Using learning object repositories for teaching Statistics

Julià Minguillón[1], Maria Antònia Huertas[1], Angel Alejandro Juan[1], Teresa Sancho[1], and Victor Cavaller[2]

[1] Computer Science, Multimedia and Telecommunication Studies
Universitat Oberta de Catalunya
Barcelona, Spain
[2] Information and Communication Science Studies
Universitat Oberta de Catalunya
Barcelona, Spain

Abstract. This paper describes an experience regarding the use of learning object repositories for supporting online students in a virtual learning environment. Before the introduction of the learning object repository, all learning resources were made available through a specific space within the virtual classroom, as part of the digital library of the university. Resources were classified according to their nature (textbooks, examples, exercises, software, data, etc.) and stored in compressed files, so students could download them as a whole package. Nevertheless, by using this traditional method it was impossible to know the real usage of these learning resources, as most students downloaded all the packages at the beginning of the academic semester and never visited the digital library again. Students also complained about the lack of additional descriptions, which makes the contextualization of each resource in the learning process very difficult. In subjects with a large amount of learning resources (several hundreds), such as Statistics in the Computer Science degree, we propose to use a learning object repository, as it seems clear that it is a basic element of any virtual learning environment, providing users with high quality contents, properly described and supported by means of metadata, taxonomies and ontologies. The integration of such repositories into the learning process is a key issue for ensuring a proper use, not just being a mere space in which to find educational resources. This will help students to better understand the basic key topics in Statistics and it will also provide online instructors with information about the real usage of the learning resources in the virtual classroom.

1 Introduction

There is currently growing interest in taking advantage of Information and Communications Technologies in general, and the Internet in particular, to develop and share quality teaching materials among universities worldwide. Projects such as the MIT Open Courseware[3] and MERLOT[4] are clear examples of this phe-

[3] http://ocw.mit.edu
[4] http://www.merlot.org

nomenon. In the field of mathematics and statistics, the interest in creating and developing web repositories with quality content that is easily accessible and usable by the university community is becoming increasingly widespread, giving rise to initiatives such as MathWorld[5], MathForum[6], Joining Educational Mathematics[7], etc.

Although this sphere may seem highly focalized, it is one of the key factors in the success of a repository. This is shown in the example of DLESE[8], a resource repository for natural sciences which, based on an initial working community, has built up a true learning community around it. The aim is thus to explore, select, develop and establish guidelines and recommendations for these technologies, standards and taxonomies that will effectively facilitate the creation of web repositories that are open (content that is completely accessible and free of charge), high quality (content that is created and reviewed by university professors), and collaborative (content developed by professors at different departments and/or universities). The contents of these repositories will be classified following a specific taxonomy and using keywords so that they can be easily located either via a portal directory or by using the repository's own search engine. These repositories should be capable of hosting and indexing a whole range of materials: texts with theoretical and practical explanations of concepts, solved exercises, examples of applications, multimedia documents (videos, recordings, etc.), examples of using mathematical and/or statistical software, and so on. Finally, these repositories should follow guidelines on scale and standards that allow their resources to be shared with other open repositories that use international standards.

2 Teaching Statistics in VLEs

The proliferation of PCs, the continual evolution of computer products (in terms of both hardware and software) and the Internet phenomenon in the last few years have all engendered a series of transformations which are helping to redefine the university education panorama in every area of knowledge, and especially in the area of mathematics and statistics. On a global level, numerous teaching groups have stressed how important it is to use ICT to improve the quality of mathematics teaching (Conference Board of the Mathematical Sciences, Mathematical Association of America, Mathematical Sciences Education Board, National Council of Teachers of Mathematics, etc.), and, as advocated by certain authors [1, 2], the use of these technologies is a key factor in the future of mathematics teaching.

In terms of Spanish universities, there is an obviously growing interest by mathematics and statistics departments in incorporating information and communications technologies in their teaching of the different degree courses [3]. The

[5] http://mathworld.wolfram.com
[6] http://mathforum.org
[7] http://www.jem-thematic.net
[8] http://www.dlese.org

upsurge of ICT in general and Internet use in particular has brought with it the emergence of numerous virtual learning spaces for mathematics which, in many cases, strengthen or complement the teaching methods based on classroom attendance. As well as the emergence of these virtual spaces, there is increasingly intensive and curricular-integrated use of statistical and mathematical software, which encourages students to be more creative (giving them the chance to experiment and work with advanced concepts and techniques), and highlights the applied aspect of mathematics and statistics in modeling and problem-solving in other areas of knowledge.

Meanwhile, it is worth remembering the other major factor that is also decisively involved in the process of transformation that university mathematics teaching is undergoing: universities are currently going through a time of significant change, driven by the implementation of a European cultural framework that imposes the need to maintain and strengthen a series of social and ethical values, by the progressive adaptation to the most recent technological and socioeconomic changes, and, most importantly, by the convergence towards an integrated European university system. As highlighted by certain authors [4], the main philosophy behind the configuration of a European Higher Education Area (EHEA) is to put the study programs of different European countries on an equal footing, which will encourage the mobility of both students and teaching staff between the various European universities and will be very beneficial for what the EHEA describes as "mutual learning". Thus the construction of this EHEA represents a huge challenge: adapting old structures (especially traditional ones in the field of mathematics teaching) in order to facilitate the transparency and comparability of higher education, making it easier to recognize qualifications and making them more uniform throughout the length and breadth of the European Union. It is very likely that the new framework defined by the EHEA will involve significant changes to educational curricula. In some universities, efforts are already being made by different mathematics departments to share their teaching experiences and unify the criteria of convergence to the EHEA, giving thought to both the general and specific skills that each area of knowledge needs to develop through the use of mathematical and statistical information.

Therefore, due to the influence of the EHEA, the new configuration of learning environments - both online and classroom-based - are centered on the students rather than the teacher, resulting in a reduction in the number of master classes and an increase in group working experiences, i.e. collaborative learning [5]. Also, there is a greater emphasis on the teaching director as the supervisor of the students' work, promoting the use of all kinds of learning resources (web sites, online libraries, learning objects, etc.) and the appropriate technologies for each subject (specific software, learning platforms, etc.). Likewise, the acquisition of transversal skills and competencies in other subjects is being introduced. In this respect, some specialists have already formulated proposals that point towards strengthening the use of mathematics as a transversal tool for use in other disciplines [6].

2.1 The UOC case

The Universitat Oberta de Catalunya[9] (in English Open University of Catalonia) is an institution which has emerged from the knowledge society. The mission is to provide people with training throughout their lives. The university's principal aim is to ensure that each student satisfies his/her learning needs in a virtual environment, gaining the maximum benefit from their own efforts. To this end, it offers intensive use of information and communications technologies (ICT), thereby enabling us to overcome the barriers imposed by time and space for offering an educational model based on personalized attention for each individual student. Within the UOC Virtual Campus, each subject has a virtual classroom for teaching and learning process and they are the virtual meeting point for learning activities, following a student centered model [7]. A digital library provides students with all the resources they need during their learning process. Although this solution satisfies some basic requirements, such as accessing digital content, it does not contextualize such content within the learning process. We propose to improve the semantics of the repository integrated in the virtual classroom for providing students with the most appropriate resources according to the learning context and his/her particularities (preferred learning style, used device, disability issues, and so).

In the particular case of the Computer Science Degree, there are a lot of courses which involve the study and use of mathematics and statistics. Among them, we have chosen Statistics because it has several interesting characteristics: it is a multidisciplinary subject across several degrees, it involves around three hundreds of students (in Computer Science only), and it has a large quantity and variety of learning resources, such as textbooks, examples, exercises, simulations, data sets, software tools and even multimedia presentations. All these learning resources are linked together through the Teaching Plan, a document which helps students to follow the preplanned schedule integrating all the learning resources into the learning process. Nevertheless, students usually complain about the lack of flexibility of the schedule and the excessive number of learning resources, which makes them unable to follow the course. Preliminary studies show that students prefer more flexible systems which allow them to find the appropriate resources when they need them, instead of having all the resources available from the beginning. Learning resources should be properly tagged and contextualized within the learning process; any learning resource should be able to answer the following questions, among others: "what is this?", "what is this related to?" and "what is this intended to? ". Other interesting possibilities are rating (usefulness, understandability, and so) and annotation (comments, errata, and so).

The concept of the repository is fundamental to the achievement of some of these functionalities, such as building true learning communities around a given theme or area of knowledge. Following the maxim of David Wiley, "learning is not just about content", which means it will be necessary not only to provide students with simple, effective access to this content, but also the tools necessary

[9] http://www.uoc.edu

to participate in its joint creation and subsequent evaluation [8], strengthening the development of transversal skills such as those that are information-related, the ability to make critical appraisals, and a capacity for decision-making. The repository, when properly integrated in the learning process, must allow students to advance in their personal development in such a way that the whole set of educational resources that can be used in the planned teaching activities is constantly available. The repository is not simply a technological tool, but something that enhances the use of educational resources, involving the student in the whole process. The repository is the equivalent of a fishing rod, rather than the fish that represent the educational resources provided with each activity and once they are used up, the context for their use is lost. In contrast, the repository helps students to understand the relationship of each educational resource within a context, whether explicitly because of the information it contains or implicitly, through its exact location by means of the taxonomy and keywords designed for that purpose. Instead of being isolated elements, the educational resources in a repository become parts of a greater design, the actual process of learning, which integrates activities and other elements necessary for the optimum acquisition and development of the skills for that particular area of knowledge. The repository can be based on a very specific initiative which addresses the needs of a particular area of knowledge, but it can also go on to transcend that and provide solutions at a higher level, whether institutional or even national [9].

2.2 Project goals

The aim of this project is based on a combination of the following factors:

1. The transversal presence of mathematics and statistics in numerous degree courses: To a greater or lesser extent, subjects under the mathematics and statistics umbrella form part of the educational curriculum for numerous university degrees relating to diverse areas of knowledge: experimental sciences, technical teaching, social sciences and health sciences. In addition, because of their instrumental nature - something that is absolutely essential in today's Information Society - this area of knowledge is also important in other postgraduate training courses such as Master's and doctorate programs. Meanwhile, subjects with a mathematical or statistical nature are, generally speaking, among those in which students perform least well, which is why they deserve special attention. In particular, the educational resources in these subjects need to be constantly updated in line with methodological improvements, curriculum changes and the different profiles and prior knowledge of the students. It is feasible to use the same teaching content or resource in several areas of knowledge, either as a case study in itself in one particular field, or as an example of the instrumental use of a mathematical or statistical concept in other subjects. The concept of a repository should allow efforts to be united in this transversal direction.

2. General interest in integrating ICT in mathematics teaching in universities: Developments in computer systems and, in general, in information and communications technologies have facilitated new ways of teaching mathematics to university students and are providing professors with teaching tools that are constantly evolving: virtual environments, collaborative learning platforms, mathematical and statistical software, Internet-based educational resources, etc. These technologies are being used with increasing intensity in both university distance learning and traditional classroom-based teaching, the second of which is increasingly using online educational elements to complement conventional face-to-face teaching. Despite the apparent explosion and success of these technologies, they often create content that already exists or is used without any criteria (turning the technology into an end rather than a means), so it is essential to carry out a study that helps to establish the ground rules for the effective use of these technologies and ensure that the resources generated are re-used.
3. The need to adapt to the European Higher Education Area (EHEA): The EHEA represents an excellent opportunity to unify academic criteria and facilitate the standardization of university qualifications in the Old Continent, yet at the same time it represents a new challenge for most European universities, which within a very short span of time will need to adapt their teaching practices to the new directives based on the principles of quality, mobility, diversity and competitiveness (the criterion of employability). The fields of mathematics and statistics are not immune to this challenge and, in fact, because of their intrinsic characteristics these fields are destined to play a key role in developing many of the generic skills that future European students will need to acquire: methodological skills (organizational strategies, troubleshooting and decision-making), technological skills (information management, computer technologies, etc.), critical appraisal ability, skills in system operations, the ability to take a global and multidimensional view of the facts, the ability to analyze complex and diffuse facts, the ability to see all the parts of a whole and how they relate, etc. Therefore, in the field of university teaching of mathematics and statistics, it will be necessary to examine and reappraise teaching methodologies, adapt academic content to each degree course, and focus on integrating information technologies in the educational process. The processes involved in acquiring and developing general and specific skills in a particular subject should be done using a different approach, not based on content as the center of the learning process, but rather on designing activities that allow students to advance in that subject, working jointly on the location, adaptation and creation of the educational resources needed in each case.
4. Availability of UOC teaching material in digital format: Over the last few years, the UOC has generated a considerable number of resources in this field. Most of them follow the editorial model of production and design, based on modules, which are learning units with one or two credits designed for learning a specific topic of the course contents. The cost of generating quality digital resources with this system has been high; the process of creating and

editing them takes on average one year, and maintaining and updating them to changes in the course subjects is complex and costly, given that it once again entails the whole editorial process. Many resources have also been generated as examples, exercises, activities, experiments and self-assessment tests associated with the subjects in question, resulting from the teaching activities of each academic semester. At present, these resources are mainly dispersed among the materials of the different course subjects; they are not classified or placed in any order, and it is not easy for them to be reused either by students or professors. This means that many students are missing out on the use of these resources and are not getting the benefit from them expected by the teaching staff. Equally, the teaching staff do not have the adequate search criteria for identifying the resources that could be reused for creating new educational resources. This means it is essential to design and create efficient web repositories to make these resources available in the form of digital learning objects that can be rapidly located and are in a format that allows them to be reused.

5. UOC policy for creating and managing educational resources: In 2007 the UOC embarked on a process of reflection on the new European Higher Education Area, setting up a series of working groups on various key issues related to the correct adoption of the model proposed in what has become known as the Bologna Process. One of these working groups was tasked with defining the technological and methodological needs of the learning process in terms of creating and managing educational resources, detecting current inadequacies and proposing specific solutions for improving them. The results from this working group clearly indicated that a centralized management model based on an editorial policy was needed to generate a set of quality resources, but that in the long term this structure would block all the new opportunities offered by information technologies today to create and share educational resources. Therefore, a decentralized model for creating and managing educational resources based on themed repositories (depending on the area of knowledge, e.g. Mathematics and Statistics) which would allow greater participation of all those involved in the educational scenario (authors, editors, teachers and students) seems to be the only viable option for guaranteeing the sustainable growth of the process of publishing quality educational material. This decentralized model is based on integrating the different repositories in the same virtual learning environment in a way that is totally transparent for the user, as is already the case with the UOC's Digital Library, where the same search interface can be used to locate any kind of resource. In this respect, the concept of a repository solves two of the problems facing many universities today: the first is how to promote the reuse of the educational resources generated during the teaching process in each academic semester, involving both professors and students, as well as the knowledge created collaboratively; the second is having a service that allows educational experiences to be developed according to the needs of each user, taking into account their individual requirements and idiosyncrasies by means of adaptable educational syllabuses created from a combination of

the educational resources available at any given time in the repository. In the first place, the creation of web repositories of educational content simplifies the process of creating and publishing new educational material for teachers; and secondly it facilitates students' access to the resources they need during their course. These repositories should also allow the available resources to be shared more efficiently between different universities, with the aim of increasing the overall quality of the resources used in the learning process. This is particularly valid in an area as important as Mathematics and Statistics, where students demonstrate a lot of gaps in their knowledge which can be identified and partly solved by the intensive use of information and communications technologies.

3 Evaluation

The use of learning object repositories for supporting learners in blended or pure virtual learning is becoming a common reality in learning management systems. Previous studies show that just allowing students to download all the resources is not effective from a pedagogical point of view, specially if the number of available resources is large (hundreds or even thousands) [10]. Learners need some guidance to use such learning resources within their learning process. The use of repositories provides instructors with a powerful tool for a better understanding of the learning process, as described in [11]. The usage data gathered from the repository can be used to establish relationships between the usage of learning resources and academic performance, but also for improving the way of describing such learning resources. In order to evaluate the results of the project, some pilot tests will be carried out on the subjects of mathematics and statistics. During these tests, the students and teaching staff will be able to use the repository we have created in accordance with the following conditions:

- Students can use the repository to locate the resources they may need in their learning process, using the taxonomy and set of content descriptors created for that purpose integrated in the search interface of the repository implemented.
- Similarly, teachers can use the repository to select and recommend resources to their students as well as using them to propose certain activities. It is hoped that the use of the repository will considerably improve the ease of generating new quality material suitable for certain specific uses and at a given time during the course, as well as the option of personalizing students' learning process.

The following activities will be used to gather data for evaluating the pilot scheme. First, questionnaires drawn up by the researchers on this project, which will be sent to the teaching staff of the subjects for them to evaluate the effectiveness of the repository and also identify any inadequacies. Two studies will be designed: one prior to the use of the repositories, to coincide with the end of the semester prior to the pilot experiment, and another after the experiment. The

first study will assess the quantitative indicators relating to the use of basic and complementary resources for that subject (frequency of use, resources chosen, timescales, efficacy of the search for resources in view of satisfaction with them, etc.), and qualitative indicators (level of satisfaction with resources, usability of the interface, general satisfaction, etc). In the second study, the questionnaires will be sent out prior to the start of the pilot scheme, and the quantitative indicators will evaluate the effectiveness and use of resources (frequency of use, type of use, resources chosen, timescales, search efficiency, etc.) and qualitative aspects (level of satisfaction with the tool and the meta-data, usability of the interface, general satisfaction, etc.) will be clearly identified in the design of the questionnaire. A comparative analysis will be made of both results. Second, questionnaires drawn up by the researchers of this project, which will be sent to students to evaluate the level of effectiveness and satisfaction with the repository. There will also be two studies: one prior to the use of the repository, thus relating to the use of resources currently available to students, and the other after the pilot scheme. The quantitative indicators (frequency of use, resources chosen, effectiveness of search, etc.) and qualitative ones (level of satisfaction with the tool - and the meta-data in the second study - usability of the tool, general satisfaction with the educational resource, etc.) will be formally defined when the questionnaires are drawn up. The design of these questionnaires, as well as those in the previous section, will be carried out jointly by expert researchers in mathematics teaching and expert researchers in quantitative and qualitative methodologies used in educational research on the Internet. A comparative analysis will be made of both results. Finally, these data will be cross-referenced with other quantitative data extracted from the actual use of the repository, available in the log files of the content management server. The analysis of the quantitative indicators obtained will offer an initial evaluation of efficiency. The team of researchers includes experts in this particular methodology. The analysis of the previous experimental data will be carried out by a team of experts in these methodologies and will allow an evaluation of the efficiency of use of the digital repositories in improving the motivation, performance and satisfaction of users as compared to the previous situation of using educational technology, as well as the effectiveness and usability of the tool itself (including the search interface).

4 Conclusions

The increasing large number of available learning resources for teaching Statistics makes impossible to manage them unless a coherent system is provided along with the learning process. In this paper we have described the introduction of a learning object repository in a virtual classroom of a pure online university, trying to fulfill two basic goals: assuring preservation and increasing reusability of learning resources, which are one of the most valuable assets of any university. With respect to the students, the repository will provide them with a personalized source of exercises, examples and so, but also with a contextualized map which may be a useful guide for understanding all the relationships between the

concepts in the Statistics course. Regarding teachers and instructional designers, the system will gather usage data that can be analyzed to better understand how students evolve during the learning process, helping also to identify those learning resources which may be more (or less) useful to students.

Current and further research in this topic includes the creation of a complete taxonomy of all the mathematical resources used in the Computer Science degree by means of an upper ontology which allows us to establish a hierarchical classification of the knowledge domain. This would allow learners to better contextualize what they are doing when using the learning resources (examples and exercises involving formulas). The integration of the repository in a personalization system which adapts the learning process to the specific characteristics of each learner is also an interesting issue that must be addressed.

5 Acknowledgments

This paper is partially supported by Spanish government grants under refs. E-MATH++ EA2008-0151 and PERSONAL(ONTO) TIN2006-15107-C02.

References

1. Kersaint, G.: Technology beliefs and practices of mathematics education faculty. Journal of Technology and Teacher Education **11**(4) (2003) 549–577
2. Chao, J.: Effective math on-line learning (EMOL). In: Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications. Number 1 (2003) 3061–3064
3. Gras, A., Cano, M.: Debates y tutorías como herramientas de aprendizaje para alumnos de ciencias: análisis de la integración curricular de recursos del campus virtual. Enseanza de las ciencias **23**(2) (2005) 167–180
4. Mas-Colell, A.: The european space of higher education: Incentive and governance issues. Rivista di Politica Economica **93**(11/12) (2003) 9–28
5. Juan, A., Daradoumis, A., Xhafa, F.: A Framework for Assessing Self, Peer and Group Performance in e-Learning. In: Self, Peer and Group Assessment in E-Learning. Idea Group Press, Hershey, PA, USA (2006)
6. Henderson, P.: Mathematics in the curricula. SIGCSE Bulletin Maths **2** (2005) 20–22
7. Sangrà, A.: A new learning model for the information and knowledge society: The case of the UOC. International Review of Research in Open and Distance Learning **2**(2) (January 2002)
8. John, N.: Digital repositories: not quite at your fingertips. Libri **55**(4) (2005) 181–197
9. Peters, T.: Digital repositories: individual, discipline-based, institutional, consortial or national? The Journal of Academic Librarianship **28**(6) (2002) 414–417
10. McNaught, C.: Developing criteria for successful learning repositories. In: Proceedings of the 2nd International Conference on Web Information Systems and Technologies. Volume 1., Setubal, Portugal (April 2006) 8–18
11. Ferran, N., Casadesús, J., Krakowska, M., Minguillón, J.: Enriching e-learning metadata through digital library usage analysis. The Electronic Library **25**(2) (2007)