# On building a web-based university

*Dana Constantinescu [1], Gunnar Stefansson [2]*

*(1. Department of Applied Mathematics, University of Craiova, Craiova 200585, Romania;*

*2. Mathematics Department, University of Iceland, Reykjavík 121, Iceland)*

**Abstract**: This paper describes some of the principles for building a freely available web-based university with open content. The "tutor-web" is an international project for web-assisted education, including such free and open access. This project was initiated by the University of Iceland in partnership with many universities around the world, among them the University of Craiova, Romania. The aim of this paper is to present this project, to point out its specificity and to arouse interest for collaboration in the project, which uses http://tutor-web.net as the home location.

**Key words:** e-learning; tutoring systems; web-based university

## 1. Introduction

Many theories and (conceptual) models are available of how students learn and many approaches have been suggested on how to change a student's learning experience or simply to drastically change approaches to teaching (with a given purpose in mind). Some of these models are used to classify different teaching methods and/or methods of assimilation of new material. For example, in many cases distinctions are made between traditional schools and adult education (Mezirow, 1981), but this distinction is blurred in the case of undergraduate and graduate studies, which is the primary interest of this project. A more formal approach to defining key dimensions of learning and teaching is considered (Felder & Silverman, 1988), indicating how the teacher can get the attention of all students by catering to how each "type" of student learns, the main features of the "transformative learning" are discussed (Moore, 2005), etc.

Currently, most of the world's teaching probably uses a blackboard and chalk, whereas the western world is moving towards whiteboards and pens along with (electronic) slide presentations in many cases. Using web-assisted in-class learning is fairly recent and in most areas considered a very modern tool.

Elaborate uses of electronic media abound but most uses actually consist of the lecturer making electronic slides available in electronic or paper format (Stefansson, 2004). This applies to the actual use of most commercial and open-source systems available today, although some systems may offer more options. These simple uses are not of much interest since they merely give the student access to copies of slides presented during class. Similarly, storing handouts online are rather petty uses of the web's potential. Apart from savings in printed matter, in neither case is anything gained over and above simply distributing printed information in the classroom. To use the possibilities of the web, a system should at least interlink the material and make it easy for the student to go from an in-class slide to the corresponding content.

Dana Constantinescu, lecturer, Department of Applied Mathematics, University of Craiova; research fields: education, dynamical systems and Hamiltonian dynamics.

Gunnar Stefansson, professor, Mathematics Department, University of Iceland; research field: statistical models in education and marine science.

The same comments apply to most online testing schemes. In many cases, these are merely repetitions of paper schemes, i.e., a student is handed a fixed set of questions and required to solve the test in a given amount of time. Although this may save instructor-time, this gives no credit to the immense possibilities in the interactive nature of the web.

Different systems for computer-aided instruction have different characteristics. Comparisons between the various approaches to storing and presenting educational content are virtually impossible since these approaches are based on completely different design principles

Two main features of the web-assisted learning systems will be analyzed in the following comparison:

(1) Most systems are used mainly for storage of educational material;

(2) Content provision alone does not offer evaluation of students, i.e., there is no grading mechanism nor are credits given in any form. Such providers do not include quizzes, slides, portability between systems or open standards for content (which are needed for complete portability from the teacher's application to the end product, printed or web page).

The complete courses and the tutorials represent the two main forms for the presentation of the scientific information. Attempting to set up an online version of a complete course is, therefore, quite prohibitive for an individual instructor in any given year. A tutorial, on the other hand, typically consists of only a few lectures, e.g. 4-10 lectures, i.e., 1-3 weeks of lectures. Setting up a computer version of such a small subset of a course is a much more feasible undertaking. The tutorial can, therefore, also be on a more isolated topic, which can also be more easily reused in several different courses.

A totally different approach is taken with the Educommons OCW (Open CourseWare, http://cosl.usu.edu/projects/educommons) approach used by many universities, including USU (Utah State University, http://ocw.usu.edu), the Massachusetts Institute of Technology (MIT, http://ocw.mit.edu/OcwWeb/web/home/home/index.htm), Johns Hopkins Bloomberg School of Public Health (http://ocw.jhsph.edu/) and others. A simple description of the system can be found on the MIT web-page, when referring to the OCW at MIT ... , "It is a snapshot in time of how a particular subject was taught by a particular member of the faculty in a particular semester ...". Notably, these tend to be PDF (portable document format) files containing lecture slides and notes, not suitable for editing by others, and thus, permanently static. This is useful material, but not the kind of material best suited for collaboration and exchange of teaching material with the intent of also enhancing it.

Encyclopedias on the web include Wikipedia which is exactly that: A free and publicly available encyclopedia on the web.

Alternate systems include Moodle (http://moodle.org/), which is not as tightly integrated as the "tutor-web" and relies on a fairly different philosophy regarding content, presentation and interactions between instructor and students. Finally, Wikiversity (http://en.wikibooks.org/wiki/Wikiversity) should be mentioned, a Wikipedia university which only stores content. Other content providers include Connexions (http://cnx.org/), which has many resemblances with the "tutor-web" but does not include any form of evaluation, nor the tight coupling of slides and content.

Several online private and closed source/content initiatives also exist. These are not really competitors with the "tutor-web", but notice should be taken by some of the approaches used. Most of these systems require extensive instructor-student interaction (more than in a regular classroom) and this is not acceptable in most scenarios. However, a few systems have been developed paying great attention to detail and learning theory. Most of these systems appear to be highly specialized and only applicable for the narrow topics for which they were designed.

The fact that content providers do not generally provide (free) evaluation of student knowledge is a weak point of a system, since it has already been demonstrated that students tend to prefer the online quiz over homework. Further, the use of the online quiz has a positive impact on knowledge, as demonstrated by the statistically significant on-going improvements while using the web (Sigurdardottir, 2006).

It will be seen in the following that the principles underlying the “tutor-web” provide all the functionality needed in a classroom, e.g., interlinked electronic slides and handouts, with corresponding quiz questions.

## 2. The tutor-web

The “tutor-web” has been developed with input from several teachers, students and programmers from around the world. This system is thus based on experience gained by instructors while teaching university courses or giving presentations at several universities and funded by several organizations. Presentation experience taken into account when designing the “tutor-web” includes regular classroom teaching through public presentations to highly variable audiences. The corresponding material includes a variety of topics (mathematics, fishery science, applied and theoretical statistics, computer science and even business proposals).

The “tutor-web” is a system for computer-assisted education and research on education, both for in-class use and for remote learning. The system is a freely accessible resource which can store the educational material used in a classroom and provide online evaluation. It includes an internal database based on structured storage of text, figures and other objects in predefined formats.

From an instructor’s view, the system permits collaboration on and exchange of teaching material from slides to books and quiz questions.

From a student’s view, the system provides freely available online access to material and the freedom to take quizzes at any location.

From a researcher’s view, the system is a vehicle for research into, e.g., the online student’s behavior and the effect of grading schemes.

### 2.1 Objectives

The main objective of the tutor-web is to contribute to the development of an accessible online system of education that can be used for in-class activities and home study. Some objectives are presented in the following.

2.1.1 To provide a database of teaching texts, courses, slides and applications

There would be considerable benefit if teachers should join hands to allow general access to all their material, free of personal or institutional concerns. It would certainly benefit students to have easy access to course materials from as many good instructors as possible.

There is a need not just for public domain software. Publicly available teaching material is also needed. The more teaching material is put into the public domain, the better a teacher can make his/her course. The more tutorials a student can get access to, the better the chance of understanding difficult material. In this manner, underprivileged students and/or universities can gain free material, evaluation schemes and collaboration by using free educational sites, but schools of any quality can improve their material through accessing high-quality publicly available material, as is clearly seen by the general use of Wikipedia.

The “tutor-web” shares the idea of using small parts of lectures as a knowledge unit. These modules are called “tutorials,” typically corresponding to 5-10 lectures.

However, the text of some complete courses can be inserted in the “tutor-web” in a PDF format, in order to be

seen by a large community of interested persons. Although not the ideal approach for storing and sharing material, this approach has been used to store (legally) scanned books which thus supplement other teaching material.

Currently, initial tutorials in mathematics, statistics and fishery science can be found on the “tutor-web”.

Since its implementation in Plone (a leading open source Content Management System, see http://plone.net/), the “tutor-web” has access control, so instructors have full control over their own tutorials as well as improved accessibility for instructors. Instructors are given access to insert whose content ranges from a handout or a few slides to a complete tutorial.

The “tutor-web” is intended for use in a wide range of situations (in-class activity, home studies, as prerequisites for taking a real-world course). Hence, the information must be organized and presented in an attractive, accessible and clear manner.

The material is aggregated around slides, which are grouped along with quiz questions into lectures, which again group into tutorials, corresponding to a topic within a course and a department. A typical tutorial may correspond to 5-15 real-world lectures, and hence, a course may, e.g., correspond to 5-10 tutorials. Figure 1 presents the “tutor-web” structure of content.

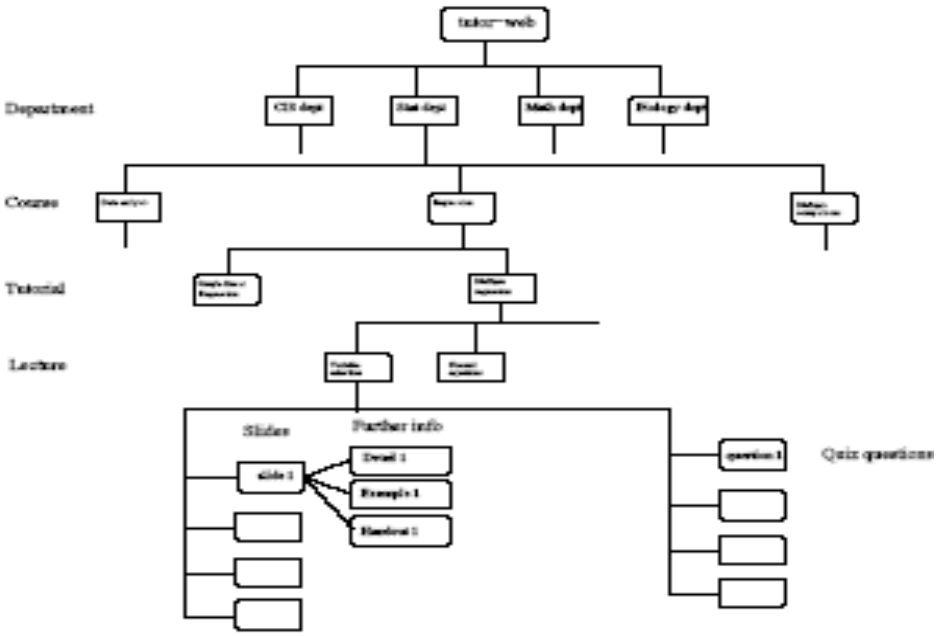


**Figure 1 The “tutor-web” structure of content**

Notes: Departments contain courses that consist of tutorials; Each tutorial has lectures that in turn contain the actual educational material and quiz questions; The material is arranged around “slides” with examples and handouts.

A slide can have certain pre-specified features (title, main graphic, and so forth). It must contain the main informational text, eventually, some representative images and examples. A slide may contain links to additional material, e.g., more detail on a topic, references, examples, handouts or homework.

The structure implies certain implicit links, the obvious being that slides belong within lectures and quiz questions also belong within lectures.

The “tutor-web” has been developed to include an easy-to-use interface for instructors. This provides the instructor with the layout seen in Figure 2. Subsequent development will include improved previews, easier text entry, more format options, and so forth.

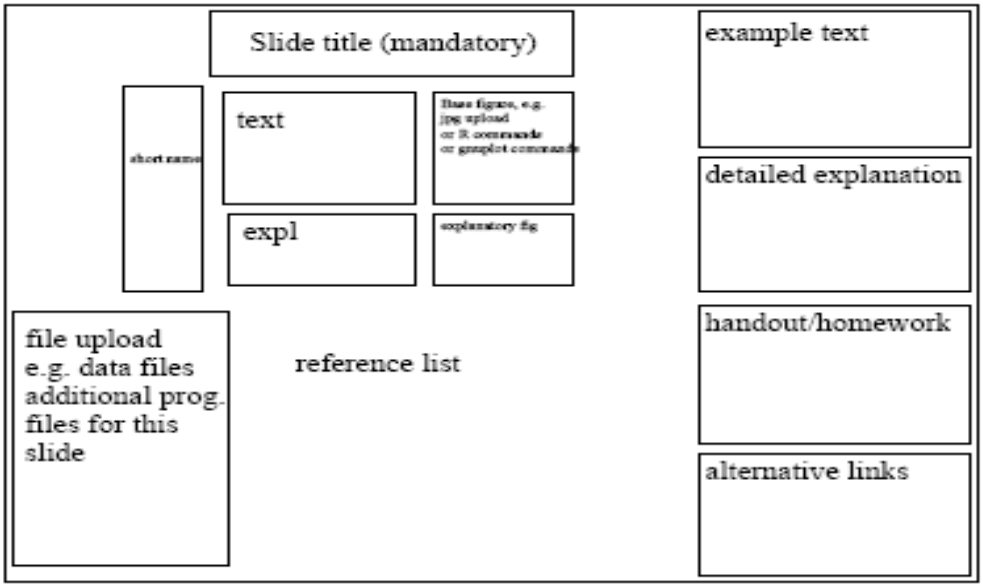


**Figure 2 Design of an interface for the teacher**

Note: This includes simultaneous access to all content related to a slide; In addition, instructors have full access to their quiz items.

The relation between item exposure and the computerized adaptive testing has been of considerable interest (CHEN, Ankenmann & Spray, 2003), but there are many more questions of interest with regard to how student learning is affected by different question allocation schemes. The “tutor-web” permits quantification of the effect of different item allocation schemes on various such aspects. Thus, it is a fairly easy matter to various programs, such schemes to see the effect of reminders on performance, iterative presentations of the same quiz items, etc.

2.1.2 To realize the online evaluation of the students

The “tutor-web” can be used in the evaluation of the students, because most lectures are accompanied by online multiple choice quizzes. The quiz formats basically consist of a question, a correct answer and 2-3 incorrect answers, with an option of a “none of the above” answer, which may of course be correct or incorrect (or a similar option of “all of the above”). This is a typical method for testing the students’ knowledge (Briggs & Wilson, 2007; CHEN & LEI, 2005).

An obvious attribute to a tutorial is a list of prerequisite tutorials; another is a definition of internal “tutor-web” credits which need to be included with the “tutor-web” as in any other system. Typical credit systems in the real world give 10-30 credits for a full-time semester with, e.g., 4-5 courses. Here, a finer scale is needed since each course may consist of 10 tutorials. An internal credit will therefore be defined so that 10 internal “tutor-web” credits correspond to 1 credit in the ECTS (European credit transfer system), where there are typically 30 credits in one 15-week semester. How (and if) the “tutor-web” credits transfer into real world credits will depend on the real world university and some research is warranted before any suggestions are made on this topic. There are, however, several possibilities, linked to the possible uses which a university may put the “tutor-web”.

In-class uses of slides and corresponding uses of quizzes for a basic usage, the instructor is in control of material and the students take an exam at the end of the semester. In this case, the “tutor-web” merely augments the usual in-class sessions.

In the more general case, students may be directed to undertake independent studies or may have done so on their own accord. It is in these cases that the most interesting scenarios arise and they give rise to the greatest

potential. A student directed to take a tutorial (sequence) in order to accommodate an instructor's requirement is a simple example. In a sense, this implies that the instructor has accepted the "tutor-web" content as a surrogate for taking certain courses and this is an easy way of merging the "tutor-web" into real-world requirements.

The scheme of the possibilities to interact with the "tutor-web" are presented in Figure 3.

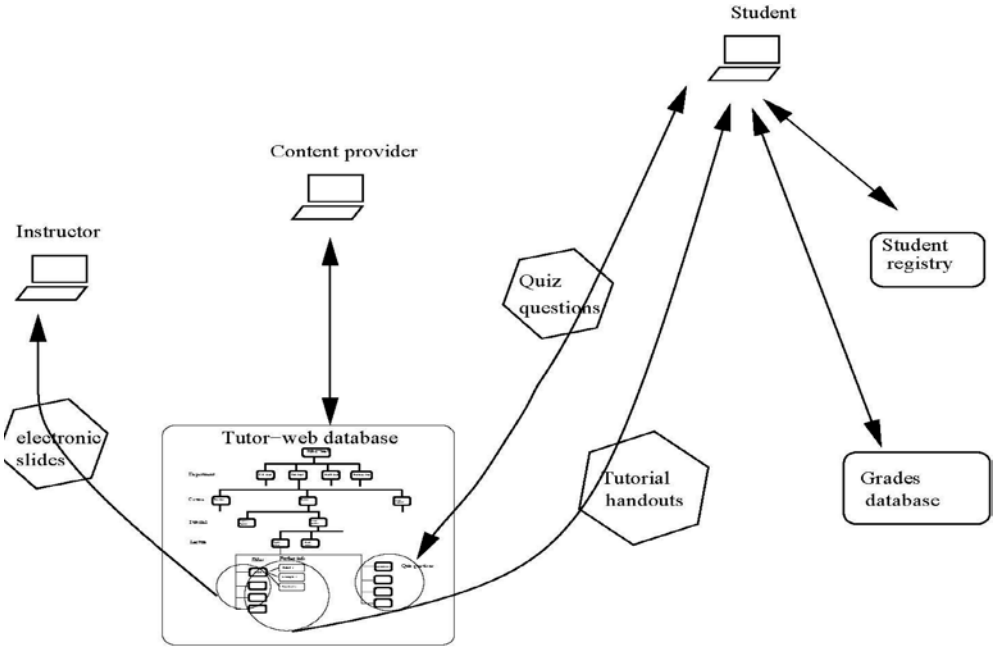


**Figure 3 Different user "views" from the "tutor-web" database correspond to "views" into a data base**

Note: These include a method to view slides in a classroom, a view for a content provides when inserting content, and several views for the student who may be accessing different parts of the system, such as registering, studying or taking a quiz.

In addition to the above examples, there are many situations when online evaluation is necessary and it is desirable or impossible to allocate instructor time to the issue:

(1) The student wants to take a course, but it is not obvious whether he/she satisfies the basic course requirements. In these cases, the students will not have completed the formal prerequisite coursework, and in many cases, it is then left to the discretion of the instructor whether or not the student is permitted to register. It requires no work at all from the instructor to tell the student to complete a certain online tutorial and come back with a high grade before taking the class in question.

(2) Some remedial measures may be imposed if a student has problems: Commonly, an instructor sees, early on in a class that certain students have problems with their homework or mid-terms. These students can then be told that they should take a remedial tutorial until they pass it with a high grade, rather than fail the course.

Many other possibilities can be envisaged on how the "tutor-web" may be used in the educational process. One such concerns applications from little-known universities for graduate studies at other (larger) universities. In such cases, it would be highly beneficial for all parties to have a general method of evaluation. The recipient university (or instructor) could simply advise the applicant to take a certain course on the "tutor-web" and submit the resulting grade. Since the student is permitted to learn within the system, thus, improving the grade, this is not a "hard" requirement. Naturally, a student might prefer to pay a colleague to take the online quizzes but this is no more of a concern than general forgery of documents.

Another important quality feature of the "tutor-web" will be to include teacher evaluation of teachers, or TET

(teacher evaluation of tutorials). This would be a useful feature in many systems, but is quite important when there may be many instructors with material of variable quality. In this case, the best approach is to allow instructors to evaluate ("grade") material.

2.1.3 To facilitate research on computer-aided education

The "tutor-web" forms an excellent platform for research on how students accumulate knowledge and how students respond to and learn from online quizzes. In particular, research is needed on the most effective online quizzing methods. These should not be designed only for evaluation but much more importantly for enforcing learning, i.e., to transform quiz-taking into a learning experience. The term "enforcement" refers to setting a grade requirement for continuation and permitting the student to continue to request work until a satisfactory grade is obtained.

The "tutor-web" has already been used for evaluating simple research questions:

(1) Is there any gain from using such a system in conjunction with a classroom? The answer is positive. It has been found that students tend to take online quizzes enthusiastically and tend to try to continue until the maximum grade is obtained, if this is permitted.

(2) How to select questions to give to students and how to evaluate their grade in a dynamic environment, where it appears to be optimal to permit students to repeat requests for questions ad infinitum?

Earlier analyses of "tutor-web" data have been based on contingency tables along with (generalized) linear models but future analyses will be based on specially designed experiments where mixed effects models will play an obvious role.

In a social research context, the present proposal will generate a more general test-bed for evaluating how on-line quiz material can be utilized. The first such test, within the project, will be a non-statistical (qualitative) social study on how low-income participants respond to a requirement of the form "You do not have the requirements for entry into this program, but you will be considered for entry when you complete course X on the "tutor-web" with a grade of Y". The same approach will be tested on active graduate students who lack background in math or stats as well as on other student groups.

The "tutor-web" provides an environment where researchers can not only test theories on real data and where it will be possible to evaluate and develop testing schemes on pre-collected data, but also to use experimental design with subjects randomly placed into groups.

It has been demonstrated that current models for analyzing quiz results are not adequate in the dynamic and learning-based quiz environment provided by the Internet (Stefansson & Sigurdardottir, 2010). The "tutor-web" provides the tools required to explore alternative methods better suited for Internet-based environments.

**2.2 Uniqueness of the "tutor-web"**

The "tutor-web" is intended for handling and storing everything an instructor might use in class, and allowing a student to use these from other locations, as well as for student evaluation, and doing this in a linked manner using only non-proprietary solutions.

The uniqueness of the "tutor-web" thus comes from having all of the following features:

(1) Storage of all educational content, e.g., slides, examples, additional details, handouts and quizzes;

(2) Stored material is linked and can be viewed in various ways: as web-slides or PDF-slides, as booklets containing slides interspersed with other material, other views can be generated;

(3) Code is "Open source";

(4) Material is "Open content";

(5) Source material is available in raw form (not just as PDF) so, for example, data behind an image can be

viewed by the student, text or graphs can be borrowed for inclusion in another lecture;

(6) Students can freely take online quizzes;

(7) Students can take quizzes repeatedly until results are satisfactory;

(8) Content is stored in a modular manner (object-orientated data base);

(9) Content can be viewed in different ways (will be user-defined);

(10) All views are easily modified.

## 3. The partnership

A considerable part of the work involved is conducted by Ph.D. students, programmers, postdocs and other staff (at present with the main thrust coming from the University of Iceland, the United Nations University). A major part of this project is to entice other instructors to use and expand the “tutor-web”, initially in statistics and mathematics. In order to obtain a critical mass of students and university lecturer using the system, the proposed strategy is to recruit academic professionals and students from Europe (in particular, Iceland and Romania) and beyond (including South America, Asia and Africa) to use and add to the “tutor-web” is considered. More than 20 academic staff of universities from Australia, Barbados, Bulgaria, Botswana, Benin, Greenland, India, Iceland, Malta, Malawi, Nigeria, Norway, New Zealand, Romania, Swaziland, Taiwan and USA make up a consortium to support the “tutor-web” initiative through submission of material, and so forth.

Most of the cooperation around the “tutor-web” will be informal in that selected professors and students in each target university will become a test-base. Test-bases will include some with a clear need for support and others with capacity to participate in evolving the “tutor-web”. The first test-base will be within the University of Craiova, Romania.

Initially, most courses within the system are developed in English, but other languages can certainly be accommodated (several tutorials in Icelandic were inserted in a pilot version of the “tutor-web”).

## 4. Future work

The current (beta) version of the “tutor-web” at “http://www.tutor-web.net” along with existing test cases should be considered a proof of concept, following an initial pilot study which led to the present system, stored within a content management system. The following describes on-going development to enhance the “tutor-web”.

Future hardware upgrades and research will be funded by grants, but the system will mostly be self-sustainable like other open systems, such as Wikipedia.

An important difference between the “tutor-web” and Wikipedia is that, since the “tutor-web” is designed in part for in-class use, content is “moderated,” i.e., only “instructors” are permitted to insert material. Further, although the basic concept of an online university already exists in several forms, none of these encompass the simple requirements of being freely available, providing complete access to all material and providing evaluation.

The documentation and much of the material is currently written in English.

Individual tutorials can be in any language and there is nothing in the “tutor-web” design, which specifies the language of content. In order to better accommodate languages, it would be useful to split up this web according to the language of the tutorial. This is a very easy thing to do and could be done with no central coordination. However, a coordinated approach, such as using “http://es.tutor-web.net” for a Spanish version is a trivial matter. A new front page could then be set up merely to guide the user to select a language. On a technical note, this

approach also implies an easy way of modularizing the “tutor-web” since different languages can reside in different domains which again can live on different servers (in different countries for that matter). This expansion of use and content in one language does not affect the use of the “tutor-web” in another language. The only links between languages occur when a student takes courses in more than one language.

Several technical upgrades will be implemented:

(1) Extensions will include user-selected designs, where a lecturer may select in-class slide format, student-selected content-view layout (e.g., view slides, theory and examples side-by-side) and quiz questions may contain pointers to explanatory material and/or an explanations for incorrect responses.

(2) The correction of errors in material may be made possible by instructors (and officially pointed out by students). The simplest is by providing an e-mail address where students can report errors in questions, and so forth. This is already very useful since it can be quite hard to verify hundreds of questions but students inevitably find these errors. More generally, students and other instructors must be able to comment on the quality of lectures, though not arbitrarily modify an instructor’s material without permission (but they are free to copy the material).

All these features will transform the “tutor-web” to a steadily more useful tool in a modern educational environment. It is thus a step towards building a web-based university accessible from any part of the world.

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