AC 2007-639: KEEPING ERROR IN CLASS ALL SEMESTER

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Keeping Error in Class All Semester

Abstract

The topic of error in measurements is fundamental to the study of elementary surveying. Textbooks used for such courses often include this topic in the first chapters of the book. Students may not always consider the error involved with measurements, particularly using modern advanced surveying techniques, unless the course is conducted in a manner that develops this premise.

The theme of error in measurements is developed through the entire semester of the course by not only traditional means common in many surveying courses and but also new assignments and activities. The current textbook used in the course covers the subject matter in the second chapter. An active classroom exercise is used to bring the experience of the subject matter into the classroom when covering this chapter. Laboratory exercises for the course still utilize the steel tape. Thus, error corrections for temperature can be used to reinforce the concept of error. An Internet investigation assignment is used to get students to search beyond the class textbook and reinforce the types of error that occur with EDM and GPS equipment. Level survey work both in the classroom and laboratory always involve "closing the circuit". Finally, near the end of the course, latitudes and departures exercises are used to bring distance measurement together with directions and subsequent computation and balancing the latitudes and departures by the compass rule.

The reinforcement of error in measurements permits this theme to stay with the subject matter of the course all semester long. The knowledge of error in surveying measurements can be an aspect of meeting a TAC-ABET program objective of quality. Students who take subsequent courses in surveying will certainly study error in measurements in more detail. However, students who only take the elementary surveying class will have the theme emphasized repeatedly during the semester and thus they also will recognize that error occurs in all measurements and be able to interpret data with this knowledge.

Background

The topic of error in measurements is fundamental to the study of elementary surveying. Textbooks used for such courses often include this topic in the first chapters of the book. The topic of error in measurements concerns all measurements performed in surveying. However, students may not always consider the error involved with measurements, particularly using modern advanced surveying techniques, unless the course is conducted in a manner that develops this premise. Since modern advanced surveying techniques are becoming more common, the knowledge that error exists with values obtained using this type of surveying is more relevant.

Error in measurements has been developed as a theme to an elementary surveying class in the civil engineering technology program at Indiana University Purdue University Fort Wayne. Not all civil engineering technology students will work in the surveying field and in fact few of them

may actually become surveyors. Furthermore, students in an architectural engineering technology degree program also take this class and may be less likely to work in the surveying industry. Nevertheless, anyone involved in the construction and design industry likely uses information gathered by surveying. It is thus important for those not only in the surveying field but also those who use information from surveying to be aware that error exists in all measurement values.

The concept for theme of error in measurements originated at a teaching workshop on campus. A question was posed to attendees, "what do you want students to know three to five years after the class". The author decided that one aspect of class that students should know years later is that error occurs in all surveying measurements. This is one piece of knowledge that may serve useful in many types of work. This knowledge reflects recognition that a student knows the issue of quality if pertinent to all surveying measurements. TAC-ABET program criteria include a "commitment to quality" (ABET). Even though a small number of students who actually take an elementary surveying class will eventually work as surveyors, all students in class can benefit from this theme. Most any student or graduate who works in the construction and design related industry will likely use information developed by surveying or rely on surveying measurements in some manner. Thus, recognition of error in measurements and interpretation of surveying information and measurement data is a valuable and worthy objective for the course.

Class Activities

The theme of error in measurements is developed through the entire semester of the course by not only traditional means common in many surveying courses and but also new assignments and activities. The current textbook used in the course covers the subject matter in the second chapter. An active classroom exercise is used to bring the experience of the subject matter into the classroom when covering this chapter. Laboratory exercises for the course still utilize the steel tape. Thus, error corrections for temperature can be used to reinforce the concept of error. An Internet investigation assignment is used to get students to search beyond the class textbook and reinforce the types of error that occur with EDM and GPS equipment. Level survey work both in the classroom and laboratory always involve "closing the circuit" of the level survey and both a math check and page check to permit computation of the error of closure and then enable distribution of the error. Finally, near the end of the course, latitudes and departures exercises are used to bring distance measurement together with directions and subsequent computation and balancing the latitudes and departures by the compass rule.

Lights Out

An active classroom activity is conducted early in the semester. Students measure the time duration from when the classroom lights are turned off until they are then turned back on (Devine 2004). Alternatively, the duration of a spinning line animation on a PowerPoint slide is repeatedly activated and measured if such computer resources are available in the classroom being used that term. During the repeated trials of these time measurements, students use various methods to measure the time. The first trial has students measure the time duration with no technology. Students accomplish this by counting something like one-Mississippi etc. The second trial has students measure the time duration with the seconds had of a dial watch or the

seconds hand of a dial clock that may be present in the room. The third trial has students measure the time duration using the stop-watch function of a digital watch. Students quickly recognize that the stop-watch function is the most precise method. In fact some attention needs to be given to not permit students to measure time with a stop-watch during the first two trials.

The time durations for all trials for the students in class are then put on the board. The greatest spread of values occurs for the data from the first trial and the least amount of spread of values occurs for the data from the last trial. Students will ask, what was the time that the lights were out or the time that the line was spinning on the PowerPoint slide. The correct answer is that the true exact time can not be measured or known. A mean time duration can be computed and each student can determine how much error existed in the measurements they made considering that the mean time duration is the best representation of the true exact duration.

Steel Tapes

Steel tapes are still used for a surveying laboratory field exercise. A main reason for this is to provide students a hands on activity were all survey crews will not measure the same values. Undoubtedly when the set of data from all survey crews is reviewed, there are differences in all distances measured. Corrections can be made for temperature, slope, and tension. Nevertheless, the measured values are not all the same and students will want to know what the true exact distances are. Students who are more familiar with the subject matter will want to measure the distances with an electronic distance measurement device. A comment students may make is that they want to determine the true exact distance. A student may consider that this expensive electronic equipment will determine the real distance.

Level Circuit

Differential level circuits are conducted during two or three surveying laboratory field exercises. Students often experience the difference between error in measurements and blunders during this work. Eventually students will perform a level circuit that has a small error of closure. This often occurs during a higher order accuracy level when students perform a three wire level circuit. While the error of closures may be very small or in some cases even compute to a value of zero, the elevations set at a temporary benchmark usually do not match. Students may consider their work to be excellent if they compute a value of zero for the error of closure for the level circuit but if there are different elevation values set by crews for the temporary benchmark, it is apparent that errors cancel between the outward and return portions of the level circuit.

Latitudes & Departures

A portion of the class deals with the subject matter of coordinate geometry. Assignments are made with closed traverse data sets and computation of the error of closure. This error of closure is then distributed through the data by the compass rule method. Software that accompanies the textbook also performs these computations. Students readily recognize that the error of closure exists because all of the distance and direction values are based on measurements. This concept seemed well understood even before emphasis was placed on the theme of error in measurements in the class.

Modern Surveying

A main challenge to keeping the theme of error in measurements in a class is the use of modern surveying technology. Activities that can be conducted to illustrate this are using GPS units on different days over the same point and noting how the reported coordinates may differ. Additionally, relatively inexpensive handheld GPS units that advertise accuracy limits can be used. A state highway is located adjacent to the campus area where the surveying laboratory field exercises are conducted. Some handheld GPS units will have road maps as a background and one particular unit consistent indicates that the position is situated on the opposite side of this state highway. GIS formats are readily used on various Internet sites to prepare travel routes and report travel distances and times. However, some distances reported by different Internet sites over the same route do indicate slightly different distances. An assignment has been made that calls for students to use three different websites to prepare a map and determine the distance between either their home and campus or between some other landmarks.

Conclusions

Students recognize that error exists in measurements through active learning activities and surveying laboratory field exercises. The reinforcement of error in measurements permits this theme to stay with the subject matter of the course all semester long. Students who take subsequent courses in surveying will certainly study error in measurements in more detail. This is done in an introductory class and does not include rigorous math associated with the computation aspect of error analysis. However, students who only take the elementary surveying class will have the theme emphasized repeatedly during the semester and thus they also will recognize that error occurs in all measurements and be able to interpret data with this knowledge.

References

2006-2007 Technology Accreditation Criteria, ABET, Inc. www.abet.org.

David Devine, *"The Experience of Significant Digits"*, Proceedings of the 2004 Illinois-Indiana Section Conference, American Society for Engineering Education Conference, March 2004.