

Reshaping Higher Education with e-Studium, a 10-Years Capstone in Academic Computing

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Abstract. E-Studium has been a long-running project of blended e-learning for higher education based on the learning management system Moodle, implemented at University of Perugia, Italy from 2005 to 2015. The capstone culminated in a refined final product, at the basis of the actual academic platform Unistudium. In its ten-years activity, e-Studium has been a learning pathway experience for a variety of applications, included STEM courses, from high school education to high-specialisation academic courses, teacher's qualification, and third mission for technology transfer, with a particular focus on usability and teacher's self-evaluation. The analysis of both objective and subjective evaluations, collected over ten years from activity logs, web analytics, global rankings, and ad hoc questionnaires, together with teachers and students' outcomes, shows how e-Studium contributed to reshaping the educational offer of large-scale learning in University of Perugia and Italy. This paper aims at showing the evolution and the outcomes of e-Studium, under the vision of the contemporary natural evolution of the technological learning economy, assessing and sharing educational experiences based on the evolution of innovative technologies for lifelong e-learning. A particular focus will be given on how such contribution can enhance the actual extraordinary situation, which sees a worldwide unexpected and abrupt need for remote communication due to the COVID-19 emergency.

Keywords: Academic freedom · Institutional diversity · ICT · STEM · Continuous education · Coronavirus

1 Introduction

The learning environment dynamically evolves, both qualitatively and quantitatively, adapting to specific educational situations both for teachers and for students. Real-time events and needs, and online opportunities and paradigms reshape the landscape of learning. Universities no longer have the monopoly of knowledge production but are an active environment where knowledge and learning can more easily meet, in a modern vision of higher education [1]. The actual COVID-19 worldwide emergency stressed the importance of broad and deep experience in e-learning for university and school environments [2]. In this scenario, intending to help who abruptly woke up in a distant learning world from one day to the next, we offered in this paper a case study report of

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a ten-years-long experience in e-learning and blended learning when it was not mainstream.

E-learning is a well-known application of Internet Computer Technology (ICT) where advanced technologies reduce space and time constraints for learning, giving to education a ubiquitous flavour. Blended learning [3] is a hybrid educational strategy combining e-learning with traditional classroom-based learning to support the educational process and distribute multimedia contents [4]. In such a complex environment, single users, groups, resources and virtual classrooms meet to transfer knowledge and information and to implement online activities [5, 6].

From 2005 to 2015, in the project named e-Studium, cooperation between e-learning technologies and traditional didactics has been implemented and developed, with the adoption of ICT methodologies and systems in the university courses of the faculties of Science and Literature of University of Perugia, Italy. This long experience has included teacher qualification and the so-called third mission, i.e., technology transfer from and to both internal spinoffs and external companies. The main aim of e-Studium, which has been broad anticipation of the STEM (Science, Technology, Engineering and Mathematics) education policy [7], has been a dynamic and versatile didactics evolution, supporting an active learning process with innovative technologies and teaching approaches, to respond to the individual needs of a comprehensive, diverse, and distributed audience. E-Studium goals included:

- integrating traditional didactics with advanced e-learning technologies, through the activation of a Learning Management System (LMS) for the distribution of courses and services, focusing on remote access for off-site students and commutators (notice that in 2005 personal Internet connection was not commonly available, as it can be now in the Covid-19 Italian school situation, where a family may not have the opportunity to connect in real-time several students and workers);
- building a learning management platform, personalised on university-level requirements, with features of usability and accessibility, following standards and establishing guidelines, to ensure equal opportunities independent from gender, culture and language, disabilities, and educational level;
- diffusing computing education with both horizontal (facilitator-students and peer interaction) and vertical (teacher-student) approaches, and increase the usage of ICT for academic teaching;
- providing teachers with both technical information and subjective belief according to their practical opportunities of technology usage in teaching and learning environments, to meet the challenge of facilitating student learning.

Specific tools have been provided for:

- students' automated assessment, where an automated correction of assignments is made by the system, with or without a teacher's proof;
- students' self-assessment;
- teacher's self-evaluation, with a specific focus on inclusion and performance, i.e., detecting and managing diverse needs of underperforming or overperforming students, and detecting which of the provided learning objects were the most or less used, where the less used probably needed a content or presentation review.

2 History of e-Studium

The e-learning an application area of information technology uses the complex ICT environment to distribute multimedia educational content by activating a remote ubiquitous learning environment. In this environment, individuals, groups, resources, natural and virtual classes meet to exchange information and carry out different online activities. The initial environment, when existent, is transformed (quantitatively and qualitatively) to adapt to the specific training situation of both the student and the teacher. Then it becomes a dynamic environment, which changes in real-time; it is reshaped according to the events of the course, the resources available, the activities proposed and how they are carried out.

It is with these prerogatives and scenarios that the idea of creating an e-learning platform that adapts to times, methods, and tools of a more modern didactics was born in the University of Perugia, Italy. Before the Italian law 240/2010 so-called "Gelmini Reform", named after the Italian minister of education of the time, didactics was provided by the Faculties through the Degree Courses. For example, the teaching of "Computer Science Laboratory" of the Degree Course in Biological Sciences, appeared under the Faculty of Science. This was the didactic organisation chart, which in reality, also provided the division into Bachelor and Master degrees. For some time now, we had been witnessing a radical change in the way of understanding and using the teaching-learning dyad, being able to synthesise a scenario that poses precise challenges, highlighting the opportunity, and at the same time the urgency, for university e-learning:

- students progressively demand a higher quality of the learning process;
- students, who for various reasons, because they are workers, or off-site or disabled, or because of regional emergencies such as the coronavirus lockdown, cannot follow lessons in the classroom, require a different way to enjoy learning;
- lecturers and other operators in universities, schools and educational environments face increasing teaching loads and require tools and support to increase teaching quality.

We are talking about the first years of the new millennium, when the need exploited for an organisational model of e-learning in an integrated form, which leads to the so-called blended e-learning, and for course management systems, for support for teaching in presence using online services and materials that allowed a broader use and participation of students (full-time and part-time). Such an approach followed the renewal of university didactics from a quality perspective. Remote participation could become a complete integration on two levels:

- vertical and reserved teacher-student interaction: the student and the teacher communicate remotely, e.g., by email, self-assessment tests, comments on assignments and papers;
- horizontal and public teacher-group interaction: the exchange takes place using both synchronous and asynchronous communication tools such as chat and forums.

In general, the aim was dynamic and versatile didactics, which could effectively support the learning process, using the innovative ICT technologies to respond in a personalised way to the needs of a broad audience of users distributed throughout the territory. With these premises, now more valid than ever, in a national context already ahead in remote communication after the diffusion of online social networks, in 2005 some teachers and researchers of the Department of Mathematics and Computer Science created the e-Studium project. The project, using information and communication technologies, has integrated the traditional teaching of university courses with e-learning services, offering technological and organisational support to all those who wanted to use and experiment with online teaching or simple training interventions. The primary goal of the e-Studium project, right from the choice of the name, was to reshape the teaching approach of the Perugia Studium, i.e., the academic communication approach: Studium was, in fact, the ancient Latin name of the university, officially sanctioned by the Super Specula, issued by Pope Clement V on September 8, 1308. The e-Studium project creation in this new scenario of e-learning technologies aimed at reshaping the university approach without losing the traditional experience obtained through centuries, which however needed to adapt to the pervasive and mass diffusion of networks and communication tools and exploit the new opportunities of the modern world.

3 Project Architecture Outline

See Fig. 1.

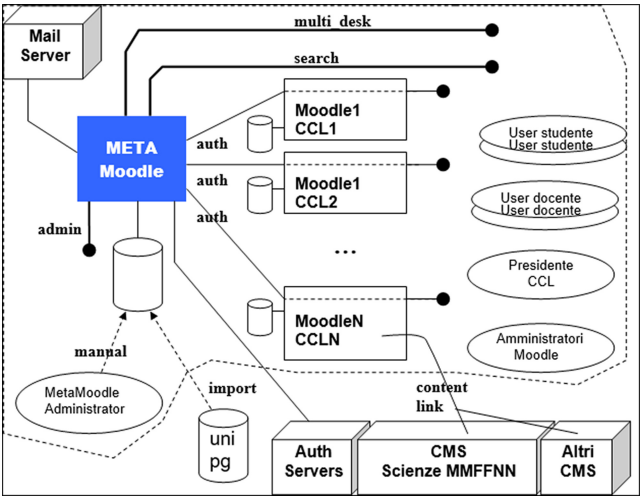

Fig. 1. Project architecture outline

4 Goals of the e-Studium Platform

The e-Studium project [3, 8, 9] redesigns university didactics towards the new scenario of information and communication technologies, with the following objectives:

- providing technological and organisational support to all those who want to use and experiment blended e-learning or remote learning interventions;
- favouring the improvement of the quality of teaching through the adoption of ICT tools.

The e-Studium group researchers have developed through the years specific innovative modules and services that have been tested in different courses, involving thousands of students from the Faculties of Mathematical, Physical, and Natural Sciences, Computer Science, Educational Sciences, Humanities and Philosophy, and others. Under the standards of an international open-source project, they offered to teachers and students various services, e.g., downloading teaching materials, registering for an online exam call, handing in papers and assignments, running tests and exercises, making an appointment, having a virtual reception with the professor, discussing with colleagues, reviewing lesson notes, participating in chats and forums. Such activities could be carried out from home, from the computer lab, as well as from any internet point, or from personal mobile devices, e.g. smartphones and tablets, when they became diffuse. The features of e-Studium have allowed teachers to structure the delivery of information by focusing it on the community of students in their course, with an enhancing interface transparent to the user gradually adapting to the technical advance, e.g., with mobile-style pages first, then responsive design, always following or in some cases preventing the progress of design of graphic users interfaces in a user-centred perspective. The teacher, in the same user-friendly way, could put online notes, exam results, discuss and evaluate projects delivered online, participate in forums with students, carry out automated tests, self-assessment tests, send urgent communications and, finally, monitor in a structured way the participation in activities and the growth path of students learning.

5 Experimental Growth of the Platform

A course in e-Studium is a space that does not replace the traditional lesson, but goes hand in hand with it, amplifying its possibilities of delivery and use, allowing the teacher to keep track of the activities carried out, which are then capitalised and can be revised, reworked and enjoyed without time or place limits. The platform architecture allowed to use it in different ways, for traditional or advanced teaching, from a simple notice board to the most sophisticated use of self-training.

5.1 Preliminary Experimental 1-Year Phase

The e-Studium project, in its first experimental phase, has given service to 13 Study Courses for a total of 301 lessons and a load of 2535 registered and active users. The results of the first year of experimentation of the project, obtained from the monitoring

of the system, were considered very positive, fostering to go ahead with the integration and experimentation of innovative functionalities. The evaluation of the results was firstly carried out mainly through surveys and access and usage statistics. The following overview emerged from the processing and comparison of the available data:

- The main activities of the teachers were:
  - Insertion of programs, alerts, events
  - Frequent updates
  - Upload educational material
  - Preparation and download of registration lists
  - Examination quiz
- The main activities of the student were:
  - Exploration and zapping of the courses
  - Reading alerts, news and events
  - Download educational material
  - Registration for events
  - Performing tests and examination quizzes
- Teachers and students have carried out different activities:
  - Mainly in the proximity of events such as course start, exams, project delivery
  - Spreading out almost evenly over the 24 h of the day (there are no preferential time ranges shown by the usage statistics, taking into account the day-night cycle), which shows the use both during lessons both for personal study
  - Less frequently on the weekend, which highlights the integration with the usual weekly participation to the study course
- The duration of the connection, depending on the type of activity and result:
  - For students on average 11 min
  - For teachers on average 5 min

An interesting aspect was highlighted by the extensive use and appreciation shown by students, who pushed and motivated teachers who initially did not participate to the project preliminary experimentation, promoting the over-time expansion to serve an increasing number of users. In all the statistics, carried out subsequently in different periods and years, students are on average, more active than teachers. To be fair, it has to be said that the most considerable boost was given by the students, who insistently and positively requested a more excellent and complete use of this e-learning tool.

Over the years, based on the matured experience and under the push of individual teachers and numerous students, many other teachings courses have been added, up to an entire degree. Among the various applications, there is the management of computing education labs in liberal studies, training and qualification courses for STEM teachers, pre-graduate and post-graduate courses of computer science, the third mission in high schools and external companies.

5.2 Experiment Evolution

To the first activities provided by e-Studium mentioned above, during the following years, essential features have been added to meet the emergent needs of teachers and students:

- Events Registration Form: Enrolment for exam sessions, Reservation for laboratory access queues/shifts, Assignment to classes/shifts, Confirmation to the user via email/SMS, Registration opening/expiration, Digital signatures for examination reports
- Multilingual Keyboard Module: Multilingual content placement, Multilingual online keyboards, with no configuration/installation required
- Mathematical Keyboards Module: Input and visualisation of mathematical symbols in lessons and quizzes
- Online student reception, i.e. one-to-one talks between teacher and student: Slides view, Real-time textual chat, Multi-colored whiteboard, Content Downloading
- Timetable and Attendance Monitoring Module: Online and offline presence, Weighted activities with virtual minutes, Attendance certification and controllability

5.3 Final Advancement Phase

More recently, starting from 2012, a third phase had been launched, called *e-Studium mobile: e-learning on the move*, which aimed to test the advanced approach to provide mobile e-learning services to students and teachers. Through the extension of the functionality of the e-Studium platform, the aim had been to offer:

- advanced support to mobility (e.g., smartphones, tablets);
- dematerialisation of documents (e.g., eBooks and multimedia production);
- social learning (e.g., training social networks, interactive content generation).

In this phase, mobile learning services had been implemented, with the following features:

- display/browse e-Studium contents on widespread mobile devices (e.g., smartphones, PDAs, iPads, Android tablets);
- push/pull communication to mobile devices (e.g., sending communications, results reports, notifications);
- activation/deactivation of services by SMS;
- support for the creation, distribution, and use of eBooks;
- support for the integration of conventional content: whiteboard for content capture and distribution;
- distributed teaching support: interactive lessons, interaction on mobile devices (e.g., video/text chat, whiteboard, low-bandwidth streaming).

The actors involved in this third phase of the project were:

- Department of Mathematics and Informatics, with the role of proposing body, coordination, technological development and integration, and experimenting with mobile learning.
- Faculty of Letters and Philosophy, with the role of experimentation development for mobile learning, development and dissemination of eBook content.
- Bachelor of Science in Primary Education, with the role of experimenting with mobile e-learning, interactive teaching methods, and developing interactive content.

In particular, the different typology of subjects, which included both humanistic and scientific faculties, allowed to experiment a multidisciplinary approach on a wide range of different problems and situations, favouring the reuse and export of the project results to a broader context (other Faculties or schools). Finally, the competences in the field of Information Technology of the Department of Mathematics and Informatics, which complement those of Educational Science Didactics Technologies, offered guarantees of technical and scientific soundness for the objectives of the project.

The implementation and the use of the third-phase functionalities, and the results obtained were strongly encouraging.

The last phase also included the introduction of the teacher self-assessment dashboards [10], and the integration with the G-Lorep platform for cloud services [11, 12].

5.4 Numbers and Facts

E-Studium had been implemented as a Moodle open-source platform [13], which is freely available from the Internet and university labs, and nowadays used by 150090 currently active sites that are officially registered from 242 countries; many of them are universities and high-education centres. Moodle has been benefitting from a broad language translation community effort, to which the e-Studium research group actively contributed. E-Studium has involved 1598 courses taught in blended mode, for a total of 19050 users over ten years. E-Studium served over ten thousand students coming to Perugia University (Italy) from 51 countries.

In ten years, the project served 40 courses, besides doctoral schools, specialisation schools and master, courses for a professional teaching license, and more, for more than 500 topics, more than 300 teachers, more than 8000 registered users.

6 Hardware and Software Resources

In this section, we list the software resources used in e-Studium for ten years.

- Moodle, Open Source Platform for Course Management System
- Multimedia platform software: Flash image compression software, Authoring software, PPT Flash environment conversion, Macromedia Studio, Adobe Suite PDF manager, SMIL.

To the hardware resources listed in this subsection, it has to be added to the network infrastructure, including Internet access and high-speed broadband network connection for the duration of the project. The hardware resources list also includes all the devices used for the project creation but not strictly required to run it:

- Linux server for CMS platform
- Linux server for multimedia distribution support
- Multimedia production station for the preparation of educational material
- Computerised and equipped classroom with at least 20 places for training and use of the platform for teachers/students.

The choice of Moodle can be easily explained through the following features: Open Source software; consolidated development and validation community; thousands of platforms installed; multi-platform and multilingual software; expandable modular approach; research and experimentation possibilities.

There was, therefore, a correct initial choice, due to in-depth research about the available resources, before Moodle gained all the advantages mentioned above, which then proved to be the right one.

7 Evaluation of Learning Outcomes

The learning-pathway and final evaluation of e-Studium came in the form of the descriptive analysis of students and teachers learning outcomes, and of wide-level global rankings and webometrics.

In particular, we had provided:

- objective statistics on learning objects and learning outcomes;
- statistic on usage, via activity logs;
- subjective evaluation from both students and teachers, for the educational project and the platform usability;
- growth in web analytics;
- growth in national university rankings.

Among the most exciting results of the e-Studium project, there is the experimentation of a model of self-evaluation for teachers, based on visual feedback of the frequency of use of their learning objects. The interface provided to the teacher's view two different dashboards, summarising in a visual way using the dimension of the title or a heatmap using colours, to emphasise the frequency of use of the learning object, where a bigger title or a warmer colour means a higher appreciation, i.e. higher number of accesses, and a smaller title or a cooler colour means that students did not use a lot the learning object. Such feedback provided to the teacher a self-evaluation method to adapt or update the learning objects basing on their practical use.

Since the project involved the use of a multimedia platform, it allowed the research group to automatically certify and collect essential data on the use of the platform by users. The evaluation criteria used to measure the achievement of the objective and the impact on the target audience were distinguished into:

– subjective indicators (collection of questionnaires and individual interviews);
– objective indicators (automatic surveys of access and paths, SEO).

In particular, highlighted aspects included the increase in the number of participants by type of user (e.g. a high number of off-site users); the number of activities (e.g., profit test, self-assessment test, distribution of material); the improvement of the teacher-student relationship from an educational and organisational point of view.

Over time, the subjective evaluation showed that the project received unanimous support both from the students who actively animated it and from the teachers who have participated in their way. The system is characterised by extreme ease of use highlighted both by students and teachers, who appreciated being able to reproduce

virtually some real entities (e.g., the “course”, the “class”, the “laboratory”) and a whole series of services such as exam registrations, virtual receptions, discussion forums, FAQs, distribution of material, collection of tasks, self-assessment exercises.

Objective data included logs on the origin of the connections, duration of the connections, data on registered and active structures, raw and refined user data such as number, role, active and non-active users, also including the exams and self-assessment results.

8 Conclusion

The e-Studium project has fully achieved its objectives, improving over the years. As an overall result, e-Studium has been considered of particular value stimulating the introduction of technologies for university teaching improvement, and to have effectively achieved this goal with the introduction in the Faculties first, then in the Departments, and later in all the other collateral structures involved. The project now represents a wealth of data, systems and mature technologies that are offered to the University in its new academic teaching service.

It remains that the management of the teaching support of a university structure is a continuous evolutionary process, where new needs and new possibilities emerge continuously, both through interaction with students and teachers, who discover the new opportunities offered by this type of tools and propose new methods and functions and through continuous technological and research innovation in the sector.

It is therefore essential a continuous learning and research activity, for a consolidation of the results, and to reach the goals it is necessary to activate an organic structure that allows continuous innovation, updating and research in support of teaching.

The entire project, with all the information content and experience, gained, represents the core of a valuable service on which the University can develop a complete e-learning service integrated with all other online services already active.

We are convinced that the systematic and organic adoption of this type of technology at University level, and the promotion of their diffusion, can produce a synergy that will bring the provision of educational services to a quality level adequate to the best standards.

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