Development of computer assisted learning tool for earthquake engineering

R. Klinc, Ž. Turk & M. Fischinger
Institute of structural engineering, earthquake engineering and construction IT (IKPIR), Faculty of civil and geodetic engineering, University of Ljubljana, Ljubljana, Slovenia

ABSTRACT: Today, we live in the world where the information and communication technologies are developing faster than ever before. We receive information and learn from a variety of sources. However, such learning is rarely related to the official programmes of higher education. Lecturers must compete with, for example, Discovery channel, games and/or other audio/video/internet media. That is why many students today have great expectations which even the well prepared and quality books cannot satisfy. Besides, it is difficult to attract their attention when the lessons are not dynamic and the lectured subject is not illustrated as it could be, considering all the technologies available.

This paper describes a possible approach for teaching the basics of earthquake engineering through the use of animations (simulations) and active participation of the students. It could be a great addition to classical teaching methods in civil and earthquake engineering. Besides, the idea and the development of the prototype of the learning tool are described. That type of media gives the lecturer the opportunity to animate students, to give them the possibility to dig deeper into the discussed subject, and to learn through experimenting ('playing') with carefully prepared examples.

1 INTRODUCTION

> "Tell me, and I will forget.
> Show me, and I may remember.
> Involve me, and I will understand."
> (Confucius, 450 BC)

Texts on paper and live talk have been the only communication and information technologies 150 years ago when the formats of academic education were set. Today, we receive information and learn from a variety of sources. However, such learning is rarely related to the official programmes of higher education where lectures and textbooks remain the dominant media. Moreover, the official learning process did not make a considerable change for decades, although many students have great expectations which the classic teaching methods cannot satisfy. It is difficult to attract students' attention if the lessons are not dynamic and the lectured subject is not illustrated as it could be, considering all the modern technologies available. The fact that textbooks are available on-line as PDF files or lectures delivered over a videoconferencing technology changes little in this picture.

1.1 *Earthquake engineering and its teaching methods*

It can be said that earthquake engineering is the science of investigating problems created by earthquakes, and finding the solutions and practical applications of these solutions, which results in planning, designing, constructing and managing the earthquake-resistant structures and facilities. Even from this definition it can be seen that it is an interdisciplinary and complex science, which principles can be difficult to understand and even more difficult to pass on. Those principles can often be explained only through the long derivations of equations and formulae, which makes the lecturers' task of animating students and creating the feeling of 'being-in-the-world' even more difficult.

Considering all said, it is not difficult to understand why the majority of lectures in earthquake engineering education is still delivered through a teacher centred approach (Figure 1), which has been criticized in recent years (Felder 2004, Christiansen 2004).

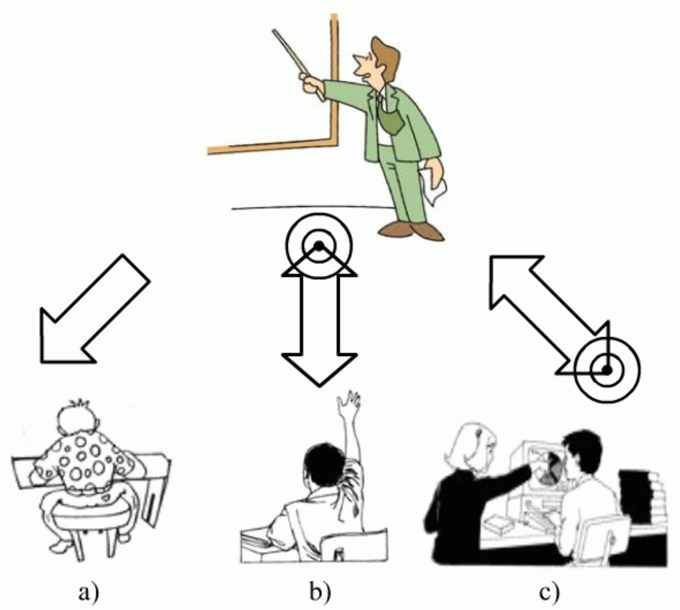

Figure 1. Teaching approaches. a) top-down model, teacher centred approach, b) student-teacher negotiated, teacher oriented approach, c) bottom-up model, student oriented approach (Aaron et al. 2004).

1.2 *Background and motivation*

The fact is that most academic textbooks contain few illustrations with no colour, although the importance of visual information in the learning process is well known. Turk & Fischinger (1999) define: "*It is estimated that the sense of sight contributes to as much as 75% of individual's knowledge, while hearing is rated at only about 13%*." Today, when lecturers must compete with, for example, Discovery channel, games and/or other audio/video/internet media, even a quality book cannot offer enough. That is why the great deal of attention in educational domain has been focused on the interactive multimedia (Rieber 1996, Rieber 1999, Nulden 1999, Felder 2004, Sadik 2004, Christiansen 2004).

On the other hand, it is worth mentioning that earthquake engineering is constantly developing science which areas are still under formalisation, therefore learning material and courses must be dynamically composed leading to the continuous update and the development of courses (Christiansson 2004).

Knowing this and considering the fact that in earthquake engineering we also learn from the past experience through the observations of structures and their components damaged by earthquakes (Fischinger et al. 1998), the need to provide students the ability of 'seeing', 'feeling' and 'being-in-the-world' can be seen. That is how the interest for the discussed subject could be deepened.

In the past years, a great deal of attention in earthquake engineering education at University of Ljubljana has been focused on finding a new way of clearing the basic concepts and principles of earthquake engineering. The idea of a complex engineering teaching tool which would gather different sources of knowledge emerged (Figure 2).

The work started in 1995, and in 1998 EASY, EArthquake engineering slide information SYstem, was introduced (Cerovšek 1998, Fischinger et al. 1998). In the following years, two other components were developed (example and EUROCODE in hypertext).

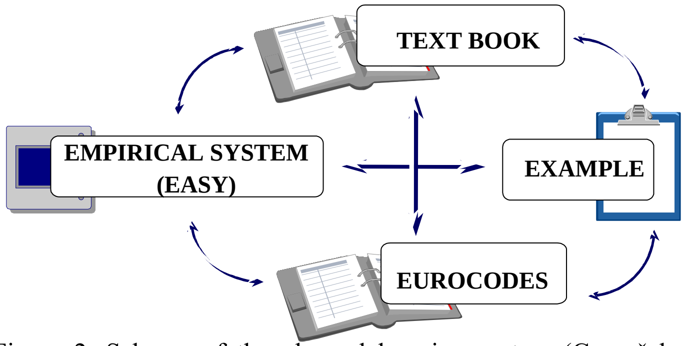

Figure 2. Scheme of the planned learning system (Cerovšek 1998).

The subject of this paper is the fourth, theoretical (text book) component.

1.3 *Goals and objectives*

We have been focusing on the development of a learning tool, which would provide students the opportunity of 'being-in-the-world'. That can be difficult task in earthquake engineering domain. Therefore, it was important to choose proper topics and present them in an appropriate way. We were hoping to create a text book, available both on the local computer as well as through the internet, with a series of simulations, explaining the basic principles of earthquake engineering, encapsulating the complexity and the background of presented examples in order to ease the learning experience. It must also be mentioned that with this tool the problems of synchronisation in time and place, and the limitations of the static nature of traditional teaching materials can be solved.

2 REQUIREMENTS AND SYSTEM ARCHITECTURE

When designing the system, the following requirements had to be taken into account:
- The developed tool must act as a standalone workbook, but must also be suitable for the integration into a more complex learning system with the previously developed components.
- To be able to easily extend the contents, the dynamic and extensible table of contents must be developed.
- It must offer more than the printed letter and picture.
- It must be usable through the internet as well as on the local computer (for the use on computers with no internet connection available).

- It must offer the opportunity for the use in the distance learning classes.
- The user interface must be plain, intuitive and simple.

It was decided that the user interface must follow the common web form, so it was divided into two separate sections (frames); one for the index (table of contents), and one for the content (Figure 3).

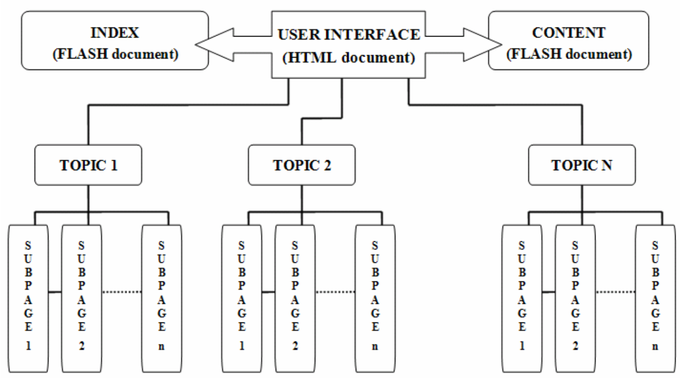

Figure 3. Caption of the system architecture.

3 IMPLEMENTATION

We focused mainly on the development of a friendly and intuitive learning tool, describing some basic concepts and principles of earthquake engineering. The main purpose was to present some topics in a new way which would attract students' attention, allow them to dig deeper, and offer them more flexibility in the time and place of studying. For this task, animations and simulations were selected.

From the developers' point of view, we wished to create a fully extensible and modern solution for the future integration into a complex system with previously developed components. A very significant limitation was also the requirement that it must be usable both on the internet and local computer. That is why the selection of the most appropriate development tool was important. We decided to use Macromedia Flash 5 due to the facts that:
- it is the most widely used tool for building high-impact web pages,
- it has a useful scripting language ActionScript built-in,
- approximately 92% of web browsers can view Flash content without the need to install any further plug-ins,
- the process of learning is quite short if compared to the time of learning working with the competitive products.

What is more, the decision was made that the whole text book will be in Flash format, so that the different parts of the text book can be build in the same manner.

3.1 *Macromedia Flash 5 and Actionscript*

Macromedia Flash 5 enables professional designers and developers to create effective next-generation web sites and applications. It can be used to create full-screen navigation interfaces, long-form animations called movies, or "tween" animations that are capable of providing a control over the object attributes. All interactive movies and complex animations are created by actions which are sets of instructions written in ActionScript (ECMAScript[1]-based programming language used for controlling Macromedia Flash movies and applications) that run when a specific event occurs.

More about Macromedia Flash and ActionScript can be read at http://www.macromedia.com.

3.2 *Index section*

The users' first contacts with the tool and content are usually through the index. That is why its structure and visual representation is important and must be properly composed.

One of the requirements was that index must be dynamic, so that adding content is as easy as it can possibly be. For this reason, it has been developed as an XML driven Flash document.

The format of the required XML file is clear, readable and can be customized quickly:

```
<TREE_MENU_NESTED OFFSET='15' MAIN-
COLOR='#000000' SUBCOLOR='#666666' OVER-
COLOR='#ff0000'>
    <TREE>Topic 1
        <TREE ACTION="URL" LINK="11.html" TAR-
GET="content">SubTopic 11</TREE>
        <TREE ACTION="URL" LINK="12.html" TAR-
GET="content">SubTopic 12</TREE>
    </TREE>
    <TREE>Topic 2
        <TREE ACTION="URL" LINK="21.html" TAR-
GET="content">SubTopic 21</TREE>
        <TREE>SubTopic 22
            <TREE ACTION="URL" LINK="221.html" TAR-
GET="content">SubTopic 221</TREE>
            <TREE ACTION="URL" LINK="222.html" TAR-
GET="content">SubTopic 222</TREE>
        </TREE>
    </TREE>
    <TREE ACTION="URL" LINK="http://www.topic3url.net"
TARGET="_blank">Topic 3</TREE>
</TREE_MENU_NESTED>
```

[1] *A standardized, international programming language based on core JavaScript. This standardized version of JavaScript behaves in the same way in all applications that support the standard. Companies can use the open standard language to develop their implementation of JavaScript.*
(http://javascript.js-x.com/core_manual/glossary.php)

The example XML above is presented in the index as shown in Figure 4-5.

Figure 4. Caption of the generated index in 'closed' mode.

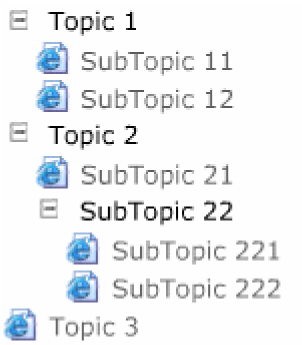

Figure 5. Caption of the generated index in 'open' mode.

It is possible to insert submenus of any depth. Changes in the XML file reflect directly in the developed index without the need to modify the actual index file.

3.3 *Content section*

Content is the most interesting (from IT point of view) and important part of the work. The interface, which delivers content, was developed as a partially automatic and external-file-driven Flash document. Some components of this document, the title and subtitle of the document for example, can be customized through the external text files, while the others (previous and next document in line) are generated automatically. This allowed us to customize the template quickly and to concentrate more on the content we wanted to deliver.

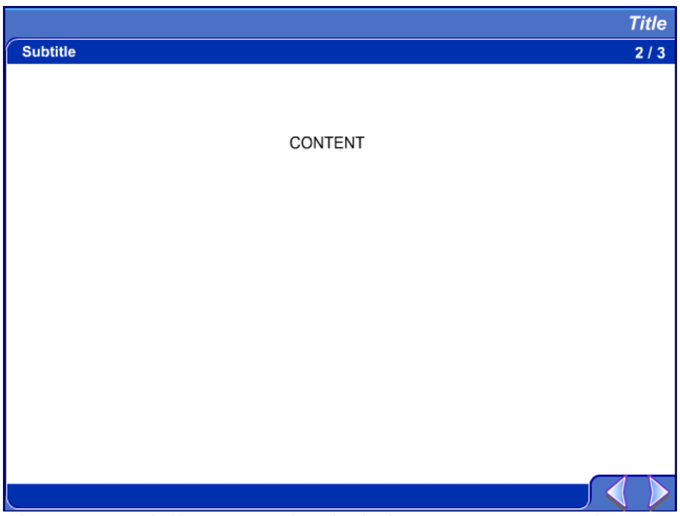

Figure 6. Partially automatic Flash document as a template.

On the top of the template some carefully prepared animations and simulations explaining basic principles of earthquake engineering were created.

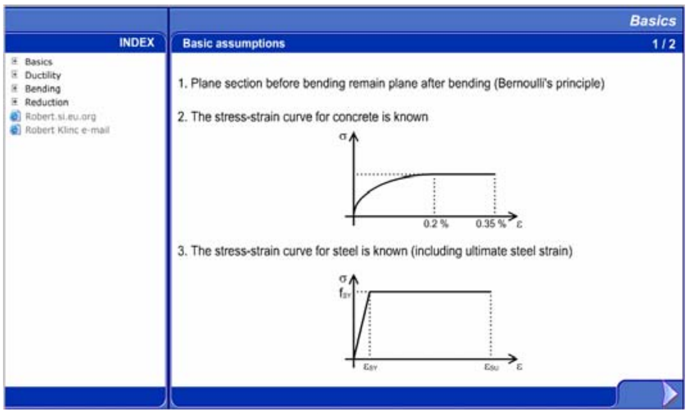

Figure 7. Caption of the text book, as seen in browser window.

3.4 *Example scenario*

Creating the sense of 'seeing' and 'feeling' the structures and their behaviour under earthquake conditions were things we wanted to bring closer to the students. There is a big difference between the explanation in words and pictures, and there is even bigger difference between the picture and the animation.

If we want to, for example, explain students the term "ductility", we would tell them something similar to the definition presented below.

Ductility is the ability of a material to withstand plastic deformations without rupture. The opposite of ductility is termed brittleness.

There are various ways of quantifying ductility, and one of them is a curvature ductility which can be presented with a moment-curvature relationship.

There are different factors affecting curvature ductility. The most critical parameter is the ultimate compression strain. Other important parameters are axial force, compression strength, and reinforcement yield strength (Paulay & Priestley 1992).

The lecture would be more effective if we try to explain the term with pictures, shown in prearranged order, describing some particularities of each picture and try to establish the link between picture and previously orally described theory. That can achieve the desired effect for the time being, although it can take a lot of teachers time answering on a good deal of "what if" questions.

But on the other hand, the term can be briefly described and students can be motivated to identify particularities and persuaded to dig deeper by themselves. The above term could be, for example, presented in the way, shown in Figure 8.

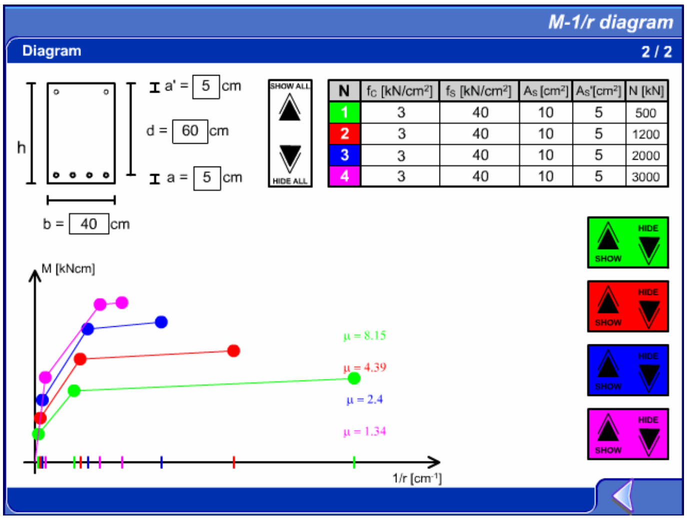

Figure 8. Caption of the example, explaining the importance and impact of the different factors on ductility.

Figure 8 shows a small ActionScript 'programme', attached and encapsulated into a Flash document. All parameters, mentioned in the text above, can be modified, and results can instantly be seen on the screen. That allows students to experiment, see what kind of influence each of the factors has on the result, and hopefully, they would be able to clarify the term by themselves.

3.5 *Examples created*

In our work, we have created some sample animations, describing the following terms of earthquake engineering:

– Capacity of a cross section (Figure 9),

– Ductility (Figure 8) and

– Reduction of the seismic forces principle (Figure 10-11).

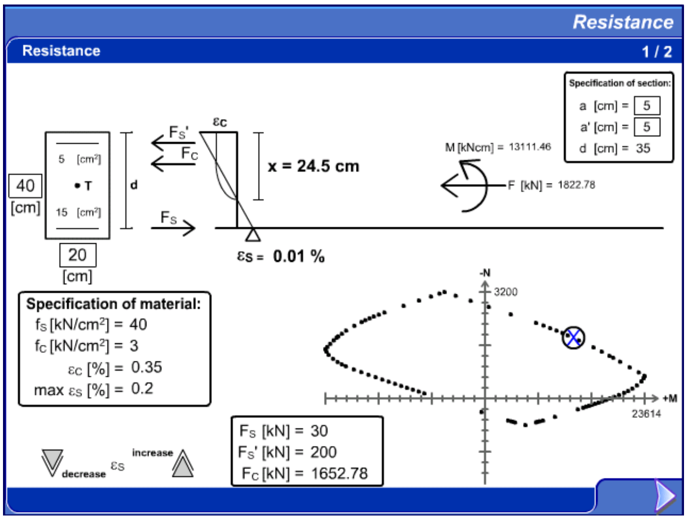

Figure 9. Caption of the interaction diagram, explaining the capacity of a cross section.

All of the examples were made in Macromedia Flash and even though we have soon realized that it has some serious limitations, the majority of computations were made with ActionScript.

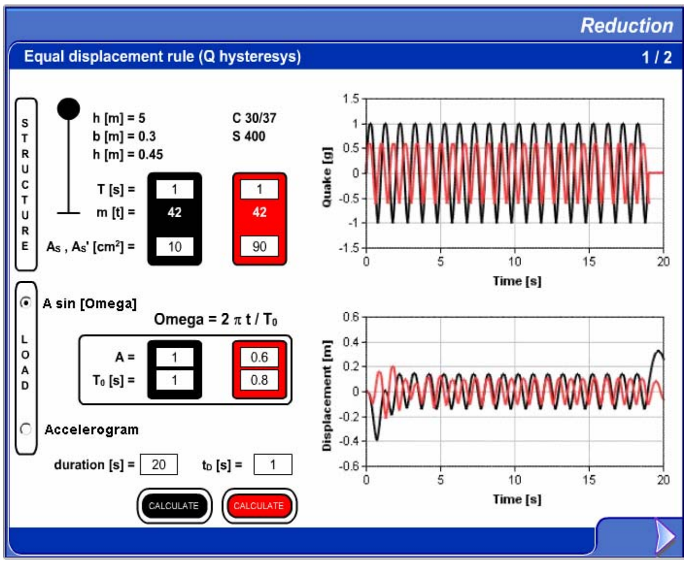

Figure 10. Caption of the example, explaining reduction of the seismic forces principle.

It was pushed to its limits and we managed to do the computations of the first two terms with it, but it failed at the example of reduction of the seismic forces principle (Figure 10-11).

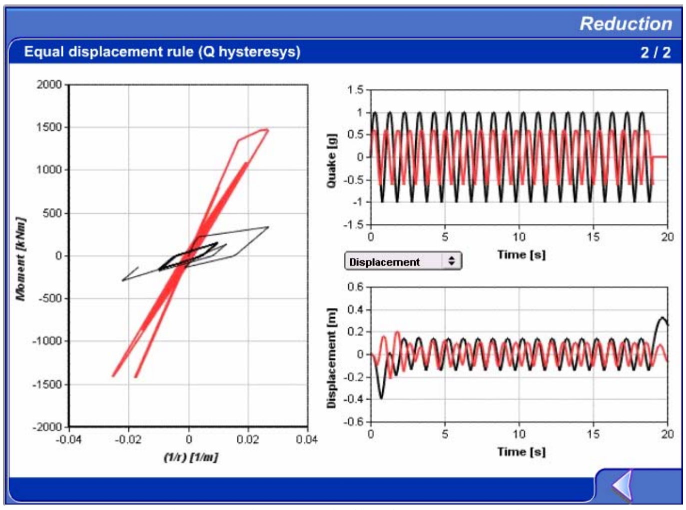

Figure 11. Caption of the equal displacement rule example

To overcome the limitations of ActionScript, we have started using Perl[2] despite the previously defined requirement that the text book must be usable also on the off-line computer. The external program DRAIN-2DX, capable of the nonlinear static and dynamic analysis of plane structures, has also been used.

[2] Perl - short for Practical Extraction and Report Language, Perl is a programming language developed by Larry Wall, especially designed for processing text. Because of its strong text processing abilities, Perl has become one of the most popular languages for writing CGI scripts. Perl is an interpretive language, which makes it easy to build and test simple programs. (http://www.rustybrick.com/definitions.php)

4 CONCLUSIONS AND FUTURE WORK

Combining information technology with expert earthquake engineering knowledge can result in a modern and efficient learning tool, usable both on the internet and personal computer, for classical teaching in classes as well as for the distance learning.

Our goal was to explore the tools needed, rapidly develop a prototype and focus mainly on the content of the earthquake engineering text book, leaving the programming and the IT perspective of the tool in the background. However, during the project we have realized that the programming part cannot be avoided. What is more, the programming (or the IT part) part demanded the greatest deal of our attention, due to the fact that the process of creating special kinds of interactions with the support of complex calculating requires specific programming expertise we did not have. The fact alone that we have used (due to the licensing issues) relatively old (from IT perspective) Macromedia Flash 5 version caused much problems. The process of learning and programming itself was very time consuming and have taken too much effort and momentum. That is why the work is not fully prepared and was presented only to a small group of students. Even though the experiment was not controlled, the 'aha' effect, noticed with students that have seen examples, could be a sign that the method is appropriate and is worth investigating further.

In the future, our efforts will be oriented towards the evolution of the current tool and the connection of the tool with some previously developed components. From the IT perspective, we are planning to invest into a newer and more powerful version of the Macromedia Flash, due to the fact that the version used cannot offer as much as the newer version can. We are also planning to redesign the current interface as a common HTML document, using Flash for animation and simulation purposes only. One of the reasons is much easier connection between the separate parts of planned learning tool.

5 ACKNOWLEDGEMENTS

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