Abstract. CAIFiM is a user-friendly and efficient set of subroutines written in Visual Basic (VB) object-oriented language for Fluid Mechanics Laboratory courses. The main user form is composed of three buttons that give the student access to the following tasks:

1) Use a computer subroutine to solve the calculations for an experiment
2) Use interactive tutorials for auto-instruction
3) Use of other computer resources such as word processing or graphics software.

This simple interface, combined with the guided practical experience in the laboratory, provides all the resources necessary for a comprehensive learning experience and efficient use of the three contact hours available for laboratory experiments.

Many experiments require data collection and data processing. Data points for a range of values are usually necessary to relate the experimental variables and to obtain statistical correlations. Usually each data point is processed independently passing through the same series of calculations. CAIFiM was created to save time in these repetitive computations, but at the same time, testing the student capacity to do hand calculations as part of the learning process. Access to the calculation software is granted only after CAIFiM tests the student understanding of the procedures involved in the experiment. CAIFiM was programmed with a series of dialogs with the user thru tabs containing command buttons, text boxes and option buttons were he/she is requested to introduce his/her own calculations made in class with a handheld calculator. CAIFiM compares the student’s results with its own calculations. If the student results are incorrect, CAIFiM provides possible sources of error and suggestions for review and try again. If the results are correct permit to input other measured data is granted and the remaining calculations are done automatically. Other tools provided in CAIFiM allow the supplement the laboratory experience by incorporating theoretical concepts and prepare valuable reports.

INTRODUCTION

The Mayaguez Campus of the University of Puerto Rico is a higher education institution that offers undergraduate and graduate programs in science and engineering. About one third of the total number of students is enrolled in the School of Engineering. The General Engineering Department offers the basic courses in solid mechanics, fluid mechanics, computer programming, and computer graphics. All the engineering students must take at least three courses offered by this Department. Civil and Mechanical engineering students must take their Fluid Mechanics course plus a one credit course in Fluid Mechanics Laboratory. These are usually taken during the third year of studies in their career.

Until recently, most of the computer software used at the Fluid Mechanics Laboratory was developed by the voluntary work of several professors and graduate students interested in reducing the workload on the students and improve the quality of education. These programs motivated the idea of developing a good supplement to traditional teaching methods. This paper describes the CALFiM project (CALFiM =Computer Aided Instruction in Fluid Mechanics), a computer center dedicated to teach fluid mechanics to civil and mechanical engineering students by using multimedia systems. The system is essentially a series of programs to process experimental data, multimedia auto-instruction modules, word-processing and utility software. Access to all these resources is possible through a simple System Integrator Manager.

DESCRIPTION OF THE CAIFiM PROJECT

About 320 students per year benefit from the experiments developed at the Fluid Mechanics Laboratory. Typically the enrollment is 16 students per section distributed in eight to ten sections per semester. During the experimental sessions the students are divided in four groups usually with four students per group. The preferred group composition is such that all the members of a group belong either to civil or to mechanical engineering. This partition allows running experiments of their respective interest at the same time. For example, compressible shock-waves is very important topic for mechanical engineering students, but they are not very much interested in hydraulic jumps. On the contrary, civil engineering students are interested in the last topic and do not show much interest in the first one. Both experiments are run at the same time according to the interests of each group. At present, CAIFiM is a small network composed of seven PC computers built with the Windows networking system. This
networking system is provided with the necessary security and protection and is easily managed by using one computer as a server. The main access to the CAIFI system computer resources is provided through a System Integrator Manager programmed in Visual Basic. This Manager Program is described next.

**THE SYSTEM INTEGRATOR MANAGER**

The first step for a successful and attractive computer system is to have a rapid access to all the resources. All the computer applications developed for CAIFI are operated from a simple System Manager. It has been observed that this Integrator is at the same time informative and understandable. It allows anyone to access the computer applications easily even if he/she does not have experience in the laboratory or computer systems. The System Manager, shown in Figure 1, is composed of three buttons that present what is available and permits access to any resource.

![Figure 1. CAIFI System Manager](image1)

The three buttons are:

1. **Use Programs for Solving Experiments**: This button loads the Experiment’s Menu listing all available experiment programs.

2. **Use Interactive Tutorials**: This button loads the Tutorial’s Menu with a list of all available tutorials.

3. **Use Other Laboratory Resources**: This button loads the Resource’s Menu listing the available software including commercial applications, older program versions and other utilities.

The student chooses the “Wizard” that he/she wants to run. The “Wizards” are menus formed by the list of software available. The user selects the desired program and presses the “Next” button to load it. Since all of these programs run under a multitasking environment, several applications can be run at the same time as required by the user. Figure 2 shows the “Tutorials Menu” obtained by selecting the “Use Interactive Tutorials” button from the System Manager. The title is shown at the top-left corner of the screen. The purpose and the description of the wizard are shown at the center followed by a series of radio-buttons listing the available resources. There are three buttons at the bottom of the screen namely: “Back” for returning to the previous form (this would be the main form of the System Manager), “Next” for running the selected program and “Cancel” to close the wizard. All of the program wizards follow exactly the same format. This similarity in all the forms permits the students to manipulate the wizards easily without having to learn new information for each selection.

![Figure 2. Tutorial’s Menu](image2)

**EXPERIMENTAL DATA PROCESSING PROGRAMS**

This part of the CAIFI system consist of a series of computer programs developed to assist the students with the computations and data processing required during their laboratory practice. By choosing the button “Use Programs for Solving Experiments” from the System Manager the user obtains the form shown in Figure 3 which is a menu, similar to the one from the “Tutorials Wizard”, that allows the student to run the computer program related to the experiment in process. Twelve computer programs have been developed for fluid mechanics applications including hydrostatics, hydrodynamics and compressible flows.
The users form shown in Figure 4 refers to one particular experiment namely “Closed Conduit Friction Experiment”, which corresponds to the program number three in the menu presented in Figure 3. This is an arrange of six tabs provided to do the following tasks:

1. Enter experimental data
2. Verify the student proficiency in the calculations required as part of the data processing.
3. See the results in the screen or make a print out.

Each tab title in this interface is common to all the laboratory experiments; however, the dialog form changes according to the experiment. The program used to study pressure losses in a pipe due to friction was chosen as an example for this publication. The students start by entering group information in the “Group Data” form shown in Figure 4. The next step is entering general data, such as ID of equipment used, fluid properties and number of observations. This is done using the “General Data” form shown in Figure 5.

A series of hand-calculations, usually done for the first observation, are required at the “Check In Data” form shown in Figure 6. This step is very important because it is a way for the instructor to verify if the students understand the experiment, know what and how the data should be processed and, obtain the expected results. The hand-calculation results are required as input to the program. The program compares the student’s results with its own computations, tells them which computations are in error and, gives them a chance to review the calculations and make corrections. Because most of the experiments are a repetitive process, hand computations for the first observation are enough to test the student’s knowledge and understanding of the experiment. This methodology allows a more efficient use of time during the experimental session and permits the students to concentrate in analysis and comprehension of results, instead of repeating calculations.
Only when the hand-computations are right does the system activate the “Next Tab” button permitting the student to go on entering experimental data from other observations. This is done at the “Experimental Data” form as shown in Figure 7. Here, the student enters the required information per observation and presses the “Update Values” button to tell the program that the data can be stored and moves to a new blank form for the next observation by pressing the “Move Up” button. Notice that, this form has part of the menu inactive. The reason for this is that, during this experiment, the students use two different instruments to measure the pressure: 1) An electronic pressure transducer and 2) A water manometer. In the General Data form (Figure 4) it was specified that seven values were taken with the transducer and, seven were measured with the water manometer. The program keeps track of the number of observations taken with each instrument and maintains the water manometer menu inactive until the user has input the first seven values observed with the transducer.

One advantage of the Visual Basic programming language is that the students can verify for any mistake in the data input by moving up or down along the forms of the experimental data and replace with the correct value immediately. Once all the data is correctly entered, the system will present the results on the screen and allows the student to print the results in a formatted form. This is done selecting the “Results-Report” tab. Finally, the “About” dialog form shows general information about the experiment and the computer program.
INTERACTIVE TUTORIALS

This component of the CAIFiM instruction delivery system is composed by a series of interactive on-line tutorials which are accessed by pressing the “Use Interactive Tutorial” button in the System Manager. This button leads the user to a menu of tutorials as shown in Figure 2. By selecting a topic the student goes to a series of pages of information which include interactive examples, demonstrations and auto-testing questionnaires to help him/her understand the fluid mechanics concepts and evaluated his/her learning process. The information presented in the computer is like in any other document or book enhanced with interactive capabilities, colors, graphics and animation that make the learning process attractive and motivating. At present, the tutorials are mainly on probability, statistics and regression analysis. These tools are needed for analysis of experimental data. The student takes a self-study session to learn or review these topics such that, the instructor can concentrate on the study of fluid phenomena. Figure 9 shows a sample of a page of one of the interactive tutorials. Other multimedia tools like sound and films may be added to the existing tutorials. The instruction tutorials were developed using the Authorware for Windows authoring tool.

Figure 8. Sample page of a self-study tutorial

OTHER RESOURCES

The third button of the System Manager (see Figure 1) namely “Use Other Laboratory Resources”, gives direct access to a set of commercial software such as word-processor, spreadsheet and graphics. Results from the laboratory experiment can be retrieved into any of these programs and the report could be generated in the same computer center without having to move to other locations. Nowadays PC computers are accessible to many students and usually most of them take their printout of results and finish the report at home or at other computer center. However, the instructor could decide to make a demonstration of “how the results look like” or make further comments about the analysis and conclusions by using graphics developed at the laboratory session.

THE STUDENT’S ASSESSMENT

The students were asked their opinion on the CAIFiM project by giving them a questionnaire. The sample size was 94 students. The evaluation included questions related to the computer programs and questions related to the self-study tutorial. Over 94% of the students agreed that the computer programs reduced the amount of work required to complete the experiment and facilitated the creation of the experiment’s report. The same percentage agreed that the Integrator Manager is easy to use and they became familiar with the computer programs rapidly. Also, 90% feel comfortable with the computation example required in the “Check in Data” form. They believe that this is a good methodology to teach and understand the calculations required to process the measured data. With respect to the auto-instruction modules, about a third of the students believe that the amount of information provided as “self-study” is excessive; however, 61% agreed that the modules help to fulfill the class objectives.

SUMMARY AND CONCLUSIONS

CAIFiM is a computer center developed to supplement the teaching of Fluid Mechanics. The system has the following characteristics:

1) The systems was created as a small network using the Windows programming environment and networking capabilities, Visual Basic as computer language and Authorware for Windows as the multimedia authoring tool.

2) A simple System Integrator Manager allows access to the three major parts of the instructional system, namely:

   a) Computer programs developed to make the experimental data processing fast and efficient,

   b) Auto-Instruction tutorials developed with multimedia tools to review course material from previous courses or introduce complementary topics and,

   c) Other resources to finish an elegant and complete laboratory report or present experimental results in graphical or tabulated form for class discussion.
4) A common set of six dialog boxes for all the computer programs helps the students to use them easily.

5) Every program for a laboratory experiment has been designed to evaluate the proficiency of the students in the calculations required to obtain the final results from the experimental data. The program is capable of pointing which results are wrong and allows the student to check and to correct the mistakes.

6) Over 94% of the students agreed that the computer programs reduced the amount of work required to complete the experiment and facilitated the creation of the experiment’s report. The same percentage agreed that the Integrator Manager is easy to use and they became familiar with the computer programs rapidly.

7) Approximately a third of the students believe that the amount of information provided as “self-study” is excessive; however, 61% agreed that the modules help to fulfill the class objectives.

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