虚拟材料力学实验的教学评估

——中英学生评估案例研究

An educational evaluation of a virtual laboratory for materials science

Evaluating the virtual mechanical testing of materials through the experience of Chinese and British students

方慕真　[英] Mark Endean　著

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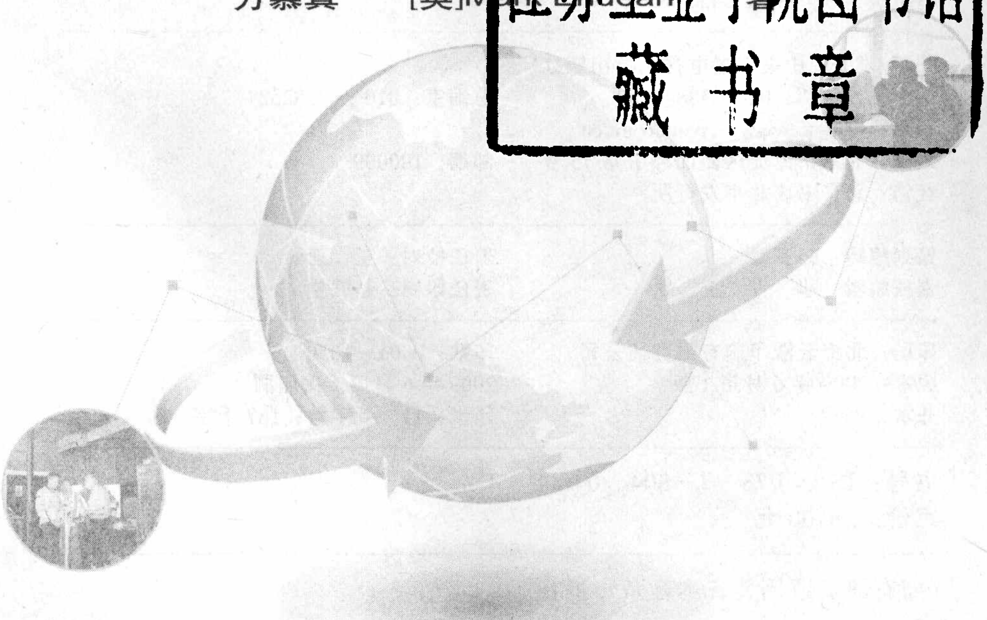

中央廣播電視大學出版社

图书在版编目（CIP）数据

虚拟材料力学实验的教学评估：中英学生评估案例研究／方慕真，（英）安丁（Endean, M.）著.—北京：中央广播电视大学出版社，2009.6

ISBN 978-7-304-04608-8

Ⅰ.虚… Ⅱ.①方…②安… Ⅲ.材料力学-实验-高等学校-教育评估-中国、英国 Ⅳ.TB301-33

中国版本图书馆 CIP 数据核字(2009)第 095493 号

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出版·发行：中央广播电视大学出版社

电话：发行部：010-58840200 **总编室**：010-68182524

网址：http://www.crtvup.com.cn

地址：北京市海淀区西四环中路 45 号 **邮编**：100039

经销：新华书店北京发行所

策划编辑：孙庆武 **责任校对**：王 亚

责任编辑：邓 肯 王 跃 **责任印制**：赵联生

印刷：北京云浩印刷有限责任公司 **印数**：0001～1050

版本：2009 年 6 月第 1 版 2009 年 6 月第 1 次印刷

开本：B5 **印张**：11 **字数**：167 千字

书号：ISBN 978-7-304-04608-8

定价：28.00 元

Preface

The work that forms the basis of this monograph began from an idea of Fang Muzhen, that there was potential to develop a simulation of a standard tensile testing machine. This could allow all her very many distance learning engineering students in China the opportunity to experience a tensile test and personally conduct the testing-something many were denied through accidents of geography or commitments of time and finance.

Fang Muzhen and her colleagues at China Central Radio & TV University(CCRTVU) duly developed just such a simulation and started using it. You can read about that in the following pages. But with all such new developments comes the suspicion that it is not somehow as good as the "real thing". Logically, therefore, a programme of evaluation should follow to attempt to establish that the new technology is at least no worse than what went before. And, of course, there's always the chance that it improves on it.

The work of the evaluation was planned while Fang Muzhen was visiting the United Kingdom Open University(UKOU), between 1999 and 2000, and it was carried out over several periods in both the UK and China. It has taken rather longer than we both hoped to publish this report of the study but we nevertheless hope that it is of some interest. At the end of the 1990s, there was still much skepticism about the role of what were then called "new" technologies in some fields of technical education. But the tide had already turned and the debate has now moved on to making sure that the technologies that are implemented are truly effective in respect of what is claimed for them.

This work would not have been possible without help from a considerable number of people. We should like to extend our special thanks to Sir John Daniel, the Vice Chancellor, who invited Fang Muzhen to visit the UKOU, which gave her the chance to start her MPhil work that forms the basis of this publication.

We should like to thank members of the Materials Engineering Department of the OU who helped to make it such a friendly and homely environment to learn as a foreign student. We are also very grateful to Peter Ledgard, Tim Gough and Colin Haynes for packing up and posting a testing machine, the infamous Hounsfield Tensometer, from the OU to Beijing for the research work in China. In China, practical support came from Liang Liuqing, Tao Jing and Wang Hong at Jing Tian RTVU, who were most helpful during the research when collecting data from students. And we should like to thank members of the OU's Institute of Educational Technology, in particular Adrian Kirkwood and Erica Morris, who provided invaluable advice during the earlier stages of the research.

None of this would have been possible without considerable and continuing financial support in both the UK and China. In that regard, we should like to thank Nick Braithwaite for supporting Fang Muzhen's return to the UK to collect more data in 2001, and Zhao Min for supporting her return to UK for further work in 2003.

Our last, and most heartfelt, thanks must surely go to the British and Chinese students who willingly gave up their time in response to a simple plea for help with our research. Without them, this study would simply have been impossible.

Fang Muzhen and Mark Endean
January 2009

CONTENTS

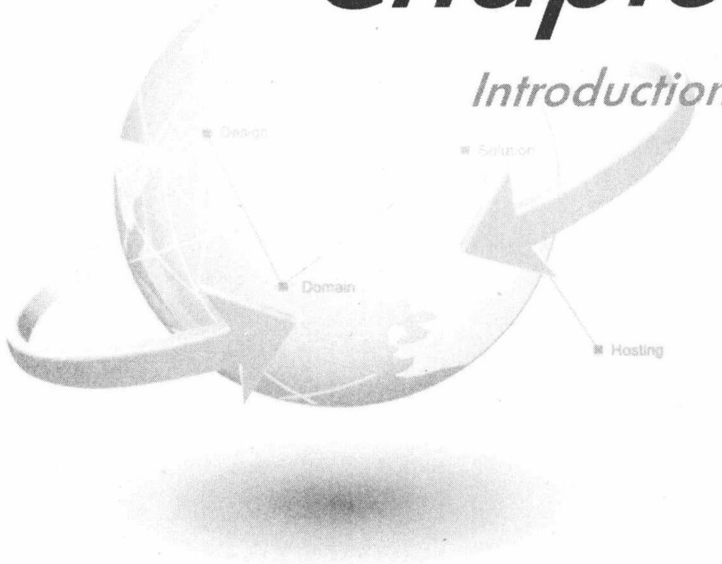
List of figures

List of figures

List of tables

Chapter 1

Introduction



1 Introduction

This is an account of the development and evaluation of a piece of software which we named the "Virtual Laboratory in Materials Science" for tension testing, which was targeted at students taking undergraduate degree programs in materials science and engineering, although it is equally applicable to very many engineering disciplines where a basic understanding of the mechanical properties of materials is paramount.

1.1 The Context for the Research

The criteria used by professional bodies to accredit engineering programs generally involve items that focus on the ability to design and conduct experiments, as well as to analyze and interpret data that are relevant to the particular field of engineering. Some of the engineering concepts and phenomena of materials science are notoriously difficult for students to grasp but can be learned more easily from practical laboratory work. Therefore there are some sorts of laboratory work involved in most materials engineering curricula at universities, such as tensile testing, torsion testing and flexural testing.

All conventional universities that offer engineering programs have engineering laboratories. Even for distance educational institutes there are various solutions to address this issue, e.g. the United Kingdom Open University (UKOU) has a summer school program and China Radio & TV Universities (CRTVUs) hire laboratories of local universities for the students to engage in laboratory work. But in distance engineering education some students do not have the opportunity to carry out the tests either because they cannot make time during their working day to attend or simply because there is no laboratory available locally to them. Therefore experiment kits and software packages are often used as supplementary materials for engineering students who need to take laboratory work. As an extension to this, a virtual laboratory that is based upon virtual technology can offer an opportunity to make up for the lack of laboratory work in distance learning engineering programmes.

1.2 The Aim of the Study

The Virtual Laboratory in Materials Science was developed in 1999 and was used by nearly 30,000 distance learning engineering students in CRTVUs by the end of 2003. Both pedagogy and technology design are involved in designing the Virtual Laboratory in Materials Science. The courseware is designed to provide a virtual experiment environment to carry out tensile and torsion experiments whilst teaching the basic properties of some typical materials. Because a non-immersive VR or VE system is feasible for wide use in educational applications, as the cost of this system is far lower than that of an immersive system (see Chapter 2), non-immersive VR technology was chosen for the courseware. By using 3D, image, sound, and video, the courseware creates a simulation of a real experiment environment to make a user feel personally on the scene. However, is the courseware useful? Do the students learn from using the courseware? Do they enjoy using the courseware? What aspects of the design of the courseware are successful, and what are not? These questions could be answered by a carefully designed evaluation. An integrated framework for evaluation including a pretest-posttest comparison was used to evaluate the Virtual Laboratory in Materials Science. This focused on comparisons of student performance before and after the tensile experiment had been undertaken.

1.3 Outline of the Research

The study used two treatment groups that worked with the Virtual Laboratory in Materials Science and two control groups that worked with a real testing machine. Engineering students at the UKOU and CRTVUs were involved in two groups in which students were randomly assigned to groups, in the hope of making some cross-cultural comparisons between learners. Triandis pointed out "Cross-cultural research is concerned with the systematic study of behaviour and experiences as it occurs in different cultures, is influenced by culture, or results in changes in existing culture" (Triandis, 1990, from Li, 2002). But this research focused on specific participants who were engineering students in distance learning and assigned to them learning performances before and after the tensile experiment. Therefore a meaningful cross-cultural comparison could not, in the end, be made. Nevertheless the results from the groups provide sufficient information to be of interest in itself, without needing to make comparisons between them.

> The technology revolution continues to change the way people live. This is particularly true in the field of education.
>
> (Birnbaum, 2001)

1.4 The Structure of the Book

Following this short introduction, Chapter 2 traces the development of distance education to the fifth generation focused on the impact of technologies. The criteria used by professional bodies to accredit engineering programs that focus on the ability to design and conduct experiments are also described in Chapter 2. A key objective in science and engineering education at tertiary level is not only to increase the students' understanding and knowledge but also to help them to develop the skills necessary to apply them. Furthermore, "it is to give the students an introduction to a community of practice" (Lave and Wegner, 1991), and this means that science learners need to be involved in some types of activity that real scientists perform. Thus, the experience of practical laboratory work is vital but this presents a particular challenge in the distance-learning context.

There is some laboratory work in materials science that is essential and important for engineering teaching programs and this is described in Chapter 3. However, the access to and sometimes the finance of the real laboratory work has been a big problem, especially for the distance learner. Therefore discussion on how these basic experiments are differently introduced in the UKOU and CRTVUs referred to in order to establish the need for the Virtual Laboratory in Materials Science.

Since computers are becoming more widely accessible and virtual technology is being applied more and more in teaching and learning, development and application of some kinds of courseware for virtual laboratory work may be one way of addressing such a problem. Several of these are outlined in Chapter 2 then, in Chapter 4 we describe some of the details of the instructional and technological design of the Virtual Laboratory in Materials Science. However, it cannot be assumed that there is a direct relationship between design and the results that the student achieve. There are four current research questions mentioned above. To address these, Chapter 2 outlines the essential methodologies of evaluation for learning and further discusses evaluation for CAL (Computer Assisted Learning). A pretest -posttest approach that "focuses on comparisons of student performance before and after the learning has been undertaken" (Calder, 2001) is also described in Chapter 2.

Chapter 5 describes the methodology used in the study. An integrated framework for evaluation including a pretest-posttest comparison was used to evaluate the Virtual Laboratory in Materials Science that focuses on comparisons of student performance before and after the tensile experiment has been undertaken. This is applied to groups of students, some of whom used a real tensile testing machine and some just the courseware. We explain the design and procedure of the evaluation in Chapter 5. The Appendix gives full texts of the Evaluation Questionnaire.