# GATEWAY COALITION - YEAR 6

# VIRTUAL CLASSROOM - FINAL REPORT

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**Goals:**

1. To implement the drainage module developed and tested in Years 3 to 5 into the required undergraduate program at Cooper Union.
2. To implement a virtual classroom and problem solving session techniques as an integral part of a required undergraduate course CE142.

**Project Description:**

A drainage module using state-of-the-art Army Corps of Engineering programs (HEC-1 and HEC-RAS) was developed in the 3rd to 5th Years of the previous project. This module was tested at Cooper Union, Case Western Reserve University, and Florida International University. The modules were implemented in a required undergraduate civil engineering course, and a virtual classroom was introduced in the second half of the semester during the laboratory/problem solving sessions.

**Work Proposal:**

1. Implement the drainage module into CE 142, a required Junior level civil engineering course at Cooper Union.

2. Revise CE142 so that:
    a) the module is used as a learning tool;
    b) the students can work out of class (Internet), i.e., a virtual classroom;
    c) the students' progress is reviewed in classroom problem sessions.

**Project Summary:**

The module was easily incorporated into CE 142, "Water Resource Engineering", a second semester junior level Civil Engineering course. There was a three hour weekly laboratory/ problem solving session in the Spring 1998 term. The module was assigned to groups of 3 to 4 students by giving each group a watershed/river site. Each group used this module to determine the runoff and flood characteristics of the site. These projects were a required exercise for each student group and took about half a semester.

The three hour laboratory/problem solving session of CE142 was revised. This laboratory/ problem solving session consisted of:

1. Short lectures (20% of course)
2. Problem-solving in class using the module (60% of course)
3. Problem-solving on the Internet using the module (20% of course)

The short lectures introduced the subject, such as descriptive and quantitative hydrology, and open channel hydraulics in a rural stream environment. This was followed by reading assignments and problem solving. All of these lectures and problems were designed so the students were prepared to use the module.

Each student group was given a watershed site and reservoir in the tri-state area (NY, NJ, CT). In an open classroom, each group was asked to determine runoff and routing characteristics of their watersheds.

The HEC-1 program was an integral part of their solutions. The overflow from the reservoir was directed into a natural stream where flooding was determined by the use of the HEC-RAS program.

There were tutoring sessions whenever necessary. The professor and student aids (graduate students familiar with HEC-1 and HEC-RAS) were in the open classroom to guide the student.

Each student had to continue their drainage project in a virtual classroom on the Internet. They were able to ask questions and interact with the professor and/or student aid on the Internet.

There were specific milestones set for the class (such as: determination of the hydraulic properties, time of concentration, precipitation characteristics, etc.), to assure that the students stayed on schedule. A written report was presented by each student group summarizing the term's work.

**Class Structure:**

Water Resource Engineering consisted of 3 hours of lecture and 3 hours of laboratory a week. This project was held in the second half of the term in the laboratory part of the course. In the

first half of the term, fluid mechanic and hydraulic experiments were conducted in the Cooper Union hydraulic laboratory. There were 21 students in the class, all juniors majoring in civil engineering. For the laboratory, the students were separated into six groups consisting of 3 to 4 students each. The students were free to choose their group. There were six laboratory experiments before the HEC project began, and one classroom experiment. Hydraulic engineering was covered during the first half of the term, and hydrologic engineering during the second half. All of these students had taken a course in Fluid Mechanics the previous term with the same instructor teaching Water Resource Engineering. The instructor had enough information to separate the groups into the following categories:

2 groups of the best students,
2 groups in the middle, and
2 groups of the worst students.

The best students had the highest academic average, scoring highest on the tests and laboratory reports. The worst students scored the lowest on the tests, and the middle students had average scores.

The instructor selected one group from each of the three categories to form two sections for the HEC part of the course. Note, the six groups consisted of the same students that conducted experiments during the first half of the term. Therefore, the students were working in groups together for over seven weeks.

The HEC part of the course consisted of six three hour sessions. Each class session began with a lecture to all of the 21 students. The lectures consisted of hydrologic engineering topics and the use of HEC-1 and HEC-RAS. The class projects were also discussed during these lectures. The lectures ran about half an hour in length. At the end of the half hour lecture, the students were separated into two sections.

One section consisting of eleven students stayed in the classroom where the lectures took place. The second section, consisting of 10 students, moved to the Design Center. Each section consisted of three small groups as described above. The students remaining in the classroom were given an additional lecture approximately 20 minutes in length. The topic of this 20 minute lecture was on the use of the HEC programs and how to prepare their input parameters. The students in the Design Center were given modules and instructed to read the modules and start on their projects. There were two projects assigned. Each of the six groups were given the same projects.

The first project was to determine the runoff hydrograph from a site located in New York or New Jersey, and to route the hydrograph through a reservoir spillway structure. The students were asked to use the Army Corps of Engineer program HEC-1 to determine the reservoir spillway capacity of their project. Each group was given the Soil Conservation Service book on the county their watershed was in, and engineering drawings of their dam spillway structure. The group members purchased topographic maps of their watersheds at a New York City map store.

The students were asked to determine the flooding potential of stream networks located in New York for their second project. Each group used the Army Corps HEC-RAS program to determine the backwater curve for their stream. Each group was given typographic maps of their stream, and site-specific information on the surface soil characteristics of the site.

Although each group had the same tasks to perform, they had different sites and could not share site information. Each project had the following procedure:

1. preparation of site information
2. computer runs
3. interpretation of program output
4. report preparation

Each group delivered one report for each project. The modules were only given to the students that were in the Design Center. There was a graduate student in the Design Center to answer any questions the students may have had. This student had taken Water Resource Engineering with the same instructor, and had used both programs and the modules.

**Organization:**

It was difficult to spend enough time with each section. At times I left one section alone for up to one hour. A group got stuck on a point and was unable to move ahead. When the whole class was in one classroom (as in previous terms), it seemed I was more available to each group. But, being separated into two different areas made it more difficult to see each group.

The graduate student (TA) was not used as much as I had hoped for. I believe this was because the graduate student was not forceful enough to determine the needs of the student groups. This was partly my fault in not clearly instructing the TA. Also, the TA could have been better prepared in the use of the modules and programs. Again, I should have made sure that the TA had the proper training before class started.

The students (module groups) made no use of the internet. This is due to the fact that Cooper Union is a small school and the students see each other on nearly a daily basis, including the TA. Therefore, there is no need to communicate on the internet.

I should have assigned each student that was part of the module section reading assignments on the internet and homework problems in the use of the module. In this way, the students would have been prepared to use the programs when the input parameters were finished.

**Previous Testing:**

The term before the virtual classroom experiment was conducted (fall semester 1997), three senior civil engineering students were given the modules and asked to conduct the same projects that the students taking Water Resource Engineering conducted the following term. These students had taken and passed the Water Resource Engineering course in the spring term 1997 with the same professor teaching the virtual classroom. Each student was given the required maps, SCS soil book, drawings of the spillway, etc. for their site. They were also given the modules and the HEC-1 and HEC-RAS programs. There was no other instructions given to these

students except to do each project and critique the procedure. That is, advantages and disadvantages and how to improve the modules and the running of the project. These students worked alone and had no further contact with the professor until the project was finished. The main critique was to add more instruction on the selection of input parameters. There was also some confusion following the directions in the HEC-RAS module because a new version of HEC-RAS was released by the Army Corps of Engineers prior to the assignment. The modules were corrected to incorporate the students' needs before the virtual classroom project began.

**Use of the Module**

The students did not make as much use of the HEC-1 module as they did the HEC-RAS module. I believe this was due to my instructions. When I handed out the HEC-RAS module I gave each of the 10 students in the Design Center the module and insisted that they read the module first before starting the project. I did not give each student in the Design Center the HEC-1 module, and wasn't clear on reading the module before starting on the project. As a result of this confusion, I believe, I had to spend time with some of the groups (particularly the worse group) on describing topics that were given in the module. For the HEC-RAS project there was less individual group instruction necessary.

The computers used for the HEC-1 and HEC-RAS programs were in the Design Center. Both sections were using computers next to each other, and the groups without the modules would look at the modules from neighboring groups when they ran into difficulty. The only way to completely eliminate this sharing of modules from different sections was to separate the sections

in different computer classrooms. This would present the same problem as in the instructional phase of the project, that is, I would have had to spend my time between two different classrooms.

Also, HEC-RAS is a windows-based program and may have been easier to access and use. HEC-1 is not a windows-based program and must be accessed by inputting data in a prescribed ridged format.

**Modules**

The study of hydraulics and hydrology is a necessary part of civil and environmental engineering. There are a number of textbooks available to the undergraduate student in these areas of engineering science. But it is difficult to find an introductory text that will cover both hydraulic and hydrologic engineering in a clear and concise manner. Presently, computer modeling is widely used in the environmental and civil engineering profession. A number of these programs are used to determine flooding potential of streams, roads, parking areas, etc. The U.S. Army Corps of Engineers has encouraged the use of two such programs: “Flood Hydrograph Package (HEC-1),” and “River Analysis System (HEC-RAS).” It is virtually impossible to find the instructions on the use of these programs in an introductory course in Water Resource Engineering. This has placed an added burden in teaching hydraulics and hydrology to the undergraduate engineering students.

Approximately a decade ago, the course in Water Resource Engineering (hydraulics and

hydrology is introduced to junior civil engineering students in this course) at Cooper Union was revised to include a three hour laboratory and problem solving weekly session. In order to incorporate the use of the latest techniques in this course, projects in urban storm water runoff and flooding were assigned. The HEC-1 program and HEC-2 program were used to determine drainage in the students' projects. HEC-RAS is basically the windows version of HEC-2. It was clear from the beginning that the students needed more than an introduction to the use of these two programs to be able to conduct watershed runoff and backwater curve computations. Longer and longer periods of time were necessary to instruct the students in the use of these necessary tools. This took valuable time away from the laboratory hydraulic experiments conducted as part of the required course. At this time, the module was developed as a learning aid in the proper use of both programs: HEC-1 and HEC-RAS. This module also includes instructions on basic hydraulic and hydrologic principles.

The module is separated into two. The first half of the module is structured around three illustrative examples. A state of the art computer program, "Flood Hydrograph Package" (HEC-1), developed by the U.S. Army Corps of Engineers, is used in all of the three examples. This program is used in engineering practice to determine watershed flooding characteristics of both rural and urban sites. The use of this program is given in the first half of the module with instructions on how to prepare the input for the three illustrative examples and the output is interpreted.

In the second half of the module, a stream flooding problem is given. As in the first half of the module, illustrative examples are used as a teaching guide. The U.S. Army Corps of Engineers' Computer Program River Analysis System (HEC-RAS) is used to solve these flooding examples. HEC-RAS is user-friendly and computationally efficient. It uses the latest user interface technology for data entry, graphics, and display of program results. Complete help screens are available for almost every program feature and option. HEC-RAS is for steady, gradually varied flow in natural or man-made channels.

The module was alpha and beta tested. The module was first alpha tested at Cooper Union on senior and graduate civil engineering students. These students were taking advanced hydrology and open channel flow hydraulics. The module was revised after reviewing the questionnaires given to the students. The module was then tested on two separate classes of junior civil engineering students taking their first course in water resource engineering. The module was beta tested on engineering faculty and students at Florida International University (FIU), and at Case Western Reserve University (CWRU).

**HEC-1 and HEC-RAS**

The surface runoff in a river basin due to precipitation is simulated by the HEC-1 computer model. The river basin is represented by an interconnected system of hydrologic and hydraulic components. A component may represent a surface runoff entity, a stream, channel or a reservoir. Streamflow hydrographs are the result of this modeling process.

The HEC-1 computer model has a large number of options such as multiple basin watersheds, flood damage analysis, dam safety, etc. The reformatted input data is printed in the output for the user's convenience. Hydrographs are printed in tabular form and graphed. Rainfall, losses and excesses are included in a table and plotted for runoff calculations. Separate values of losses and excess are printed for rainfall. For storage routings, storage and stage are printed/plotted along with discharge. The program produces hydrologic summaries of the computation throughout the river basin.

The HEC-RAS model can handle a full network of channels, a branching system, or a single river reach. The steady flow component is capable of modeling subcritical, supercritical, and mixed flow regime water profiles.

The solution of the one-dimensional energy equation is used as the basic computational procedure in HEC-RAS. The flow in natural and man-made channels is estimated by the use of the one-dimensional Manning equation. Energy losses are evaluated by friction and contraction/expansion coefficients (coefficient multiplied by the change in velocity head). Where the water surface profile is rapidly varied, the momentum equation is utilized. By the use of these equations, the program can handle hydraulic jumps, hydraulics of bridges, and evaluate profiles of stream functions.

**Classroom and Design Center**

The lectures were given in a classroom on the second floor of the Cooper Union Albert Nerken School of Engineering. This classroom can easily accommodate the 21 students taking the course. Each student had their own desk to sit at during the lectures. The Louis and Jeanette Brooks Engineering Design Center is also on the second floor, and is located approximately 70 feet from the classroom. At the heart of the Brooks Center is the Design Studio. Here, one finds four clusters of seven networked workstations, including SGI Octanes, Sun Ultra Sparcs, IBM RS 6000 workstations and Intel-based high-end PC's running Windows NT.

This sophisticated hardware is supported by a full array of advanced design software tools, which replicate a contemporary professional engineering design office capable of 3-D design and modeling. The main elements used in the Design Center for this project were a series of carrels located at one end of the center, and two rows of computers running the length of the center of the room. These computers are adjacent to each other and designed for a single student, although two can just fit in front of the screen. The Design Center is new and only went into operation a week before the students ran the HEC programs. Therefore, the HEC-1 and HEC-RAS were only installed on six computers. This limited access of computers forced a whole group to use a computer at one time. This made the area in front of each computer congested with students. Groups overflowed and intermingled. The groups without the module had access to groups with the module. Therefore, there were times when the module was passed to groups without the module. This appeared to be more the exception than the rule. Also, due to the limited access to the computers, approximately half of the students did not run the program. These students were

forced to return to the Design Center to run the programs. Unfortunately, not all of these students returned to the Design Center to run the HEC-1 and HEC-RAS programs.

The use of the carrels was successful. These designs made it convenient to work quietly in groups, and for the professor to tutor the students.

**Reports and Tests**

At the end of the term a one hour test was given to the class on the use of the HEC-1 and HEC-RAS projects. This test included the use of the program, preparation of input parameters, and interpretation of input results. The section of 11 students that remained in the classroom, and that were given the classic lecture mode, averaged a 67.6 on the test. The section of 10 students that were given the modules (virtual classroom) averaged a 63.7 on the test. Their grades were approximately 15 points lower than the grades these students received on previous classroom tests. I believe this may have been due to the fact that I gave no partial credit on the test, told the students the test counted for less than 5 percent of their grade, and the test could have been clearer. The best students in the class received the highest grades and the worst students the lowest grades. The distribution of the grades was independent of the section the students were in.

The average of the two reports on the projects were 90.3 for the section without the module and 91.8 for the section with the module. Again, the better groups received the higher grades and the worse groups the lower grades, independent of the section.

When the final numerical average for the course was determined, the categories were separated correctly (best to worst). The final numerical average was determined from two class tests, a final test, and eight laboratory reports. The two HEC reports were part of the eight reports, but the HEC test was not used to determine the final numerical average. The final categories determined from the final numerical average (with one [1] the best and six [6] the worst) were:

Module groups: 1 (77), 4 (71), 6 (48.25)
No Module groups: 2 (70.75), 3 (75), 5 (53.67)

The worst group received the lowest grades in the class for the HEC test and HEC reports (number six [6]), and the second worst set of scores was number 5. The best group received the highest grades on the test (number one [1]). Note, the average HEC test scores for each group are given in parenthesis next to and following the ranking. Group six has a large skew to the average of the module group. This is the reason for the lower average on the HEC test for the module group. If groups five (5) and six (6) grades are dropped from the average, the module groups' average (1 and 4) has a higher average than the no module groups' (2 and 3).

The largest difference in grades between the module and no module sections (HEC test and reports) is less than 4 points out of 100. This is within the statistical spread.

**Assessment:**

A faculty member specializing in assessment designed the assessment forms that were handed out to the students at the end of the term. The assessment took into account:

1. The goals of the course, as expressed by the instructor/professor in personal interview and as reflected in written materials (syllabus, project instructions).
2. These goals were approached and "operationalized" by taking into account the fundamental set of ABET criteria 2000. Consistent with this, we customized the set of competencies specifically for the course.
3. The assessment of the course was consistent with the overall goals of assessment at Cooper Union. Therefore, the assessment was customized for Water Resources Engineering (CE 142) by following, whenever possible, the assessment already performed in other courses at Cooper, such as Freshman Design (EID 101).

The assessment forms for this course were divided into two parts. First, a set of core competencies directly derived from ABET criteria 2000. Second, a set of "technical" competencies proposed by the evaluator and consistent with ABET, but leaving room for customization on the part of the instructor. Specific competencies which were relevant to CE 142 were selected from the 13 competencies assessed for EID 101, and then additional relevant competencies were added.

The purpose of the assessment was to specifically evaluate the usefulness as a learning tool of the teaching technique devised by the instructor. The assessment is comparative in nature. It follows

the design of the course, which divides students into two main groups: one group exposed to the modules HEC-1 and HEC-RAS, and another which works with a traditional classroom lecture mode. Consequently, the assessment form contained:

A. A few questions pertaining only to the module HEC-RAS, to be answered by the students using it, so we could assess its usefulness. This part contained two open questions, in which students are asked to describe both the best and the improvable aspects of the lab as they have experienced it. By collecting this information we were prepared to qualitatively assess the virtual classroom.

    Q1. Do you think the modules HEC-1 and HEC-RAS is a useful learning tool? How? Please explain.

    Q2. Do you have any suggestions to improve the design of the modules HEC-1 and HEC-RAS? Please explain.

B. A set of questions for both groups of students, for comparative purposes; these questions referred to both the goals of the course, and the main competencies that may be developed through the course (more particularly through the lab tasks). They addressed aspects in the organization of the course and how to improve it.

    Q1. What's your opinion about the organization of the HEC part of the course? Would you prefer to work outside the class with less formal lectures or in a traditional format? Would you need more time to ask questions to the professor/teaching aid? Would you need more instructions to start the project?

How could the organization of the course be improved?

The blank assessment forms are given in the appendix with the students' comments, analysis, and recommendations.

**Conclusion**

The drainage module was incorporated into a required undergraduate course in civil engineering "Water Resource Engineering" (CE142). The drainage module makes use of the U.S. Army Corps of Engineering programs: "Flood Hydrograph Package" (HEC-1) and "River Analysis System" (HEC-RAS). The drainage module was used in two different projects for the second half of the term in a three-hour laboratory/problem solving session.

A virtual classroom was also tested in this three-hour laboratory/problem solving session. The concept of the virtual classroom is to substitute class lectures for modular based teaching aids and an open classroom where the professors meet with small groups of students in an informal setting. The virtual classroom was tested by dividing the class into two sections. One section was given class lectures and in the other section the virtual classroom was used. Both sections were given the same test and had similar reports to present. The average of the tests and reports for the two sections were basically the same.

We believe that even though the section using the virtual classroom did no score higher than the section given classroom lectures, the concept was a success because the virtual classroom concept could have been improved in the following ways:

(1) The students could have read the module before the watershed project started and made better use of the internet.

(2) The teaching aid was not sensitive to the students' needs. He should have been prepared to answer their questions when the professor was not available.