FEASIBILITY STUDY: USING A VIRTUAL SURVEYING INSTRUMENT IN SURVEYOR TRAINING

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***Abstract* - This paper presents a feasibility study for using a virtual survey instrument, *SimuSurvey*, for surveyor training. *SimuSurvey* was developed for visualizing and simulating surveying scenarios in a computer-generated virtual environment. In this research, we studied the feasibility of introducing the use of *SimuSurvey* in regular surveyor training courses. Both quantitative and qualitative evaluation methods were used. The quantitative evaluation method included a questionnaire to 323 students from three vocational schools and 205 copies of in-class quiz that followed a 25-minute teaching session on *SimuSurvey*. The purpose of the questionnaire was to understand the attitudes of students toward using virtual surveying instruments in the training course. The results show that 91% of the students believe that using virtual surveying instruments in training will benefit their learning experience. The results from the in-class quiz indicate that the employment of *SimuSurvey* yield satisfied learning outcomes, with approximately two-thirds of participating students able to answer follow-up questions correctly. The qualitative analysis was obtained from interviewing five experienced instructors of different backgrounds. They were generally optimistic to the idea of including *SimuSurvey* in regular surveyor training.**

***Index Terms* - virtual surveying instrument, survey, virtual reality, engineering education**

INTRODUCTION

One of the major purposes of a surveying training course is to help novice surveyors understand and become familiar with surveying instruments. However, to manipulate a survey instrument requires a clear understanding of the spatial relationship between the instrument and target object. Because many imagined lines are involved in the concept, instructors often find difficulty in providing clear explanations to novice surveyors. Traditionally, the instructors teach the surveying course by following three steps: (1) explain the theoretical background either by using the example in the textbook or by illustration on a chalkboard, (2) demonstrate the manipulation using a real instrument and (3) ask the students to practice in groups on a real instrument.

This three-step procedure has several drawbacks. First, many surveying instruments are required because each group of students needs at least one instrument on which to practice. The expense for purchasing and maintaining the instruments can be very high. Second, the effectiveness of the lesson is often influenced by the weather, location and time of day. Third, because many operations involve fine actions, the instructors often face the difficulty of clearly demonstrating each step to every student in the field.

In order to solve these problems, many instructors have introduced electronic teaching aids in the class. For example, Bai (2007) used video to demonstrate survey procedures. Yeh (2005 and 2006) employed virtual reality technologies to simulate the environment for surveying. Recently, *SimuSurvey* was developed by Lu et. al(2007). It is a virtual tool that allows the user to simulate survey instrumentation on computer.

A comparison between the electronic teaching aids is summarized in Table 1. From the comparison, we can see that the virtual instrument has advantages for most features in terms of benefits to the survey training and owning cost. In this research, we further study the benefits that may result from the use of a virtual surveying instrument in the surveying courses, and verify whether this tool can help students better understand the surveying topics.

TABLE 1
FEATURES COMPARISON OF ELETRONIC TEACHING AIDS

Teaching media / Features	Text book and real instrument	Video	Virtual reality	Virtual instrument
Learning feedback	No	No	Good	Very good
Presentation of abstract concept	No	No	Good	Very good
Support for instructors' demonstration	No	Good	Good	Very good
Measurement reading	Very good	No	No	Good
Detailed manipulation	Very good	No	No	Good
Weather resistance	No	Fair	Good	Very good
Repetitiveness	No	Fair	Good	Very good
Accessibility	No	No	No	Good
Virtual instrument	No	No	No	Yes
Owning cost	High	Medium	Low	Low

BRIEF BACKGROUND OF SIMUSURVEY

In this research, we used *SimuSurvey* as the target of the feasibility study. *SimuSurvey* was developed using the OpenGL graphic language [5] and the C# object-oriented programming language [6]. The five subsystems (that is, the level simulator, theodolite simulator, accessory simulator, and total station simulator) and the tangible controller are included in *SimuSurvey* to support various training activities. *SimuSurvey* (Figure 1) was designed for supporting teaching activities in surveying courses. It provides an interface that allows students to manipulate the virtual instrument on computer. The major features of *SimuSurvey* are:

- Visualization of a survey instrument and measurement poles involved in an assigned survey task.
- A control interface similar to that of real surveying instruments.
- An interface to record the time history of trainees' manipulation processes.
- An interface allowing instructors to design teaching activities so that students can practice survey tasks in a simulated environment.

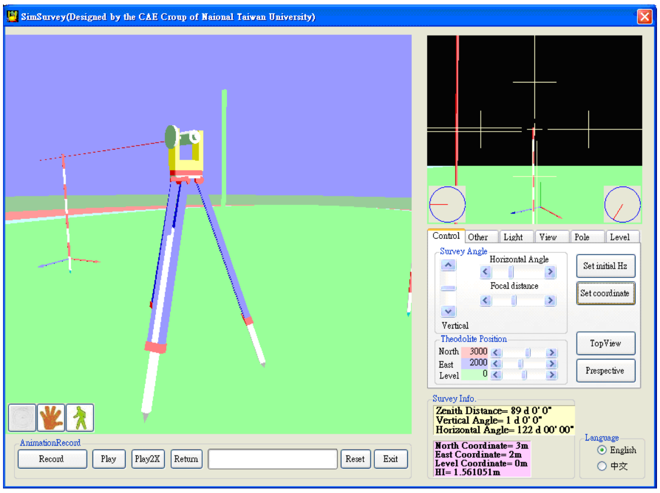

FIGURE 1
THE USER INTERFACE OF *SimuSurvey*

FEASIBILITY STUDY

This research studies the feasibility of using a virtual surveying instrument in surveyor training. The study included: (1) questionnaire survey: a questionnaire to students of various backgrounds, ,(2) in class study: a in-class session using the virtual surveying instrument to teach a survey topic, and (3) interviews with experienced instructors

(1) QUESTIONNAIRE SURVEY

Questionnaire design: The questionnaire was designed to gain an understanding of students' attitudes toward using the virtual surveying instrument in the surveying class. Three sections are included in the questionnaire.

The purpose of the first part of the questionnaire was to understand the background of the students. It includes gender, age, department, year of studies and experiences in survey-related courses. In this study, this part of the questionnaire will allow us to answer two questions: (1) are the users who get higher scores in surveying courses more likely to take courses over the internet?; and (2) are the users who have taken courses over the internet also likely to learn the content of surveying courses by internet?

The purpose of the second part of the questionnaire was to understand the learning environment in a surveying training course. The questions focused on the three issues: (1) the average time students spend on learning the skills required to operation the surveying instrument once leaving classroom; (2) the degree of interest students have in learning how to operation the surveying instrument; and (3) the main challenge students face in learning how to operate the surveying instrument.

The third part of the questionnaire was to identify students' attitudes toward computer-based training in a surveying course. The questions in this part included two sets. The first set of questions aimed to find the expected time for a student to spend in surveying course learning using a virtual surveying instrument after class. The second set of questions aimed to find the expected effectiveness of learning, using a virtual instrument, the skills of operating a surveying instrument. These questions will help us identify: (1) the relationship between score and attitude on surveying course learning using a virtual surveying instrument; (2) whether a student's motivation is increased with the use of a virtual surveying instrument in the surveying course; and (3) the effectiveness in surveying training that uses e-learning material.

Questionnaire delivery: In this research, the questionnaire delivery was separated into two stages, a pre-survey and a post-survey. The pre-survey focused on the students who had no experience with using a virtual surveying instrument. We surveyed 323 students, selected from two vocational high schools and two colleges. The post-survey stage focused on the students who had previously used *SimuSurvey*. The post-survey stage involved 208 students.

Questionnaire analysis: The questionnaire data was analyzed and the detailed results are presented in table 2. They are summarized in nine points: (1) the reliability of the questionnaire is high (Cronbach's α=0.74~0.88); (2) the backgrounds of the students are diverse in terms of gender, age (18-21), and departments (architecture and construction); (3) gender has a significant influence toward the preference of surveying courses before using *SimuSurvey* but an insignificant influence after using *SimuSurvey*; (4) both male and female students had positive attitudes toward using the virtual surveying instrument in the survey class; (5) it is insignificant that students who have a higher GPA in surveying course have a more positive attitude toward using *SimuSurvey*; (6)whether students who have experience with e-learning show a more positive attitude toward *SimuSurvey*; (7) students who are interested in the surveying course are more likely to spend more time practicing the operational skills after class; (8) on average, students agree that the virtual instrument is an incentive for them to take the survey course; and (9) 91 percent of students agree or strongly agree that the virtual instrument is helpful for learning surveying in the course.

2) IN-CLASS STUDY

Training session: In this research, we observed 205 students in six regular surveying classes in which the instructor used *SimuSurvey*. In these classes *SimuSurvey* was used to explain the measuring process for obtaining the included angle made by two imaged lines connected from two measurement poles to the location of the surveying instrument. All classes were held in a classroom equipped with computers that had *SimuSurvey* software installed. The total instruction time was 25 minutes consisting of a five-minute introduction to *SimuSurvey*, 15 minutes practice, and five minutes calculation time.

Follow-up quiz: After the instruction, a 25 minutes follow-up quiz was conducted to assess students' learning results. The quiz included four similar problems to test whether the students had learned how to operate the virtual instrument to find the included angles. One of the example problems in the quiz is shown in Figure 2. Given the coordinates of the four poles (numbered 1 to 4) and the coordinate of the instrument (point A), students needed to find the included angle between the poles, that is, ∠1A2, ∠2A3 and ∠3A4. Since a survey instrument can only measure the azimuth angle (the angle measured from exact north) of the poles, that is, ϕA1、ϕA2、ϕA3、ϕA4, students needed to know how to calculate the included angle from azimuth angles.

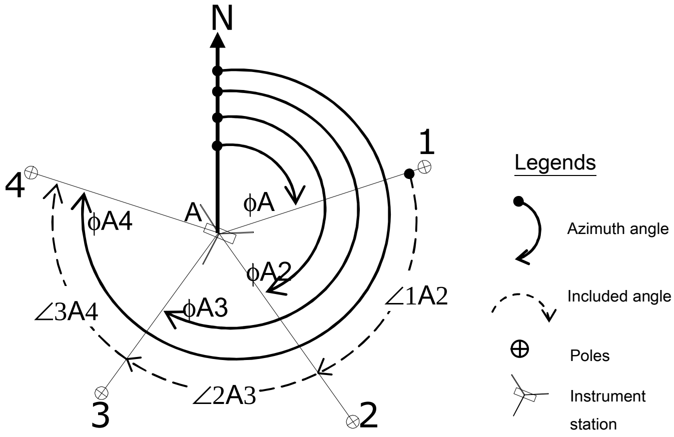

FIGURE 2
EXAMPLE PROBLEM FOR FINDING INCLUDED ANGLE

Results: From the 205 copies of quiz, 126 students (61%) obtained full marks (answered four questions correctly), 12 students (6%) obtained 75 marks (answered three questions correctly), 8 students (4%) obtained 50 marks (answered two questions correctly), 3 students (1%) obtained 25 marks (answered one question correctly) and 59 students (28%) obtained zero marks (no correct answers), shown in Figure 3. Because the four questions were very similar, the score graph appears as an M shape, concentrating on both full score and zero. From the result, we find that approximately two-thirds of the students fully understood the procedure for finding the included angle using the virtual surveying instrument. From the instructors' experiences, this learning result is significantly better than those obtained using traditional teaching methods. Furthermore, the instruction time was only 25 minutes and without disturbances of outdoor weather conditions or the hassle of equipment setup. The virtual surveying instrument for surveyor training is valuable.

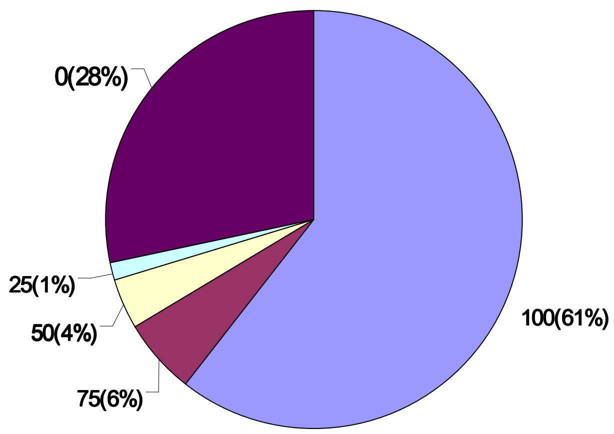

FIGURE 3
QUIZ SCORES AND DISTRIBUTION

3) INTERVIEW WITH INSTRUCTORS

We interviewed five experienced instructors from three schools (four different departments) to obtain their opinions on using virtual instruments in regular surveying courses. The background of these interviewees is listed in Table 3. The experience of the interviewees ranged from four years to twelve years, three of them are male and two of them are female.

During each interview, we first overviewed the concept of the virtual instrument, and demonstrated the major functions of *SimuSurvey*. The interviewees were encouraged to ask questions and try-out the functions of *SimuSurvey*. Once the interviewees became familiar with how to apply this tool in the surveying course, we asked them to compare the differences between using the virtual instrument as a teaching aid and the traditional teaching method. The results of the comparison are listed in Table 4.

TABLE 3
BACKGROUNDS OF THE INTERVIEWEES

School	department	Teaching seniority	Teaching courses	Gender
Taipei Municipal Da-An Vocational High School	Department of Architecture	4 years	engineering surveying practice, computer aided drawing	male
National Jui-Fang Industrial Vocational High School	Department of Architecture	12 years	engineering surveying, advance engineering surveying	male
Hwa Hsia Institute of Technology	Department of Construction Engineering	8 years	Surveying, engineering surveying practice	male
Hwa Hsia Institute of Technology	Department of Architecture	12 years	engineering surveying practice, computer aided drawing	female
National Jui-Fang Industrial Vocational High School	Department of Architecture	12 years	engineering surveying practice, computer aided drawing	female

CONCLUSION

SimuSurvey is a virtual surveying instrument that can support the training of surveyors. To study the feasibility of introducing this virtual tool into a regular surveying course, we developed a questionnaire to find out students' attitudes toward the virtual surveying instrument. We also designed a 25-minute training session and conducted a follow-up quiz to assess students' learning outcomes. Five face-to-face interviews were also carried out, with interviewees being experienced surveying instructors but of different backgrounds. The interviews helped us identify the differences between the traditional surveying methods of training with the surveying course that integrates the virtual survey instrument.

The results indicate that using a virtual surveying instrument in surveyor training is beneficial to both students and instructors. Teaching surveying instrument operational skills using a virtual instrument can enhance students' learning interest and improve learning efficiency. Using a virtual surveying instrument allows instructors to design the class activity with more flexibility. The virtual surveying instrument also solves the problem of the high-expense on mass instrument purchases and maintenance. This research will continue in the future with aims to designing course material that integrates virtual surveying instruments with traditional surveying education. In addition, we will also work on integrating CAD systems with *SimuSurvey*. This will allow instructors to import real terrain data into *SimuSurvey* so that students will be able to practice the surveying skill in a virtual environment that reflects reality.

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TABLE 2
THE RESULTS OF THE QUESTIONNAIRE SURVEY

Topics	Results		Explanation
	Pre-survey	Post-survey	
1. Using Cronbach's α to measure the reliability.	α1 = 0.88; α2 = 0.88	α1 = 0.79; α2 = 0.74	If α□0.6 means the reliability is well.
2. The background of the students.	Gender-specific (male 68%, female 32%); Age (85% 18 years old; 15% 21 years old); Department (85% Department of Architecture; 15% Department of Construction Engineering)	Gender-specific (male 78%, female 22%); Age (74% 18 years old; 26% 21 years old); Department (73% Department of Architecture; 27% Department of Construction Engineering)	The result is representative.
3. Using T-test to analysis whether gender causes the different learning attitudes.	P = 0.004; $\bar{x}_{\text{male}} = 2.9$ $\bar{x}_{\text{female}} = 2.8$	P = 0.68; $\bar{x}_{\text{male}} = 2.6$ $\bar{x}_{\text{female}} = 2.6$	P>0.05 insignificant The result of pre-survey is conspicuous and the result of post-survey is inconspicuous.
4. Using T-test to analysis whether the different learning attitude cause of the different gender-specific for virtual surveying instrument in computer classroom can help student to learn surveying.	P = 0.81; $\bar{x}_{\text{male}} = 2.8$ $\bar{x}_{\text{female}} = 2.9$	P = 0.96; $\bar{x}_{\text{male}} = 2.9$ $\bar{x}_{\text{female}} = 2.9$	P>0.05 insignificant The results both are inconspicuous in pre-survey and post-survey. The males and females agree using virtual surveying instrument in computer classroom can help students to learn.
5. Using the one way ANOVA to find the correlation between score and using the virtual surveying instrument in surveying learning.	P = 0.76 $\bar{X} = 2.8$	P = 0.07 $\bar{X} = 2.9$	P>0.05 insignificant The result is inconspicuous. Most students agree in using virtual surveying instrument in computer classroom can help student to learn.
6. Using T-test to analysis whether students who have used internet to learn accept using the virtual surveying instrument in surveying learning more easily.	P = 0.55 $\bar{x}_{Option} = 2.8$ $\bar{x}_{No\ option} = 2.8$	P = 0.26 $\bar{x}_{Option} = 2.9$ $\bar{x}_{No\ option} = 2.9$	$P \geqq 0.05$; The result is inconspicuous.
7. To find the correlation of students who will spend more time on surveying learning after classroom are interested in virtual surveying instrument.	R = 0.3	R = 0.11	R > 0 represents positive correlation; The result appears to have a positive correlation.
8. Whether or not using the virtual surveying instrument in surveying training increases your likeliness to take the surveying course.	$\bar{X} = 3$	$\bar{X} = 3$	Some agree
9. How helpful is using the virtual surveying instrument in surveying training?	unhelpfully 2%; few helpful 7%; some helpful 52%; very helpful 39%	unhelpfully 2%; few helpful 7%; some helpful 55%; very helpful 36%	

Note: 4 points = strongly agree; 3 points = agree; 2 points = disagree; 1 point = strongly disagree

TABLE 4
THE COMPARISON BETWEEN TRADITIONAL SURVEYING TRAINING AND THE SURVEY TRAINING THAT INTEGRATES THE VIRTUAL INSTRUMENT

Compared dimensions	Survey training with a virtual instrument	Survey training without a virtual instrument
Interactive and feedback	The instructors are able to observe and find individual students' learning problems by viewing the student's monitor.	In traditional teaching, the chalkboard and slide provide little functions for interaction and real-time feedback for instructors.
Visualize the abstract concept	The virtual surveying instrument provides a high-fidelity interface for instructors to design teaching activities to address abstract concept visually.	Instructors demonstrate abstract concepts by sketching on the chalkboard. Sometimes it is very difficult to present the concept well.
Class management	Using virtual surveying instrument to demonstrate the surveying process will help students.	It is very difficult for instructors to demonstrate operations using a real instrument to as many as fifty students .

TABLE 4
THE COMPARISON BETWEEN TRADITIONAL SURVEYING TRAINING AND
THE SURVEY TRAINING THAT INTEGRATES THE VIRTUAL INSTRUMENT (CONT.)

Compared dimensions	Survey training with a virtual instrument	Survey training without a virtual instrument
The reading training of the measurement data	The developed virtual surveying instrument allows students to easily read measurement data displayed by character sets. But this method perhaps does not help students to learn how to read the measurement data.	Students read the measurement data on a real surveying instrument. They must be familiar with the procedure for reading the level ruler during training.
The detail of the instrument operation procedure	The virtual surveying instrument provides a simulated environment. Some details about the instrument operation are missing.	The real surveying instrument provides physical interface for students to learn the operation procedures.
The influence of the weather conditions	The virtual surveying instrument is not affected by weather conditions.	The real surveying instrument is sensitive to weather conditions.
Tracing learning processes	The virtual surveying instrument provides functions that can record the operation history for students.	The real surveying instrument has a complicated structure making it difficult for students to learn the operational skill or to practice repeatedly.
The use efficiency of the instrument	The cost for providing a virtual instrument for each student after class is very low.	It is almost impossible to provide a real instrument for students to practice after the class.
The owning cost of the instrument	The owning cost of the virtual surveying instrument is very low.	The purchasing and maintenance cost of real surveying instruments is often expensive.