

VIRTUAL PRE-UNDERGRADUATE COURSE TO REDUCE FIRST YEAR STUDENTS' DROP-OUT

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Abstract

In this work, authors present a pre-undergraduate course for first-year students of Bachelor's Degrees. It is designed to adapt a previous blended-learning program to a virtual environment and to correct some deficiencies detected in the current pre-undergraduate formation. The course includes materials regarding subjects such as Mathematics, Physics, Chemistry, Electronic Circuits, and Programming Fundamentals. The project has pursued three aims: the creation of teaching materials with actual learning value and value-added accessibility, the implementation of a coherent virtual learning pre-undergraduate program, and the definition of a quality protocol based on Moodle tools regarding information collection and evaluation.

Keywords: e-learning, pre-undergraduate course, multimedia learning.

1 INTRODUCTION

The transition between secondary school and university studies may be a hard process for several reasons that can lead to an early university dropout [1]. Students arrive at a new environment where a certain degree of autoregulation, independence and self-responsibility is required. University is addressed to an adult audience while most first-year students have just left secondary school, where the guidance is stronger and teachers and parents constantly control their learning activities and advances. Sometimes their emotional and intellectual capacities are not enough to cope with the characteristics of the University life, which prevents a real integration. In addition, they may not be ready enough to face University studies due to a deficiency in prior knowledge or an inappropriate attitude towards learning. The importance of this first experience to the academic success makes the analysis of these phenomena a necessary field of study [2-5]

In view of the above, most Universities have developed orientation programs that, among other aims, help first-year students to know and integrate into the University dynamics. This includes activities to know how the university services work, personal tutoring and support carried out by selected teachers and last year's students or welcoming meetings where new students can meet their new mates in a relaxed atmosphere [6]. These orientation programs, however, do not address the lack of prior knowledge. This problem is faced by pre-undergraduate courses as the one that is presented in this paper.

In Spain, country where the study takes place, this lack of prior knowledge is not because inadequate coordination between the formative programs of secondary school and University degrees. This problem is mainly due to the variety of training background that allows students to Higher Education access. This flexibility, which makes possible that students change their career orientation without losing many years of education, can be the origin of one of the main handicaps to the engagement in the University courses. Some authors [1, 7-8] argue that curriculum coherence between secondary school and University is a key factor that enhances a rewarding experience during the first year studies. They affirm that avoiding these knowledge gaps should prevail over the previously mentioned flexibility, and encouraged more coordination between both educational levels and the development of pre-undergraduate programs as the one presented in this work [9].

The College of Engineering of Teruel (EUPT) of the University of Zaragoza offers a blended pre-undergraduate course for first-year students, which combines the work with learning materials through the Moodle learning environment platform with two weeks of face-to-face sessions. As EUPT intends to increase their educational offer purpose, important work is being made to implant a blended learning University degree in parallel with its face-to-face learning that is currently taking place. Distant learning stands for asynchronous and delocalized training that adapts to the students' schedules and social responsibilities and eliminates unnecessary trips. Apart from adapting the educational materials and learning methodologies of the academic subjects [10-11], all the University services must be

accessible to the students who do not visit the educational facilities as the case of the orientation program [12] or the pre-undergraduate course.

The great advantages of this training modality are, on the one hand, a pedagogical model centred on the student, who is being placed in charge of their own learning process. They use class time in other activities through which students not only acquire knowledge but also skills. On the other hand, it is the convenience of being able to access the platform at any time and from anywhere as the 7x24 training model is followed: 24 hours a day, 7 days a week. The main difference between this new approach and the traditional practice is the strong change in the role of the main agents of the learning process: students and teachers [13-14]. Learners must play an active role in order to reach meaningful learning. They leave their passive role as mere receivers of the information provided by teachers and create their own knowledge from their personal and social experiences. Students acquire autonomous learning competences: "Learning to learn". Teachers assume a guiding role in the process. In this way, students increase their responsibility level.

These changes in the learning agents' roles also affect the type and use of didactic materials [15]. From a traditional point of view, learning materials were static products, developed in different formats, created by an authoritative source. All students within the same level worked with these contents in the same way, following a closed learning itinerary. They were discipline-centred materials. The evolution to learner-centred methodologies implies working with a new kind of learning materials that let the learners choose their own pace and itinerary through the construction of their knowledge. The hypertextuality that characterizes multimedia materials supports this kind of interaction, if the didactic materials are properly conceptualized. By the use of different formats, it is possible the adaptation to different learning styles and to reach a degree of personalization in the learning process. This instructional strategy enables students to use higher order thinking skills. However, this is only possible if the different informational formats are connected in a way that a positive redundancy is created. The use of graphic and textual information together is beneficial if there is a clear link between them [16]. Some common mistakes must be avoided as giving more importance to the aesthetical aspect and the fusion of different media than to the instructional design. It is not necessary to replace all the previous learning materials by multimedia at a single step. It is advisable to adjust the contents progressively [17].

In what follows, we will describe the characteristics of the college where the training takes place and the students that access to this college. In addition, the results of the current pre-undergraduate course are summarized, which are the base of the objectives of this project. Next, in point 3, the instructional design of the new virtual course is presented together with a description of the type of learning materials created. Section 4 focuses on the quality criteria defined to evaluate this course and on how to measure those using Moodle registers. Finally, the main conclusions are presented.

2 CONTEXT DESCRIPTION

The EUPT of the University of Zaragoza is located in Teruel, Spain. This city has a population of about 35000 people. Two Bachelor's degrees are taught in the EUPT:

- Electronic and Automatic Engineering.
- Informatics Engineering.

Around 200 students are enrolled in the EUPT. Approximately 30 students start each of the two Bachelor's degrees every year. In Spain, Higher Education can be accessed with very different training backgrounds. Several years ago it was detected a lack of required previous knowledge of some of the enrolled first year students. This problem fosters the first year students' frustration, and early university dropout [1]. In order to try to overcome this problem, in the summer of 2014 a pre-undergraduate course for first-year students was devised and started in the EUPT. This course provides learning materials for the first year students through the "Moodle" learning environment platform, which are available two months before the beginning of the course, and are completed with several face-to-face sessions, where teachers summarize the main concepts. The course includes materials regarding subjects such as Mathematics, Physics, Chemistry, Electronic Circuits and Programming Fundamentals. The face-to-face sessions are given the two weeks before the beginning of the course. Nevertheless, we have observed that quite a few students are not yet enrolled at the beginning of the course and the home/residence of some of the enrolled students is far from Teruel. Therefore, the reference materials and the face-to-face sessions are only available for approximately 35-40 students every year. Among these students, only between 7 and 20, depending on the year,

attended the face-to-face sessions and consulted the learning materials before the beginning of the first course of the corresponding Bachelor's degree. We have also noticed that after the beginning of the Bachelor's course more students consulted those reference materials. Some years the students have filled out a student satisfaction survey of the pre-undergraduate course. The results of these satisfaction surveys show that most students are satisfied with the course and all the students considered it useful.

On the other hand, due to the sparse population of Teruel, the EUPT has decided to offer the Bachelor's degree on Electronic and Automatic Engineering in a blended learning mode in addition to the current face-to-face mode.

Taking into account the discussion above, we thought that the creation of a well-designed virtual pre-undergraduate course could allow us both to increase the number of students taking advantage of this course and to provide teachers with a good experience in blended learning for the future modality of Electronic and Automatic Engineering.

The project has pursued the following three aims:

- **The creation of teaching materials with actual learning value, and value-added accessibility.** In the initial courses, the learning materials provided were mainly the ones used in classroom training adapted to the virtual environment. In this project, materials specifically designed for virtual teaching have been created with value-added accessibility. Hypermedia materials, where different media (text, image, video...) are used to present educational content, have well-known advantages, as adaptation to different learning profiles or redundancy, which can be positive for meaningful learning creation. These documented features are only possible if the materials are designed accordingly to the aims pursued and the target learners [18]. Following the learning-by-doing paradigm, these materials include activities that enhance meaningful learning and serve as evaluation tools with feedback to the students. Intellectual property rights issues have been also taken into consideration.
- **Implementation of a coherent virtual learning pre-undergraduate program.** So far, the different subjects of the pre-undergraduate course were completely independent. This work aims to create a learning program, not just a compilation of educational contents. Therefore, a uniform aesthetic appearance is pursued with the use of common templates and structure. The way the learning is evaluated is also common and the qualifications got by students are shown together in Moodle. At the same time, a degree of flexibility is kept, allowing students to study what they really need.
- **The definition of a quality protocol based on Moodle tools about information collection and evaluation.** In order to implement a continuous improvement process, we have defined quality criteria and their corresponding metrics. The reports tool integrated in Moodle eases the process of information collection.

3 DESCRIPTION OF THE TRAINING PROGRAM

3.1 Curricular design

The virtual pre-undergraduate course is focused on strengthening the knowledge base of new students of the EUPT. Specifically, this course reviews and reinforces basic concepts that students should have in their background knowledge when they begin their engineering studies. In particular, the pre-undergraduate course reviews concepts of subjects such as Mathematics, Physics, Chemistry, Electronic Circuits and Programming Fundamentals, as the previous blended course does.

All the learning materials are available through the "Moodle" learning environmental platform of the University of Zaragoza. In this way, this pre-undergraduate course helps new students to familiarize with the learning management environment that will be useful for them during their university studies.

The concepts reviewed in each subject are summarized as follows:

- **Mathematics:** Vectors; Matrices; Determinants; Systems of Linear Equations; Polynomials; Trigonometry; Derivatives; Integrals; Complex Numbers.
- **Physics:** International Unit System; the Field Concept; Electric Field; Basic Circuits; Magnetic Field.


- **Chemistry:** Introduction to the Periodic Table; Basic Principles of Inorganic Chemistry Formulation; General Aspects of Carbon Chemistry.
- **Electronic Circuits:** Resistors, Ohm's law, series, parallel and mixed circuits.
- **Programming Fundamentals:** Introduction to Programming, Pseudocode and Python
- **Digital numerical coding:** Binary Coding. Binary Representations and Calculations.


As will be further discussed in section 3.2, all the subjects follow the same structure, which has been defined both in relation to the learning-by-doing paradigm and to keep a degree of flexibility to enable students to manage their own learning progress schedule. Specifically, the different subjects include an interactive presentation of the contents, downloadable pdf files with the contents and different practical activities to enhance student's meaningful learning. Within the activities that will be performed by the students, there are included: i) an initial test that will be used as initial diagnostic evaluation tool for the students, allowing them to identify their weaknesses, if any, and thus, to focus their effort in those subject that they have more lack of knowledge, ii) middle stage tests that will be used as formative evaluation to inform the students about their progress in the different topics of the given subject, and iii) a final test that will be used as summative evaluation to provide information about the worth of the pre-undergraduate course.


Moodle communication tools allow the interaction between teachers and students. Asynchronous channels as forums and messages are used to ask and clear up doubts. Forums enable group communication that helps to create a learning community. Messages can be used to personal communication between a student and the teacher.


Fig. 1 shows an example of topic, where the quizzes, documents, and activities, together with a forum, are included.

CAMPO ELÉCTRICO: 


 Cuestionario inicio Campo Eléctrico.
Si eres capaz de resolver el cuestionario, eso quiere decir que tienes los conocimientos necesarios para seguir correctamente la parte asociada a ondas.

 Apuntes del tema Campo Eléctrico.
En este documento se recogen los contenidos del tema que se trabajan en el resto de actividades.

 Carga eléctrica. Conductores y dieléctricos.
Vamos a recordar que es la carga eléctrica, cómo podemos cargar un material y cuáles son los dos comportamientos más usuales ante la carga eléctrica. Para avanzar por la lección tendrás que ir completando las actividades propuestas.

 Ley de Coulomb
Material introductorio de la Ley de Coulomb. Aplicación al cálculo de fuerzas electrostáticas entre cargas puntuales. Para avanzar en la lección, tendrás que ir completando las actividades propuestas.

 Problemas
En este documento se proponen unos problemas con su solución para resolver y fijar los conceptos aprendidos en las lecciones anteriores.

 Campo eléctrico. Cuestionario final
Comprueba si tienes claros los conceptos vistos en la sección campo eléctrico.


 Dudas sobre el campo eléctrico
Podéis plantear en este foro las dudas que os surjan al leer los materiales o realizar los ejercicios asociados al tema Campo Eléctrico. Los profesores daremos respuesta a esas dudas, pero vosotros también podéis responder a vuestros compañeros.

Figure 1. Learning activities corresponding to a topic of the subject Physics. All the contents are in Spanish.

3.2 Training materials

3.2.1 Multimedia design and accessibility issues

The didactic contents of the training program acquire an important relevance in this modality of virtual learning, centred on the methodology of learning by doing. In addition, the homogeneity of the structure between subjects, and the compatibility between formats and accessibility, will determine largely the success of student learning.

In our training program proposal, we first considered the characteristics of the recipients to whom the course is aimed, that is, what is the target group, what is their level of reading and writing, what degree of familiarity do they have with the management of information, the language (text, images, audio), which will be used in the materials, as well as other aspects such as the number of participants

and the resources available. Age is an aspect of great importance, since it is not the same to elaborate didactic material for children, adolescents and/or adults. The learning style also plays an important role, since not all of us learn in the same way. According to [19], learning styles are cognitive, emotional and physiological traits that serve as relatively stable indicators of how students perceive interactions and respond to their learning environments. Learning style determines: a) the tendency of students to select and use certain strategies to learn, b) the preference of certain strategies over others, and, c) how to operate strategies by the learner. Secondly, and since in our case the fusion of auditory and visual languages predominates, a powerful tool emerges in learning that is multimedia materials, which allow us to attend to a varied selection of formats (standard SCORM, PDF, videos, hypertext, etc.) that obey the different objectives for each subject and that students can use autonomously, both in the classroom and at home.

Virtual learning is not incompatible with the use of a reference textbook, but if what is involved is that the student learns for himself, draws conclusions, searches, filters, and selects, new activities in different formats must be offered. These formats are audio visual (videos or podcasts) materials, usually lasting no more than five to ten minutes (through which the main ideas or key concepts of each lesson are presented), notes in text format, links to articles in magazines/blogs/specialized video channels, interactive activities presented, etc. Some of this material has been prepared specifically for this course and some proceeds from some of the resources that the teaching community repositories shared on the network. The format should be more than just videos or interactive quizzes and more or less innovative technologies. The key is to design the content interlacing, weaving it, with what students consider relevant and engaging, so encourage them to explore intellectually.

In addition, it is necessary that multimedia contents are accessible in order to provide equitable access and equal opportunities for people with disabilities and advanced age. Accessibility refers to the ability to access the Web and its contents by all people regardless of the disability (physical, intellectual or technical) that they present. The authors of this contribution considered very important to ensure that multimedia teaching materials developed for the pre-undergraduate course of the EUPT comply with Priority 2 of UNE 139803: 2004 "Computer applications for people with disabilities. Accessibility requirements for content on the Web "and with the AA of the" Guidelines for Accessibility to Web Content (WCAG)".

To facilitate the development of these multimedia materials, and ensure that they are designed according to the criteria discussed above (pedagogical and accessibility), the authors have carried out two tasks: content writing and multimedia scripts. In the task of content writing, guidelines are provided that facilitate the realization of multimedia materials considering the characteristics of the format in which they are presented. In this sense and in terms of the readability of the contents on the screen, we consider that it reads 25% slower than on paper, so it is recommended to write 50% less, and also tends to read by selecting keywords and paragraphs of interest. Therefore, this proposal recommends: a) distribute the text in paragraphs that are not extensive so that each paragraph conveys an idea, b) introduce examples, if possible related to the context where they will be applied, since it allows students to better understand the contents and connect them with working life, c) highlight key ideas and definitions using tables, d) introduce reminders to resume and reinforce ideas or concepts already studied in the unit, e) include self-evaluation exercises of the true / false type, selection and incomplete sentences, which allow the students to know their assimilation of contents, f) use tables, vignettes, representative icons, etc. that allow to visualize the contents in a clearer and more attractive way, and g) introduce figures or graphics that help to understand the content. These should include a foot and an explanatory text.

Regarding the second task, a multimedia script is a document that reflects all the elements that will appear on the screens of the online course: contents, didactic and multimedia resources. Our proposal focuses on answering the six classic questions [20]):

- What (the contents that we are going to tell)
- How (the way in which we articulate the multimedia presentation of each resource)
- When (informative and interactive sequence)
- Who (what we use to present the information)
- Where (model of structural organization, distribution ...)
- For whom (our wanted reader)

Once answered, the process of writing the script will include the phases of a) content, which indicates the textual material that will be used, b) narrative, which establishes how this information will be presented, c) iconic, which marks the images that are available (graphics, photos, figures, pictures, video, animations, etc.), d) sound, which must be sequential and reflect the direct records (voice recording of one voice) and indirect (music used), and e) technical, which consists in defining the bases of the realization, the methodology, the programs use, presentation formats, screen design, effects to be used in each part, etc.

In the pre-undergraduate course designed, phases a), b), c) work on the content writing, focusing on this task in phase e). Currently, we work with the following representation formats: conceptual maps, PDF, AVI and SCORM (Sharable Content Object Reference Model).

Then, when offering content to students to work in and out of the classroom is necessary to provide a common thread with some kind of organization that makes them easily accessible; It would not be efficient to offer a lot of unconnected links every day, that is, some online publication support is needed, such as a blog, a wiki, a portfolio or a Learning Management system (LMS), which articulates the classes in a clear and orderly manner for the students. In our case, this support is offered by the Moodle platform, known as the Digital Teaching Ring (ADD, "*Anillo Digital Docente*" in Spanish), in which a basic template for the course has been designed.

The creation of the multimedia materials that will form the course can be carried out by means of software (author tools). In this sense, it is known the existence in the market of a multitude of author tools (SnowFlake Multiteach, eXeLearning, etc.) that facilitate the creation of multimedia contents, but the products generated not comply 100% with the accessibility criteria [21] marked in Priority 2 of UNE 139803: 2004. However, Moodle tools have been mainly used to create this formative content, as it is explained below.

3.2.2 *Type of created multimedia material*

Based on the previous analysis, different materials were created. They cover a variety of approaches to learning.

The courses include notes in pdf files ready to be printed, similar to a typical book. This is the traditional approach to learning. It is still very useful for learning scientific and engineering concepts. The pdf documents are generated from slide presentations (Power Point, latex with the beamer package), word documents (Microsoft word) or latex documents (book template). We have created templates for all the formats used by the teacher group. All of them have a similar appearance in the first page, indicating, title, author, institutional information and the license. We have decided to use a Creative Commons License (Attribution-Share Alike-Noncommercial). In addition, basic usability criteria have been taken into account.

There are also Moodle *lessons*. This kind of activity allows students to navigate through a series of html pages in which the teacher has decided to present a sequence of concepts to be learned. The html pages were created using the built-in Moodle editor. This editor is flexible enough to include several text-formatting, list, links to external web pages, equations (including the possibility of using a latex editor), etc. This kind of web contents has been designed to answer the six basic questions described previously. This design can also be used to create content compliant with the Shareable Content Object Reference Model (SCORM). The SCORM standard allows packaging a piece of educational content so that it can be reused in different LMS, in our case Moodle. Though this portability is a remarkable advantage, the use of the activity *Lesson* of Moodle is more intuitive and simple. In this way, the workload associated to the generation of new training materials is reduced.

Some teachers offer also educational videos. They can be included as standalone material or integrated in Moodle lessons. They have been created using several tools: Powtoon, Movie Maker or Active Presenter.

As mentioned above, the courses include also quizzes, the Moodle activity that allows student to answer on line questions. At least two quizzes have been implemented for each topic, one at the beginning of the topic and another as the last item of the topic. Depending on students' background, they may have already the knowledge required by the topic. With the starting quiz, students can check whether this is true. If the quiz is successfully completed, students can skip the topic if they want to focus on the weakest parts of their skills. The last quiz allows them to test the fulfillment of the topic. It is important to include self-evaluation of students in a virtual learning course like this, although

students can also attend voluntary tutorial sessions in the teachers' offices or use the communication tools.

4 EVALUATION

Several approaches can be adopted to evaluate the course or the resources described in this paper. The work of García-Barrera [22] proposed the application of E-rubrics to assess technological educational materials. In this sense, Avila et al [23] developed a model to evaluate inclusive and accessible open educational resources. On the other hand, the "Universidad Politécnica de Madrid" presented a study [24] with the results of evaluating courses on the Moodle platform. Similarly, Pineda-Herrero et al. [25] published a model to evaluate e-learning in the public institutions. Therefore, to evaluate the virtual course and the resources described in this paper, different models to evaluate either virtual courses or educational resources could be used.

In relation to the evaluation of Moodle courses, the model of Garcia-Bargado et al [26] can be used. Their work propose an evaluation system based on dimensions and indicators. Three dimensions are considered: 1) structure of the virtual platform, 2) pedagogical aspects and teaching learning process, and 3) operation with the virtual platform. For the first dimension, the following five indicators are considered:

- The presentation of the course in the virtual platform.
- The design and contents of the first lesson.
- The presentation of the pedagogical units.
- The inclusion in the course of different activities that are available in the virtual platform.
- The use in the course of the different resources that are available in the virtual platform.

The second dimension (pedagogical aspects and teaching learning process) comprises the following indicators:

- The inclusion of recommendations for the learning activities in the virtual environment.
- The promotion of learning in the virtual platform.
- The presence of stimuli to promote collaborative work.
- The use of evaluation activities and resources to follow the learning process in the virtual environment.
- The level of agreement between goals and teaching and evaluation activities.

As for the third dimension (operation with the virtual platform), two indicators are considered:

- Correct operation of the elements included in the course.
- Correct indexing of the dynamic elements.

However, instead of using a comprehensive model, another option could be the application of a survey, for example [27]. This survey includes twenty-seven aspects that should be evaluated in a Moodle course. A summary is presented in Figure 2.

Another possible option could be not to evaluate the course but the specific resources. In that case, the *Evaluareed* model [28] could be a valid option. This model indicates the criteria and sub-criteria to be owned by the educational resources. Additionally, a weight is provided for each sub-criteria. The criteria considered are authorship, content, upgrade level and accessibility. The criteria authorship includes the sub-criteria credibility, contact information and information about the sources. The sub-criteria associated with the content category are organization, relevance, suitable results and references. The criteria upgrade level includes the sub-criteria topical issues, unavailable links and creation/update date. Finally, the accessibility criteria consider the sub-criteria option to download/print, visualization/readability and navigation. The weight distribution is as follows: authorship (30%), content (40%), upgrade level (15%) and accessibility (15%).

These are some of the valid evaluation options for the proposed course, although other evaluation models focused on the course in the virtual platform or the specific resources may also be applicable.

As for the case of the course described in this paper, the model of Garcia-Bargado et al [26] will be used to evaluate the Moodle course, while the *Evaluareed* model [28] will be applied to the

assessment of the specific educational resources. For collecting course data, different tools will be used: Moodle reports tools, student surveys and internal and external auditing.

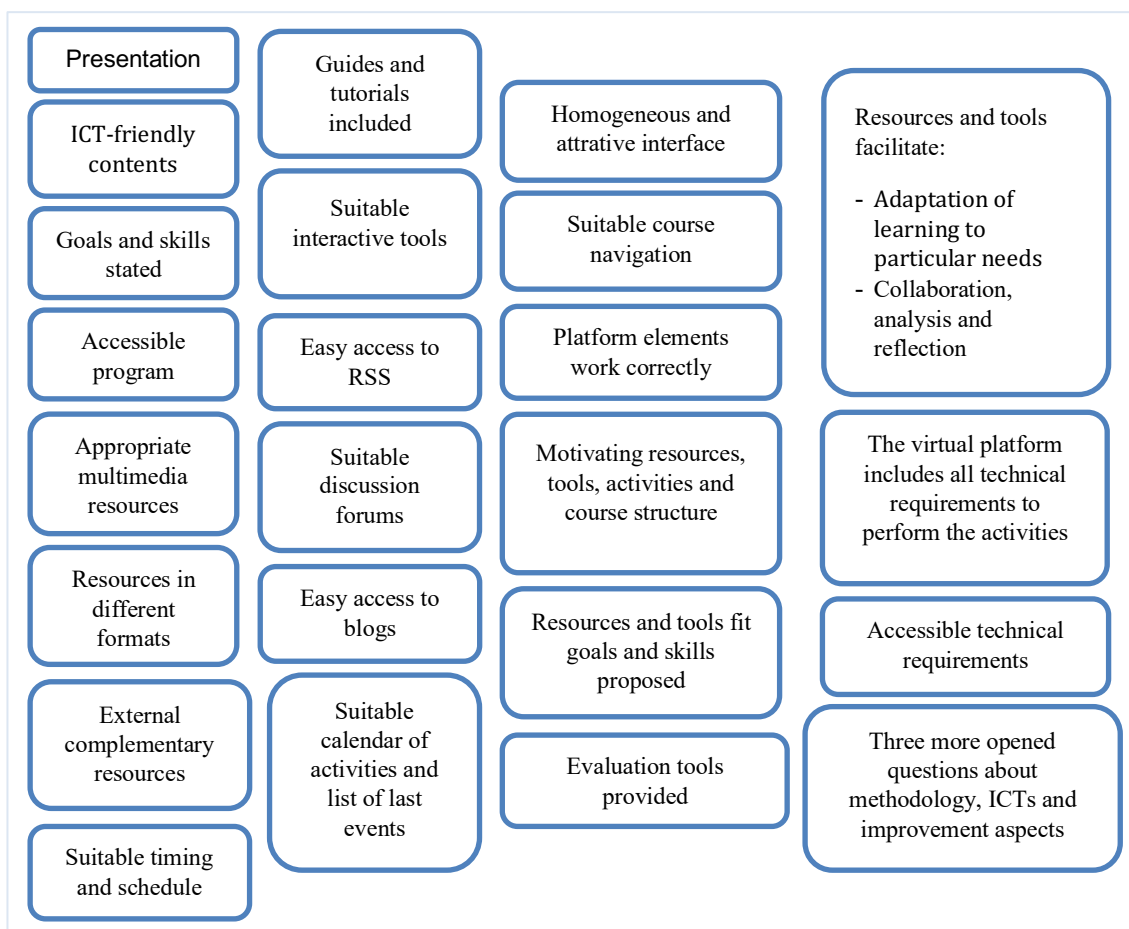


Figure 2. Summary of an evaluation survey for a course in a virtual platform.

5 CONCLUSIONS

Aware of the problem regarding the lack of prior knowledge necessary to study the subjects of the first courses for students who enter the University, the faculty of the EUPT of the University of Zaragoza, launched a pre-undergraduate course in blended modality. The future implantation of distance University degrees together with the objective of avoiding unnecessary displacements to the face to face students has motivated this project, in which a completely virtual pre-undergraduate course is created. The Moodle learning management environment has been used for the development of this training course, using its evaluation, control and communication tools for distance teaching. Special interest has been placed on the creation of multimedia materials with real value for learning, taking into account considerations of accessibility and protection of intellectual property. In addition, deficiencies detected in the previous courses have been corrected. A heterogeneous set of materials associated with the different subjects that shared virtual space have become a homogeneous course in which the subjects share structure and work tools. This work has been completed with the design of an evaluation plan for this virtual training, for both the design and operation of the course, and the quality of the materials created.

ACKNOWLEDGEMENTS

This work has been funded by project PRAUZ_18_375, Vicerrectorado de Política Académica, University of Zaragoza, Spain.

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