Using Database of Calculus Problems in Teaching of University Level Mathematics

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Abstract: We have created in our university material management environment, which uses database created by using LaTeX-files, and LaTeX2HTML translator and PHP language. In this paper we will define how these LaTeX-files are transformed into our database. In this paper, we present work which we have done for providing the material used in the teaching of calculus to students at Lappeenranta University of Technology. This procedure can be divided into three separate steps: 1) creation of the LaTeX-files, 2) implementation of these LaTeX-files in 3) conversion of the base LaTeX-files to the HTML-files. So far, we have stored hundreds of exercises with hints and solutions on our web server in addition to some theory that we felt is necessary for the students. In this paper we will also discuss the benefits and future of our functioning Web-environment [1].

Keywords: LaTeX, LaTeX2HTML, PHP, SQL-database, learning environment

1. Introduction

In the beginning of 2002, we initiated an investigation to develop possible solutions for providing the material used in the teaching of calculus to students at Lappeenranta University of Technology. We decided to write the pages in question in the LaTeX language. We also wanted to use database and network solutions for the finalized version of these pages. We had chosen to use network solutions because the material, which is available on the Internet: i) is easy to reuse, transform and combine with other materials, ii) can be easily accessed at least with fast connections, iii) is accessible 24 hours a day, iv) can be accessed by many users. We wanted to use a database in order to provide students with tools for performing searches on the calculus information. The students can then study the material that they feel is the most interesting and then hopefully begin to carry out their own research and form a view of mathematics. Therefore we have taken a constructivist approach to the learning process. The LaTeX-files, which are entered into the database with all the necessary keywords, form the core of the solution. Based on the keywords, the database knows where each file is located, including specifics, from the area of mathematics, to whether the file is an exercise, solution, hint or general information. The database alters the user's view of its contents by using the keywords that are included in the above-mentioned base LaTeX-files. Now, any of our lecturers can contribute new material to the database by using a very simple interface and LaTeX. Lecturers can also easily combine weekly tutorials and even whole examinations from the contents of the database. So far, we have stored hundreds of exercises with hints and solutions on our web server in addition to some theory that we felt is necessary for the students. In this paper, we present the complete procedure from the creation of the LaTeX-files to a functioning Web-environment [1]. Our lecturers have found that this new interface saves a lot of their time and is also flexible enough for their needs. Student satisfaction with this new material is also apparent, since they do not have to, for example, suffer from the obscure handwriting of the lecturer any more.

This paper is supported by Lappeenranta University of Technology.

2. Converting LaTeX-files to a functioning Web-environment

All of our LaTeX-files are articles or exercises which are executed by a cover file. Article files include theory and exercise files include tutorials of different kinds and cover files (`kuori.tex`) are files which call the previously mentioned document files. Cover files use `math.sty`, which includes macro definitions of mathematical formulas and all other necessary definitions. Dvi file is a fruit which comes by execution of a cover file. All of these LaTeX-files have originally been made by a lecturer, Simo Kivelä. from Helsinki University of Technology (HUT).

2.1. Writing down LaTeX-files

Base LaTeX-files, articles and exercises include categorization which defines the final destination of the file in our Web-environment. Categorization is done in the following way and order:

- At the beginning there is `\begin{Artikkeli}` or `\begin{Tehtava}`, which defines if the file is an article or an exercise.
- The name of the file `\tunniste{}`, for example `\tunniste{lta179}`. Comes from the words Liisa, Torikka, article and the number of the article.
- The highest categorization in our content dictionary `\alue{}`, for example `\alue{tavdy}`,
which means ordinary differential equation.
- Next categorization area is a section `\luku{}`, for example `\luku{2kdy}`, means second order differential equations.
- Then comes lowest categorization area which is a chapter `\kappale{}`, for example `\kappale {vali}`, means constant coefficient linear.
- Then comes the name of the file `\otsikko{}`, for example
`\osikko{Toisen kertaluvun vakiokertoimiset lineaariset DY:t}`,
means second order constant coefficient linear ODE.
- Then come two arguments which characterize the file `\luonne[]{}` for example `\luonne [Matlab]{teoria}`, here the first argument, Matlab is to address that you need a computer program cal-

led Matlab to run the issued theory part, the second argument teoria means theory.

- A short description of what the file includes `\kuvaus{}`.
- Name of person who has typed the file issued for example `\tekija{Liisa Torikka}`.
- Date `\pvm{29.8.2002}`.
- Language `\kieli{}` Finnish is the default.
- Original source `\lahde{LTKK/Pekka Jauhon moniste, kevät 2002}`.
- Copyrights `\kayttooikeus{}`.
- Source code, for example `\lahdekoodi{LaTeX}`
- Level of the material's first argument and the institution name, for example `\laitos[hard] {LUT}`.
- Then come the keys which are to help database searches for example `\avain[Calculus] {course}`, normally we use many keys to make files easy to find from our database.
- After these definitions comes the actual article or exercise.

All of these files which are written are then included in the previously mentioned cover file, executed and tested.

2.2. Adding files into the database

After we have a functioning and properly formulated LaTeX-file and possible additional files we can send them to the database using a very simple form, see figure 1. Additional files can be images, example programs or anything that the author might want to be along with article or exercise. Once person pushes a button called Send a PHP-script does the following things for the files:

Fig. 1. A view of the add file page

- its keywords get extracted,
- content of these keywords will be checked,
- LaTeX-files containing several sections get splitted,
- splitted LaTeX-files will get converted to HTML-format,
- keyword information will be added into the database and
- HTML-pages will be sent to the right directory

Conversion is done by using LaTeX2HTML translator after original file is splittet based on its contents. All this is done based on the information included into the original LaTeX-file.

2.3. Finalization

After all this is done we have our file in our web page where the starting page looks like figure 2. Now a user can perform

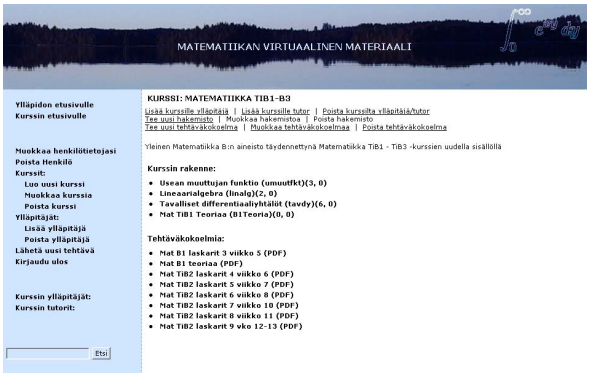

Fig. 2. A view of the starting page of calculus

different searches in our Web-environment. A file which was added can be found from our categorization, from its place, or it can be found by doing searches with a word which can be any word included in the file categorization. For example the result of a successful search might look like figure 3.

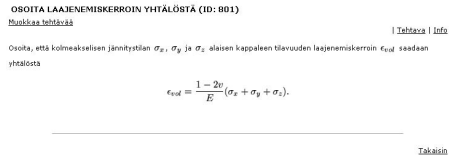

Fig. 3. An example of a file

3. Conclusions and future

We have gotten a lot of positive and a very few negative comments from these pages that we have created. Our pages have been used in our normal basic courses and both lecturers and students have taken them as their own. We have also done both qualitative and quantitative usability testings for these pages and the results have been very promising. We have gotten a lot of positive and a very few negative comments from these pages that we have created. Our pages have been used in our normal basic courses and both lecturers and students have taken them as their own. We have also done both qualitative and quantitative usability testings for these pages and the results have been very promising. We have also for example automatized the way the text will be caught into the paper in for example examinations. This makes usability in our pages better if one thinks for example of distance education. We will also continue developing these pages a lot of animations, etc. are going to be a part of these pages in near future.

References

[1] Jaakko Ketola, Kalle Saastamoinen and Tuomo Kauranne (2004). "Database Web pages", `http://www.it.lut.fi/mat/virtuaali/VM/`