THE PSSC DIDACTIC MOVIES, SOME “OLD FRIENDS” REVISITED THROUGH MODERN TEACHING TECHNOLOGIES

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ABSTRACT
An evergreen problem affecting the management of distance learning is the difficulty to devise laboratories suitable to either synchronous or asynchronous e-learning. The relevance of these activities is inevitably clear as fundamental step toward the development of additional skills/abilities for our students. Today, thanks to the continuous R&D activities put in place by Institutions, a plenty of different solutions are available/usable to provide realistically reliable experimental activities to e-courses.

By this paper we want to propose a novel solution to the previous problem. In a few words, we have restored old didactical movies (anyway available). The Physical Science Study committee (PSSC) between the 50s and 60s prepared the originals. The activity of this group, hosted at Massachusetts Institute of Technology, was devoted to devise new teaching approaches. In particular, PSSC aimed to supply learning materials able to communicate to students a methodological approach more than the brute memorization of the concepts. They were looking for a veritable and deep understanding of the discussed arguments. The materials realized by PSSC include several textbooks and a large number of didactical documentaries. We used these documentaries to realize a modern learning product which at once restores the original PSSC spirit and enriches it of presently available multimedia contents. Using modern technologies we built a 3D virtual laboratory blending special portions of the original movies with additional video materials, computer simulations and self-assessment activities.

Our final product is composed by ten “physics pills” each of this dedicated to a specific argument of General and Applied Physics courses. The insertion of new materials, the presence of the instructor with the role to explain and lead students, together with the realization in agreement with responsive technology offers the possibility to learn in a different and modern way preserving the veritable charm of a laboratory.

KEYWORDS: Methodology, Physical Science Study committee, Physics, Virtual laboratory

1. INTRODUCTION
During last years, we faced a huge increase of courses delivered online through distance learning technique. This route can be applied to a plurality of aims: academic courses, professional update courses, lifelong learning, etc. Surely, the most remarkable revolution in this sector lies in the use of e-learning approaches within the university education. As evident, the number of students enrolled in distance courses grows worldwide continuously (Lockwood, 2013). The reason of this trend is in part due to the most known advantages of distance learning. Among the others, the lack of a rigid “time-schedule” is one of the most relevant aspects for today’s students. Independently of their daily organization, they earn the possibility to work and study at
will as well to contact their teachers (professors, tutors) in the most appropriate moments. Surely, the aspects already listed are important for distance learning growth but their implementation was possible only thanks the extraordinary R&D performed by institutions during last decade. The use of modern technologies together with an important study on students response have permitted today to reach a mature phase for e-learning (Lockwood, Gooley, 2012). In the framework of online delivered courses, a topic frequently discussed is the realization of didactic laboratories. Obviously, the availability of effective laboratory experiences, namely for STEM courses, is mandatory to develop additional skills for our students and to strengthen their analytical aptitudes are fundamental to educate future workers. This topic is constantly studied from e-learning researchers since the use of modern technologies can fulfill this lack in different ways. According to the current literature on this sector this subject can be divided into three main areas: computer simulations, modern devices, technological solutions (Martini, 2014a).

Undoubtedly most among well-known laboratory experiences exploit computer simulations to reproduce traditional laboratories and real life applications. Nevertheless, these are not the only possibility available today since a huge number of experiences can be realized using modern technological devices like smartphone and tablets but also using stand-alone micro-controller like Arduino and Raspberry Pie (Martini, 2014b). These solutions are suitable to realize actual laboratory experiences under the guide of instructors. Even at the student’s own home. As a consequence, it is possible to provide an important answer to laboratory lack in distance learning.

However, as it happens in traditional University, each experience must be preceded by a proper training to supply our students a way of thinking to understand and better exploit laboratory itself. For this reason we discuss here a new multimedia product realized for engineering courses. Our definite aim is to teach to our students a laboratory culture intended as a “way of thinking” which we think be a fundamental feature of technical workers.

### 2. The Physical Science Study Committee

During 50s, secondary school teachers in US complained about physics books used for high schools. In their opinion, these texts were not suitable to teach students the physical approach to problems and, in particular, these books were not able to thrill future generation toward STEM subjects. For this reason, the Physical Science Study Committee, PSSC, was founded and financed by American National Science Foundation (Holton, 1976).

PSSC was initially created in Massachusetts Institute of Technology by Jerrold Zacharias and Francis Friedman but a large number of important physicists of those years joined immediately the committee. As already written, the principal aim of this project was to define new quality parameters to change physics teaching showing simple laboratory experiences (French, 1986).

To be honest, the previously quoted aim of this committee (i.e. the definition of a teaching methodology) was somewhat pushed by the need to shade the Russian success of Sputnik in 1957 (Rigden, Stuewer, 2006). As well known, along these years, the political scenario between US and the soviet URSS suffered of a delicate balance. The Space was a strategic field and the “space race” had a temporary end in 1969 when the first man landed on Moon. After Russian
Sputnik success, the US government was afraid that the U.S. educational system could not provide a robust scientific preparation to the next generation of scientists. Consequently, it financed PSSC and its didactical aims.

3. The PSSC Didactical Method

The PSSC team focused its work to the realization of a series of textbooks for American high school supported by documentaries realized into academic laboratories. Quite differently to the old teaching approach, PSSC aims to privilege the comprehension respect to a mere storing of physical concepts. Under this respect, in these textbooks each physical phenomenon is not explained through a mere mathematical analysis of the equations but is introduced by means of simple and clear experiments. Through a pathway which allows to discuss real situations analyzed under their physical point of view (Holton, 1976). Lessons realized using this “inductive” approach are more interesting for students and greatly help learning process (Seliger, 1975). Moreover, thanks also the great communicative skills of the people involved into PSSC, the realized didactical products are able to thrill students to laboratory activities.
4. PSSC Documentaries Selection

PSSC realized a large number (around 100) of documentaries. These movies were distributed in
a large number of countries and translated into various languages. The reason of this success
was explained in the previous section and is clearly due to the innovative and revolutionary
didactical approach used by PSSC.

Unfortunately, during years, the memory of PSSC activity was quite completely lost. Today, only
some schools preserve the PSSC documentaries but in many cases these documents are no
more usable since they are in too old formats like 8 mm or VHS.

Despite this, during 90s a restricted number of these films were re-ripped by private companies
or passionate people and these products are available in different websites copyright free. After
a long and deep search, we selected ten of these movies and we decide to use them in our
didactical activities to create a Physics Laboratory course.

The selected films cover the entire program of this kind of courses and are relative to specific
arguments not so friendly for students:

- Periodic motions
- Inertia
- Forces
- Angular momentum
- Reference frames
- Mechanical and thermal energy
- The Millikan Experiment
- Coulomb law
- Gravitational law
- The Cavendish experiment

Our final aim is to exploit these films to give to our students a different point of view respect
to standard courses and this represents an alternative solution to teach them the so called
“lab approach”. Even if we are talking about movies released more than 50 years ago, these
documents are still actual and they represent a “didactical asset” usable even today with modern
students.

5. A Multimedia Product Based on PSSC Films

Even if PSSC documentaries maintain today a great didactical power, we can exploit modern
technologies to give them some important additional values.

Our initial idea, as explained in previous sections, is very simple: we want to use these films
to give the double possibility to our students to: learn in a different way arguments already treated
during lessons but also give them the possibility to experience the laboratory environment with
simply understandable experiments. In this context, PSSC documentaries offer an extraordinary
possibility to insert indirect laboratory activity for STEM subjects delivered online.
The average duration of PSSC movies is around 1 hour. If this duration was suitable for students during 50s, modern generations have a different approach. As clear, our students tend to annoy themselves very simply and rapidly. From a social point of view, this is due to the rapidity of nowadays communications and in the continuous search for effective approach (Dobos, 1996). In this context, we decide to create a novel multimedia product based on PSSC films but using, for each item, a limited number of movie parts spaced out with multimedia contents. The selected parts are relative to specific and effective laboratory scenes while the multimedia contents can be different.

Each selected movie (Ref. previous section) has been divided into sub-parts relative to different scenarios and/or experiments. Every argument, corresponding to a single PSSC movie, has been used to create what we called “a pill”. The final laboratory is then composed by 10 pills on the arguments reported in previous section.

For a single pill, that is composed by a certain number of film frames, each video part is no longer than 5 minutes. In our opinion, this is a good solution to maintain students attention.

To avoid student boredom the total duration of each pill, including also additional multimedia contents is no longer that 45 minutes.

6. Self-assessment activities

At the end of each movie part, a self-assessment activity has been included. This insertion is fundamental to consolidate students knowledge and to solve, through specific learning activities, eventual doubts arising from the vision (Fontana, Martini, 2015a).

The simplest solution to insert self-assessment activities is using multiple answer questionnaires with feedback. If a student gives a wrong answer, a feedback-page appears proposing a short textual explanation to correct mistakes and giving the possibility to try again the same questionnaire. In case of a second error, a pop-up appears suggesting to student to follow again the specified part. Obviously, when the correct answer is given, student passes to the following step.

Our laboratory is hosted on Guglielmo Marconi Learning Management System. This solution permits to collect statistical data about students fruition and to measure their appreciation (Fontana, 2005). Moreover, LMS is used to collect data about self-assessment activities and this data are fundamental to understand what are the arguments felt unfriendly from our students and eventually correct their learning process before final exam (Fontana, Martini, 2015b).

7. Additional multimedia contents

Exploiting modern technologies, we have enriched the original content of PSSC documentaries with multimedia contents explicitly realized to better learning process and to show physical phenomena in a different way.

Obviously the type and quantity of multimedia contents are different for each pill since every experience is relative to a different argument.
Just to give some examples, we divide these contents into two main classes: additional videos and simulations.

### 7.1 ADDITIONAL VIDEO

Since PSSC films were realized during 50s, they were recorded in black and white with a resolution typical of the cameras used during those years. Moreover, in some cases, laboratory experiences were recorded with large shots without zooming on experimental apparatus.

For a better explanation and increase visibility, when necessary, we inserted an additional movie superimposed to the original from PSSC. The simple technique used is the one of the “Picture in Picture”, or PiP, that is used to insert a small screen in a corner to show additional contents (Strubble, Gentner, 1990). This technique is also used to insert additional materials to increase students learning. The result of this insertion is shown in Figure 2.

![Figure 2. Picture in Picture used to insert additional video contents](image.png)

To increase quality and originality of our product, a large number of the additional video contents have been realized recording real equipment used also in our real didactical laboratories. Just to give some examples, in Figure 3 a Maxwell pendulum together with a pendulum waves are shown. These instruments have been used in the pill relative to the harmonic motion to better explain the important concept of periodicity and waves of these phenomena.
Using these additional contents prepared recording real laboratory equipment, we satisfy to specific requests. First of all, we increase, as already explained, the quality of this product but, at the same time, we better transmit to our students the passion for laboratory pushing them also to attend real laboratory courses that are part of our didactical offer.

7.2 SIMULATIONS

Computer simulations represent one of the most powerful solutions used in distance learning. Even if this category includes a large number of different products, computer simulations are normally used in STEM distance courses to reproduce virtually real situations or specific instrumentations.

For our physics pills we built a large number of computer simulations that are obviously different for different arguments. The use of this solution represent a great help to enhance learning process since through simulation we can show to our students also specific applications not simply realizable into a didactical laboratory.

Just to give some example, through computer simulations we can reproduce the motion of the planets into our Solar System and use this example to explain Gravitation. Otherwise, we can realize a hypothetical laboratory in which students can move electric charges to observe Coulomb force or visualize shape and intensity of electric field. As clear, this kind of experiences is not realizable into a didactical laboratory but only using computer simulation. In a large number of these simulations, the possibility to change parameters is given to student obtaining an interactive product.
8. Virtual 3D Laboratory

As discussed in previous sections, the selected parts of an original PSSC documentary are used to create a physics pill. Since our final aim is to use this product not only to explain basic concept but also to provide a different solution to insert laboratory activities into distance learning courses, we built a 3D virtual laboratory as core of this product.

The 3D laboratory represents the central environment of the product and it host instructor with the precise duty to introduce each part of the movie, give additional explanation, describe additional materials and also guide students to self-assessment activities.

Considering the setting of the original PSSC movies, we decided to reproduce what we can define an “old fashion” laboratory. This environment was completely built using virtual set and recording each intervention of the instructor into our green screen room (Ingram, 2010). This special recording room, as the name suggests, has completely green walls and floor and this color is very suitable to build virtual set since it can be easily removed during postproduction.

Our virtual laboratory is realized to host instructor in the center of the screen and into this environment real instrumentation is positioned on appropriate supports. Moreover, some screens are present to launch movie zooming on the screen and to show additional multimedia contents while a blackboard is used to show textual learning materials. The set reproduces accurately the classical style of the laboratories of the 50s as shown in Figure 4.

At the beginning of each pill, instructor introduces the argument referring to theoretical concepts and giving some hints on the experimental aspect of the PSSC movie. As already explained, the role of the teacher is always central since his duty is to guide students through the entire path.

In agreement with today request, our physics pills have been realized to satisfy responsive technologies and they are fully compatible with every mobile device. Obviously, to permit a clear visualization also on smallest screens, some expedients must be taken: 3D laboratory furniture is in a limited number and their size is not so small, the PiP additional contents are shown on a secondary screen with specific shots, the texts of the self-assessment activities are short, etc.

All these precautions are necessary to permit the fruition of this product also on mobile devices.
9. Conclusions and Future Prospects

The work done during 50s and 60s by the Physical Science Study Committee represents an enormous didactical capital. This material includes a large number of documentaries realized with the precise aim to revolutionize teaching method for STEM subjects pushing curiosity and thrilling students. Still today, these movies are present and we decided to use a certain number of them to create a novel multimedia laboratory for our Physics course.

Our laboratory is composed by ten “pills” and each of these is relative to a specific argument and based on an original PSSC film. To realize each pill, the original movie has been divided into parts relative to specific experiment and only the most significative are used into the product. This operation has been necessary to reduce the duration of the movie (the original films have an average duration of 1 hour) obtaining a very effective product.

The original documentary was then enriched using multimedia contents exploiting modern technologies. Each part of the movie has been enhanced including additional materials and self-assessment exercises. In particular, we realized specific movies with real laboratory equipment to explain better the presented concepts and to show “alive” what happens into a real laboratory. Moreover, computer simulations have been realized with the same aim and to show to our students very specific applications.

The setting of the laboratory has been completely realized using 3D technology creating a virtual environment. Instructor is present into the lab and his role is to introduce each video contribute but also to give additional explanation and present multimedia contents.

The final aim of this product is to exploit the important legacy of PSSC activity to realize a modern teaching solution able to transmit to students enrolled in distance courses the importance of
laboratory activity and how the studied laws can be reproduced and visualized with simple experimental experiences. During its activity, PSSC produced a large number of didactical documentaries and some of these are also dedicated to modern physics. Using exactly the same scheme presented in this paper, our future prospect is to select a certain number of these films and to use them also for other subjects like: Nuclear Physics, Radiation protection, etc.
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