
TEACHING INNOVATION IN TECHNICAL STUDIES: A CASE STUDY

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1. **ABSTRACT IN ENGLISH:** 500-700 characters

   New technologies are changing the way the education is being carried out. Subjects can be now taught remotely using online learning platforms. In this context, technical studies in traditional, on-site based universities have to innovate via IT technologies not to lose potential students interested on e-learning systems consistent with developing a professional career at the same time. This paper presents some initiatives being carried out in the Department of Electronics, Polytechnic School, University of Alcalá, and the IT & Technical Education Department, Faculty of Education, Charles University in Prague, to combine on-site, traditional education with online, distance e-learning.

2. **KEYWORDS** in English**:** 3

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Innovation in higher education, e-learning, virtual experimentation.

3. **FIELD OF KNOWLEDGE:** Indicate the subject area of your proposal:

- 1st option: Engineering and Architecture
- 2nd option: Sciences

4. **SUBJECT AREA:** Specify the subject area you propose for your paper:

- 1st option: Innovation In Higher Education
- 2nd option: Autonomous Student Learning

The Scientific Committee reserves the right to decide the final area of the proposals.

5. **PRESENTATION CATEGORY**:

- 1st option: Oral Presentation
- 2nd option: Poster Presentation
- 3rd option: Electronic Presentation

The Scientific Committee reserves the right to decide the final presentation category.

6. **DEVELOPMENT:** 25.000 – 35.000 characters (with spaces)

a) Objectives

One of the main objectives of the Bologna Process started in 1999 was to settle the European Higher Education Area (EHEA), aiming to ensure more comparable, compatible and coherent systems of higher education in Europe (EHEA 2012). The

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rapidly-changing global market demands professionals able to solve completely new issues, in many cases autonomously. To this end, one of the core goals of the EHEA is to promote the students' individual and collective homework outside the classroom.

Engineering and scientific studies are very good candidates to implement such learning innovations. Students of technical university degrees are usually very familiar with new technologies, and autonomous, on-line learning methodologies can be smoothly introduced. On the other hand, many of the subjects in technical studies require practical laboratory tests, which can be challenging to implement for distance learning.

The innovations proposed are being implemented first in two different subjects (Electronics Instrumentation, and Optics & Photonics) from the Electrical Engineering degree offered at the University of Alcalá (Spain). Similar cases are being carried out on Informatics degree studies from the Czech Republic. This paper presents results on the initial surveys carried out between students at both institutions.

b) Description of your work

b.1) Innovations in Optics & Photonics teaching

The first topic addressed by this work is the development of virtual experiments in Optics and Photonics. Today there are several resources which allow to performing virtual simulations on optical experiments from a computer connected to the Internet. These web-based tools, usually developed in Java (Oracle 2012), are suitable to get a first

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introduction to the physical phenomenon. In some cases, these resources allow interaction with real, on-going experimentation in the laboratory (G.W. Chang 2005). On the other hand, websites with videos of real experiments in Optics are also common (Carreño 2012) but usually they do not allow user interaction via simulation.

To supplement traditional, on-site classroom teaching on Optics & Photonics, a set of software tools has been developed at the University of Alcalá, allowing virtual and physical laboratory testing of different optical phenomena through the same software platform (Gamo 2011). Developed in MATLAB (Mathworks 2011), these tools cover different topics in Optics, including Diffraction, Radiometry and Photometry, Acousto-Optics interaction, Moiré phenomenon, and Computer-Generated Holograms (CGHs).

Fig. 1 shows the main window of the Diffraction tool. When clicking on the corresponding icon, the software launches the application for that aperture. Classical apertures, as well as pre-stored images provided by the user can be simulated using this tool.

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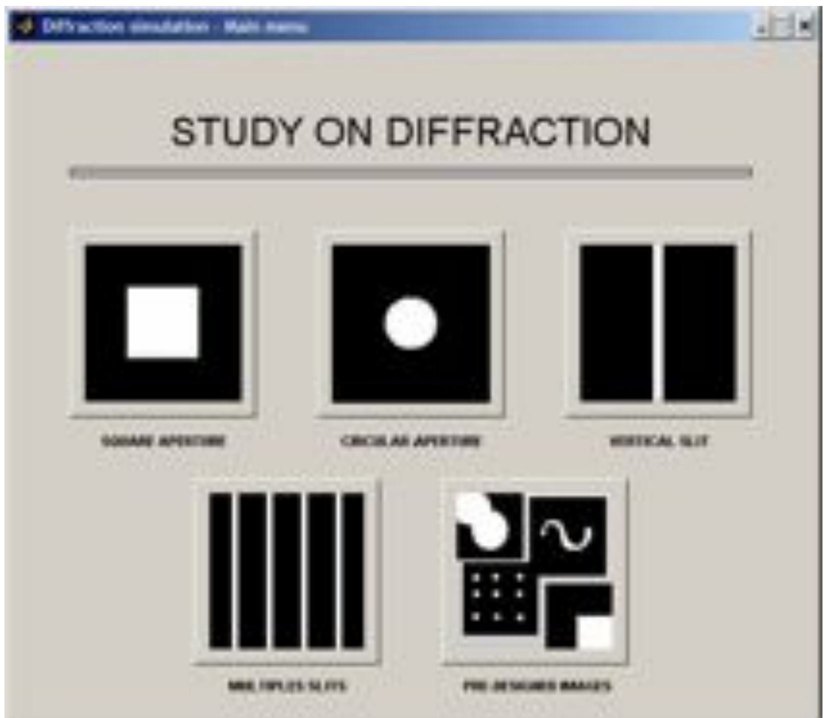

Fig. 1. Diffraction tool: main screen

All the applications were developed under the following structure:

- Theoretical module
- Simulation module
- Laboratory experimentation module

The **theoretical background** module introduces the student to the corresponding optical phenomenon throughout a multi-page environment. Fig. 2 shows the theory module for

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the diffraction tool. The basis of Fresnel and Fraunhofer diffraction is explained using some typical optical apertures such as a single slit, multiple slits, and circular aperture, which in turn produces the well-known Airy disc (Hecht 2012).. The *MANUAL* button launches the users's manual of the tool, where the functionality of each module is fully described. Moreover, the user can get interactive help on each module at any time.

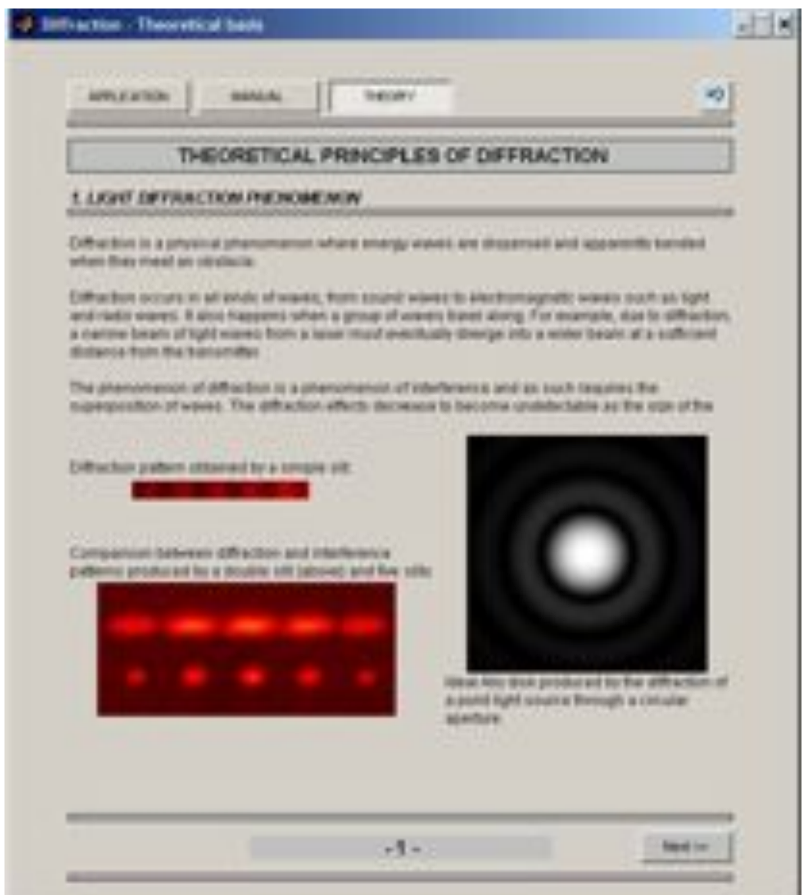

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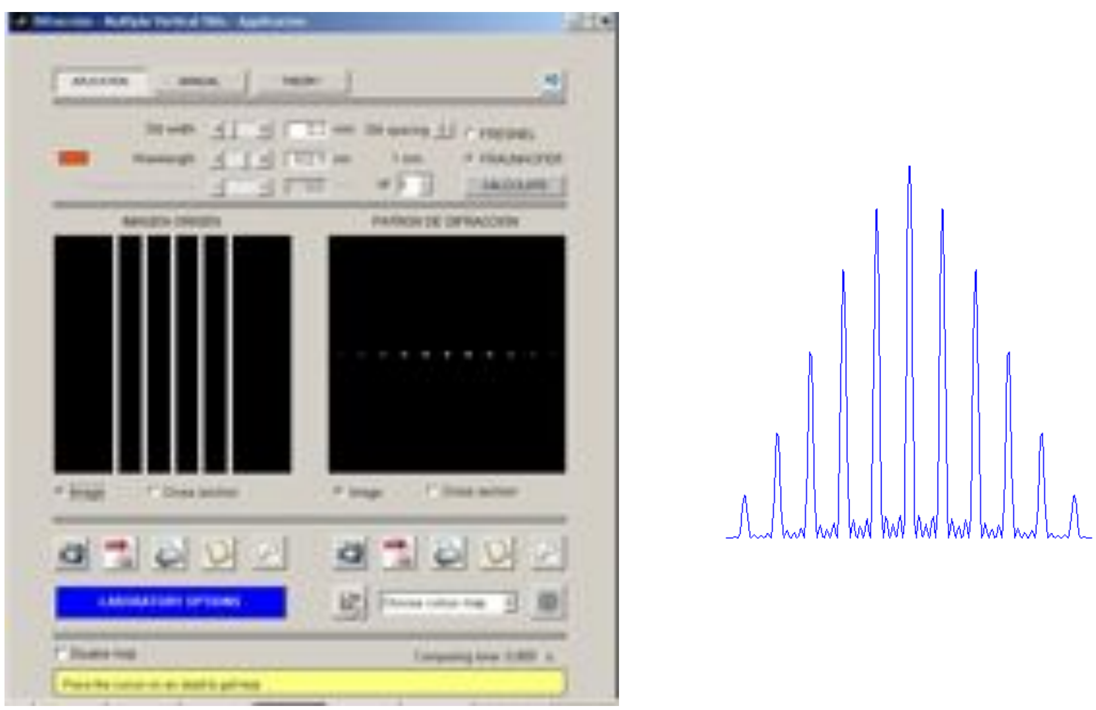
Fig. 2 Theoretical module of the Diffraction tool

The **simulation module** allows the user to carry out simulations of the optical phenomenon using the power and flexibility of MATLAB. Fig. 3 (a) shows the simulation module of the Diffraction tool. The intensity of the computed diffraction pattern is shown on the right-side image frame in Fig. 2 (a). Such diffraction pattern can be sent to a printer, or stored as an image file on the PC for further processing. By clicking on the *Cross section* button, a profile of the intensity diffraction pattern can be plotted, as shown in Fig. 3 (b).



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(a) Computed Fraunhofer (far-field) pattern for 5 vertical slits illuminated with red light

(b) Cross-section of the computed diffraction pattern

Fig. 3. Application module of the Diffraction tool

One of the most interesting features of the tool is the possibility to compare simulations with real experiments. Fig. 4 (a) shows the basic laboratory setup. The real experimental implementation is shown in Fig. 4 (b). A collimated He-Ne laser illuminates the object (aperture), and the corresponding diffraction pattern projected on the output screen is stored by a video camera, provided with the necessary filter to prevent image saturation on the CCD sensor. Images captured by the video camera can be stored and processed by the laboratory experiment module, as described below.

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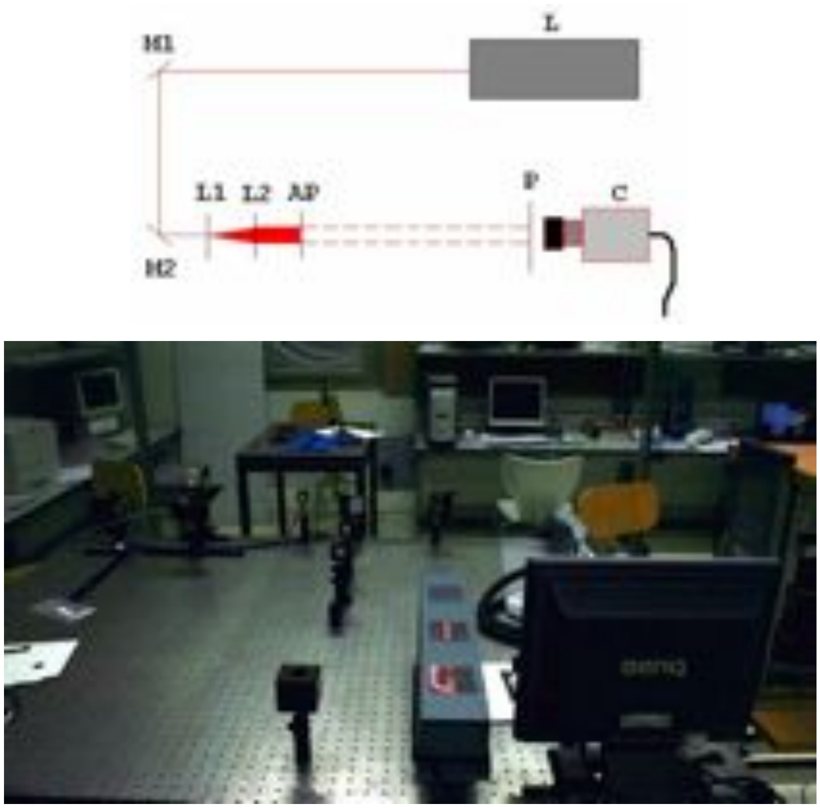

Fig. 4. Layout (top) and experimental setup (botton) for the Laboratory Options in the Application module of the Diffraction tool

The comparison between real and virtual experimentation is done by the laboratory experimentation module. Fig. 5 shows the main application of this module on the Diffraction tool. The computed diffraction pattern can be compared to the real pattern captured by the CCD camera in the output plane of the experimental layout shown in Fig.

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4. A cross-correlation between the two patterns gives the degree of similarity between simulated and real experimentation.

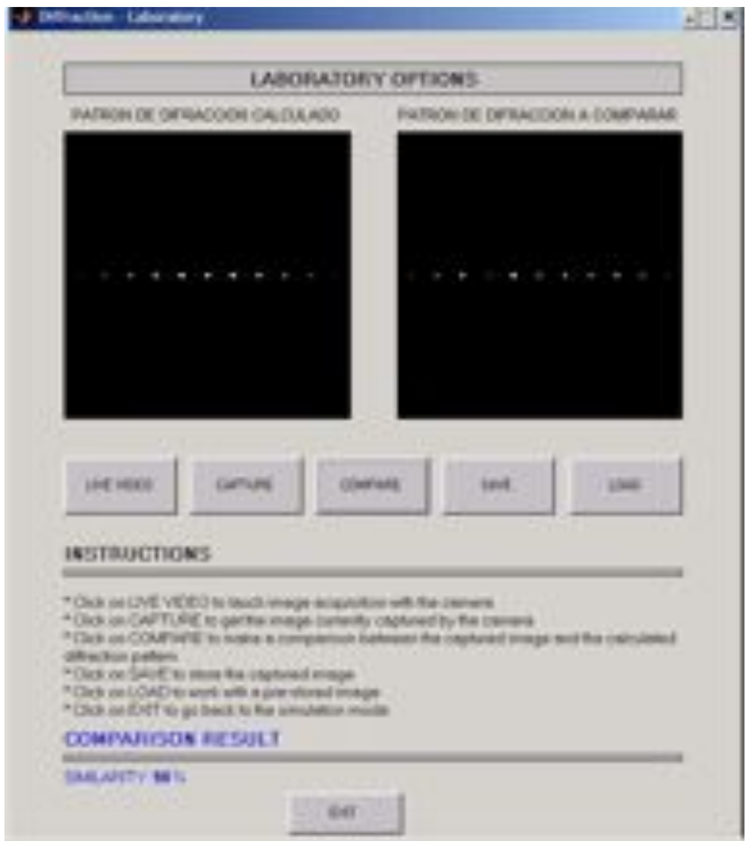

Fig. 5 Laboratory experimentation module of the Diffraction tool

An on-going project is being carried out to run all these tools from a website. The user would only need a web browser to execute the desired application.

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One of the key aspects in distance learning is the possibility of making self-evaluation tests, prior to taking the term-end examination. Fig. 6 shows the self-evaluation test module for the Radiometry and Photometry application. Similar self-evaluation tests have been built for the rest of the applications. Once registered within the system, the student can choose the number of questions, and enable/disable the *Suggestions* area to make it more realistic. When finished, some statistics are available, including the point average and the time employed to complete the test.

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Fig. 6. Self-evaluation test module for the Radiometry and Photometry application

<u>b.2) Innovations in Electronics Instrumentation</u>

Innovative experiences In Electronics Instrumentation for engineering studies are being carried out at the University of the Basque Country (Oleagordia y San Martín 2010).

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A similar pilot platform that allows to running electronic instrumentation experiments remotely is being conceived. The project, named RemoteDAQ, will try to implement data acquisition practices which can be executed and monitored remotely. The students could then have the opportunity to connect to a dedicated electronics benchmark equipped with instruments such as oscilloscopes, power supplies, wave generators, and real sensors (pressure and temperature) to test their data acquisition programs.

In this way, the student may undertake such practices anywhere through the internet (computer rooms in the University facilities, home, etc.). The advantages are straightforward, especially for those students who have already entered into the working world.

b.3) Educational innovative model

To implement the innovations described in previous sections, the Model of School Improvement (Medina 2009), has been adapted to our scenario. We chose the following stages for the development of this innovation model, partly inspired in (Gairín 2002):

- **Preliminary stage**: diagnosis, needs improvements. Search for similar experiences in other schools.
- **Planning**: determining the actions to take, choosing experimental practices that would be the subject of virtualization on both subjects.
- **Pilot implementation** of the innovation plan: Before proposing the global implementation of the Directorate of the Department, voluntary pilot experiments

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will be conducted with a small group of students and teachers involved in both matters.

- **Quantitative and qualitative evaluation** of the innovations in the pilot implementation: review proposed plan and areas for improvement, according to the results obtained in the previous pilot evaluation.
- **Institutionalization**: proposal to incorporate the innovations made to the Directorate of the Department, and potential extention to other subjects and Departments.

To ensure the success of the proposed innovation model, all stages will be supervised by the coordinator of each of the two subjects which will extend the proposed innovations. A joint effort and commitment of all actors teachers involved in both subjects, and students receive these material) is mandatory to succesfully implement the proposed innovations (Medina 2009) This is especially critical in the pilot implemetation, therefore it is worth to design incentive mechanisms for the voluntary participation of students and teachers in these pilots experiences.

Fig. 7 summarises the innovative model, from the skills point of view. Each block of skills is fully described below.

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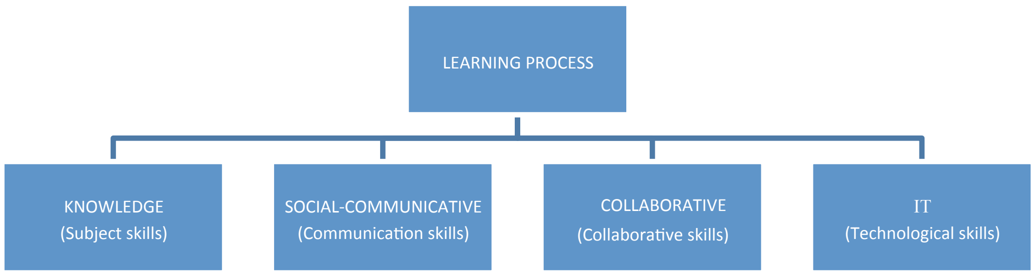

Fig. 7 Outline of proposed innovative model

Knowledge block (subject skills)

The contents of this block are shown in Fig. 8. First, one must analyse the skills acquired by students and teachers, and combine traditional and virtual teaching in teaching the subjects.

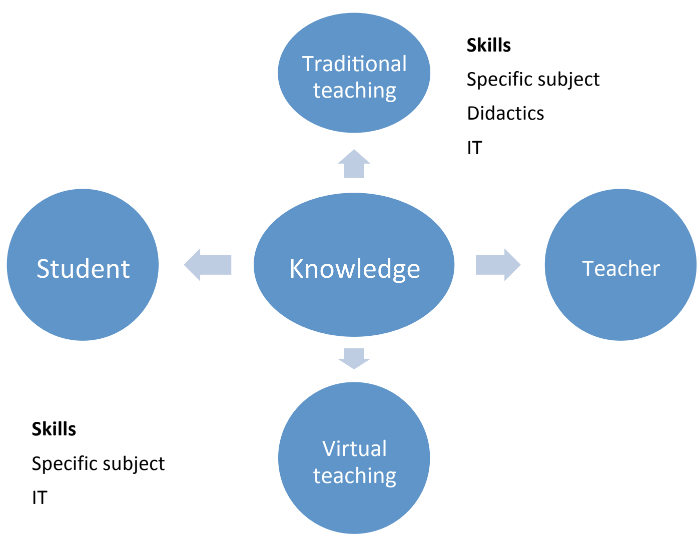

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Fig. 8. Knowledge block (subject skills)

Let us apply the knowledge block model to the subjects mentioned in this work:

Elctronics Instrumentation

The objective of this subject is the study of the data acquisition system together with its associated software, as well as analysis of various measurement systems, analysing some sensors and conditioners.

The student's competencies associated with the traditional teaching of this subject are:

- Understand the structure and philosophy of running a data acquisition card on personal computer (PC).
- Conduct software applications to drive the electronics sensors and communicate with the user.
- Understand the component parts of systems as explained in the theoretical course.

The new skills proposed for the student, associated with virtual learning, are complementary to the above, and can be summarized as:

- Using the new technologies (learning platforms, web browsing, email, FAQs, etc.).
- Ability to search for information online (criteria selection, results analysis, etc.).
- Collaborative attitude in discussion forum.

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On the other hand, the teacher should acquire the following additional skills to those already owns in the traditional teaching:

- **Use of new Information Technology (IT) tools**: The IT tools chosen should be flexible and easy to use. For this specific subject, we propose using BLACKBOARD as a tool to implement the virtual platform (Blackboard 2011). Additionally, the development of a website to remotely execute the software code written by the students is foreseen. This point is developed in detail in the IT block below.
- **New didactics resources**: the use of new technology also involves the development new materials for the web. This point is really important, and sometimes not given due attention. New technologies also require new formats for teaching resources, which must coexist with traditional, text-based materials. Too often, the contents of the slides are just almost verbatim transcripts of written texts (and thus lose the effect of "attractive visual communication"), and *vice versa*: there are times when the slides are virtually empty of content, which ends up frustrating the student. To overcome these drawbacks, in the course "Electronic Instrumentation Laboratory" is proposed to develop two types of documents:

  a) Documents written in a traditional style, to recount in detail practice scripts to perform.

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b) Slides in support of these documents, which serve to capture students' attention and motivate them in doing such practices.

Besides these documents, it is also proposed to develop:

- **Video Tutorials**: this is a great advantage of new technologies. The teacher can record some classes and put them on the web, so if a student cannot attend a particular session, he/she can always check the video of that class. Streamming technology allows storage of videos which can be reproduced with sufficient quality using a standard ADSL connection. In addition, there are interesting programs like Debut Video Capture (NCH Software 2012) which can capture the actions that the user does on the computer, including audio and video. This is especially interesting for the Electronic Instrumentation Laboratory, greatly based on experiments using a programming language (National Instruments 2011). Obviously, interaction provided by live classes is lost, although video chats are also available.
- **E-mail, chats, forums, FAQs**: these are common tools in distance learning courses that will be analysed in the socio-communicative block.

Photonics Technologies

Still having similar subjects currently taught within the Department of Electronics, the subject "Photonic Technology" in the Electronic Engineering Grade. has ben chosen. This subject has not yet begun to be given (it will start in the next academic year 2012-

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2013), being included within the new degree in Engineering, under the new European Higher Education Area (EHEA 2008). Work in this direction has been to develop the teaching guide for the course, including therein the innovations proposed in this paper.

The student's skills associated with traditional teaching referred to this subject are:

- Ability to perform the analysis of components and specifications for communications systems guided and unguided.
- Ability for the selection of antennas, equipment and transmission systems, wave propagation guided and unguided by electromagnetic, radio frequency or optical and radio spectrum management and allocation of frequencies.
- Ability to apply electronics and technology support in other areas and activities, not only in the field of IT.
- Ability to design interface devices, data capture and storage, terminal services, and telecommunication systems.

The new skills proposed for the student, associated with virtual learning, coincide with those reported previously for the course "Electronic Instrumentation Laboratory," and can be summarized as:

- Ability to use search tools and on-line resources for information related to telecommunications and electronics.

Social-communicative block (communication skills)

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This block describes all the skills required for an adequate communication between different actors (teacher-teacher, teacher-student), thereby ensuring the successful implementation of the innovative model.

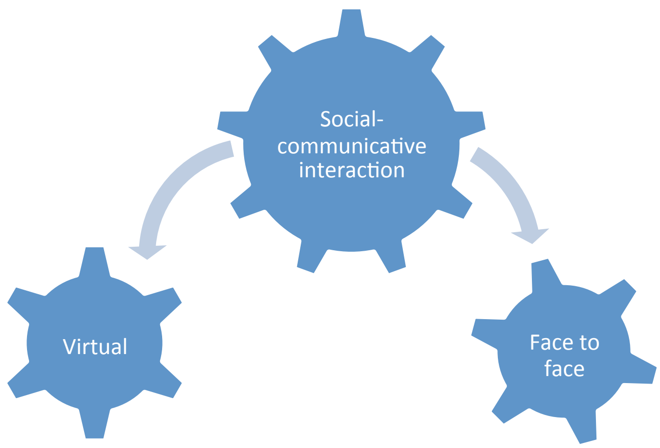

Fig. 9. Social-communicative interaction block (communication skills)

As shown in Fig. 9, once again the traditional forms of interaction have to live with new forms of virtual communication. Let us analyse the teacher-student communication and interaction among teachers who share teaching of this subject.

- **Teacher-student**: face to face tutorials will have to live with virtual tutorials, both being necessary for the two subjects tested. The "virtual tutor" takes a more active role in the process, guiding and ensuring higher quality and more

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personalized tutoring (Alberca, y otros 2010). Virtual tutorials are proposed to be develop in two ways:

- At individual level, by e-mail.
- Collectively, through chat sessions and open forums.

- **Teacher-teacher**: apart from the usual (and necessary) face to face coordination meetings, alternative communication channels between teachers are being proposed, as discussed in the collaborative block below.

Collaborative block (collaborative skills)

The contents of this block are shown in Fig. 10. It would be desirable to establish incentive mechanisms to increase participation of students and teachers.

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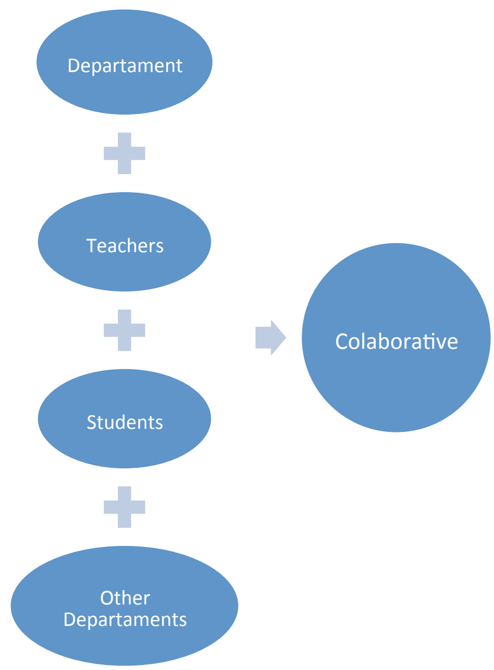

Fig. 10 Collaborative block (collaborative skills)

Regarding students, the following *Innovation Survey* has been developed. The survey seeks to test the students' willingness to make use of virtual content that will be part of the subjects. The outcome of this survey is described in the **Results and/or conclusions** section below.

INNOVATION SURVEY

This questionnaire is anonymous so we expect you to answer honestly.

1. Have you ever taken a course using a virtual teaching platform? (YES / NO)

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2. Would you be in favour of using a remote data acquisition platform, in support of classroom teaching in the laboratory? (YES / NO)

3. Do you have internet connection at home? (YES / NO)

4. If so, what type of connection do you have?

- *ADSL 20 MB*
- *ADSL 10 MB*
- *ADSL 6 MB*
- *ADSL < 4MB*
- *Do not know*

5. How much time per week devoted to remotely connect to the platform?

- *Less than 1 hour*
- *1 to 3 hours*
- *3 to 6 hours*
- *More than 6 hours.*

6. Rate the preferred time slot to connect to the platform (1 = "strongly disagree" and 5 = "strongly agree")

Rate (1 to 5)

- From 8.00h to 14.00
- From 14.00 to 20.00h
- After 20.00h

7. From which location will you preferably connect to the platform? (1 = "strongly disagree" and 5 = "strongly agree")

Rate (1 to 5)

- From home
- From University facilities
- From work

8. Rate what you consider most useful tools (1 = "strongly disagree" and 5 = "strongly agree")

Rate (1 to 5)

- E-mail with Professor and other students
- Open forums to raise doubts
- Chat sessions with Professor
- Tutorials and examples

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9. Additional comments / suggestions

THANK YOU FOR YOUR COOPERATION

The following new collaborative methodology for teachers and students is the use of the platform BLACKBOARD in the subjects described in this task (NCH Software 2012), as described in the IT block (technological expertise).

With regard to collaboration between the various teachers involved, a new way of setting coordination meetings has been established throughout DOODLE (Doodle 2011), as explained in the IT block below.

Finally, as additional novelty, the teachers have begun to develop learning materials cooperatively by using DROPOX (Dropbox 2012), as also described in the IT block below.

IT block(technological skills)

The proposed tasks contain a big technological workload that must be made as easy as possible to both teachers and students. Figure 5 shows the outline of contents to develop the IT block.

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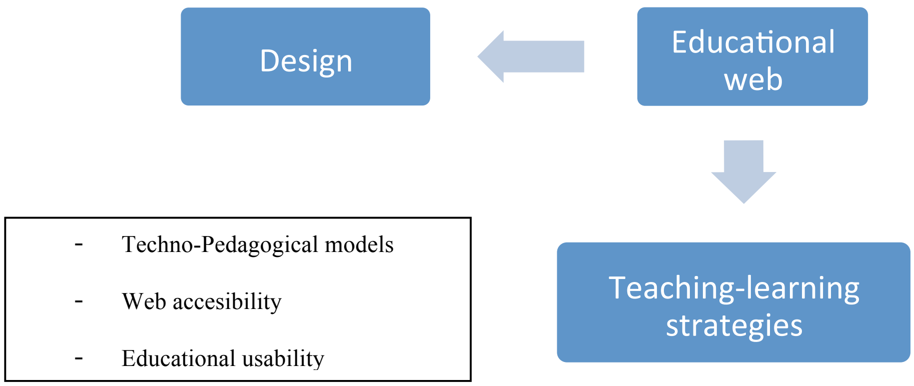

Fig. 11 IT block (technological skills)

The web is the basic framework for virtual platforms. The contents of the website must be designed so that its use is kept simple, accessible and intuitive, while the content and services should be as complete as possible. To achieve this, it is necessary to seek a teaching-learning strategy coherent, combining the advantages of remote platforms with the development of the face to face teaching model in the classroom.

The spirit is to develop an educational website as an open platform, not limited only to a restricted number of users. The idea is that the platform could be accessible to the general public, providing the possibility to register on the site to get additional functionalities, and therefore extending the scope of diffusion.

The educational website aims to become a reference for both students and outsiders who are interested in the study of the subjects mentioned (Optics & Photonics, and Electronics

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Instrumentation). To this end, apart from virtual experiments, the website will include theoretical explanations as described in the previous section, and some interactive tools such forums/blogs where users can communicate with each other to keep the spirit of sharing and exchange of experiences among different users.

One of the options considered for continuous improvement of the educational website is the generation of statistics (number of connections, connection time per user, etc.). This will serve as feedback to improve the functionality of the website in the future.

For login control, the website will include advanced access method such as digital certificate and electronics ID.

In line with the new guidelines of the Bologna Process, the website should be a tool to adapt to new teaching methods, moving part of the workload from the classroom to each student's desktop, where he/she can progress along the subject autonomously, having online communication with the teacher and other colleagues.

The main tools of the IT block are summarized below:

- **E-mail:** is undoubtedly the communication tool of our time. However, care must be taken not to abuse its use, because many times the tool is used for "infoxication" rather than information (Benito-Ruiz 2010).
- **BLACKBOARD:** After evaluating several options, it has been decided to use BLACKBOARD as the main platform for virtual learning (Blackboard 2011). This is a very powerful product that allows task scheduling for students,

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document uploading (for task delivery) and downloading (lectures, etc.), on-line assessment tests, etc. Students also have forums for consultation, e-mail, calendar dates subject to delivery of tasks.

- **DROPBOX:** This excellent tool allows for free to share up to 2 Gigabytes of information through the internet (Dropbox 2012). It also facilitates automatic synchronization of files on local (personal computer) and on the shared folder on the web. It is very useful for the preparation of teaching materials on a cooperative way, as identified in the knowledge block above.
- **DOODLE:** This web-based tool allows to easy scheduling dates for the coordination meetings. The tool is being widely used among all teachers involved in both subjects from the current academic year (Doodle 2012). . Throughout a simple web-based interface, the coordinator of one subject can easily design dates for meetings so that the involved teachers can choose the date bands compatible with their own agendas DOODLE has been also used this term with the students to fix recovery dates for the laboratory sessions lost for different reasons (business trip of the teacher, sickness, etc.).

c) Results and/or conclusions

Up to 83 students participated on the above mentioned survey during 2012. Participants are taking different technical degrees at the Department of Electronics, University of Alcalá (51 students) and IT & Technical Education Department, Faculty of Education,

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Charles University in Prague (32 students). No big differences to this survey were found between the responses coming from these two universities.

The results are summarized graphically in subsequent charts, as shown in Fig. 12. As it can be seen, even with the high level of IT deployment in today's universities, 28% of the students never took a virtual teaching course. We can then conclude that, to date, e-learning courses seem to be more common in professional, specific teaching rather than in university education.

On the other hand, this type for remote learning platform would be highly appreciated by a vast majority of the students (88%). All but one students interviewed reported that they have internet connection at home. Many of them (30%) have large, wideband connection (20 Mbit or higher). This paves the way to include heavy-traffic applications (e.g. heavy-load numerical simulations), and services such as video streaming (e.g. video-taped real experiments, interactive video-chat, etc.). Most surprisingly, 35% of the interviewed does not know which type of connection they have, probably because they still live in their parents' house and/or shared apartments where the internet connection already existed.

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Fig. 12. Results on the innovation survey

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The best-rated dedication time for using the platform was 1 to 3 hours per week (58%). Regarding the time slot, there is a strong preference in using the platform from home (63%) during late evenings (67%). This has to be taken into account when designing the platform architecture, since concurrent accesses are likely to happen. The platform design should be also robust to avoid overnight maintenance.

Tutorials and examples are the most appreciated services demanded by the students (71%). This indicates some preferences for autonomous working. Email with teacher and other students is the second most-demanded service (60%).

The following comments and suggestions were also received from the participants on the survey:

- Contents can be increased since many practices can be done now from home.
- The platform should not replace totally on-site classroom teaching.
- More realistic practices, with real conditioning circuits and sensors should be implemented.
- Full documentation should be developed, not only PowerPoint presentations.
- Clear instructions for each practice should be given, otherwise it will be difficult to work autonomously from remote.

With all these considerations, for the authors it is clear that the evaluation methodology currently available should be revisited to accommodate this new paradigm. The Innovation Survey, whose design is inspired in the Model of School Improvement (Medina 2009), will undoubtedly pave the way to new teaching practices. The

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participants should also play a key role in the design of such practices, to achieve a successful implementation and future use of the remote platforms.

Besides, the survey also shows that both remote and on-site teaching systems must coexist, since a pure, virtual environment does not seem to be enough for the students to complete a technical matter. The evaluation methodology will allow the students to consolidate the technical knowledge (subject skills) before facing the final exam. We also believe that teachers from other subjects can find some inspiration from these proposals for their own matters.

7. ACKNOWLEDGMENTS

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