

2006-250: DEVELOPMENT OF ONLINE MULTIMEDIA BASED PROTOTYPE E-LECTURE INTERFACE USING HUMAN-LIKE ANIMATED PEDAGOGICAL AGENT FOR EFFECTIVE DISSEMINATION OF FINITE ELEMENT METHOD

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Development of Online Multimedia based Prototype e-Lecture Interface using Human-like Animated Pedagogical Agents for Effective Dissemination of the Finite Element Method

Abstract

Multiple e-Learning platforms have been designed, implemented and evaluated over the past decade for effective implementation of teaching and learning in engineering education. This study deals with the development of an interactive prototype interface for the finite element method e-Lecture. The e-Lecture interface integrates life-like animated pedagogical agents, computer mediated communications and multimedia technologies. The use of animated pedagogical agents in engineering education tries to overcome the challenges of current e-Learning techniques with a new effective and efficient intellectual human computer interface. Available animated pedagogical agents with gaze, gesture and voice capabilities are used in the prototype e-Lecture to actively/interactively communicate with the students. New animated pedagogical agents called Mr. and Ms. FEMur (Finite Element Method universal resource) will be used to deliver online finite element method e-Lectures. A prototype e-Lecture interface using Mr. FEMur demonstrates the concepts of “Degree of Freedom” in this paper. These e-Lectures will be integrated into the finite element method learning environment that is a part of bigger effort to develop the FEMur web site.

Introduction

From the days of Socrates, besides live demonstrations, teaching has largely involved instructors lecturing to their students under a tree, in an arcade structure or in a brick-and-mortar school room. The Internet today is used to communicate and share information created in digital form. The worldwide information infrastructure of connected computer servers and computers is used to implement electronic-learning (e-Learning) within several disciplines. Widespread access to the Internet has provided educational opportunities that enable students and professionals to learn anytime and anywhere (24/7) while keeping pace with technological and managerial changes despite their busy daily schedules¹. The interconnected computers facilitate the creation of hypermedia based interactive e-Learning content that can be disseminated through the computer network as the associated costs of hardware and software keep declining. These developments have led to many national and international initiatives to promote e-Learning for the specific purpose of teaching and learning in many subject areas²⁻⁵. Thousands of technical and management courses, including degree and certificate programs, are being offered by universities, for-profit professional development centers, and industry training facilities worldwide¹. Furthermore, learning activity is shifting from instructor based to learner-centered. Although several efforts has been carried out in this area, further developments with the aid of emerging technologies is needed to make e-Learning an effective tool for the teaching/learning process.

e-Learning Review

A literature review⁶ revealed that the three theories of learning are behaviorism theory, cognitive theory and constructivism theory. e-Learning closely follows the constructivist approach. It is student-centered focusing on the learning needs of the student. It involves learning activities in which students are actively engaged in the learning process, rather than passively absorbing lectures. Furthermore, the inclusion of hypermedia based digital content in the learning environment also engages today's younger generation, who are more tuned into the visual culture.

e-Learning is defined as the mapping of traditional teaching and learning practices to the Virtual Learning Environment (VLE). The three major components of e-Learning are as follows:

1. *Client Computer Hardware*. This includes desktop and laptop computers and small form factor computing devices such as Personal Digital Assistants (PDA) that are all connected to the Internet.
2. *Computer Server System*. The computers that run the web server and application server software include Learning Management Software (LMS) and Learning Content Management Software (LCMS)⁷. The implementation of the learning design^{8,9} is accomplished through the learning design software tools¹⁰ that are add-on to the application server software.
3. *e-Learning Digital Content*. The e-Learning digital content for engineering can be subdivided into the following five categories:
 - e-Content. Deals with the subject matter similar to a textbook in the form of an e-Book.
 - e-Lecture. Represents virtualized version of traditional lectures.
 - e-Assessment. Replaces traditional tests and surveys with the web-based ones.
 - e-Computation. Stand alone and web-based numerical and symbolic computational tools.
 - e-Simulation. Represents/imitates real life problems within engineering.

The focus of this work is on the e-Lecture category of e-Learning digital content.

A timeline sampling of e-Learning digital content using ICT (Information and Communication Technology) in teaching Structural Mechanics and Numerical Analysis is shown in Table 1. It is observed that researchers have mainly focused on only two elements of e-Learning digital content, i.e., e-Content and e-Simulation. The other categories have not been fully implemented to represent a complete e-Learning methodology.

From Table 1 it is also observed that except for the e-Courses developed by Gramoll¹⁴, no course contains an e-Lecture. Gramoll's work¹⁴ includes e-Content (in the form of e-Books), e-Lecture, e-Assessment and e-Simulation. However, Gramoll's e-Lecture interface seems to be lacking the affective components (learning motivation, maintaining learner's attention and subject retention). It is anticipated that the inclusion of animated pedagogical agent will add the affective components to the e-Lecture. A literature review²⁵⁻³⁰ suggested that animated pedagogical agent establish social collaboration with learners and facilitate learning.

Table 1: A timeline sampling of e-Learning digital content using ICT in teaching Structural Mechanics and Numerical Analysis.

Timeline	Area	e-Learning Digital Content				
		e-Content	e-Lecture	e-Assessment	e-Computation	e-Simulation
1997	Finite Element Method ¹¹	X				X
	Finite Element Method ¹²	X				X
1998	Introduction to Vibration ¹³	X				X
1999	Statics, Dynamics and Mechanics of Materials ¹⁴	X	X	X		X
2000	Finite Element Method ¹⁵					X
	Structural Mechanics ¹⁶					X
	Finite Element Method ¹⁷	X				X
2001	Mechanics of Materials ¹⁸	X				
	Finite Element Analysis ¹⁹					X
2002	Structural Analysis ²⁰					X
	Engineering Mechanics ²¹	X		X		
2003	Boundary Element Method ²²					X
2004	Structural Analysis I ²³	X		X		
	Numerical Methods ²⁴	X			X	

e-Lecture Interface and Need Analysis for Pedagogical Agents used in e-Learning

e-Lecture is the virtual equivalent of a conventional lecture or oral presentation that is enriched with integrated interactive elements and access to additional learning resources³¹. It is an active, student-centered approach of learning, and assumes that students learn by receiving and assimilating knowledge individually, independent from others³¹. e-Lectures of various e-Courses are available on the web in different formats that includes MS Word documents, PDF files, MS PowerPoint presentations, Macromedia Flash presentations and HTML files. The availability of increased bandwidth for computer networking has enabled instructors to develop online versions of sound and video based e-Lectures³²⁻³⁵.

A recent survey conducted by Bersin & Associates³⁶ revealed that Macromedia Dreamweaver, MS PowerPoint and Macromedia Flash are the top three e-Learning tools for developing online e-Courses. Among these tools MS PowerPoint is most commonly used by engineering faculty for the delivery of classroom lectures found on many course web pages. A research report from Brandon Hall Research³⁷ gives six reasons for PowerPoint being used as an e-Content authoring tool. However, one of the major drawbacks of PowerPoint is that it is missing the instructor's voice. To overcome this drawback, MS Producer³⁸ allows the inclusion of PowerPoint slides that synchronize with the sound/video of the presenter or instructor. The embedded sound and video are captured live during the presentation. We found that this technique of creating e-Lectures has the following drawbacks:

1. *Expensive*. It is expensive to have live actors or instructors to produce narrative sound and video.
2. *Time*. Editing of the sound and video components is time consuming. Any minor or major modification in the recorded sound or video requires extensive work.
3. *Instructor Availability*. It is not easy to find the narrator or instructor if any modification is desired in the original sound or video.
4. *Website Update*. The website has to be updated every time there is a change in the sound and video digital content.

Similar e-Lecture interfaces can also be created using Macromedia Flash MX that has the added benefits of interactivity and the ability to create innovative user interfaces^{39,40}. However, apart from the above mentioned shortcomings, developing such e-Lecture interfaces in Flash is time consuming and tedious for the instructor. There is a need to develop an effective e-Lecture interface that is interesting, interactive and easy to create.

To make the e-Lecture interesting and interactive for the students, interfaces consisting of animated pedagogical agents have been developed in recent years. The animated pedagogical agent replaces the live presenter or instructor within these e-Lecture interfaces. This eliminates the first three drawbacks of the embedded streaming sound and video that includes expense, time and availability of the live presenter or instructor. Research has shown that pedagogical agents enhance the appearance of an e-Lecture and also make it more interesting and humane⁴¹. Furthermore, when used properly these agents actually improve and facilitate learning⁴¹. Pedagogical agents also offer great promise for broadening the bandwidth of tutorial communication, ability to engage and motivate students, and by enhancing the virtual learning environment⁴². Educational research⁴³ suggests that one-on-one tutoring can significantly

improve learner's performance. However, individual tutoring poses financial and logistical challenges. Therefore, embedded animated pedagogical agents also offer a low-pressure learning environment that allows students to learn at their own pace leading to student-centered learning⁴³.

The literature review shows that many pedagogical agents have been developed in the past few years for e-Learning purpose⁴⁴ although very few have been used in engineering education^{15,44,45}. All of these agents used within engineering education appear more like a cartoon character and lack human look and behavior. To improve upon the previous work in engineering education a human-like pedagogical agent called Mr. FEMur with moving eyebrows, blinking eyes and synced lip movement is created for this work.

e-Lecture Creation Tool Survey

The four hypermedia components that can be used to create an e-Lecture interface are as follows:

- Hypertext (includes hyperlinks)
- Graphics (Images, Photographs and Vector-based Drawings)
- Digital Sound
- Animation/Digital Video

A web browser is specifically designed to help users view and navigate hypertext, on-line documentation, or a database hosted by a web server. Popular browsers include Microsoft Internet Explorer (IE) and Mozilla Firefox. The file format for a web page is HTML and is identified in the HTTP protocol. Creating document in the HTML format is carried out using Macromedia Dreamweaver MX. Dreamweaver allows creating and maintaining digital documents in different file formats in a short time and allows easy conversion into other file formats.

The tools that were used for graphic creation, editing and processing included: Macromedia Fireworks MX for editing images and photographs and Macromedia Freehand MX for creating vector-based drawing. Macromedia Dreamweaver can also be used for organizing the digital images in the form of photo galleries that can be shared on the web.

Digital sound is an integral part of the e-Lecture interface. The TTS (Text-To-Speech) process was used to create synthetic sound from text. The male and female voices in the Voice TextTM software from Neospeech are used. Sound files created through TTS eliminate the need of a human narrator and provides flexibility in editing the narration file content. However, the quality of sound file only approximates the speech pattern of a live human narrator.

The animations (interactive graphics) and digital video also form a part of the e-Lecture interface. Lifelike talking characters that act as pedagogical agents in the e-Lecture interface were created using the Sculptoris Voices Lite software. This software can be used to create two- and three-dimensional lifelike talking characters quickly in Macromedia's Flash file format. The pedagogical agents are computer based animation characters and constitute the digital video

component. The interactive e-Lecture interface was created using Macromedia Captivate. It also creates e-Lectures in both Flash and executable file formats.

The hypermedia components and the software tools used to create the finite element method “Degree of Freedom” e-Lecture in this paper are summarized in Table 2.

Table 2: Hypermedia components software tools used to create the finite element method “Degree of Freedom” e-Lecture.

Hypermedia Component		Software Tool	Software Tool Company
Hypertext		Macromedia Dreamweaver MX ⁴⁶	Adobe-Macromedia
Graphics	Images	Macromedia Fireworks MX ⁴⁷	Adobe-Macromedia
	Vector-based Drawings	Macromedia Freehand MX ⁴⁸	Adobe-Macromedia
Digital Sound	Text-To-Speech	VoiceText™ ⁴⁹	Neospeech, Inc.
Animation/Digital Video		Sculptoris Voices Lite ⁵⁰	Sculptoris Voices Studio
		Macromedia Captivate ⁵¹	Adobe-Macromedia
		Macromedia Flash ⁵²	Adobe-Macromedia

From the discussion in this section, it appears that digital e-Lecture creation is much more complex than the creation of traditional printed documents, e.g., textbooks and handouts. It involves several software tools depending upon the use of hypermedia components.

e-Lecture Creation Process

The creation process flowchart for the e-Lecture on the topic of “Degree of Freedom” is shown in Figure 1. The different sections of this flowchart will now be discussed from top to bottom.

The top section of the Figure 1 shows narrated text of the pedagogical agent saved in text file format. This text file is processed through TTS using VoiceText™ software to generate digital sound in wav format. These steps complete the speech synthesis process for the pedagogical agent.

The upper central section of Figure 1 shows the creation of human-like pedagogical agent using Sculptoris Voices Lite software shown in Figure 2a. The same text file that was used to create the synthesized sound file was again used as a script file to lip-sync the pedagogical agent with the narrated text and to create the human-like animated pedagogical agent, Mr. FEMur, for the prototype e-Lecture in Macromedia Flash file format. The character ‘Adam’ shown in Figure 2b was employed from the software Sculptoris Voices Lite to create Mr. FEMur. Other available animated characters that could be used as pedagogical agents are shown in Figure 2b.

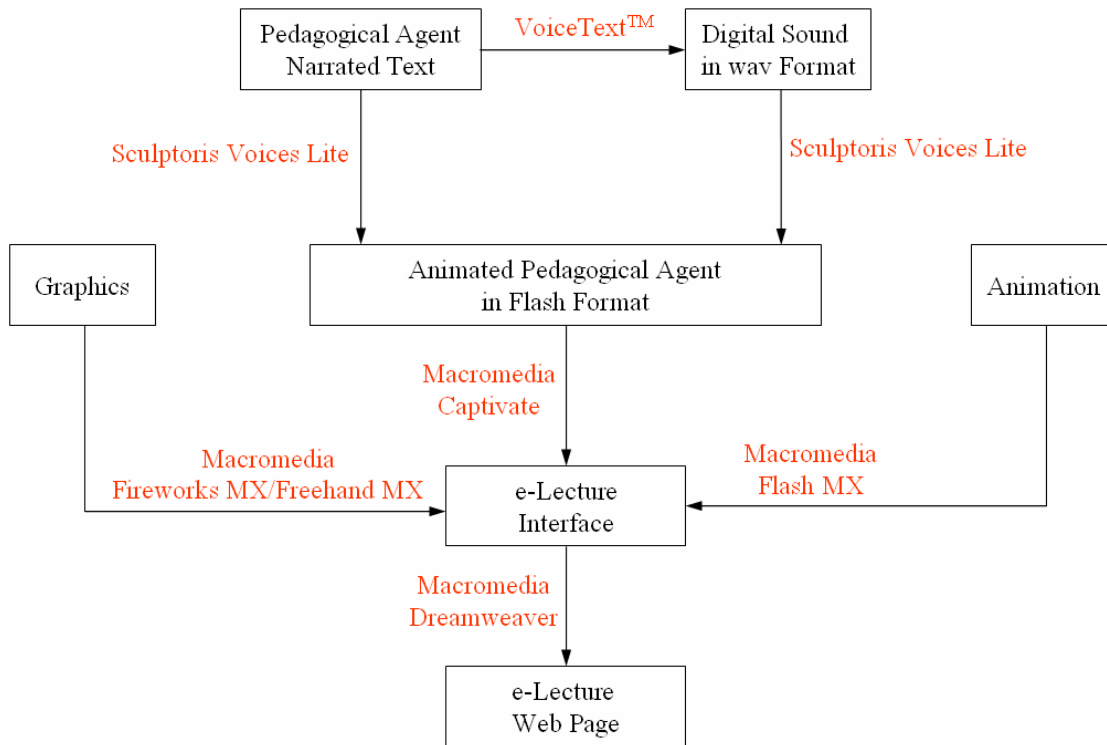
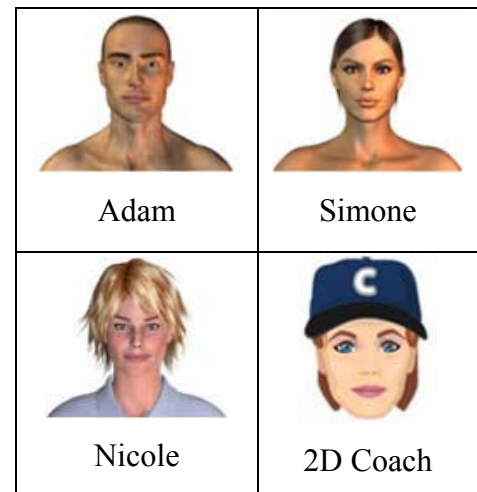


Figure 1: e-Lecture creation process flowchart.



a. Interface example.



b. Animated characters.

Figure 2: Sculptoris Voices Lite⁵⁰ interface and some of its available animated characters.

The lower section of Figure 1 demonstrates the process of e-Lecture interface creation. Figure 3 shows the e-Lecture interface developed in Macromedia Captivate by integrating graphics and Mr. FEMur. The left side of the Figure 3 shows different slides used within the prototype e-Lecture. The right side of the same figure shows one sample slide of the prototype e-Lecture

containing the pedagogical agent. The bottom right side of the figure shows the timeline of different elements contained in the e-Lecture slide.

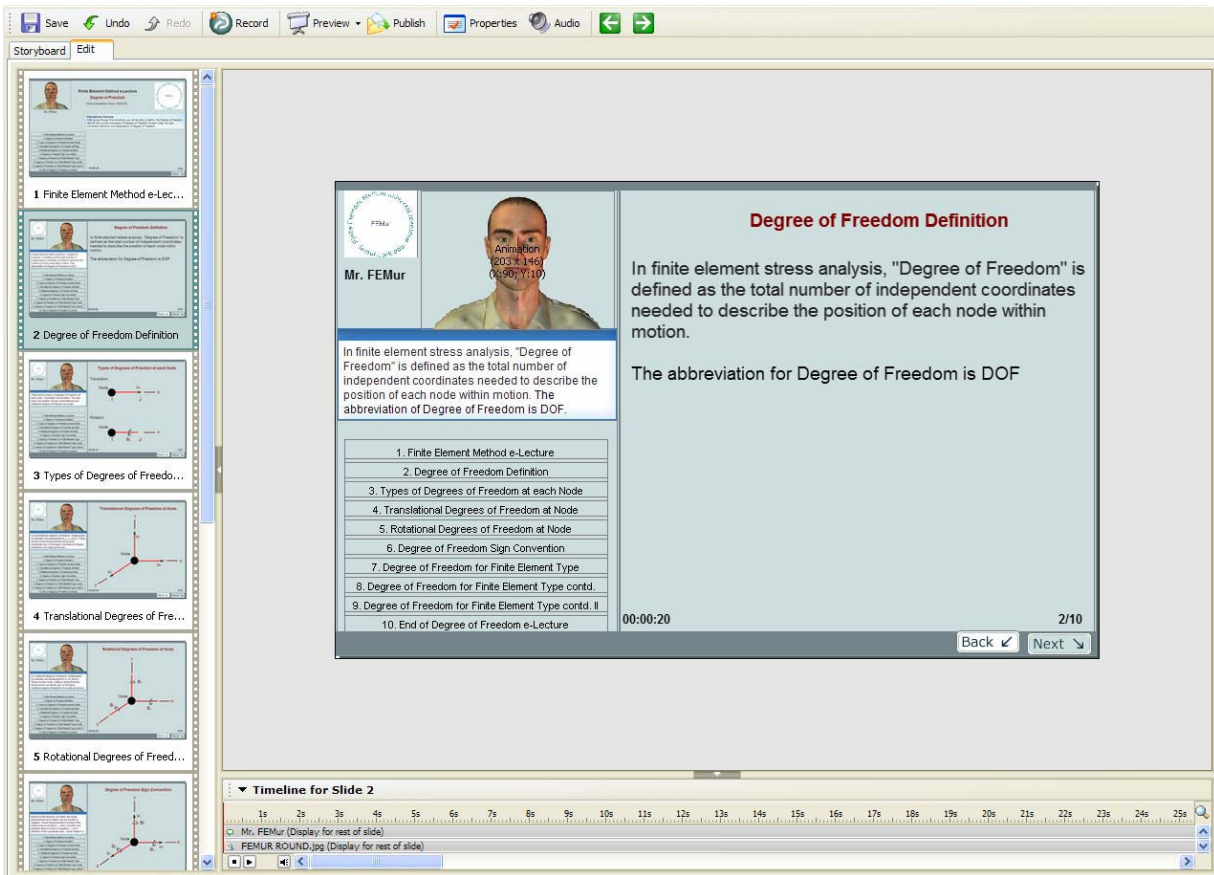


Figure 3: Macromedia Captivate⁵¹ e-Lecture interface.

Figure 4 is one of the views for the prototype e-Lecture on the topic of “Degree of Freedom”. Each individual view of the prototype e-Lecture is divided into a left window, a right window and a bottom toolbar. The left window has the following four elements:

1. FEMur Logo
2. Mr. FEMur (Pedagogical Agent)
3. Pedagogical Agent Narrated Text
4. Slide Index

The text and the graphics shown in right window are used to describe the different characteristics and explanations of “Degree of Freedom”. The top center part of the right window contains the slide title and the bottom part contains the duration of each slide and the slide number.

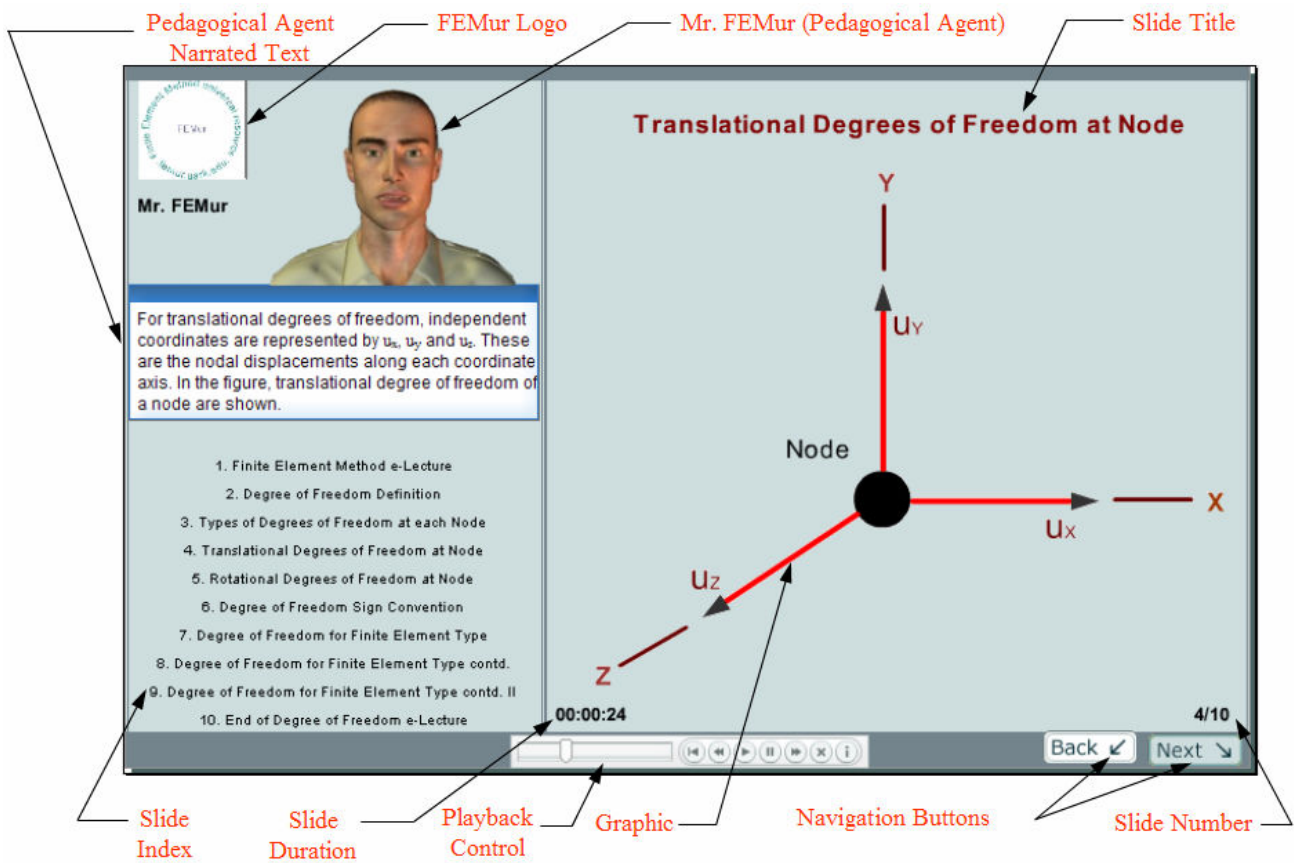


Figure 4: Sample view of the prototype e-Lecture slide.

The bottom part of the view contains a navigation toolbar with two options. The first option is a playback control that allows playback of the current slide and scrolling to the beginning of the presentation, end of the presentation, the previous slide and the next slide of the presentation. The second option at the bottom right corner of the e-Lecture interface view allows the student to view the previous slide and the next slide.

The prototype e-Lectures created by the process described earlier will be integrated into finite element method learning environment webpages using Macromedia Dreamweaver. The finite element method learning environment is a part of the bigger effort to develop the FEMur web site.

Description of the Prototype e-Lecture on Degree of Freedom

The prototype e-Lecture on “Degree of Freedom” using a human-like animated pedagogical agent, Mr. FEMur, demonstrates the concept of “Degree of Freedom” as used within finite element stress analysis. This prototype e-Lecture can be used as a teaching aid within any course on the finite element method. There are a total of nine slides within this prototype e-Lecture and two sample slides are shown in Figures 5 and 6. Figure 5 describes the definition of the “Degree of Freedom”. Figure 6 displays the different types of “Degree of Freedom” along with positive sign convention.

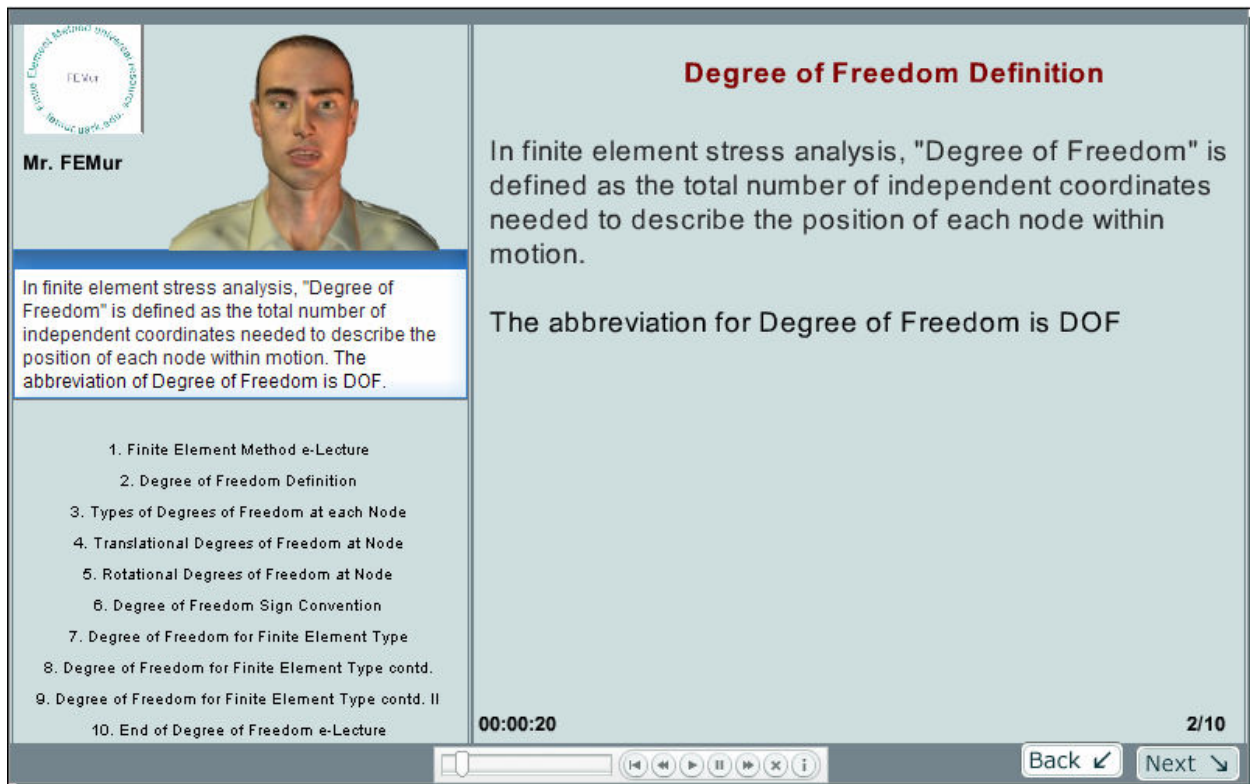


Figure 5: Degree of Freedom definition interface view.

Mr. FEMur

Based on the direction of motion, the nodal displacement and rotation can be positive or negative. Nodal displacement is positive if the node moves in positive x, y and z direction and negative when it moves in negative x, y and z direction of the coordinate axes. Nodal rotation is

1. Finite Element Method e-Lecture
2. Degree of Freedom Definition
3. Types of Degrees of Freedom at each Node
4. Translational Degrees of Freedom at Node
5. Rotational Degrees of Freedom at Node
6. Degree of Freedom Sign Convention
7. Degree of Freedom for Finite Element Type
8. Degree of Freedom for Finite Element Type contd.
9. Degree of Freedom for Finite Element Type contd. II
10. End of Degree of Freedom e-Lecture

Degree of Freedom Sign Convention

Node

Y

U_y

θ_y

X

U_x

θ_x

Z

U_z

θ_z

00:00:30

6/10

Back

Next

Figure 6: Degree of Freedom sign convention interface view.

Conclusion and Future Work

In this work, an attempt to develop an effective e-Lecture with a human-like animated pedagogical agent for online engineering education in the teaching of finite element method was accomplished successfully that overcome the existing shortcomings addressed in this paper. Developing e-Lectures in Macromedia Captivate by integrating human-like animated pedagogical agent is fairly straightforward and simple requiring less time and effort. This approach proves that e-Lectures can be created that are more expressive and engaging when compared with the e-Lectures created using MS PowerPoint or MS Producer. In the future more e-Lectures will be created on various concepts used for teaching and learning finite element method using this approach.

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