E-learning and blended learning in textile engineering education: a closed feedback loop approach

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E-learning and blended learning in textile engineering education: a closed feedback loop approach

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Abstract. E-learning has gained a significant role in typical education and in professional training, thanks to the flexibility it offers to the time and location parameters of the education event framework. Purely e-learning scenarios are mostly limited either to Open University-type higher education institutions or to graduate level or professional degrees; blended learning scenarios are progressively becoming popular thanks to their balanced approach. The aim of the present work is to propose approaches that exploit the e-learning and the blended-learning scenarios for Textile Engineering education programmes, especially for multi-institutional ones. The “E-Team” European MSc degree programme organized by AUTEX is used as a case study. The proposed solution is based on (i) a free and open-source e-learning platform (moodle) and (ii) blended learning educational scenarios. Educational challenges addressed include student engagement, student error / failure handling, as well as collaborative learning promotion and support.

1. Introduction
E-learning has gained a significant role in all grades of typical education as well as in training, thanks to the flexibility it offers to the time and location parameters of the education event framework. Although purely e-learning scenarios are mostly limited either to Open University-type higher education institutions across Europe or to graduate level or professional degrees, blended learning scenarios are progressively becoming popular in undergraduate education, where students’ physical presence and participation in classes and labs has traditionally been mandatory. Blended learning employs conventional, face-to-face instruction in class and e-learning in a complementary role; students benefit from the merits of each approach. Research focusing on the learning outcomes of undergraduate degree programmes provides evidence for the advantages of blended learning over either the pure e-learning or the pure face-to-face approach, [1].

During the last decades, modern Textile Engineering education in Europe has steadily been putting the emphasis on quality rather than bulk, volume or numbers, in an attempt to counterbalance the negative impact of the migration of textile industrial production basis to Asiatic countries. Both modern cognitive / learning theory results and advanced ICT technology have been exploited to this end; as a result, Textile Engineering has become a pioneer in modern education, [2]. Today there exist
a number of joint-degree programmes, such as the one offered jointly by ENSAIT and North Carolina State University, USA, or the “E-Team” European MSc degree programme organized by AUTEX and offered by 24 partner institutions. Course organization and management as well as the mobility of students, professors and researchers have been largely dependent on ICT, [3]. However, given the very nature of Textiles as an Engineering discipline, instruction has been bound to the traditional side, [4].

The aim of the present work is to propose approaches that exploit the e-learning and the blended-learning scenarios for Textile Engineering education programmes, especially for multi-institutional ones. The proposed solutions are based on
(i) free and open-source e-learning platforms, such as moodle, and
(ii) collaborative education scenarios.
Challenges addressed include student engagement, student error / failure handling, as well as collaborative learning promotion and support.

2. E-learning technologies in the Blended Learning and the Flipped Classroom models
Information and Communication Technologies (ICT) can offer considerable advantages
(i) in the organization, structure, delivery and management of academic or vocational training courses and the presentation of the course contents (educational material) in electronic form, and
(ii) in the pedagogical scheme applied by the course instructors and lab tutors.
Both these aspects have a significant impact on the ultimate goal of every taught course, i.e. the learning outcomes achieved by the students upon successful completion of the course. E-learning platforms, such as the moodle platform, offer functionalities that support these educational aspects, keep track of the progress at the student, the class and the course levels and at the same time manage the financial aspect of tuition paid by the students, where applicable; all under an integrated environment and through a user-friendly, web-based interface, [5].

In relation to the pedagogical strategy adopted in a course, a fundamental advantage of the moodle platform is the integration of easy-to-use features that allow students to receive immediate and focused feedback through all types of (self-) evaluation activities. Errors made by students are thus transformed into opportunities for discussion and clarification of subtle points in the course content, [6]. They offer the instructor an opportunity to communicate with his/her students, encourage them and direct them to study the specific course modules they need (personalized learning). In face-to-face instruction scenarios, live teachers will do all this in class, drawing from their experience and relying on their training as well as on intuition. In e-learning, however, this has to be carried out by the platform which should be adequately equipped.

According to the degree of the use of e-learning in an educational scenario adopted for the instruction of a given class, the scenario is characterized as purely face-to-face, purely e-learning or blended learning. Today, blended learning is considered as both the most practical and the most advantageous approach, as it allows learners to benefit from the advantages of both face-to-face and e-learning instruction. The e-learning component makes the course attractive to learners thanks to the interactive and multimedia aspects it involves, while allowing them to go through the material at a personal pace, asynchronously to the rest of the class. At the same time, the face-to-face component promotes the solidarity of the class and the sense of belonging to a team, facilitates live discussion with the instructor and classmates and allows questions to be answered and difficult points to be clarified immediately.

Engagement of the learners is known to be a weak point of purely e-learning systems and educational scenarios. While the interactive and multimedia features of e-learning have been seen to attract the learners’ attention to the learning content of the course, the retention of the initial interest and attention and the lasting engagement of the learners in the educational activities are objectives not fully conquered as yet. The impressively low percentage of learners subscribed to MOOCs, [7], that complete their courses (an average of 12% reported in 2015) is an aspect of the same problem, the MOOCs being typical examples of purely e-learning education. To address this weakness, modern e-
learning platforms incorporate learning style recognition in adaptive learning platforms that can personalize both the learning content and the media through which this content is offered, [8], [9], narration, Animated Pedagogical Agents (APA), [10], [11], affective computing, [12], [13], gamification, [14], 3D or Virtual Reality environments, [15], and other such state-of-the-art technologies.

It essentially amounts to a question of motivation: motivated learners will not drop out; they will do their best to overcome difficulties and complete activities, assignments and eventually the course. Blended learning exploits the live teacher’s skills and experience to motivate and engage the learners during the face-to-face sessions and relies on the e-learning component attractive features to sustain interest and engagement during the remote, e-learning sessions.

It has been observed worldwide that, in general, typical K-12 education learners have to be motivated by their teachers, in order to (i) achieve the required educational outcomes and (ii) complete the education cycle and not drop out of it. Motives may be intrinsic (genuine interest or curiosity awakened by the teacher on a specific field or subject) or extrinsic (high grades or other bonuses and prizes); the former are verified to be the most efficient and trustworthy ones. On the other hand, students in higher education or professionals in training courses or seminars are usually strongly motivated, either internally, as they study their preferred and chosen subject or externally, as they need to complete a course or a seminar in order to keep a job or to acquire higher qualifications and get a better salary or otherwise improve their professional position and prospects. Graduate studies are such an example: a typical master’s student is expected to combine an intrinsic (chosen field of study) and an extrinsic (better professional prospects) motive; either a purely e-learning or a blended learning with a strong e-learning component is therefore considered as an appropriate educational scenario at the graduate level.

A pedagogical model that has recently evolved out of blended learning is the flipped classroom model, [16], [17], [18]. In the flipped classroom approach, contact hours between instructor and students are considered too valuable to be “wasted” for the presentation of new material with examples and practice / exercises, which are the activities devouring the most part of the class hours in conventional education models. Rather, students spend time at home to study the new material on-line, supported by an e-learning platform. This may include any type of educational technologies such as on-line material, videos, simulation environments or collaborative environments for study, practice and collaborate. In class, they discuss difficult points, ask questions, resolve ambiguities and in general collaborate with the instructor and their classmate in a more productive way. Contact and remote sessions are regularly interleaved within an instruction term (e.g. semester). The learner-centered model is adopted under the flipped class paradigm, [19].

Although the first experimental applications of the flipped classroom have been in high school classes (physics, chemistry), it has soon entered the higher education area where it is today considered to be a valid alternative to the conventional instruction approaches. A major advantage is the efficient use of the class hours and the instructor’s time; this is counterbalanced by the need for careful and detailed preparation of the on-line material to be studied remotely and of the educational aims and objectives sought in class during contact hours. Within the higher education area, the flipped classroom model is very well suited for graduate programs where contact hours tend to be limited and yet the expectations regarding learning outcomes and academic achievement are high. Indeed, in the graduate level students are expected to take over the full responsibility for and load of their studies.

3. The proposed methodology and tools
The proposed methodology is based on blended learning and relies on moodle (i) for student preparation before the course and (ii) for student (self-) evaluation at specific milestones during the course and upon course completion. The “Industrial Information Systems” (IIS) course module within the E-Team AUTEX MSc course is selected and used as a case study, thanks to its intensive nature and its multi-institutional organization, two features that make IIS ideal for illustrating the strengths of the proposed approach. In brief, students study through the platform preparatory material before the
intensive two-week IIS course delivery commences. Students are evaluated on-line. Feedback on errors and progresses made is provided by the platform both on a personal and on a class basis - the second one in a statistical form. Feedback is complemented by a personalized recommendation as to missing knowledge units that have to be studied in more detail or refreshed.

Figure 1 presents the introductory web page of the moodle platform e-learning environment developed for the IIS course module. It is hosted in the Electronics Engineering departmental moodle server, in the Piraeus University of Applied Sciences, Athens-Egaleo, Greece, [20]. Information on course title, course contents, learning outcomes, ECTS credit units gained, language of instruction and name of instructor is provided through the same platform. A Forum facility is also made available for students and instructor(s), given the essential role held by on-line communication and interaction facilities in e-learning and/or blended learning.

Through the navigation menu offered in the left-hand side frame of the introductory page, students may easily and directly access specific part of the learning contents, either for study or for evaluation. A News and Upcoming Events menu is available in the right-hand side frame, in order to aid students to keep track of actuality and interesting events related to the course module. RSS feeds from academic or research sources relevant to the IIS subject are also included in this frame.

Figure 1. The introductory web page of the moodle platform e-learning environment built for the I.I.S. course module offered within the E-TEAM MSc programme.

Figure 2 shows the structure of the learning contents that directly reflects the organization of the IIS course module material to be taught in a two-week session, It is currently broken down into seven (7) Sections, namely,

1. Introduction to I.I.S.
2. Signals
3. Systems - Control Systems
4. Sensors
5. Industrial Control Systems
6. Computer Networks
7. Computer-Integrated Manufacturing - PLCs
The platform offers (i) a link to the Section learning content and (ii) a link to the Section student self-assessment quiz, uniformly across all seven Sections.

The learning content is presented in a linear, sequential manner. Linearity implies that Sections should be studied sequentially, from (1) to (7), each followed by the corresponding evaluation task (quiz). This arrangement of the material follows the behavioristic educational model, [21], which is considered today as obsolete. In the second half of the 20th century, constructivistic and collaborative models have been proposed as more advantageous for the students, in terms of initiative, engagement, development of high-level, “horizontal” skills such as critical thinking, analytic-synthetic skills, ability to collaborate, etc., [22], [23], [24]. Digital, on-line forms of education relying on ICT, such as e-learning and blended learning, lend themselves nicely to the support of these models because experimentation, simulation and interaction with the material and with fellow-learners are of great importance within them. At this initial phase of the development of the platform, however, the linear arrangement is chosen as the simplest and clearest structure; it is the first step in the designed evolution of both the course module and the platform into a more dynamic and interactive version.

![Image](image.png)

**Figure 2.** The learning content structure of the I.I.S. course module, organised in a sequence of seven (7) Sections, each complete with a study and a (self-)assessment part.

Features available in *moodle* that are interesting from a pedagogical aspect include

(i) The option to enforce the sequential study of the material Sections, by activating the *moodle* option for Section sequence control: the next Section is made accessible to a student only upon completion of the previous Section – and, possibly, only upon successful results obtained in the previous Section Quiz. Quantification of the term “success results” is flexible; the instructor may differentiate the pass/fail line according to the profile of each of his/her classes. These features may be turned on or off by the instructor according to the pedagogical scenario he/she adopts during a given semester.

(ii) The option for automatic, manual or mixed grading of the quizzes. *Moodle* allows both for multiple choice quizzes that are graded automatically and immediately by the platform and for “open-type” questions where students are expected to reply in free text form or insert diagrams, plots or images created in their computers to answer the given questions. In the later case the instructor grades manually the specific quizzes or quiz questions and the platform merges results according to predefined grading rules to yield the final grade for the students.
(iii) The option for feedback offered by the platform in each and every quiz question, made available to the student along with the grading information. The feedback may contain (a) a model answer proposed by the instructor or a reasoning or a documentation of the correct answer / choice, (b) comments on the errors made by the student, (c) a recommendation as to the part of knowledge the student has to study, as concluded by his/her errors. The student may inspect the quiz and review his/her answer and the instructor’s model answer in comparison. The student is then redirected in the appropriate learning content Section available through the platform, in order to complete parts of missing knowledge or background.

Figure 3 shows a sample page of the material on PLC programming offered in Section 7.

![PLC programming](image)

**Figure 3.** IIS course contents: a sample page from the IIS course module material in moodle.

The proposed blended learning scenario to teach this course aided by the *moodle* platform material presupposes that the instructor makes a part of the course material available to the students before the intensive course delivery period. This may also include review of background knowledge, such as electronics, computers or programming. Students spend time to study this part of the material off-line and possibly take the corresponding tests or quizzes.

Before the instructor commences teaching the course module, he/she is updated in detail through the platform both on each student’s personal performance on the preparatory material and on the time and effort he/she had spent to interact with the material. The later is made possible through a custom design API inserted into the *moodle* platform in order to collect and extract platform access and usage data per user (student). These are subsequently analysed using data mining methods to extract meaningful information about the student effort and the outcomes achieved, [25].

During the intensive IIS course module delivery period, the instructor may use the platform to upload new material, give students assignments, keep them updated through the News option, communicate with them and answer questions on-line through the Forum and Chat options and monitor their individual and collective progress through the statistical information options available in *moodle*.

Figure 4 shows a sample of statistics results from the *moodle* API, illustrating the webpage loads requested by students while interacting with the learning content in *moodle* (actual results drawn from another course module offered through the same platform). In fact, this is only one example of a multitude of statistical information that the *moodle* platform may provide the instructor with, either automatically or by developing and inserting appropriate API modules in it. What is interesting is that
such “snapshots” of the class progress, both at the personal and the class level, may be obtained at any time during the course and not only once upon the closure of the course module. It is also possible to automate this option for the instructor and ‘program’ moodle to produce a personalized statistics report for him/her upon request.

**Figure 4.** A sample of statistics from the moodle API: number of page loads requested by students while interacting with the content (actual data drawn from another course module offered in 2016).

4. Conclusions
A blended learning scenario for the instruction of graduate programmes in Textiles Engineering is proposed in this study, based on ICT, e-learning and the moodle platform. The “E-Team” European MSc degree programme organized by AUTEX is used as a case study. The blended learning approach proposed here complements face-to-face instruction in class with asynchronous study and (self-)evaluation at home, in two phases: a first phase where students study preparatory material and a second phase that runs in parallel to the actual course delivery. The IIS course module of “E-Team” is used as a sample module to illustrate the advantages of this approach. Educational aspects referring to student initiative and engagement, error handling, feedback and recommendation for further study are supported. The proposed scheme supports the instructor to identify the students’ strengths and weaknesses and to assess the effort they have put in the preparatory study for the course. Further research currently underway aims to introduce a dynamic and interactive character in the course layout and in the course delivery method, through the incorporation of stronger constructivistic and collaborative elements.

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