Lecture Notes in Artificial Intelligence, Vol. 3683, 2005, pp. 756-762

Intelligence-Based Educational Package on Fluid Mechanics

K.W. Chau[1]

[1]Department of Civil and Structural Engineering, Hong Kong Polytechnic University, Hunghom, Kowloon, Hong Kong
cekwchau@polyu.edu.hk

Abstract. From the student feedback questionnaire, some students opined that the concepts of fluid mechanics are quite abstract and that they have difficulty in grasping the phenomena in real life situation. Hence, it demands some innovative learning methodologies to help arouse their interest. This paper depicts the development and implementation of an interactive teaching package on learning of basic fluid mechanics with a knowledge-based system approach. The prototype package is designed to guide engineering students in self-directed learning through the processes of interaction, reflection, and application, thus furnishing an opportunity of stimulating pedagogical environment. Diagnostic assessment is undertaken for every scenario of possible prompted answer on a specific topic, so as to evaluate the most probable shortfall or misconception of that particular student.

1 Introduction

From the student feedback evaluation, some students in civil engineering and mechanical engineering fields opined that the concepts of fluid mechanics, which involves the fundamental principles of physical science and applied mathematics, are too abstract and that they have difficulty in fully grasping the real phenomena. Hence, some innovative teaching and learning methodologies are necessary to help arouse their interest. With the advancements in the fields of computer and education technology, innovative learning package is becoming a general trend [1-2]. It appears that new technology will build a new paradigm on education, with self-directed learning as a foundation strategy. It has the potential for effecting fundamental changes in the design of pedagogical processes and the instructional system. Moreover, the traditional learning and training system is sometimes considered not effective enough since it offers little facility in tracking the progress of the student. It is suggested that simply to present materials to the students is not enough.

Recent advancements in artificial intelligence technology have made it possible for computer programs, by encoding knowledge and reasoning, to simulate human expertise in narrowly defined domains during the problem-solving process. There exist the most important trends in intelligence-based educational systems (IBES), which comprise various intelligent technologies such as knowledge-based system (KBS), fuzzy systems, neural networks, genetic algorithms, artificial immune systems,

and their implementation in a multi-agent framework and in form of hybrid intelligent systems. These smart interactive tutoring systems are actually required and are able to fit themselves to the student's individual unique needs [3-4]. Being one form of IBES, a KBS is capable to incorporate systematically the heuristic knowledge and expertise. By knowledge processing facilities, individual expert's knowledge could be stored under rule frame on a permanent basis so long as such rules are valid and update of such knowledge base whenever necessary is accomplishable over passage of time. The progress and development of KBS suggests that "machine expert" can play a vital role in decision making. It has been proven to be appropriate in furnishing solutions to domain problems that require considerable rules of thumb, judgment or expertise, in particular under the following types of classification, namely, education, diagnosis, interpretation, planning, and design. KBS has made widespread applications in a variety of domain problems and is proven to be capable of attaining a standard of performance comparable to that of a human expert [5-25]. It is towards this direction that the present study goes for extensive knowledge base for teaching and learning of fluid mechanics. In this paper, the development and implementation of a prototype interactive teaching package on learning of basic fluid mechanics with a KBS approach is delineated. Figure 1 shows the block diagram of this intelligence-based tutoring system.

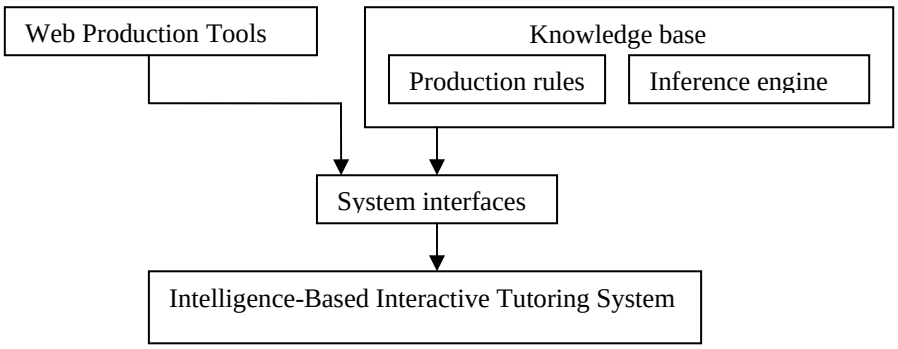

Fig. 1. Block diagram of the intelligence-based tutoring system

2 Use of Technology on Education

Nowadays, an expanding multimedia communication system offers the advantage of furnishing diversified and enhanced delivery mechanisms of quality education. However, effective instruction with technology must be driven by sound pedagogical principles, involving critical thinking, and providing a real community to students. With the increasing quality and availability of technology, learning has become rapid, effective, flexible, and convenient. In addition, it furnishes the immediacy and range of interaction comparable with face-to-face learning. It is apparent that the groups best served by technology are individuals who have special demands, have family responsibilities, and work and reside in remote areas. Moreover, there is stronger demand on educational institutions to be more efficient, to improve in areas including

instructional quality, mode of study, access, and costs. There exists strong demand for higher education to become more convenient, flexible, and effective for these individuals.

Moreover, it permits the students to acquire quality learning experience to suit their specific demands or capabilities. Students can freely and directly gain access to various parts of the course contents, and if they envisage any queries at any stage, they can point straight back into the relevant sections or into the references and back again. As such, it furnishes a dynamic and active learning environment and provides an opportunity of stimulating pedagogical environment to take care of engineering students in self-directed learning through interaction, application and reflection.

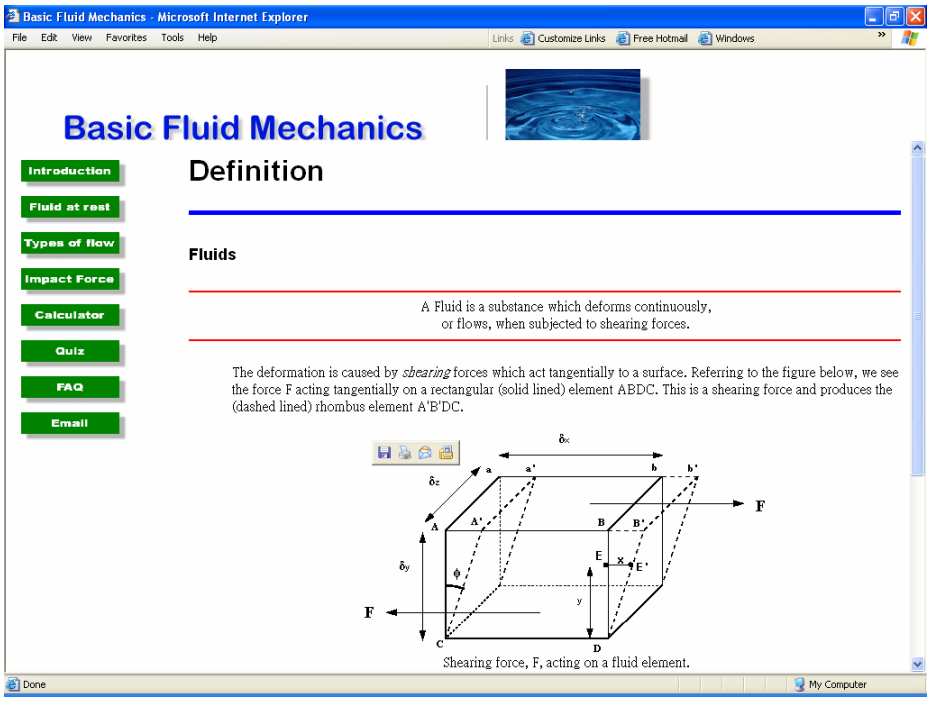

Fig. 2. Screen displaying instructional knowledge on basic fluid mechanics

Queries have been raised regarding the pedagogical quality that technology furnishes. Some educators may be concerned that teaching package is neither personal nor interactive and is consequently less effective than face-to-face instruction. A serious criticism is that it fails to create an effective learning environment due often to poor design. The common weakness of many learning packages is their misapprehension that information is equal to learning and material is laid out basically on the package in a regular textbook format. In such cases, learners are merely passively involved in electronic page turning when reading and sorting through material.

Novel technologies may provide flexible as well as prosperous media for representing what students know and what they are learning. Yet they should function

as intellectual tool kits that assist learners in establishing meaningful personal interpretations and representations of their environment. Hence, this new learning package is founded on learner demands for quality content, delivery, and service that leads to desired learning outcomes. It comprises a more constructivist view where learners are encouraged to reorganize, manipulate and personally synthesize course materials under an active and dynamic environment.

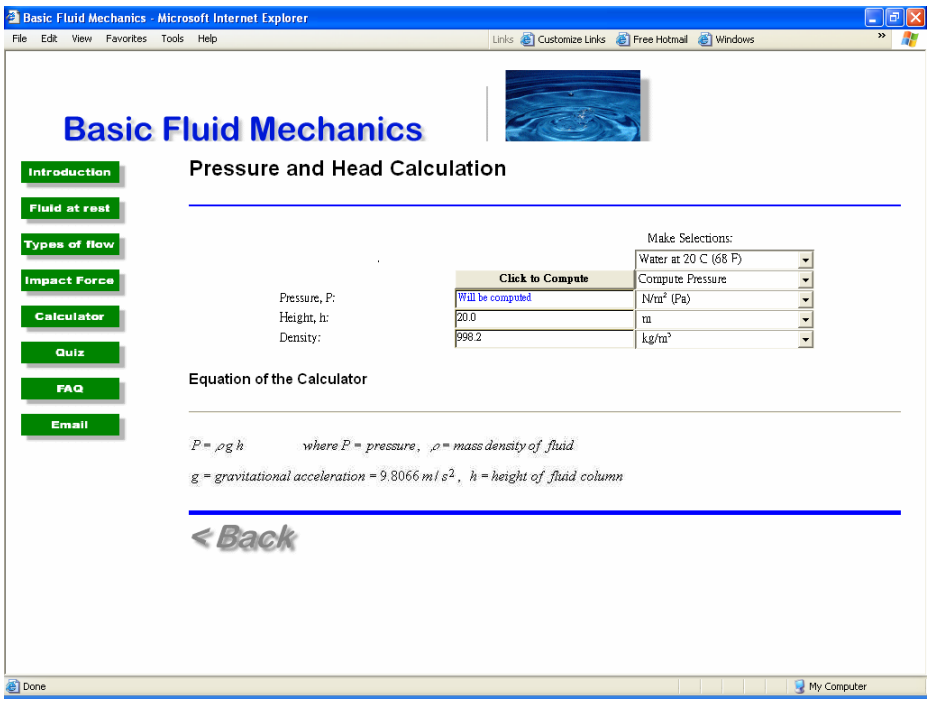

Fig. 3. Screen displaying the interactive "What-if" analysis on pressure and head

Table 1. Evaluation of the package on the basis of student feedback questionnaire survey

Questionnaire item	Average rating#
The presented material is relevant to the domain subject.	4.2
The package is easy to comprehend and greatly accessible.	4.3
The package is very helpful in understanding the topic.	4.1
The system is interactive and user-friendly.	4.3
The material with multiple formats of presentation is interesting.	4.1
The tool greatly arouses their interest in this subject.	4.2
Users can actively control the pedagogical process via the tool.	4.0
Users are proficient in using computer.	3.5

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

It necessitates a shift in teaching paradigm where instructors may need to adopt a more student-centered approach to their teaching. The emphasis is now placed on collaboration and active learning. The contexts should cater for learners of wide-ranging perspectives. Interactions are significant in that they render participation in the cycle of instruction, training, performance assessment, and improvement processes. They enable learners to tailor learning experiences to meet their specific capabilities or demands. Interactions allow clarification and the transfer of new ideas to extant conceptual frameworks.

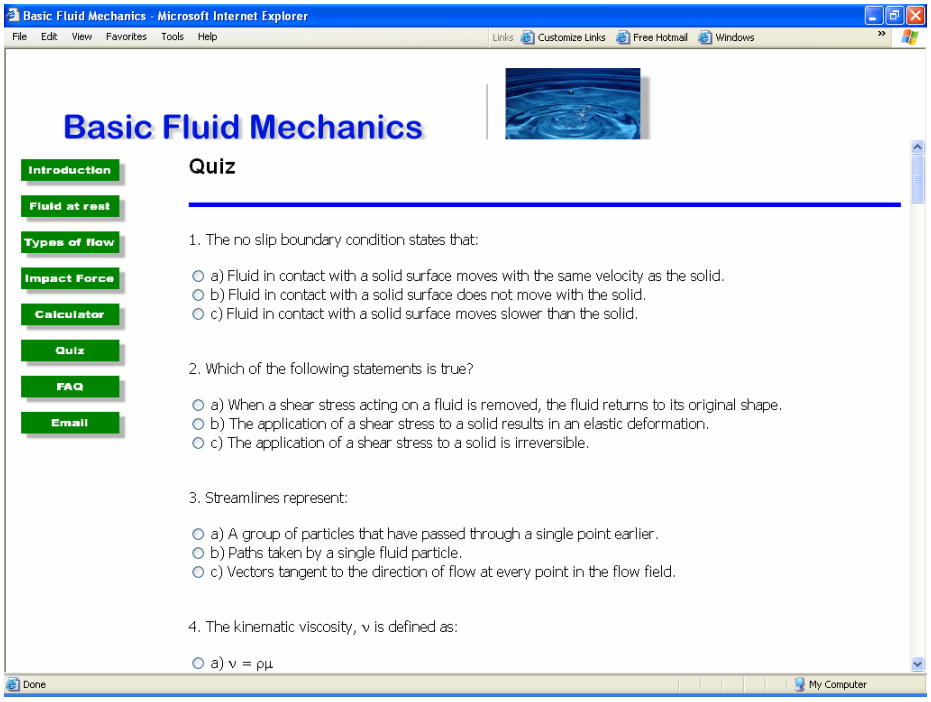

Fig. 4. Screen displaying quiz on basic fluid mechanics

3 Development Shell

This system has been developed and implemented using a microcomputer-based KBS shell Visual Rule Studio in order to facilitate development of the knowledge base on fluid mechanics. It is a hybrid application development tool under object-oriented programming design environment. This shell acts as an ActiveX Designer under the Microsoft Visual Basic 6.0 programming environment. Both production rules and procedural methods are employed to represent standard and heuristic knowledge on fluid mechanics. Rules are isolated as component objects, which are separated from both objects and application logic. As such, it produces objects that can interact with most modern development software.

4 The Prototype Teaching Package

The emphasis of this study is on the diagnostic assessment of learning performance and on the ensuing learning directive designed by the intelligent system, which depends on the response of the learner and the assessment outcome. Assessment exercises are carefully designed for each selected topic in fluid mechanics, covering all possible answers from the learner in mind. The covered topics include fluid at rest, types of flow, impact force, similitude, pipe flow, open channel flow, hydrology, hydrodynamics, coastal hydraulics, unsteady flow, and wind loading on structures. For each scenario of prompted answer from the student, diagnostic assessment is performed by the system to determine the most probable shortfall or misconception of the specific student on that particular topic. This heuristic knowledge can be represented by knowledge rules under the KBS approach. Figure 2 shows the screen displaying instructional knowledge on basic fluid mechanics. Figure 3 shows the screen displaying the interactive "What-if" analysis on pressure and head. Figure 4 shows screen displaying quizzes on basic fluid mechanics.

The prototype package is evaluated on the basis of a student feedback questionnaire survey. Table 1 shows some preliminary findings of the users' feedback on several useful points regarding the scope and effectiveness of this package. From the results, it can be concluded that the tool is found to be very relevant, easy to comprehend, accessible, helpful in understanding, interactive, user-friendly, interesting, arousing their interest and highly controllable although their computing literacy is not too high.

5 Conclusions

In this paper, the development and implementation of a prototype interactive teaching package on learning of basic fluid mechanics with a KBS approach is depicted. It is demonstrated that various theories on hydrology, fluid motion, etc. can be performed using this package through an active and dynamic learning environment. The flexibility and open infrastructure of the package have been shown to be able to act as a media for developing learning application. It offers the possibility of providing a stimulating learning environment to engage learners in meaningful learning through reflection, application, and interaction. The engineering students can gain deeper insight on this abstract subject through the interaction furnished in this package.

References

1. Berge, Z.L.: Guiding Principles in Web-Based Instructional Design. Educational Media International **35(2)** (1998) 72-76
2. Wiens, G., Gunter, G.A.: Delivering Effective Instruction via the Web. Educational Media International **35(2)** (1998) 95-99
3. Negoita, M.G., Pritchard, D.: Developing a "Virtual Student" Model to test the Tutor and Optimizer Agents in an ITS. Lecture Notes in Computer Science **3213** (2004) 240-252

4. Negoita, M.G., Pritchard, D.: An Optimizer Agent that empowers an ITS system to "On-the-Fly" modify its Teaching Strategies. Lecture Notes in Computer Science **3213** (2004) 914-921
5. Albermani, F., Chau, K.W.: Web-Based Knowledge-Based System on Liquid Retaining Structure Design as Instructional Tool. Lecture Notes in Computer Science **2436** (2002) 95-105
6. Chau, K.W.: An Expert System for the Design of Gravity-type Vertical Seawalls. Engineering Applications of Artificial Intelligence **5(4)** (1992) 363-367
7. Chau, K.W.: A Prototype Knowledge-Based System on Unsteady Open Channel Flow in Water Resources Management. Water International **29(1)** (2004) 54-60
8. Chau, K.W.: Knowledge-Based System on Water-Resources Management in Coastal Waters. Water and Environment Journal **18(1)** (2004) 25-28
9. Chau, K.W., Albermani, F.: Expert System Application on Preliminary Design of Liquid Retaining Structures. Expert Systems with Applications **22(2)** (2002) 169-178
10. Chau, K.W., Albermani, F.: A Coupled Knowledge-Based Expert System for Design of Liquid Retaining Structures. Automation in Construction **12(5)** (2003) 589-602
11. Chau, K.W., Albermani, F.: Knowledge-Based System on Optimum Design of Liquid Retaining Structures with Genetic Algorithms. Journal of Structural Engineering ASCE **129(10)** (2003) 1312-1321
12. Chau, K.W., Albermani, F.: Hybrid Knowledge Representation in a Blackboard KBS for Liquid Retaining Structure Design. Engineering Applications of Artificial Intelligence **17(1)** (2004) 11-18
13. Chau, K.W., Albermani, F.: An Expert System on Design of Liquid-Retaining Structures with Blackboard Architecture. Expert Systems **21(4)** (2004) 183-191
14. Chau, K.W., Albermani, F.: A Knowledge-Based System for Liquid Retaining Structure Design with Blackboard Architecture. Building and Environment **40(1)** (2005) 73-81
15. Chau, K.W., Anson, M.: A Knowledge-Based System for Construction Site Level Facilities Layout. Lecture Notes in Artificial Intelligence **2358** (2002) 393-402
16. Chau, K.W., Chen, W.: An Example of Expert System on Numerical Modelling System in Coastal Processes. Advances in Engineering Software **32(9)** (2001) 695-703
17. Chau, K.W., Cheng, C., Li, C.W.: Knowledge Management System on Flow and Water Quality Modeling. Expert Systems with Applications **22(4)** (2002) 321-330
18. Chau, K.W., Cheng, C.T., Li, Y.S., Li, C.W., Wai, O.: An Intelligent Knowledge Processing System on Hydrodynamics and Water Quality Modeling. Lecture Notes in Artificial Intelligence **2358** (2002) 670-679
19. Chau, K.W., Cheung, C.S.: Knowledge Representation on Design of Storm Drainage System. Lecture Notes in Computer Science **3029** (2004) 886-894
20. Chau, K.W., Ng, V.: A Knowledge-Based Expert System for Design of Thrust Blocks for Water Pipelines in Hong Kong. Journal of Water Supply Research and Technology - Aqua **45(2)** (1996) 96-99
21. Chau, K.W., Sze Y.H.: AI-Based Teaching Package for Open Channel Flow on Internet," Lecture Notes in Computer Science **3143** (2004) 98-104
22. Chau, K.W., Yang, W.W.: A Knowledge-Based Expert System for Unsteady Open Channel Flow. Engineering Applications of Artificial Intelligence **5(5)** (1992) 425-430
23. Chau, K.W., Yang, W.W.: Development of an Integrated Expert System for Fluvial Hydrodynamics. Advances in Engineering Software **17(3)** (1993) 165-172
24. Chau, K.W., Yang, W.W.: Structuring and Evaluation of VP-Expert Based Knowledge Bases. Engineering Applications of Artificial Intelligence **7(4)** (1994) 447-454
25. Chau, K.W., Zhang, X.Z.: An Expert System for Flow Routing in a River Network. Advances in Engineering Software **22(3)** (1995) 139-146