Eric Ras
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# Contents

# Case Study Analysis on Blended and Online Institutions by Using a Trustworthy System

M. Elena Rodríguez[1], David Baneres[1(✉)], Malinka Ivanova[2], and Mariana Durcheva[2]

[1] Open University of Catalonia, Rambla del Poblenou, 156, Barcelona, Spain
{mrodriguezgo, dbaneres}@uoc.edu
[2] Technical University of Sofia, Kl. Ohridski 8, Sofia, Bulgaria
{m_ivanova, m_durcheva}@tu-sofia.bg

**Abstract.** For online and blended education institutions, there is a severe handicap when they need to justify how the authentication and authorship of their students are guaranteed during the whole instructional process. Different approaches have been proposed in the past but most of them only depend on specific technological solutions. These solutions in order to be successfully accepted in educational settings have to be transparently integrated with the educational process according to pedagogical criteria. This paper analyses the results of the first pilot based on the TeSLA trustworthy system for a blended and a fully online institutions focused on engineering academic programs.

**Keywords:** Trustworthy system · Authentication · Authorship
Blended learning · Fully online learning

## 1 Introduction

Assessment of students in online and blended education is one of the most important ongoing challenges [1–3]. Educational institutions are, in general, resistant to wager for an online education and, at the end, keep relying on traditional assessment systems such as final on-site exams, face-to-face meetings, etc. Unfortunately, this attitude is shared by accrediting quality agencies and society at large, being reluctant to give the social recognition or credibility that online alternative may deserve [4]. This causes obstacles in the acceptance of online and blended education as an alternative to the traditional model. However, many citizens simply cannot continuously attend an on-site institution, especially in regards to higher and lifelong learning education and new approaches are needed to fulfil the requirements of these students [5–7].

The TeSLA project [8] has appeared to give an answer to this challenge. The overall objective of the project is to define and develop an e-assessment system, which provides an unambiguous proof of students' academic progression during the whole learning process to educational institutions, accrediting quality agencies and society, while avoiding the time and physical space limitations imposed by face-to-face examination. The TeSLA project aims to support any e-assessment model (formative, summative and continuous) covering the teaching-learning process as well as ethical, legal and technological aspects. In order to do so, the project will provide an


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e-assessment system where multiple instruments and pedagogical resources will be available. The instruments may be deployed in the assessment activities to capture students' data to ensure their authentication and authorship. Such instruments need to be integrated into the assessment activities as transparent as possible and according to pedagogical criteria to avoid interfering in the learning process of the students.

The TeSLA project is funded by the European Commission's Horizon 2020 ICT program. In order to provide an achievable and realistic solution the consortium is composed of multiple Higher Education institutions (including online and blended universities), technological companies (specialised in security, cryptography and online recognition techniques) as well as accrediting quality agencies.

To test the e-assessment system the project plans to conduct three pilots from 500 students in the first to 20,000 in the third. This paper focuses on the first pilot of the project. Specifically, the paper aims to analyse and compare the challenges and findings of the preparation, execution and evaluation of the pilot in a blended institution and a fully online institution focused on academic engineering programs. This will help to identify the strengths and weaknesses to ensure a better design of the upcoming pilots.

The paper is structured as follows. Section 2 introduces the objectives of the first pilot, while Sect. 3 describes the used technological infrastructure. Next, the preparation and execution, and the evaluation are explained in Sects. 4 and 5, respectively. Finally, the conclusions and future work are detailed in Sect. 6.

## 2 Objectives of the First Pilot

The first pilot had several objectives. The most relevant one was related to the identification of the key phases (and the tasks included in each phase) of the pilot agreed for all the universities involved in the pilot. At this stage, the development of the TeSLA system was ongoing. Thus, the second objective was to use the instruments to ensure authentication and authorship of the assessment activities for validating how student's data should be collected, and for further testing of the instruments when the initial version of the system was ready. Also, the pilot aimed to identify legal/ethical issues at the institutional level, to identify the requirements of students with special educational needs and disabilities (SEND students), to envisage the critical risks at institutional level, and to study the opinions and attitudes of the participants (mainly students and teachers) towards the use of authentication and authorship instruments in assessment.

The expected number of participants for the first pilot was 500 students, homogeneously distributed among the 7 universities involved in the pilot (i.e. approximately 75 students per each university).

The instruments to be tested were face recognition, voice recognition, keystroke dynamics, forensic analysis and plagiarism. Face recognition uses web camera and generates a video file with the student's face. Voice recognition aims to record student's voice by creating a set of audio files. Keystroke dynamics is based on student's typing on the computer keyboard and recognises two key features: the time for key pressing and the time between pressing two different keys. The forensic analysis compares the writing style of different text typed by the same student and verifies that he/she is their author. Plagiarism checks whether the submitted documents by a student

are his/her original work and they are not copy-pasted from other works. On the one hand, face recognition, voice recognition and keystroke dynamics allow students' authentication based on the analysis of captured images, audio and typing while the students perform an assessment activity. In the case of face and voice recognition, authentication can also be checked over assessment activities submitted by the students (for example, video/audio recordings). On the other hand, forensic analysis checks authentication and authorship based on the analysis of text documents provided by the same student, while plagiarism detects similarities among text documents delivered by different students ensuring thus authorship. The authentication instruments require learning a model for the user (i.e. a biometric profile of the student needs to be built). This model is used as a reference for subsequent checking.

The identified key stages of the pilot include three main phases: (1) preparation (2) execution and (3) reporting. At the preparation phase, each university designed its strategy and criteria for selecting the courses and for motivating the students' participation in the first pilot. Similarly, each university planned and designed the most appropriate assessment activities (and the instruments to be used in them for authentication and authorship purposes) to be carried out by the students participating in the pilot.

At the execution phase, the technological infrastructure provided for the execution of the first pilot was a Moodle instance for each university which constituted an early development of the TeSLA system. The execution phase is described next:

1. Sign consent: Students signed a consent to participate in the pilot due to the collection of personal data (i.e. biometric data) for authentication and authorship purposes.
2. Pre-questionnaire: Students and teachers gave their opinion about online learning and assessment and project expectations.
3. Enrollment activities: These special and non-assessment activities were designed to gather the required data to generate a biometric profile for each student.
4. Assessment (or follow-up) activities: Students solved and submitted some assessment activities using the Moodle instance.
5. Post-questionnaire: Students and teachers gave their opinion about the pilot experience.

At the reporting phase, all the collected information was analysed to obtain the findings related to the pilot preparation and execution.

## 3 Technological Infrastructure

Aforementioned, one of the objectives of the first pilot was to test how to collect data from participants. The TeSLA system was not ready at the beginning of the pilot. Therefore, another technological solution was required in order to conduct the pilot. Figure 1 illustrates the relationships between the stages of the pilot execution and the technological solutions used in the pilot that are almost similar for both universities – The Technical University of Sofia (TUS) that is a blended institution and the Open University of Catalonia (UOC) that is a fully online institution.

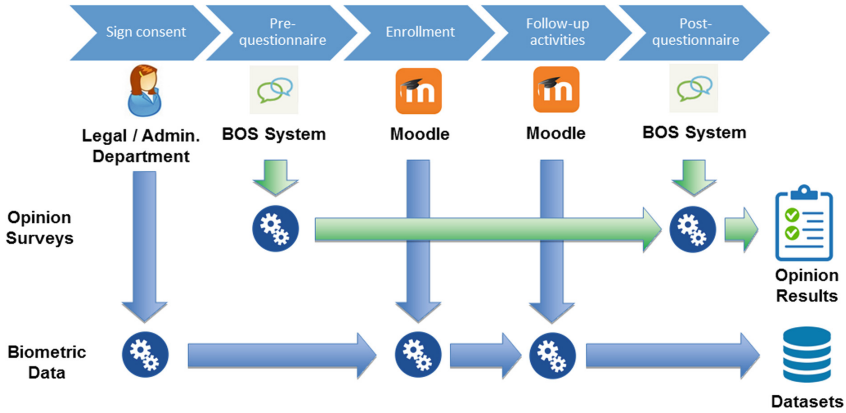


**Fig. 1.** Technological infrastructure and outputs produced in the pilot

In the beginning, the signature of a consent form was required to participate in the pilot. This step was critical because impersonation should be avoided. On the one hand, TUS decided that the process should be performed manually by signing a physical document. The students' registration was provided by university e-mail system. Administrative personal was responsible for processing and validation all the documents, and for validation the learners to the Moodle instance as students. On the other hand, at UOC, the signature of the consent form was managed by the legal department. The consent form was shared in the classrooms of the UOC virtual learning environment (VLE) in the course selected for the pilot. Students willing to participate sent an email (using their UOC credentials) which included personal information to the legal department who validated the petitions. Based on that, students were granted to access to the Moodle instance.

Questionnaires were handled by another tool, the BOS online survey tool [9]. It was used due to its flexibility to create personalised surveys and export the data for further analysis. Both TUS and UOC followed the same strategy. The links to the pre and post questionnaires for students were posted in the Moodle instance, while the links to the pre and post questionnaires for teachers were sent via email.

Finally, the instructional process concerning the pilot was performed on a standard instance of Moodle because it met all the requirements to carry out the pilot. Moodle [10] is capable of providing support during the teaching-learning process by accepting different learning resources (e.g. videos, wikis, electronics books, open source solutions, etc.), communication tools (e.g. forums, videoconferencing) and different assessment activities (e.g. documents submission, automated questionnaires, essays, question with open answer, third-party plugins etc.). The Moodle instances were standard ones without any adaptation. Only a third-party plugin was used to record online videos and audios from students and to capture their keystroke rhythms and texts for forensic analysis and plagiarism checking. For both universities the access to Moodle was using an LTI connection available in the classrooms. Note that, the collection process of all students' data was a post-process at the end of the pilot by

**Table 1.** Distribution of instruments on assessment activities and courses at TUS

| Course | Assessment activity | Exercise | Face recognition | Keystroke dynamics | Forensic analysis |
|---|---|---|---|---|---|
| Internet Technologies | Continuous assessment Activity 1 | Multiple-choice quiz combined with open answers | √ | √ | |
| | Continuous assessment Activity 2 | Individual project work | √ | √ | |
| Computer Networks | Continuous assessment Activity 1 | 5 multiple choice quizzes | √ | √ | |
| | Continuous assessment Activity 2 | 2 practical tests | √ | √ | |
| Higher mathematics | Formative/summative assess. Activity 1 | 2 quizzes combined with open answers | √ | √ | |
| Course project on Information technologies in public administration | Continuous assessment Activity 1 | Project analysis and investigation | √ | | √ |
| | Summative assessment Activity 2 | Project presentation | √ | | √ |

accessing to the Moodle database and extracting all data referred to the enrolment and follow-up activities. This information was stored as datasets for testing the real instruments for the second pilot.

## 4 Preparation and Execution at Institutional Level

This section discusses the preparation and execution phases of the first pilot of the TeSLA project in both institutions.

### 4.1 Blended Learning Institution

The Technical University of Sofia [11] is the largest educational institution in Bulgaria preparing professionals in the field of technical and applied science. The educational process occurs in contemporary lecture halls, seminar rooms and specialised laboratories following the principles of close connection with high-tech industrial companies, increased students' mobility and international scientific partnership. It is supported by the university VLE facilitating the access to educational content, important information and collected knowledge. Typically, the exams are organised in written form in face-to-face mode, but also assessment process is facilitated through quizzes, engineering tasks

and projects organised in online form. The e-assessment is not well developed in TUS, because it is a blended-learning institution where the offline practical sessions play an important impact on the future engineers. Thus, the TeSLA project gives a new opportunity to enhance the assessment process by implementing new methodologies for improving students' knowledge and skills evaluation.

In the first pilot, several courses were involved: "Internet Technologies" and "Computer Networks" that belong to the College of Energy and Electronics and "Information Technologies", "Higher Mathematics" and "Project of IT in Public Administration" that are part of the curriculum of Faculty of Management. They were selected, because it was considered that different assessment models should be covered during the pilot: continuous, summative, formative and their combination, as well as to evaluate projects activities. Table 1 summarises the applied assessment models and used instruments. Face recognition, keystroke dynamics, and forensic analysis was tested. The same instruments were utilised during enrolment and all assessment activities planned for a given course. TUS team discussed whether to include the instrument for voice recognition and decided not to test it. The main reason is that this instrument does not match to the pedagogy of involved courses. For the included courses the most suitable instruments were face recognition and keystroke dynamics, and the instrument for forensic analysis in the course "Course project on IT in public administration". The TeSLA assessment activities were combined with standard face-to-face examination and thus TUS realised a blended assessment model.

A big part of students participated in the first pilot successfully accomplished the assessment tasks and their final grades were higher than the grades of the rest students. For instance, for the course "Higher mathematics", results of the exam of the students, who participated in TeSLA, are on average 10–15% higher than those of the other students. This phenomenon is explained for two different reasons: On the one hand, mainly motivated students, who have a deeper interest in science, participated in the pilot. On the other hand, the fact monitoring during the assessment also led the students who were less ambitious to take more care and effort. The teacher who tested a combination of the instruments face recognition and forensic analysis reported that most of the students in her course suggested innovative decisions in their course projects.

Participation in the pilot worked on a voluntary basis and the initial canvas was set to 240 students from the different faculties and departments. The involved students had to perform almost the same assessment activities than the rest of students who were not part of the pilot. The main reason for differences was the presumption for decreasing the number of assessment activities performed with instruments to 2 or 3 in comparison to the number of the assessment activities that were planned for the standard courses. This stems from the decision of the consortium the instruments to be tested in 1 enrollment activity and 1 or 2 follow-up activities. Also, there were differences in the form how these assessment activities were done. The students who were involved in the pilot had to perform their assessment activities in Moodle using the planned for testing instruments, while the other students performed their activities in a paper-based format, in other learning management system (LMS) or/and using other applications.

### 4.2 Fully Online Institution

The Open University of Catalonia (UOC) [12] is a fully online university that uses its own VLE for conducting the teaching-learning process. Currently, more than 53,000 students are enrolled in different undergraduate and postgraduate programmes. Present challenges at UOC are to increase the students' mobility and internationalisation. This leads to a situation where maintaining the requirement of a face-to-face, on-site evaluation at the end of each semester becomes inefficient and not cost effective. However, as a certified educational institution, the university cannot ignore the baggage in moving to a fully virtual assessment, since it might heavily impact on its credibility.

The course selected to participate in the first pilot of the TeSLA project was "Computer Fundamentals". The course belongs to the Faculty of Computer Science, Multimedia and Telecommunications, and it is a compulsory course of the Computer Engineering Degree and Telecommunications Technology Degree. In the course, the students acquire the skills of analysis and synthesis of small digital circuits and to understand the basic computer architecture.

The course has a high number of enrolled students, and a low ratio of academic success (40%–50% of enrolled students), mainly for course dropout. This is due to two main factors. On the one hand, the course is placed in the first academic year, i.e. it is an initial course that presents core concepts relevant for more complex courses (e.g. computer organisation, networking and electronic systems). On the other hand, most of the students have professional and familiar commitments, and they can have some problems until they find a balance between these factors, especially when they are unfamiliar with online learning. Nevertheless, the course was considered a suitable course to participate in the pilot due to the following reasons: (1) the feasibility of reaching the expected number of participants with only one course; (2) the course is taught by a researcher involved in the TeSLA project; and (3) students have technical expertise, helping to minimize problems regarding the use of the Moodle.

The delivery mode of the course is fully online, and the assessment model is continuous assessment combined with summative assessment at the end of the semester. Continuous assessment is divided into 3 continuous assessment activities (they assess numeral systems, combinational circuits and sequential circuits, respectively) and one final project (that assesses finite state machines design). Summative assessment is based on a final face-to-face exam. The final mark is obtained by combining the results of the continuous assessment activities, the final project and the exam. The students have to reach a minimum mark of 4 both in the exam and the final project to pass the course (the Spanish grading system goes from 0 to 10, being 5 the lowest passing grade).

Although participation in the pilot worked on a voluntary basis, students were encouraged to participate in the pilot. Firstly, the importance of the pilot was properly contextualised in the case of a fully online university. Secondly, given that participation in the pilot implied a certain workload on the students' side, the minimal mark for the final project was set to 3 instead of 4. Despite this, it was expected a low participation rate and a negative impact of the known dropout issue on the course. Thus, UOC team internally planned to involve at least 120 students in the pilot instead of the 75 participants agreed at the project level.

**Table 2.** Distribution of instruments on assessment activities at UOC

| Assessment activity | Exercise | Face recognition | Voice recognition | Keystroke dynamics | Plagiarism |
|---|---|---|---|---|---|
| Continuous assessment activity 2 | Short answer | | | √ | √ |
| | Video recording | √ | √ | | |
| Continuous assessment activity 3 | Short answer | | | √ | √ |
| | Video recording | √ | √ | | |
| Final Project | Short answer | | | √ | √ |
| | Video recording | √ | √ | | |

The TeSLA instruments tested in the pilot were face recognition, voice recognition, keystroke dynamics, and plagiarism. In addition to enrollment activities, students performed some exercises included in the second and third continuous assessment activities and the final project (see Table 2). All the students enrolled in the course (independently whether they participated or not in the pilot) performed the same assessment exercises. Differences were related to the way these exercises were performed and submitted (in the Moodle instance with instruments enabled, e.g. keystroke dynamics) and in their format (instead of textual answers included in a file document delivered in the specific assessment space at the UOC VLE, students recorded videos that were uploaded to Moodle for being processed by the corresponding instruments).

## 5 Pilot Evaluation

This section evaluates the first pilot. For space constraints, the analysis mainly concentrates on preparation and execution phases. Firstly, evaluations for each institution are described independently. Next, a discussion is performed to detect common findings.

### 5.1 Blended Learning Institution

The students participated as volunteers and their dropout rate was minimal. The achieved final results are better than students' results who do not participate in the piloting courses. Therefore, it may be concluded that the first pilot had a positive impact on the academic success of the involved students.

For the first pilot, the canvas was set to 240 students from different faculties and departments to take part, but for some organisational reasons, the canvas was reduced to 202. TUS planned at least 150 of them to sign the consent form, but in fact 126 of them signed it, the others did not want, pointing out various reasons. For some courses, the TUS team arranged additional assignments (i.e. assignments that were not mandatory for passing the exam), only to test the TeSLA instruments. This is one of the reasons because some students did not want to take part in the pilot. Another reason they claimed was that they felt uncomfortable about cameras and microphones, as if

someone was monitoring them, so they could not work calmly. There were also students who worried that someone could abuse their personal and biometric data.

The initial plan was to involve 70 students to test face recognition, but 90 were achieved. The main reason for this success was because the TUS team worked hard to explain to the student what the goal of the TeSLA project was, and assured them that their data would be secured, anonymised and encrypted and no one will be able to misuse their data. Students were made acquainted with the project aims and objectives face-to-face with a presentation. The information letter explaining the purpose of the TeSLA project and the role of TUS as a project partner was uploaded in Moodle. Also, it was distributed via a specially created e-mail distribution list for all piloting courses.

The TUS team thought that the keystroke dynamics instrument will be the most useful in its work and planned 95 students to test it. Finally, 84 students tested this instrument only for enrolment and 73 for real activities. The assessment activity that included quiz with questions from type essay was not planned in the curriculum of the course and such activity had to be additionally designed to satisfy the project requirements related to testing the keystroke dynamics instrument.

Except for the Faculty of Management, there are not many courses in TUS that are suitable for testing instruments like forensic analysis and plagiarism checking. Moreover, in the pilot, only teachers from TeSLA team were involved and this limited the diversity of the piloted courses. The plagiarism instrument was not tested, but the students expressed their desire to do that in the future. Considering this, TUS planned to collect only 10 documents (from a master course in Public Administration) for forensic analysis and not to test plagiarism instrument. All 17 students in the course agreed to test the instrument for plagiarism checking in the upcoming pilots.

Four SEND students were involved in the pilot – 1 student with a physical disability, 2 pregnant students and 1 who was a mother with small child. It is worth noting that they considered the TeSLA system as a new opportunity for the realisation of flexibility in e-assessment, because they would have the possibility to perform their activities online in time and place suitable for them.

During the first pilot, TUS faced different problems. The main problems can be summarised in the following way:

- Some of the students did not have the interest to be educated by new methods and a part of them (a small part) did not have an "intellectual curiosity"; there were students who afraid that new assessment methods would require more time to be spent and more efforts to be made. A small part of students explained that if something was not included in the curriculum they did not want to perform it.
- In some of the piloted courses, the course design was not the most suitable for the opportunity for technology supported performance by TeSLA; TUS is a blended institution and the typical assessment activities are related to standard online quizzes or creation of engineering schemes that not include, for example, voice recording or free text typing (except the students of the Faculty of Management).
- Some technical difficulties were met concerning plugins versioning and their integration in the Moodle instance.
- Additional laboratories for the TeSLA activities had to be arranged. For example, the students studying "Higher Mathematics" did not use any computer laboratories

for online knowledge testing, but with their involvement in the project required computer laboratories equipped with cameras to perform their assessment activities online.

To solve these problems, the TUS team applied different approaches:

- To stimulate students to participate by announcing some stimuli. To motivate students to participate in the first pilot, The TUS team used various stimuli, such as: follow-up activities to contribute to the mark of the final exams; to give the students certificates for participation in the pilot; to publish the best course works done during the project in a virtual library.
- To use more advertisement materials; TUS made a video in Bulgarian for presenting the TeSLA system. In this video, TeSLA members explained the purpose and the functionalities of the TeSLA system to different students. Questions and discussion were also recorded. The project was announced on the TUS website and different online media.
- To discuss the problems with TeSLA members of other universities.

From the first pilot, the TUS team learned various lessons. Some of them are:

- It is very useful to make a good presentation and to involve other media events in explaining the idea of the TeSLA project both to the teachers and to the students.
- There is a need of information dissemination in more and different media channels, especially multimedia, which is important for students at technical universities.
- There is a need for the announcement of proper stimuli to both teachers and students.
- In the next pilot it is natural to involve only courses in which assignments, projects and quizzes are provided during the semester, not only for the end of the semester;
- It is important to involve only teachers that have some experience with Moodle and other VLE.

### 5.2 Fully Online Institution

UOC exceeded its original plan of 120 students: 154 students signed the consent form (3 were SEND students, they reported mobility or physical impairment), but only 96 performed the enrolment activities (2 were SEND). Here, the effects of the dropout in the first-year course involved in the pilot was noticed in a small period of two weeks between the consent form signature and the enrolment activities processes (in this period students submitted the first continuous assessment activity proposed in the course). The course had more than 500 enrolled students. Thus, only the 30% of students accepted to participate. Most of the students were not interested in participating in a pilot that would imply more workload (their time is limited, they used to have professional and familiar commitments). So, even stimulating them to participate, they evaluated the effort. Moreover, some students were really concerned about sharing their biometric data. Also, some students did not have microphone and webcam on their computer.

When face and voice recognition is analysed, 86 of the 93 students continued the course and did the follow-up activities. Here, the course dropout had less impact in the pilot dropout, i.e. the students who were in the course mostly continued in the pilot.

Related to keystroke dynamics similar numbers were obtained. 90 out of 96 students performed the follow-up activities. Finally, documents of 83 students were collected for plagiarism checking. 2 SEND students completed all the follow-up activities.

For students within the course, not many technical issues were reported, probably their knowledge related to ICT reduced the potential issues. Moreover, some students found workarounds to do the activities when they faced an issue and shared their experience in the TeSLA forum created in the course classrooms in the VLE of the UOC.

The most important issues at UOC were:

- The consent form signature procedure required time and effort both to the students and to the legal department.
- Low involvement of SEND students. UOC has strict rules (related to the Spanish Act of Personal Data Privacy) regarding the communication with SEND students (they cannot be identified nor contacted, unless they share this information).
- Technical issues with the third-party plugin installed the Moodle instance (especially video recording).
- The correction of the follow-up activities (they had an impact in the marks) implied a workload for the teachers. Although the Moodle instance was accessible from the classroom, not all the exercises were delivered in the Moodle (i.e. some exercises were delivered in the devoted space in the UOC VLE). In addition, some students recorded several videos for the same exercise.
- The previous issue is also applicable to the students. They had a certain workload in performing and submitting the activities planned during the course and the pilot.
- The course dropout affected the pilot dropout.

To solve these problems, the UOC team applied different approaches:

- To isolate as much as possible the teachers from the set-up of the technological infrastructure (the Moodle instance) and the design of the enrollment and follow-up activities. This work was assumed by the teacher involved in the TeSLA project.
- Detailed information was provided to teachers and students to reduce overload, –e.g. Frequently Asked Questions (FAQ) and instructions were placed in the Moodle.

The UOC team has also learned several lessons for the upcoming pilots:

- To improve the consent form signing procedure to reduce its negative impact on the pilot participation.
- To design a strategy for the recruitment of SEND students.
- To select a combination of courses with a high number of students (probably with a high dropout) with courses with a lower number of students but with a good ratio of academic success, and promoting learning innovation (e.g. in the activities design).
- To plan extra courses (in the preparation phase) as a contingency plan, if required.
- To prioritise courses that commonly do assessment activities that produce data samples that are useful for testing the TeSLA instruments.
- To find a trade-off between educational and technological needs (e.g. use real activities as enrollment activities).

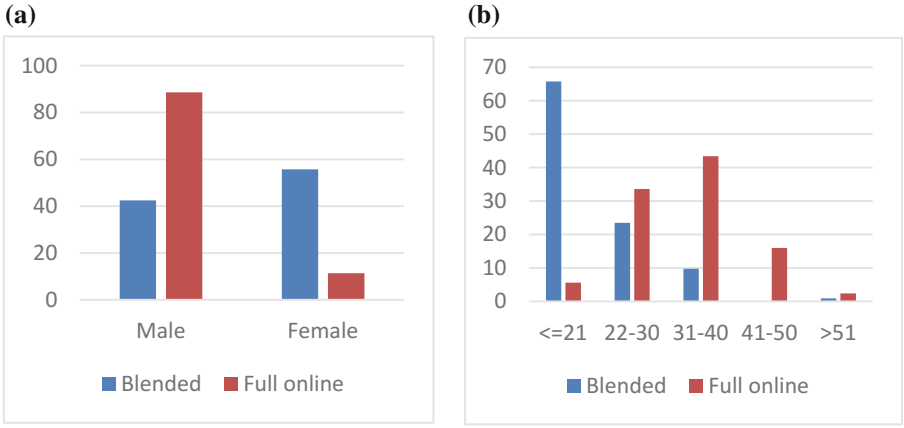


**Fig. 2.** (a) Gender distribution (%) on the pilot (b) Age distribution (%) on the pilot

- To ensure that follow-up activities have an impact in the marks.
- To guarantee that the TeSLA instruments, as much as possible, work transparently to the student (i.e. in background and integrated into the UOC VLE).
- To have access to the TeSLA system with enough time before the semester starts.
- To create multimedia material for advertising the pilot and the TeSLA project to students and teachers, for providing guidelines and tutorials for conducting the different phases of the pilot, amongst other.

### 5.3 Discussion

Regarding the demographic characteristics several differences can be observed between both institutions (see Fig. 2a and b). For gender, TUS had a more balanced participation, while at UOC the low presence of women can be observed (13%). This is due to the diversity of the selected courses in TUS. A closer look at the courses in TUS (not shown for space reasons) also shows a gender gap in the courses related to the ICT field ("Internet Technologies" and "Computer Networks") where only the 30% of the participants in the pilot were women. The low presence of women in STEM field and particularly in computer science has been deeply analysed in the literature [13] and cannot be attributed to the pilot. For example, in the case of UOC the 88% of the students enrolled in "Computer Fundamentals" were men, while the percentage of women was 12%. Therefore, women were well represented in the pilot. Concerning the age of participants, different results were also found. While in TUS students mostly enrol when they finish high school and are full-time students (the 63% are aged under 22 and only 12% have a full-time job), UOC students are incorporated into the labour market (the 62% are aged over 30 and the 75% have a full-time job). As in the case of gender, the participation in the pilot was not influenced by the age of the students.

Note that both TUS and UOC exceeded the expected number of participants in the pilot, although they mainly used different strategies. TUS involved 5 courses while UOC only involved one course. Selecting multiple courses in TUS had an added value

that different assessment models were covered, but there was a trade-off between more data related to different assessment models and different types of assessment activities, and more complexity in the management of the pilot. As a common strategy, both institutions involved in the first pilot courses taught by teachers involved in the TeSLA project. At the end, both institutions learned that fewer courses improve the execution phase and obtaining more data can be accomplished by deploying different instruments in different activities in the same course. The students' motivation was also a crucial aspect. UOC anticipated that at the preparation phase, while TUS successfully managed it during the execution of the pilot. A shared good practice was to guarantee that the follow-up activities had a small impact in the students' final mark. Finally, the development of the pilot did not negatively affect the academic success of the students that participated in the pilot.

When problems are analysed, similar problems were detected in TUS and UOC. The most relevant ones were the technical issues. The TeSLA system was not ready and the Moodle instance only served as a temporal platform to conduct the piloted courses. It is expected that the technical problems would be mitigated in the upcoming pilots. UOC also pointed out the need of integrating the TeSLA instruments in its own VLE.

Another remarkable problem was the design of the follow-up activities to meet the technical requirements of collecting data for instruments testing. New assessment activities were introduced (sometimes artificially) to collect biometric data, and this is not a real objective of the TeSLA project. Therefore, it is needed that the TeSLA instruments would be transparently integrated into the instructional process. For example, for the next pilots, TUS and UOC plan to select some courses based on the assessment activities where the instruments could be transparently deployed. Another problem was how the TeSLA project should be explained to students and teachers. If the project (and the pilot) is not well explained to students, they may misunderstand the real objectives and they may feel that the university mistrust them. TUS and UOC agree that detailed information in textual and multimedia formats could be a good idea to describe the project to the different users of the project.

Finally, the schedule of the different phases of the pilot also influenced the pilot dropout negatively, especially at UOC. Follow-up activities should be started as soon as possible and this implies that preliminary steps (consent form signature and enrollment activities) should be performed in the first weeks or even before the course starts.

## 6 Conclusions and Future Work

This paper has presented a case study of a trustworthy based system in two institutions focused on engineering academic programs in two different contexts: blended and fully online learning. Although the system was not ready for the first pilot, a technological solution was found by using a Moodle instance in each university, which allowed that students involved in the pilot may carry out their assessment process without a negative impact on their academic success.

Even though students were significantly different in their demographic characteristics, the results analysis of the preparation and execution phases of the first pilot has pointed out the design of similar strategies, as well as the detection of analogous problems and learned lessons in TUS and UOC.

As future work, the learned lessons will be incorporated in the upcoming pilots of the TeSLA project as best practices in TUS and UOC, and their impact will be analysed. Furthermore, the analysis will be extended with the results of the other institutions of the project participating in the pilots, in order to detect the major issues and to share the best practices. The overall objective is to achieve a better integration of the instructional process with a technological solution oriented to enforce authentication and authorship.

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