts on the current curriculum of heavy civil classes in construction management, students' desire on which class this program should be implemented, interviews with current lecturers of the desired classes to find potential ways to implement the program, and the potential outcomes of using this program.

Background

AGTEK Sitework 4D provides three main functions: field control, project modeling, and takeoff. AGTEK allows users to import either CAD files or PDF files of civil project plans where the program takes the topography lines of the civil drawings. These topography lines can then be either edited or compared to another set of topography lines, usually the design or finish elevations. AGTEK also allows for entry of topography lines which lets users customize excavations for underground structures and trenches for underground utilities. Each set of either entered or imported topographic lines are used as a form of layers typical in CAD; however, named surfaces in AGTEK. The program allows for up to six different surfaces that can be compared to one another. Users can also create multiple views of the 2D topographic map including profile views and 3D views using multiple surfaces. Volume calculations can be utilized for takeoff purposes which allows users to compare two surfaces and the program accurately calculates the cut and fill volumes for a project. AGTEK is a program that makes estimating earthwork an easier and more streamlined process. This gives users a modern alternative to calculate earthwork as well as giving estimators an important tool to use in site planning and value engineering for projects before it is started.

Literary Analysis

Curriculum for Building Information Modeling Programs

The development of curricula for building information modeling programs for construction students is an ongoing process. The goal of BIM courses is to have students become familiar with a variety of programs that are implemented throughout the construction industry. In a recent study interviewing BIM expert on topics that should be included in a BIM course the highest response was quantity take off. (Song, Alzarrad & Kim, 2022) Another study surveying construction management programs across the country from 2011 found that the skills that are being taught most often were constructability, model-based estimating, design, and visualization. (Becerik-Gerber 2011) Building off this data a case study was developed in implementing a BIM course structure for construction engineering students. The study was implemented through analysis and selection of specific courses for BIM. The results of this case study yielded findings such as: continuous BIM education is necessary, BIM can enhance students' knowledge and capability of engineering topics, and programs should encourage students to experiment and improve their knowledge of BIM. (Pikas, Sacks & Hazzan, 2013)

In a study in developing a systematic course regarding BIM for undergraduate construction students had a main goal to develop the courses following three stages: preparation, development, and improvement. (Ahn, Cho & Lee, 2013) This model of course development benefited students and called for a steady improvement of the courses. The latter of the three stages were an important part of course development to keep the courses up to standard and as new technology and methods are introduced each year into the industry. The development and improvement of the courses were completed by BIM professionals in the industry and the course professors. One interesting conclusion of the study was, "it is necessary to investigate appropriate alternative approaches to integrating BIM into the construction curriculum (e.g., as part of existing courses)" (Ahn, Cho & Lee, 2013)

Heavy Civil Construction and Building Information Modeling

The heavy civil construction industry is a complex sector of construction mainly working for the public sector. From a variety of projects mainly revolving around infrastructure, the sector accounts for a significant portion of the construction industry. In 2019, four of the five largest construction companies based on revenue were heavy civil contractors. (Kolmar 2023) As the heavy civil sector tackles a variety

of infrastructure projects there is no doubt that there is increasing use of building information modeling for these projects.

Building information modeling has been adopted increasingly in the heavy civil industry, however not as quickly as other sectors. This may be due to the competitive bidding process which can limit competition, especially for smaller civil contractors. A study in implementing BIM in highway projects explains, “In this bidding process, there may be no room for BIM costs to win the bid” (Lee, Salama & Lang, 2012) Despite this the industry has seen an increase in research regarding BIM in this industry. The literature of the BIM infrastructure has increased twelve-fold from 178 articles in 2014 to 2209 articles in 2019. (Bu, Xu & Huang, 2020) The implementation of BIM can be utilized in a majority of public projects. The projects that see the largest use of BIM are general infrastructure, transportation, and bridges. (Bu, Xu & Huang, 2020) The BIM implementation in the heavy civil industry can improve project quality and communication, “ 4D BIM models can simulate the specific or entire process of highway and bridge construction to identify design errors, reduce uncertainties, and improve level of quality” (Lee, Salama & Lang, 2012) Implementation of building information technology in the heavy civil industry will be a slow process regardless, the benefits of the technology will improve the industry as a whole.

Methodology

With the attributes and topics introduced in the background section of this paper the most acceptable and appropriate courses that this program can be implemented into are construction surveying (CM-239) and heavy civil construction management (CM-314). With these two classes as viable courses for this program, this paper’s intent is to find the most appropriate form to teach this program and the best class to implement the program. This is accomplished through a survey of students that have completed both classes as well as unstructured interviews of current lecturers. The unstructured interviews followed three aspects:

- The current teaching method of topics in AGTEK
- Possible methods of implementation of AGTEK for students (asynchronous/synchronous)
- Lesson format for learning AGTEK (shown in Table 1) and discussion of what the project examination would look like

Lessons	Functions Covered
Video 1: Takeoff from PDF	Starting a New Job, Importing a PDF/TIF, Scaling, File Transfer Window, Check Scale
Video 2: Enter Existing Data	Existing Perimeter, Existing Contours, Spot Elevations, Stripping
Video 3: Enter Design Data	Design Lines, Offset Lines, Design Perimeter
Video 4: Enter Design Data	Snap, Line Snap, Area Snap, Sectional Areas, Report Regions
Video 5: Review Graphics	3D Views, Vehicle Controls, Profile view, Profile Entry
Video 6: Volumes	Specifying the Surfaces, Calculating Volumes, Volume Report
Video 7: Printing Reports	Configuring a Printer, Sending Objects to Print Page, Resizing Objects, Sending the PDF, Sending Report to Text File, Scaling Objects, Adding Text to Print Page

Project Examination	All of the above
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Table 1: Proposed lesson format for AGTEK implementation

For the student survey, five options were proposed for responses: strongly agree, agree, neutral, disagree, strongly disagree. The questions that were released to students are as follows:

1. The BIM programs I have learned and been involved with are directed toward commercial and residential construction.
2. I have a relatively good understanding of topics regarding cut and fill diagrams, grading, and earthwork calculations learned in CM-314.
3. I have a relatively good understanding of topics regarding site work, elevations and topography maps learned in CM-239.
4. A BIM program would help me understand topics such as surveying, grading, site work, earthwork calculations, and cut and fill diagrams.
5. Having explanatory videos on hand for directions and guidance for functions in a BIM program would be helpful in my learning experience.
6. I would be more interested in the heavy civil construction industry if a heavy civil BIM program was implemented in relevant CM classes.
7. I believe that the Heavy civil class (CM-314) should include a BIM program regarding cut and fill diagrams, site work, and grading.
8. I believe that the surveying class (CM-239) should include a BIM program regarding cut and fill diagrams, site work, and grading.

Results & Analysis

Student Survey

Question 1

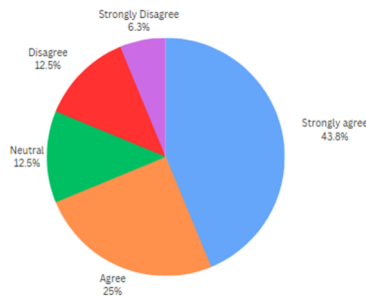


Figure 1: Thoughts on current BIM programs relating to construction sectors.

The results of this survey question showed strongly that most students that responded believed that the previous BIM programs that they have learned were directed toward the commercial and residential industry. The specialty construction option was omitted from this question. Nearly seventy percent of the students surveyed answered in the affirmative to the first question showing a lack of diversity in the BIM programs learned regarding different sectors of construction.

Question 2 & 3

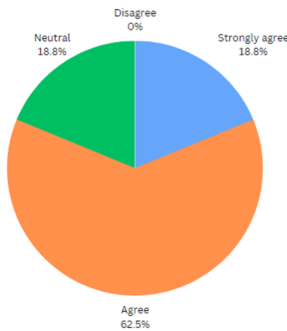


Figure 2: Students grasp on topics in CM-314

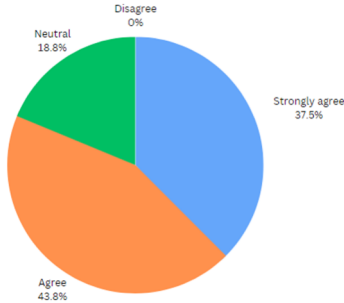


Figure 3: Students grasp on topics in CM-239

These questions gauged students' capability to grasp topics associated with AGTEK. On a positive note the students' responses showed that they do have a grasp on topics associated with AGTEK with no respondents in the disagree or strongly disagree categories. These questions show that the current curriculum in CM-314 and CM-239 have appropriately discussed and taught topics that can be further reinforced with AGTEK and provide that students will be comfortable with the program's concepts that are in AGTEK given the course's current curriculum.

Question 4

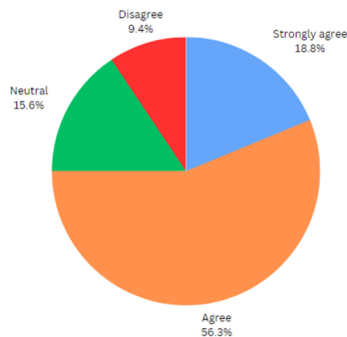


Figure 4: Students beliefs on heavy civil topics in BIM

This question was in regard to gauging students in their perception on BIM and heavy civil topics, more specifically topics associated with AGTEK. Most students agreed or were neutral with a small percentage thinking that these topics would not be understood well in a BIM program.

Question 5

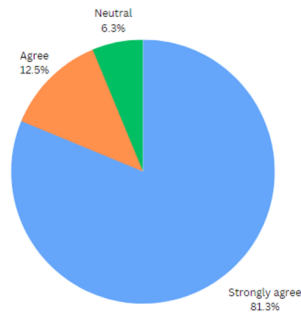


Figure 5: Students perceptions on video learning in BIM

This question gauged students' perceptions on whether tutorial videos were a good option to teach the mechanics and functions in a BIM program. The students surveyed responded very positively with a majority in strong agreement over video instruction. AGTEK provides users with video instruction on how to use the program with a variety of topics. This strong response from students provides a viable teaching method that students would agree with.

Question 6

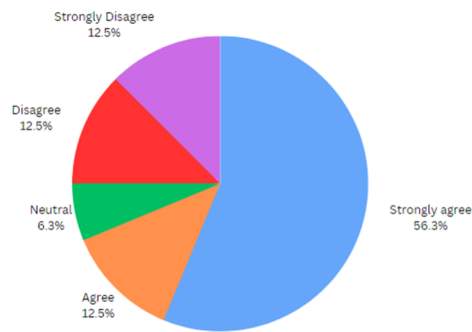


Figure 6: Students interest in heavy civil industry if a heavy civil BIM program was implemented.

The students responded mainly in agreement that a heavy civil BIM program would increase their interest in the heavy civil industry. With the heavy civil industry being a smaller portion that graduates select to pursue a career at Cal Poly, an implementation of a heavy civil BIM program can influence students' decisions for a career pursuit in the heavy civil industry. If AGTEK was implemented into heavy civil classes, it could lead to a stronger influence for students to pursue the heavy civil industry and possibly pursuing the heavy civil minor.

Question 7 & 8

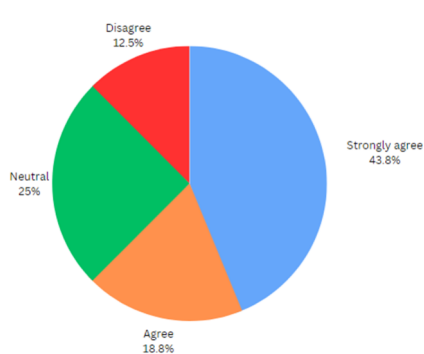


Figure 7: Responses on AGTEK in CM-314

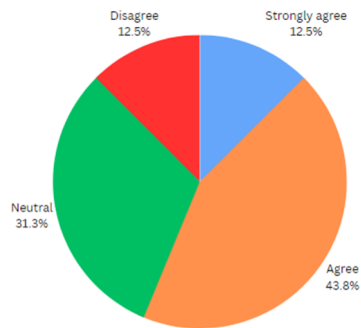


Figure 8: Responses on AGTEK in CM-239

CM-314 had a stronger desire for students to be introduced to a heavy civil BIM program instead of CM-239. Students responded in heavier numbers in strong agreement for CM-314 compared to the CM-239 option, students had a heavier response in just agreement or neutral over the subject. Implementation of AGTEK in CM-314 would be a more viable option for learning the program as the class allows for a longer meeting time with more meeting times throughout the week compared to CM-239.

Unstructured Interviews

Interview for CM-239

For CM-239, the interview was held with Bryan Knakawitz, the current lecturer of CM-239. For the current methods of teaching topics that are related to AGTEK Bryan explained that there is a small use of Civil 3D, another BIM program. This program is used to teach topics such as cut and fill and site visualization. Bryan explained after seeing AGTEK that the Civil 3D use is roughly similar to the process of AGTEK.

Talking about possible implementation in CM-239 Bryan expressed interest in the tutorial videos. Bryan explained that there is a plan in the works to implement asynchronous videos in future courses. Bryan expressed a desire for utilizing the AGTEK videos as an option for some of the asynchronous videos that are planned to use in future classes.

Bryan generally agreed with the format of the lesson plan in structure and agreed upon the final examination of learning the program to be in a project-based format. As for what the final project would look like, a suggestion was made using as-built plans of buildings around Cal Poly which more than likely have civil drawings associated with them. Using the skills of AGTEK students would be able to calculate the volume of earthwork required for the project. For grading purposes, the grade would be administered based on how close each student was to the actual volume.

Interview for CM-314

For CM-314, the interview was held with Enrique Ivers, a current lecturer of CM-314. The knowledge of AGTEK was familiar for Enrique as explained that on a prior project that AGTEK was utilized for the project. On the current state of topics that would relate to AGTEK Enrique showed that the

majority earthwork calculations were done through excel with problems given on paper. Enrique pointed out that recent students did have trouble regarding stripping sections referring to the topsoil spoils that cannot be reused as fill material. This is one of the functions that is covered in AGTEK which could help students understand the topic a little more.

For the implementation of AGTEK Enrique was for either the asynchronous or for the synchronous implementation. Enrique slightly favored the synchronous implementation thinking that all students that were having trouble understanding the videos should be able to receive immediate help. Enrique thought that the extended time would be able to help students learn the program at a more controlled and steadier pace instead of pressing students for time. Enrique also suggested that using this program should be in a class on its own, possibly as a higher-level tech elective class for construction management majors that desired to go into the heavy civil industry.

As for the lesson structure Enrique agreed with the lesson format in video learning and promoted the idea of using example files working alongside the videos. As for the project examination that would gauge students overall grasp of the program Enrique also agreed with the idea of using as-builts for Cal Poly buildings and having students calculate the earthwork that is required.

Implementation Analysis

After the unstructured interviews and the student survey the class that would be most viable for implementation for AGTEK Sitework 4D would be in CM-314 based on student choice and a more flexible time frame. The bigger question regarding the implementation of the program in regard to having the program implemented in an asynchronous or synchronous manner. The asynchronous option would have students download the program to their personal computers and learn the program on their own time. The synchronous option would have the program be downloaded into computers available at Cal Poly in computer labs. Each of these options presents their own challenges. The synchronous option would be difficult to implement for the construction management department due to the changing of the CM computer lab to a CM student lounge. To implement the synchronous option, the heavy civil class would have to reach out to other departments around Cal Poly to ask for time in their computer labs and would have to ask to download the program to their computers.

The asynchronous option presents a challenge in implementation in having the chance of having computers that would not be able to handle the program. AGTEK can be downloaded to both mac and windows however different sections of the program can be downloaded mainly the field options of the program can be downloaded onto apple software. Meanwhile the main estimating parts of the program can be downloaded to windows. AGTEK Sitework 4D would have to be downloaded on windows computers. Students with tablets would be unable to download this program and would be left out.

Future Research

AGTEK Sitework 4D is just the tip of the iceberg for AGTEK. Other uses that are included in AGTEK are grade work, fleet tracking, and underground construction. All these along with the other products that AGTEK can provide can also be implemented into heavy civil construction management. Reaching out to AGTEK for comments on their program was unfruitful, unable to get a response from the sales division; there are many unknowns to the program that could affect the implementation of the program into the curriculum. Price and billing options should be further explored for the decision of the

department to implement this program. Future research into further implementation along with other applications of the program should be pursued.

Conclusion

AGTEK Sitework 4D is a BIM program that revolves around the heavy civil industry. Students at Cal Poly have mainly agreed that their previous experience in BIM has mainly revolved around residential and commercial construction. AGTEK provides an opportunity for the Cal Poly construction management department to utilize this program to give a more rounded out BIM experience for construction management students. After a student survey and unstructured interviews of current lecturers of the potential classes for implementation it has been determined that the heavy civil construction management class would be the most optimal class for implementation. A synchronous or asynchronous approach could either be implemented with each option having their own potential problems. The synchronous option for CM-314 would be the most viable option for the implementation of this program for simplicity and control purposes.

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