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Web-Based Interactive Computer-Aided Learning Package on Open Channel Flow: Innovations, Challenges and Experiences

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ABSTRACT

In this paper, the development and implementation of a web-based interactive computer-aided learning package on open channel flow is delineated. The principal purpose of the tool is to support classroom teaching for better understanding of the basic principles and practical aspects of the theories on open channel flow. Several up-to-date expert-system-shell and web-production software are employed during its development. Various theories on open channel flow, design, and interactive “What-if” analysis on various design parameters are performed using this package through an active and dynamic learning environment. Through evaluation of its learning effectiveness and teaching efficiency, in comparison with traditional course delivery, pertinent innovations, challenges and experiences on the possible impact the Internet is having in the field of engineering education are discussed. It is shown that, if used appropriately, web-based learning has the potential to enhance both learning effectiveness and teaching efficiency.

KEYWORDS:

Computer-aided learning package; expert-system-shell; open channel flow; web-based learning

INTRODUCTION

Society has entered into the information age, in which people intend to acquire information as quickly as possible. The widely used World Wide Web can be characterized by widespread availability via the Internet, short learning time in using the graphic interface browsers and open standard, and portability between different operating systems and platforms. The information released in the Internet is no longer limited to text and graphics as normally presented in the conventional textbooks. The linked material can be in a variety of formats including pictures, sound, video, three-dimensional modeling, animation or application. These characteristics enhance the feasibility of the World Wide Web in developing new packages of educational materials. With technological advancements in the fields of computer technology, artificial intelligence technology, education and instructional technology, web-based learning (WBL) has been becoming somewhat common place in what are considered traditional higher educational settings. At a minimum, most schools try to incorporate some aspects of WBL into their curricula.

WBL provides the opportunity for interaction among the learners, allowing them to tailor learning experiences to meet their specific needs or abilities. It allows a student to dip-in and dip-out of the different course sections. As such, participants can directly access different headings, and, if they need further information about some topic, they can jump into the pertinent headings, or into the reference materials, and then back again. WBL supports an active and dynamic learning environment and offers a stimulus to engage learners in meaningful learning through reflection, application, and interaction. It allows people work at their own pace from different locations and allows organizations to add their specific

knowledge to tailor-make the teaching materials.

For effective teaching and learning, it is not enough just to supply materials to the learners. The instructor has to monitor whether they have accessed the pertinent information, or whether they need to be chased at times. It is imperative that their records are kept up-to-date and that their progress is tracked and recorded. Web technology can be blended well with active learning (Novak et al. 1999), through automation of this monitoring task in counting the frequency of visits by students, pages that are accessed, number of discussion messages that are posted, etc.

Under the traditional educational systems, quite wide variations in age, experience, and background can be detected among students. In recent years, the demand for higher education at different age groups has been increased, particularly in adult age group. Society increasingly demands people to possess better educational quality. Hence if the adults desire to earn more money in order to improve living conditions for their family, they have to upgrade themselves through various channels. But time constraints and places where they are living usually impede them. WBL can provide a flexible and cost-effective means and opportunity of lifelong access to educational opportunities for diverse ranges of individuals who would not normally be able to further their education. This study, however, focuses on its use to enhance classroom education.

Recently, the rapid development of WBL from a text-only medium to an expanding multimedia communication system has increased and diversified delivery mechanisms of quality education (Brown 2000; Hammer 2000; Javenkoski and Schmidt 2000; Özer et al. 2003). Commonly used WBL tools include e-mail, listservs, web-based bulletin boards, chat, online courses, electronic performance support system, static web pages and interactive web pages. There are, however, relatively few papers discussing application of WBL tools in Civil Engineering literature, in particular in the disciplines related to water-resources and environmental engineering. Oreta (2000) furnishes an example of a WBL module to supplement a Civil Engineering Course. Froese et al. (2001) incorporates web-based courseware into Civil Engineering education.

A knowledge-based system (KBS) is able to systematically encapsulate the heuristic expertise and knowledge about a domain problem (Calkins 2000; Chau and Yang 1992, 1993; Chau and Zhang 1995; Froese et al. 2001; Özer et al. 2003). The recent advances in KBS technology have rendered a user-friendly environment for development of knowledge bases. It is believed that the integration of the latest KBS technology with WBL can facilitate the development of a learning package.

In this study, a web-based interactive computer-aided learning package on open channel flow is developed and implemented, by employing the latest KBS technology and web production software. One of the key objectives is to enrich the Civil Engineering literature on novel applications of WBL in the field of water resource engineering. An evaluation of the effectiveness and impact of this package is also undertaken.

BACKGROUND AND MOTIVATION FOR DEVELOPING THIS PACKAGE

The course “CSE 306: Hydraulics and Hydrology” is comprised of three main topics: open channel flow, weeks 1 to 5; pipe flow, weeks 6 to 9; and, hydrology, weeks 10-14. Each section contributes almost the same weight to the final examination. It is a required undergraduate course for full-time Civil and Structural Engineering students, full-time Civil and Environmental Engineering students in their second year of study and part-time day-release Civil and Structural Engineering students in their first year of study. The enrollment in this course for the past five years ranged from 113 to 123, with an average enrollment of 120. There has been no change in enrollment criteria, the syllabus, the location, the organization or the course time/requirements during these years. The course presents several

teaching and learning challenges. There is great disparity in the level of age and experience amongst different groups of students. Whilst the two groups of full-time students have advanced level entry background (equivalent to upper secondary school level), their part-time counterparts possess either Higher Certificate in Civil Engineering (acquired after one or two years study in Technical College) or Higher Diploma in Civil Engineering (obtained after two or three years study in Technical College) and are currently working full-time in the industry.

Most students that drop a course do so in the first few weeks of the semester. Drop out rates of the part-time students in the past were much higher than those of the full-time students. Many part-time students have indicated that their full-time workload deprived them of the time necessary to attend lectures as well as scheduled tutorial sessions. A self-paced and asynchronous learning mode may be more appropriate for them. Moreover, the resources that are required to develop the package can be justified by the large number of students in each year. The use of web-based multimedia seems to be particularly useful for classes involving participants with diverse educational backgrounds since they can have active control on their own progresses. Good learning effectiveness is not easily attainable simultaneously for all groups of students in conventional learning. These and other aspects of the course suggest that this course may prove a good candidate for placing much of the material on a web site.

Motivation behind this study into a courseware-development project principally comes from the potential advantage of this approach. This may lead to improved learning effectiveness and/or teaching efficiency. It is imperative to consider each of these issues explicitly since these two factors are quite distinct and advantages in one area can justify developments that have disadvantages in another area.

DEVELOPING TOOLS

An expert-system-shell and several web-production software are employed together to suit the characteristics of the circumstance.

Visual Rule Studio™

In order to facilitate development of the knowledge base on open channel flow, an expert-system-shell containing specific representation methods and inference mechanisms is employed. This system is implemented with the aid of a microcomputer shell Visual Rule Studio™, which works under the Microsoft Visual Basic™ 6.0 programming environment. Production rules as well as procedural methods are used to represent heuristic and standard engineering knowledge.

Web-Production Software

The main structure, frame and most of the functions of the web pages are built by using the software Dreamweaver™.

A number of Java programs are written and incorporated into the WBL to illustrate some open channel design calculations. JavaScript™ is used in the search function to provide multiple web site searching and used to add some functions such as the timer in the web page. Hence the user can easily select the web site from the pull down menu. Flash™ shows some interactive graphics, which make the web page more active and alive. Photoshop™, which is a pixel based image editing program, is employed to edit all the pictures and graphics in the package. PhotoImpact™ is used to perform some special effects in the pictures.

INTERACTIVE LEARNING PACKAGE ON OPEN CHANNEL FLOW

The uniform resource locator for the web site for this system is

http://www.hkpolyu.net/home_html/index.html. This is a password-protected course server and interested readers are required to contact the author to acquire a guest login password. Figure 1 shows the overall organization chart of the interactive tool. Some tools built into the University's WBL software shell SMILE™, provided by SMILE Technologies Limited and adopted university-wide, are incorporated into the course. These domain-independent tools include the forum, bulletin board, chat room, contact us, course management tools, etc. Figure 2 displays the opening menu of the computer-aided learning package on open channel flow. The web pages can be divided into fourteen headings under three parts. The first part provides the *basic concept* of open channel flow, which is a WWW-based instruction from the webmaster to users. This includes: *introduction*; *concept of open channel flow*; *type of flow*; *fluid properties*; *Manning coefficient*; *flow measurement*; *glossary*; *site maps*; and *acknowledgement*. The *introduction* covers basic *characteristics* and *type of channel*. The *concept of open channel flow* comprises: *general approach*; *energy principle*; *velocity distribution*; and *hydraulic jump*. The *type of flow* includes *uniform flow* and *gradually-varied flow*. Figure 3 displays the screen showing instructional knowledge on the *concept of open channel flow*. Symbols are defined on the page and links are provided to other pages for definition. The second part is termed *design exercise* which gives details on *design of open channels*. It is further sub-divided into three sub-headings: *"What-if" analysis*; *design examples*; and *on-line quizzes*. The interactive *"What-if" analysis* offers experiential learning so that the students can realize instantly how a change in parameter in Manning's equation or gradually-varied flow equation will affect the behavior. Some *design examples* are given to demonstrate practical applications of open channel flow. The *on-line quizzes* provide a chance for users to test how they understand the domain topic. The final part provides *other auxiliary functions*: *forum*; *links*; *contact us*; and *course management tools*. The *forum* enables the students to have open interactions with the tutor and with one another. It comprises: a *bulletin board*; a *'Frequency-asked-question' list*; a *chat room*; and a *synchronous help session prior to the examination*. *Links* are used to connect with other reference materials such as web sites discussing appropriate use of significant figures. *'Contact us'* furnishes direct private interaction with the tutor, through sending electronic messages. The *course management tools* are responsible for tracking of the progress of each student with access limited to instructor. Amongst them, two specific aspects of this package are highlighted in this paper: practical design of open channels with *"What-if" analysis*; and *synchronous help session prior to the examination*.

Practical Design of Open Channels with "What-if" Analysis

Knowledge on design of open channel with various shapes is included in this sub-heading. Users can perform some design exercises as well as the "What-if" interactive analysis, which can help to relieve the intensive computation work for the analytical solution in the design of open channel. In the package, it is flexible to perform the "What-if" analysis by setting various design parameters through the interface as shown in Figure 4. The production rule (IF-THEN rule) inference mechanism under a KBS is used to select the appropriate user-input screen and solution algorithm based on the set of dependent variables that the user selects such as the specific geometry and boundary condition. Different computational options of basic geometries and downstream boundary conditions are provided under this sub-heading. The geometries include rectangular open channel, circular culvert, and triangular channel. The downstream boundary conditions can either be uniform flow or a specified depth. Users input values for a subset of parameters in Manning's equation or gradually-varied flow equation (depending on the downstream boundary condition) as independent variables and then the program determines values for the remaining dependent variables.

Some educators might struggle with the philosophical question of the value of a

“black box” calculator that furnishes a solution in response to a set of input values. Nevertheless, the computer-based interactive analysis can offer students experiential learning, which is a key component of synthesizing knowledge to higher-level learning (Holzer and Andruet 2000). This type of learning cannot be obtained from presentation of the theory alone. This pedagogical method may be of more value to a second year course when the students have already built up certain domain knowledge, than a first year course which places more emphasis on the fundamental principles. In this approach, students can alter various physical characteristics and have the opportunity to obtain the corresponding changes in solutions to other parameters instantly. For example, if the students utilize this tool to determine upstream water levels in a river channel during flooding assuming normal flow and certain other downstream boundary conditions and then compare the resulting designs, it furnishes a more accurate solution than the case of simply assuming normal flow. Although a spreadsheet can be used instead, it will involve more than six different tables representing all combinations of geometries and downstream boundary conditions and will need to address the problem of infinite loop when independent variables are also dependent variables. A centrally-controlled web-based program is much better in terms of maintenance and updating than a lot of spreadsheet programs distributed to all students which may be revised inadvertently. The web-based client/server and KBS aspects enhance great opportunity for this type of experiential learning.

Synchronous Help Session Prior to the Examination

Prior to each examination, a live and synchronous help session is offered on the website. It includes basically an on-line video conference and a whiteboard, on which both the tutor and students can make diagrams, drawings, sketches or hand calculations. Students can also ask questions or made responses through a text mode. It is not held during regular classroom time. A specially-scheduled time slot is allotted about one week prior to the examination when students at off-site locations can access this synchronous facility for discussion. This session is, however, strictly synchronous and students are not able to review the session asynchronously.

It is well received and the student tracking tools show that some students who are less active during other online discussion sessions (bulletin board and chat room) are more willing to participate (including asking question, answering questions, logging in and observing) in this session. Whilst the bulletin board and chat room are asynchronous and can be reviewed at any time, this session is synchronous. Hence, one of the possible reasons of their higher participation rate is that if they miss the session, they lose the chance to review it any more. Moreover, feedback from the students in a questionnaire survey conducted at the end of the semester reveals that they consider this session to be extremely helpful. Details of the questionnaire survey are presented and discussed under the following section.

EVALUATION OF LEARNING PACKAGE

Learning Effectiveness

In order to gauge the learning effectiveness of the learning package, students are required to complete a questionnaire with 14 questions that evaluate the on-line material at the end of the semester. The feedback and written evaluations of the students on the scope and instruction effectiveness of the web-based package comprise several useful points. Table 1 shows the results of the student feedback questionnaire survey on using the teaching package whilst Table 2 shows the corresponding results prior to the use of this package. It is generally recognized that student feedback often follows some clear trends (Wankat and Oreovicz 1993). In order to indicate the clear trend, the detailed breakdown for full-time Civil and

Structural Engineering degree; full-time Civil and Environmental Engineering degree; and part-time Civil and Structural Engineering degree is made. It should be admitted that the two sets of survey questions between the pre- and post-WBL courses are not exactly comparable and that only three questions are the same. However, the results from these three questions illustrate that there are little change between the pre- and post-WBL years. This can be used to infer that the population is largely unchanged in their overall view of the course. It is on this basis that reasonable comparison between the two sets of results can be made. From the results, it is delighted to notice that no aspect of the WBL system receives an unfavourable ranking. Owing to the inherent variability in student rankings, only extreme rankings, such as exceeding a rank of '4-Agree', are considered significant. Hence, the following two aspects are particularly significant:

- ❖ the accessibility of instructional material and discussion session 24 hours a day furnishes great assistance in studying and tutoring, as and when required;
- ❖ the live and synchronous help session prior to the examination is helpful.

In summary, the results show that the material generally works well for the students, with both perceived advantages and disadvantages. The disadvantages include: WBL places higher reliance on the student's own effort to progress through the course; and WBL cannot easily customize and alter course content immediately in response to developments in class. As revealed from the survey results, another disadvantage is the apparent diminished interactions among students and between students and the tutors. However, it should be noted particularly that students rate the overall effectiveness of the material to be somewhat more effective than traditional lectures. This rating is even higher for the part-time students, than the full-time students. The tool assists in exciting students about the subject and in encouraging student-student and student-instructor interactions. This reinforces the belief that, under certain conditions, the quality of the learning experience for students need not suffer and may actually increase by supporting traditional classroom lectures with on-line courseware material.

Traditional classroom lectures and tutorials are supported and supplemented by the WBL in the open-channel flow section. Apart from this, no changes, including the text book, instructor, format and organization, have been made to the course. Table 3 shows a direct comparison of the average open-channel flow section as well as remaining (pipe flow and hydrology) examination scores under the support of the teaching package (in Years 2001 and 2002) and in traditional formats (in Years 1998, 1999, and 2000) of the course. The results show that students with the support of the package generally score about 6% higher than those in the traditional one. A two-sample T-test indicates that the differences shown are statistically significant at the $\alpha = 0.01$ level. There are two assumptions in such comparisons: the examinations have the same level of difficulty; and the average calibre and background of the students who took the course during the last five semesters are basically similar. The former assumption is considered to be reasonable after having reviewed the examination papers by an independent moderator whilst the latter assumption can be justified by comparing entry qualifications of the different categories of students. Moreover, whilst pre- and post-WBL scores for the two non-WBL units are essentially unchanged with only 1.5% difference, the corresponding scores for the WBL unit were significantly improved by about 7.6% which are statistically significant at the $\alpha = 0.01$ level. This augments evidence for the advantages of this tool and helps to address some of the concerns about changes to the population sampled.

Apart from the improvement in the examination results, another advantage is found specifically on the part-time students with the use of the teaching package. Table 4 shows the drop-out rates of the students to the course prior and subsequent to the support of the package. It can be noticed that, whilst the drop-out rates of the full-time students are in general low,

the high drop-out rates of the part-time students have been lessened after the introduction of the teaching package. This improvement probably can be attributed to the suitability of WBL to distance and asynchronous education, which allows students to work their way through at their own pace and convenience.

Teaching Efficiency

Teaching efficiency, defined as students per unit cost, corresponds to teaching more students and/or using fewer resources. It is not clear that WBL offers improved teaching efficiency, but it does have different resource requirements, which create a possibility for better efficiency. It is indisputable that creating this teaching package is a huge undertaking with more effort and preparation than for traditional formats. It requires commitment of considerable initial time and resources for organising course content in multi-media formats including photos, audio, interaction, hyperlinks, drawing, to name a few.

However, the greatest potential for improvement in teaching efficiency is probably in the discussion forum. A once-and-for-all response can be made to the same question from different students. The forum allows students to answer each other's question, through which an excellent active-learning process is also accomplished. The other potential for efficiency is by furnishing on-line quizzes and exercises that are graded by the software, rather than the instructor grading many paper copies of quiz homework. Furthermore, the user-friendliness of the latest KBS technology and web production software has proven to facilitate development of the package, thus lowering the resource requirements substantially. Moreover, KBS is a very helpful learning tool in guiding the student to learn, through decision-making corresponding to the on-line quiz result of the individual.

The web-based instruction package has been implemented for two years. At the end of each semester, some typical questions posted by the students and their corresponding answers responded by both the tutor and other students in the discussion forum are archived and consolidated into a 'Frequency-asked-questions' list. The questions are organized by topic and the database is searchable. The number of questions from students recorded in the discussion forum is substantially reduced from 152 in the first year to 74 in the second year of operation. At the same time, the student tracking records show that the average number of hits for the discussion forum per student increases from 252 times to 488 times whilst the average time of hit changes from 2.8 minutes per hit to 3.5 minutes per hit. This proves its capability as well as usefulness in serving as good frequently-asked questions for students in later years. Hence, it can be deduced that this feature is a very useful resource for students as well as a means for real long-term resource savings in dealing with fewer student questions.

CONCLUSIONS

The development of a prototype web-based computer-aided learning package on open channel flow, by employing several up-to-date expert system shell and web production software, is delineated. The paper shows how various elements of a traditional course on open channel flow are translated to Internet courseware and shares the experience gained together with the development considerations. Furthermore, practical design of open channel flow can be enhanced using the interactive "What-if" analysis, whose ease of usage and ability to give instant results are found to be particularly helpful. Through this package, pertinent innovations, experiences and challenges on the impact the Internet is imposing on engineering education are presented. It is shown that, if used appropriately, WBL has the potential to enhance learning effectiveness as well as teaching efficiency. It is reinforced, in particular, that this type of pedagogical instruction can fulfill certain demands of part-time or self-paced students that are so far not fully satisfied by the extant delivery system.

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Table 1. Results of the student feedback questionnaire survey on using the teaching package

	Year	2001			2002		
	Program [#]	a	b	c	a	b	c
Students basically possess good basic skill in using the computer.		3.9	3.8	3.7	4.0	3.9	3.7
Students can actively control the information flow, with highly flexibility to pursue education.		3.7	3.6	3.8	3.5	3.5	3.6
Accessibility of discussion session 24 hours a day furnished great assistance in studying and tutoring.		4.0	4.0	4.1	4.1	4.0	4.2
The course material with multimedia formats of presentation was interesting.		3.6	3.6	3.7	3.9	4.1	4.0
The presented material was easy to comprehend.		3.9	3.7	3.8	3.6	3.6	3.7
There were more interactions between tutor and students.		3.6	3.7	3.8	3.5	3.5	3.6
There were more interactions amongst students.		3.4	3.4	3.5	3.6	3.5	3.7
Students were more comfortable to ask questions in Internet than in classroom.		3.8	3.9	4.0	3.7	3.7	3.8
The on-line internet search capabilities facilitated students to seek out their own references.		3.6	3.7	3.5	3.6	3.5	3.5
The content material was relevant to the future professional development of students.		3.2	3.2	3.3	3.4	3.3	3.5
The web-based courseware environments facilitated timely and effective means of furnishing feedback to students.		3.8	3.7	3.6	3.5	3.6	3.5
The live and synchronous help session prior to the examination was very helpful.		4.1	4.2	4.1	4.2	4.3	4.1
The course workload was reasonable.		3.6	3.5	3.5	3.5	3.6	3.5
The overall effectiveness of the material was more effective than traditional lectures.		3.6	3.6	3.9	3.5	3.6	3.8

[#] a = full-time Civil & Structural Engineering degree; b = full-time Civil & Environmental Engineering degree; c = part-time Civil & Structural Engineering degree

* 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Table 2. Results of the student feedback questionnaire survey prior to the use of the teaching package

	Year	1998			1999			2000		
	Program [#]	a	b	c	a	b	c	a	b	c
The instructor has furnished adequate assistance in studying and tutoring.		3.5	3.4	3.3	3.6	3.4	3.2	3.8	3.5	3.1
The course material was interesting.		3.4	3.5	3.2	3.7	3.5	3.1	3.8	3.6	3.2
The course material was easy to comprehend.		3.7	3.9	3.7	3.9	3.7	3.8	3.7	3.8	3.6
There were good interactions between tutor and students.		4.2	4.0	3.9	4.1	4.1	3.9	4.2	4.0	3.8
There were good interactions amongst students.		3.9	4.0	3.8	4.1	3.9	3.9	3.7	3.8	4.0
Students have sufficient occasions to ask questions in classroom.		3.5	3.3	3.2	3.6	3.3	3.1	3.4	3.2	3.1
The teaching facilities were adequate for students to seek out their own references.		3.4	3.3	3.1	3.5	3.4	3.2	3.4	3.3	3.2
The content material was relevant to the future professional development of students.		3.2	3.3	3.4	3.4	3.1	3.3	3.2	3.3	3.5
The feedback to students was timely and effective.		3.6	3.4	3.3	3.5	3.8	3.2	3.7	3.6	3.2
The course workload was reasonable.		3.7	3.5	3.2	3.6	3.3	3.1	3.5	3.4	3.2
The overall effectiveness of the material was good.		3.4	3.3	3.7	3.5	3.6	3.5	3.3	3.3	3.6

[#] a = full-time Civil & Structural Engineering degree; b = full-time Civil & Environmental Engineering degree; c = part-time Civil & Structural Engineering degree

* 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

Table 3 Direct comparison of average open-channel flow as well as remaining (pipe flow and hydrology) examination scores under the support of teaching package (in Years 2001 and 2002) and in traditional formats (in Years 1998, 1999 and 2000)

	1998	1999	2000	2001	2002
Open-channel flow score for full-time Civil & Structural Engineering degree students	3.05	3.07	2.98	3.23	3.20
Open-channel flow score for full-time Civil & Environmental Engineering degree students	2.91	2.86	2.83	3.01	3.03
Open-channel flow score for part-time Civil & Structural Engineering degree students	2.52	2.60	2.47	2.85	2.83
Open-channel flow score for all students	2.84	2.87	2.78	3.05	3.04
Score of remaining topics for full-time Civil & Structural Engineering degree students	3.06	2.96	3.01	3.07	3.03
Score of remaining topics for full-time Civil & Environmental Engineering degree students	2.93	2.89	2.88	2.85	2.94
Score of remaining topics for part-time Civil & Structural Engineering degree students	2.55	2.49	2.56	2.59	2.64
Score of remaining topics for all students	2.86	2.79	2.83	2.86	2.88

* Grade point: 4.5 = A+; 4 = A; 3.5 = B+; 3 = B; 2.5 = C+; 2 = C; 1.5 = D+; 1 = D; 0 = F.

Table 4 Drop-out rates of students under the support of teaching package (in Years 2001 and 2002) and in traditional formats (in Years 1998, 1999 and 2000)

Drop-out number/total number of students	1998	1999	2000	2001	2002
Full-time Civil & Structural Engineering degree	0/51	1/52	0/52	0/50	0/48
Full-time Civil & Environmental Engineering degree	0/32	0/31	1/31	0/30	0/28
Part-time Civil & Structural Engineering degree	8/40	6/39	8/40	2/39	3/37

List of Figure Captions

Figure 1. Overall organization chart of the interactive tool

Figure 2. Screen displaying the opening menu of the computer-aided learning package on open channel flow

Figure 3. Screen showing instructional knowledge on the *concept of open channel flow*

Figure 4(a) & (b). Screens displaying interactive analysis of circular culvert that can demonstrate the effect of variation of various design parameters on the result

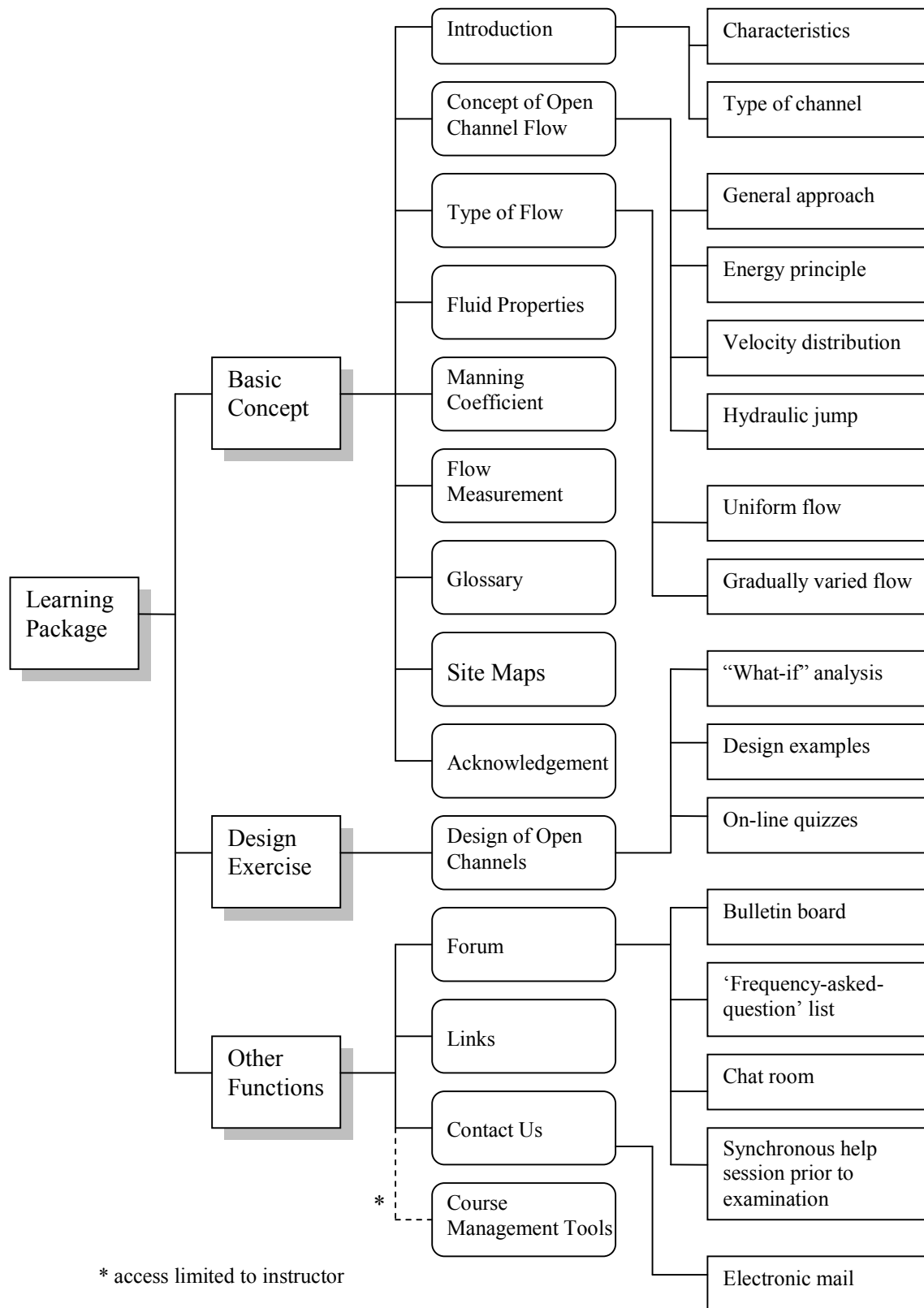


Figure 1.

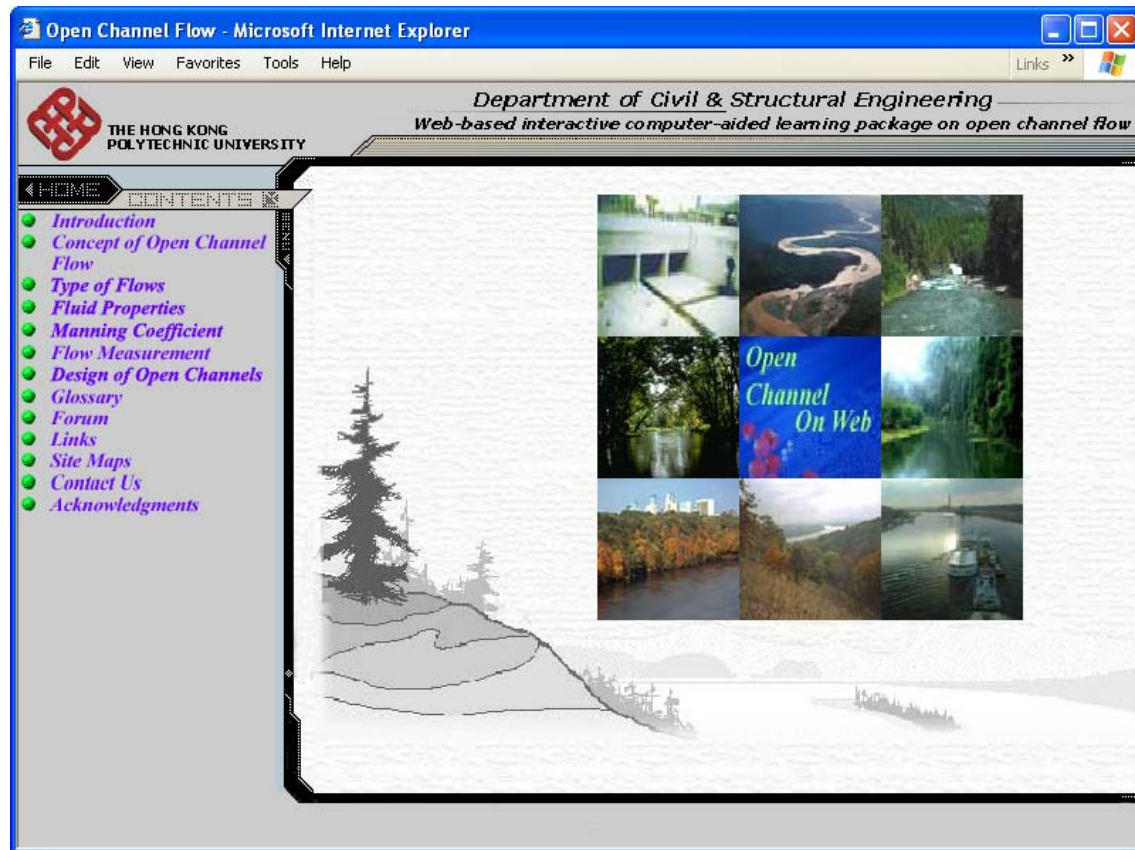


Figure 2.

Open Channel Flow - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Department of Civil & Structural Engineering
Web-based interactive computer-aided learning package on open channel flow

THE HONG KONG POLYTECHNIC UNIVERSITY

HOME CONTENTS

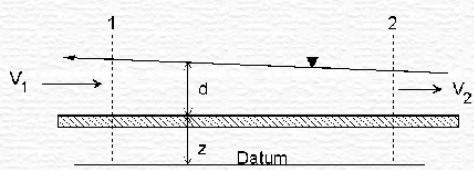
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General Approach

Assumption:

- fluid incompressible and homogenous (no air entrained or density gradients)
- pressure distribution at control surface is hydrostatic
- [steady flow](#)

The main equation used in describing open channel flow is the Bernoulli Equation. This equation can be derived by integrating the expression resulting from the application of Newton's second law to open channel flow.



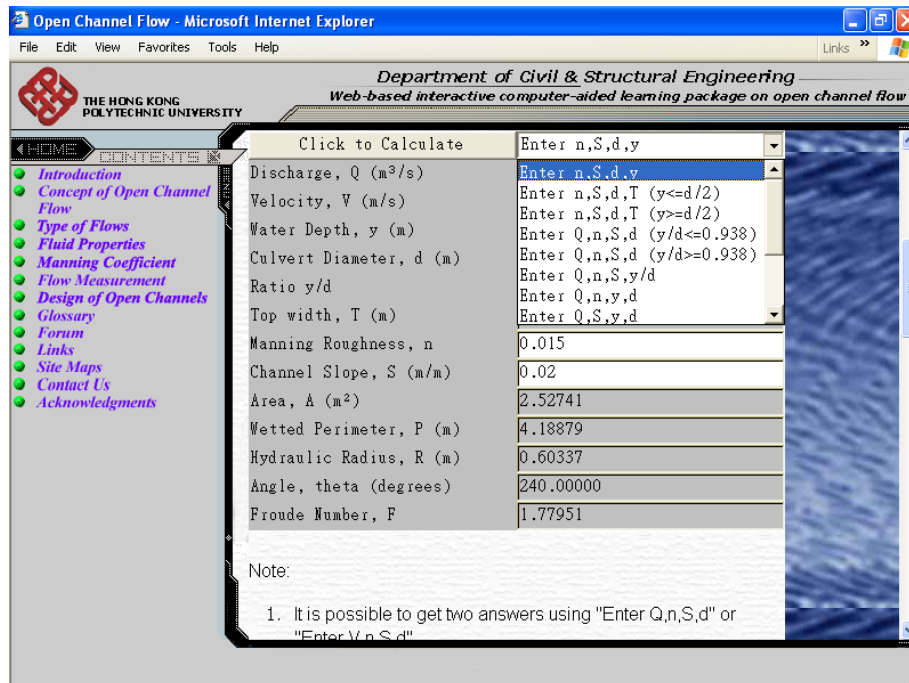
Bernoulli Equation:

$$H = \frac{V^2}{2g} + d + z$$

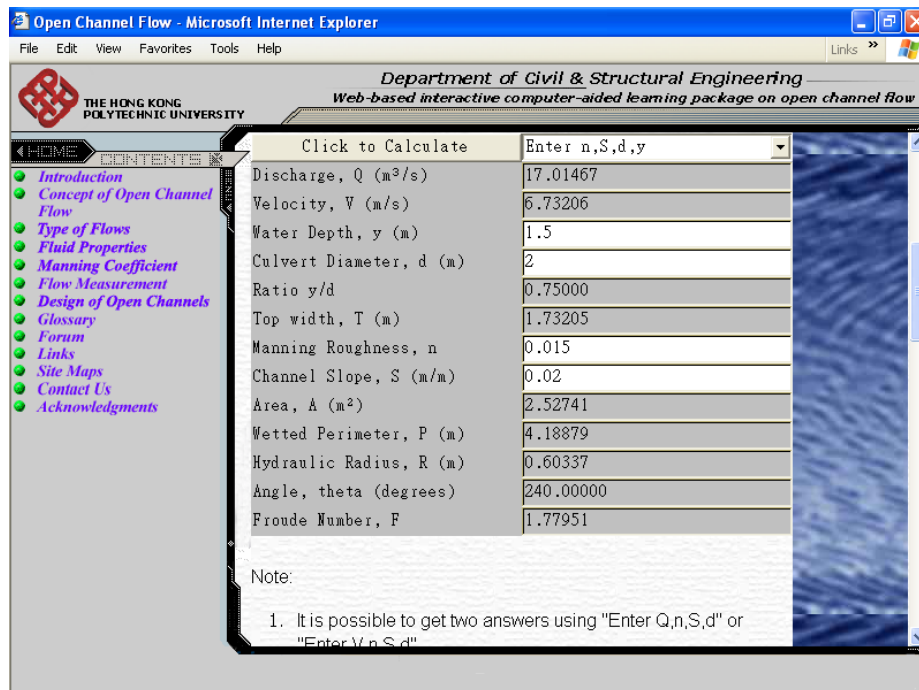
where

- H = total flow energy
- V = flow velocity
- d = flow depth
- z = elevation of the channel bed above the datum

Figure 3.



(a)



(b)

Figure 4(a) & (b).