USING BOOKS, TABLES AND LIVE GRAPHS TO ENHANCE INTERACTIVE NOTEBOOKS FOR HEAT TRANSFER COURSES

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Abstract

Over the last few years we have been producing learning materials for Engineering courses, particularly for heat transfer. We started developing simulators (using Wolfram Mathematica), which allow students performing more complex and generic calculations than the ones they usually carry out in conventional courses (where most of the times they still depend on using static tables and graphs). Later, we embedded these simulators within interactive notebooks in which students could follow, each one on his own computer or tablet, the teacher’s lesson in real time in the classroom. Results of these two developments have been presented at previous Edu Learn conferences. In the current development, we are converting the interactive notebooks into self-learning materials. In this way the new versions of the interactive notebooks could become suitable as support materials for innovative pedagogical methodologies such as the flipped classroom or as self-study materials. To achieve this goal, we have embedded text, live tables and graphs selected from a web-based application integrating engineering and technical references (Knovel) within the notebooks. The methodology we used to develop the new version of the notebooks was as follows: we began by analyzing our own current presentations to elaborate a script of the items we were going to search for in the web-based application. Then, the course’s teacher (one of the authors) selected, based on his experience, among the huge diversity of available sources, those texts, live graphics and tables that we were going to incorporate in a given notebook. The texts in the web-based application are all written in English and have a Portable Document Format (PDF), so they must be converted into a text format and translated into Spanish before they can be incorporated into the notebooks, which are intended for Mexican students. Once the translation is done, the materials in Spanish were incorporated into the interactive notebooks. We present here examples of the new version of the notebooks developed with this methodology as well as examples of how they have been used in a heat transfer course at the Universidad Nacional Autónoma de México (UNAM).

Keywords: Interactive notebooks, Heat transfer, Mathematica simulators, Knovel references, live tables.

1 INTRODUCTION

The purpose that we have been pursuing in recent years with the development of Interactive Notebooks, described in another paper (1) has been to improve the students’ experience in the classroom by incorporating the systematic use of ICT to support the learning process.

The methodology we used was based on simulators developed with Mathematica that the students used in a computer lab. Once a week the students attended a three hours theory class with support from Mathematica notebooks and slide presentations. The notebooks contained the same information as the slide presentations, described in another paper (2), together with the simulators that they would use later on in the computer room.

Within the approach we currently use, students no longer attend the computer classroom. Instead they work, twice a week, in a conventional classroom, doing the exercises on their own mobile devices.

In order to reformulate the methodology, it was necessary to adapt the materials so that: a) each of the 16 weekly themes were broken down into two weekly topics, b) replace the sentences of the slide presentations (Bullets) by complete texts that the student could study on his/her own, and c) integrate these texts together with the proposed activities into a single interactive notebook for each session.

To guide the autonomous reading of the new notebooks, each of them incorporates questionnaires and interactive exercises to texts in digital format, taken from various sources. This was planned to allow using the notebooks in different methodologies: e –learning, blended learning [3] or flipped classroom [4].
With a little humor and in obvious allusion to Thomson’s atomic model, we have called this way of integrating the contents and interactive exercises in a notebook: Plum Pudding.

2 METHODOLOGY

The first step of the methodology was to move from a set of 16 notebooks, supporting the oral presentation of the teacher and another set of 16 thematically classified activities used in the computer classroom, to a single set of 32 interactive lessons. This new interactive lesson will incorporate more comprehensive texts and exercises to be used either in a conventional classroom or remotely by students.

Once the 32 topics were defined, the content of each one of the 16 existing materials were split into two. The same was done with the 16 questionnaires and with the 16 activity lists. Fig. 1 shows the reorganization of the contents, for the first two weeks, in topics to be taught in four days, two per week.

<table>
<thead>
<tr>
<th>Weekly subject</th>
<th>Lesson topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>The importance of heat transfer in Engineering</td>
</tr>
<tr>
<td></td>
<td>Heat transfer study tools</td>
</tr>
<tr>
<td>Equations and solutions</td>
<td>Boundary layer</td>
</tr>
<tr>
<td></td>
<td>Pi Theorem and similarity</td>
</tr>
</tbody>
</table>

Fig. 1 Fragment of the table that was built to divide the 16 original weekly subjects into 32 lessons topics.

The simulators that were used in the computer classroom sessions were labeled to identify the topic or subtopic, to which they corresponded and to be able to link them within a scheme of lesson’s topics instead of weeks.

From the lesson topics, a list of the texts and materials that we needed to search in the electronic database was developed. In the canvas were also pointed out: a) the sites of the interactive notebook in which solved examples must be placed and b) the sites in which the student will develop activities using the simulators.

Fig. 2 is an example of the canvas developed to create the notebook for “Introduction to convective heat transfer”.

Fig. 2 Canvas developed for the topic “Introduction to convective heat transfer”.

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Once the guide was prepared, the digital texts to be included in the new notebook were selected from the diversity of possible sources. The selection was made according to the teacher’s experience. The platform used allows users to create folders for better management of the files. Fig. 3 is an example of the folder that was created to work on the “Introduction to Convective heat transfer” lesson.

For the case we are using as an example, six texts from four different sources were selected. Table 1 shows the selected texts and their origin.
Table 1. Texts we choose and their sources.

<table>
<thead>
<tr>
<th>Text</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td><a href="https://app.knovel.com/hotlink/toc/id:kpCHTE0001/convection-heat-transfer">https://app.knovel.com/hotlink/toc/id:kpCHTE0001/convection-heat-transfer</a></td>
</tr>
<tr>
<td>Convection heat transfer coefficient</td>
<td><a href="https://app.knovel.com/hotlink/toc/id:kpMEH00001/mechanical-engineers/mechanical-engineers">https://app.knovel.com/hotlink/toc/id:kpMEH00001/mechanical-engineers/mechanical-engineers</a></td>
</tr>
<tr>
<td>Boundary layer heat transfer</td>
<td><a href="https://app.knovel.com/hotlink/toc/id:kpMEH00001/mechanical-engineers/mechanical-engineers">https://app.knovel.com/hotlink/toc/id:kpMEH00001/mechanical-engineers/mechanical-engineers</a></td>
</tr>
</tbody>
</table>

The materials to be placed are in PDF format within the database, so they must first be converted to text format.

Also, the materials that are in English, were translated into Spanish, so that they can be used in Mexico by those students who do not have proficiency in that language.

The graphics and images that will be included in the interactive notebooks were selected from the same database (Knovel) and from the stock generated by the authors. Fig. 4 shows examples of the figures used in the interactive notebook for “Introduction to convective heat transfer”.

![Fig 4. Example of the images inserted in the notebooks: a) and b) from the authors stock and c) taken from https://app.knovel.com/hotlink/pdf/id:kt00TVI823/heat-transfer-2nd-edition/governing-equations.](image)

Insertion in interactive notebooks. Once translated, materials are inserted into the interactive notebooks together with the activities, the simulators, the graphs and the images. Fig. 5 shows an example of the interactive notebook with the topics in Spanish.
Finally, an exploratory questionnaire was applied to the students that attended the course.

The questionnaire consisted of 4 questions, designed to find out: 1) if the experience was satisfactory, 2) if they would like to have more materials of this type, for the rest of the lessons, 3) if they thought that the higher time involved while using this methodology could prevent them from its adoption, and 4) which was the greatest benefit of using this methodology.

The first three questions were binary and had to be answered with a yes or a no. The fourth question could be answered freely.

### 3 RESULTS

Following this methodology, two new interactive notebooks were produced, and it is planned to produce another thirty, over the next year and a half.

The notebooks were used to teach the Lessons “Introduction to convective heat transfer” and “Correlation and dimensionless numbers in convective heat transfer study” during the last term.

In the questionnaire, all the students (10) said that they were satisfied with the experience and expressed their interest to have similar materials for the other parts of the course.

Although it seems to them that this methodology requires more time for independent study, they do not believe that this represents a problem for its adoption.

What most students considered the greatest benefit was not having to use the computer classroom, which involves going to another building on campus. Other answers were to have different sources for the texts and to have a guide for study on their own.

### 4 CONCLUSIONS

Having access to a database of materials in digital format allows us to enhance the contents of interactive notebooks.
This makes them autonomous materials that the student can cover independently, which makes the new notebooks suitable for use in an inverted class scheme.

The production process we use is almost entirely manual.

It is necessary to know better how the database is integrated and if they use some markup language to automate part of the process.

It is necessary to analyze which is the most convenient approach to use the materials of the database, when integrating them into the interactive notebooks, so that the corresponding copyright legislation is

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REFERENCES


